Exploring the interplay between Process improvement approaches and Product innovation

By

Rima Wahid Al Hasan

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

University of Warwick, Warwick Business School,

November 2019

To the soul of my grandfather

To my Parents Wahid & Arwa and to my brothers,

Omar, Ali, & Mohammed

"The important thing is not to stop questioning. Curiosity has its own reason for existence. One cannot help but be in awe when he contemplates the mysteries of eternity, of life, of the marvelous structure of reality. It is enough if one tries merely to comprehend a little of this mystery each day"

(Albert Einstein)

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

- CI: Continuous improvement
- CRM: Customer relationship management
- DFSS: Design for six sigma
- DMAIC: Define, Measure, Analyse, Improve, Control
- GE: General electric
- II: incremental innovation
- JIT: Just in Time
- NPD: New product development
- OM: Operations management
- PDCA: Plan, Do, Check, Act
- PDCS: Product Creation and Deliverance System
- PI: Process improvement
- RI: Radical innovation
- SCDS: Strategy Concept Development System
- SIPOC: Supplier, Input, Process, Output, Customer
- TCDS: Technology Creation and Deliverance System
- TKO: Technology Kick-Off
- TOC: Theory of constraints
- TQM: Total quality management
- 5S: sort, set in order, shine, standardize and sustain

ACKNOWLEDGEMENT

This work would not be possible without God blessings, thanks God for giving me the ability and the opportunity to learn and complete this thesis. I would like to express my sincere appreciation to my supervisor, Prof. Pietro Micheli for his valuable guidance, fruitful conversations, insightful comments and continuous support throughout my PhD. I also would like to extend my appreciation to Prof. Sotirios Paroutis, my second supervisor for his academic advice, and valuable support.

I would like to thank my viva examiners; Prof. Chris Voss and Prof. Par Ahlstrom for their invaluable comments on my research, constructive feedback and professional conversation during the viva. Also, I would like to extend my thankfulness the annual review panel members and the operations group members for their constructive comments on my research over the years.

A special gratitude goes to the University of Jordan for giving me the chance to enrol in this PhD Programme through their financial sponsorship and thanks to Prof. Zu'bi Al Zu’bi my MBA supervisor and to Prof. Samer Dhyat for their support and for encouraging me to do a PhD.

Additionally, I would like to express my gratefulness for my Mom and Dad, who instil in me the love to learn, to brothers, Omar, Ali, and Mohammed for their unconditional love, support and encouragement throughout this journey. Thanks to friends whom I met in the UK for sharing with me the ups and downs of this journey.

Lastly, I wish to extend my gratitude to the research participants for their time and contributions to this research.

Thank you

😊

DECLARATION

This thesis is submitted to the University of Warwick in support of my application for the degree of Doctor of Philosophy in Business and Management. It has been composed by myself and has not been submitted in any previous application for any degree at any other university. All the work presented here, including the data generation and analysis, was carried out by the author.

Parts of this thesis have been published:

- Al Hasan, R. & Micheli, P. (2018). The productivity dilemma revisited: how process improvement can lead to product innovation. EurOMA, Budapest, 2018.

- Al Hasan, (June 2018). The four powers of innovation, 3-Minutes thesis competition video, University of Warwick. Available at URL: https://warwick.ac.uk/services/skills/pgr/opportunities/showcase/films [Accessed: March 2019].

- Al Hasan, R. (2018). Exploring the Interplay between Process Improvement Approaches and Product Innovation. OSCM Division Joint Junior Faculty and Doctoral Consortium, Academy of management annual meeting, Chicago, USA, 2018.

- Al Hasan, R. & Micheli, P. (2017). Perspectives into the interplay between process improvement and product innovation. A systematic literature review and research agenda. IPDMC, Reykjavik, Iceland, 2017.

- Al Hasan, R. & Micheli, P. (2017). Perspectives into the interplay between process improvement and product innovation. A literature review and research agenda. British academy of management, Coventry, UK, 2017.

- Al Hasan, R. & Micheli, P. (2016). The impact of process improvement on innovation. A literature review and research agenda. EurOMA, Trondheim, Norway, 2016.

Working paper

- Al Hasan, R., Micheli, P. & Paroutis, S. (2019). Configurations for managing the interplay between Process improvement and innovation. Working paper.

ABSTRACT

Purpose

Organizations' capacity to reconcile innovation, adaptation and exploration with efficiency, productivity gains and exploitation is crucial for their success, yet this constitutes a fundamental and enduring management challenge. Over the past decades, scholars in operations management, strategy and innovation management have proposed divergent conceptual arguments and drawn conflicting empirical conclusions in relation to the impact of process improvement (PI) approaches - such as lean, total quality management (TQM), six sigma, and theory of constraints – on incremental and radical product innovation. For some, PI can lead to both types of innovation; for others, PI inevitably hinders organizations' capacity to innovate their products, particularly in a radical way. In addition to the heterogeneity of theoretical and empirical arguments that exist in the literature, little is known about how PI interacts with innovation and what mechanisms that companies can use to manage the interplay between PI and incremental and radical product innovation. Therefore, this thesis focuses on exploring this interplay and on identifying the mechanisms that organizations use to manage it.

Method

This research used a qualitative multiple case study approach. Four companies were purposefully sampled. All of the selected companies are large manufacturing companies based in the United Kingdom. However, they operate in three different industries - automotive, aerospace and pharmaceutical - and vary in their implementation of PI approaches and in the degree of their product innovativeness. Over a 15-month period in 2016-2017, 44 semi-structured interviews with informants from different functional specialisms were conducted, and relevant documents collected. Data were analysed through a multi-stage iterative process.

Findings

This thesis' findings depart from previous arguments made in the literature by identifying four different configurations for managing the interplay between PI and product innovation - "strategic and holistic", "facilitating and empowering", "operational", "project-based" – and several associated mechanisms. These configurations comprise of multiple factors including how PI is deployed in the

organization (scope and formality), the adaptation of PI to the area that it is used in, and various managerial and structural features in the organization. The interplay between PI and product innovation substantially differs depending on the configuration, as it is managed through “integration” under the “facilitating and empowering” and “strategic and holistic” configurations, and through “separation” under the “operational” and “project-based” ones. Additionally, PI has the potential to enable product innovation (both incremental and radical) if it is loosely integrated with it; however, if it is formally integrated in the innovation processes it might constrain radical innovation.

Originality and Contributions

This thesis unpacks the interplay between PI and product innovation and posit a configurational view of the interplay. In particular it highlights the importance of PI deployment (formality, scope, adaptability) in shaping the potential innovation outcome. In doing so, research findings provide nuance to the debate on the “productivity dilemma” and question the dichotomic perspective on efficiency and innovation, as articulated in the organizational ambidexterity literature. Indeed, adopting a configurational perspective, productivity and efficiency enhancing activities, such as PI, appear not necessarily as barriers or enablers of innovation, but as having various types of impacts depending on several factors. Additionally, this study re-conceptualizes PI as a bundle of approaches that evolve over time due to different contextual factors, rather than a set of discrete, clearly codified sets of tools and practices. Finally, *how* and *where* PI is used in the organization seem to matter more than the types of tools being implemented when considering the impact of PI on product innovation.

Keywords: Process improvement, innovation, ambidexterity, configuration

CHAPTER 1: INTRODUCTION

> *"In corporate strategy we have two arms. One is to pack down the operations to make them more efficient, and [the second one is that this partly enable us] to free-up money that we can use to explore new things at the front end. And we need to do both". (Competitive and market intelligence manager in Fast-CarCo)*

For over a century, researchers in operations management have advocated the introduction of process improvement (PI) methods and standards to increase organizations' efficiency and productivity (Taylor, 1911, Womack et al., 1990). At the same time, strategy and innovation scholars have stressed the negative effects of efficiency and productivity gains on organizations' capacity to adapt and innovate. In relation to this, Abernathy (1978) introduced the notion of the *productivity dilemma* and "conjectured that short-term efficiency and long-term adaptability are inherently incompatible" (Adler et al., 2009, P.99). This argument has since been framed in different but related ways, for example stating that "exploitation" crowds out "exploration", that "stability" conflicts with "change", and that "standardization" hinders "creativity" (Schad et al., 2016). In line with these perspectives, several researchers in strategy and innovation have considered process improvement (PI) and product innovation and their associated processes, practices and concepts as conflicting, if not entirely incompatible (e.g. Benner and Tushman, 2003, 2015, Mehri, 2006). For example, PI approaches, such as lean, six sigma, theory of constraints (TOC) and total quality management (TQM), have been associated with exploitation, stability, efficiency, standardization, alignment and control, whereas innovation has been associated with regarded as requiring exploration, change, flexibility, creativity and adaptability (Benner and Tushman, 2002, 2003, 2015, Benner, 2009).

On the other hand, a considerable amount of research in the operations management literature highlights the benefits that PI approaches bring to organizations, not only in terms of greater efficiency and flow, but also in creating customer value, increasing customer satisfaction and innovating products and services (Modig and Ahlstrom, 2012, Sousa and Voss, 2002, Swink and Jacobs, 2012). In doing so, several scholars have suggested that PI approaches consists of two distinct dimensions; for example, Schroeder et al. (2008) argue that "Six Sigma can be viewed from two different structural dimensions: structural control and structural exploration" (p. 544). Also, Sitkin et al. (1994) identify two distinct approaches for TQM such as total quality control and total quality learning. More recently, the discussion has turned toward distinguishing the role of the technical and behavioral elements of various PI approaches on performance (Bortolotti et al., 2015, Choo et al., 2007a, Zeng et al., 2015). More specifically, in relation to the impact of PI on innovation, some researchers have adopted a primarily control-oriented view of PI approaches, arguing that PI approaches hinder product innovation; other scholars have adopted a learning-oriented view, arguing that PI approaches create a learning environment that fosters innovation (Pekovic and Galia, 2009, Prajogo and Sohal, 2001). The control-oriented perspective is linked to the more mechanistic side of PI (Abrunhosa and Sa, 2008, Bourke and Roper, 2015) such as process management, waste minimization, and the use of tools such as statistical process control (Benner and Tushman, 2003, Perdomo-Ortiz et al., 2006, Martinez-Costa and Martinez-Lorente, 2008). On the contrary, those adopting a learning-oriented view have considered "softer", behavioural characteristics of PI such as employees' involvement, team work, human resource practices, leadership, people management, etc. (Martinez-Costa and Martinez-Lorente, 2008, Choo et al., 2007b, Abrunhosa and Sa, 2008) in addition to the "hard" practices. Nonetheless, empirical research shows mixed results regarding the relationship between different PI approaches and incremental and radical product innovation (see, e.g., Benner and Tushman, 2002, Kim et al., 2012).

In addition to the heterogeneous theoretical and empirical arguments that exist in the literature, the strong focus on defining the elements (tools and practices) of PI that affect innovation has meant that other important questions have received considerably less attention, namely how PI is deployed, how it interacts with innovation related activities and thus shape the product innovation. Therefore, this thesis empirically *explores the interplay*[1] *between PI and incremental and radical product innovation.* In particular, this research addresses two research questions:

- *What are the factors that play a role in shaping the interplay between PI and incremental and radical product innovation?*
- *How do organisations manage the interplay between PI and incremental and radical product innovation related activities and what effect it leads to?*

[1]The term "interplay" refers to the way in which two concepts/ activities/ processes interact together. In the context of this thesis, the "interplay between PI and product innovation" refers to the association between PI related activities (approaches, tools, practices, processes) and the product innovation related activities (processes, practices, or units) across the organization and at different functional units.

It does so by carrying out a qualitative multiple case study research. An in-depth analysis was conducted to disentangle the characteristics of PI deployment, new product development and the perceived PI impact on innovation in four multi-national organizations from different industries- automotive, aerospace and pharmaceutical- in the United Kingdom. Various data sources were utilized, including interviews with informants from different functional specialisms (R&D, Design, Engineering, manufacturing, and/ or marketing), internal and online documents. To help unpack the organizations' approach for managing the interplay between PI and innovation, this thesis draws on the paradox and ambidexterity lens. Paradox refers to conflicting yet interdependent elements (Schad et al., 2016, Smith and Lewis, 2011), organizational ambidexterity to the ability to pursue contradictory goals (Benner and Tushman, 2003, Raisch and Birkinshaw, 2008). Studies in these areas have aimed to identify approaches for managing conflicting goals in organizations such as innovation and efficiency, exploration and exploitation, creativity and standardization and are, therefore, relevant for this study (Papachroni et al., 2015, Raisch and Birkinshaw, 2008). (See Figure 1).

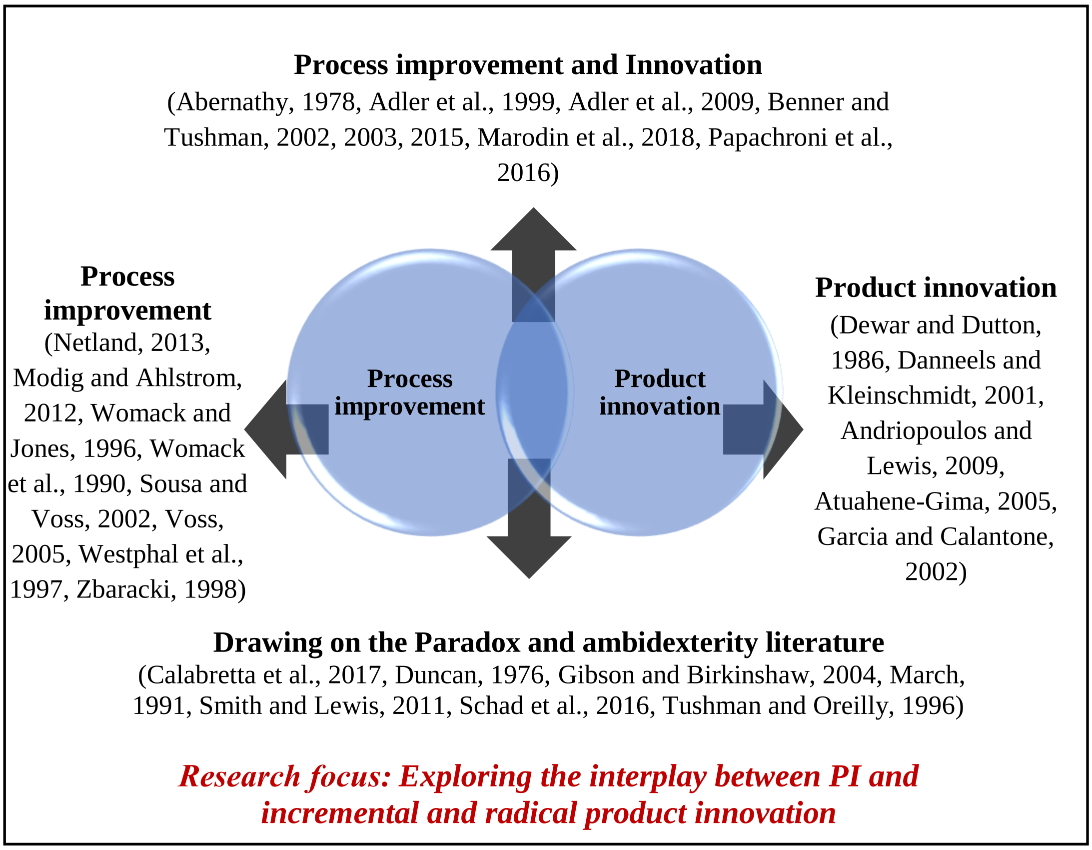


Figure 1: The Focus of the research

This thesis makes significant contributions to the literature on PI, innovation and ambidexterity. First, by untangling the interplay between PI and incremental and radical product innovation (Kim et al., 2012) and by introducing four different configurations for managing the interplay, namely: "Strategic and holistic", "facilitating and empowering", "operational", and "project-based". Second, by shifting the conceptualization of PI as several "discrete" approaches to a bundle of approaches (lean, six sigma, TQM) that have developed over time and combined through various organizational events. Third, expanding the PI deployment dimensions to include "PI scope" (Marodin et al., 2018, Jones and Womack, 2017, Netland and Ferdows, 2016), "PI formality", and "PI adaptation". Moreover, this thesis proposes some insights into the ambidexterity and paradox literature including: suggesting a different perspective to the dilemma (either/or) view of the productivity, efficiency and innovation debate by proposing a both/and perspective; and recommending a horizontal approach for managing contradictory goals (e.g. PI implementation and innovation related activities) at the NPD level.

1.1 Thesis structure

This thesis consists of eight chapters (see figure 2). Chapter two presents a comprehensive review of the literature on PI, innovation, and ambidexterity and paradox. The review of the PI literature includes its evolution, conceptualization, critics and its effects on innovation. From here, key theoretical puzzles in relation to the interplay between PI and innovation are discussed. In order to explore this interplay, this thesis draws on the ambidexterity and paradox debate on managing contradictory goals. Thus, this section discusses the evolution and conceptualization of the concept of ambidexterity, the relationship between various poles, and the proposed approaches for dealing with conflicting yet important goals for organizations. This chapter concludes with the key aims of the research.

Chapter Three presents the research methodology. A multiple case research design was employed, and a purposeful sampling for selecting the case organizations, that vary in their usage of PI and product innovativeness, was chosen. Multiple sources of evidence (semi-structured interviews, internal and online documents) were used. The interview protocol design and the data collection processes are discussed as well as the multi-stage iterative data analysis process employed.

Chapter Four provides information on the empirical contexts considered providing a brief description of the mission, vision and main activities for each of the case organizations, followed by a general analysis of the extent of PI implementation and product innovativeness.

Chapter Five unpacks PI characteristics, innovation development features, and organizations' managerial and structural-related features, in addition to the perceived interplay between PI and innovation.

Chapter Six - cross-case analysis - starts by identifying the similarities and differences between case organizations in terms of PI, innovation, and organizational features. In doing so, it becomes apparent that the deployment of PI differs between the case organizations across two main dimensions: scope and formality. The managerial and structural mechanisms that are used for managing the interplay between PI and innovation vary as well, and so does the type of interaction at different stages of the NPD process. This section concludes with the identification of four different configurations for managing the interplay between PI and innovation: "strategic and holistic", "facilitating and empowering", "operational" and "project-based."

Chapter Seven discusses the research findings in light of previous debates concerning PI, PI and innovation, and the concept of ambidexterity. Specifically, this research suggests that PI approaches are dynamic and interrelated, and that PI deployment is multidimensional and not simply a set of tools and practices. Also, this thesis suggests that the interplay between PI and innovation is configurational and therefore challenges the appropriateness of the question 'what is the impact of PI on innovation?' as posed in previous studies. Only once the relationship between the two is made explicit, can the effect of PI on innovation be examined. This chapter concludes with an elaboration of the research insights to the ambidexterity and paradox debates by proposing a different view to the dichotomic perspective over the link between productivity-enhancing activities, such as PI and innovation.

Chapter eight first provides an overview of the research contributions to theory and articulates several avenues for future research. Subsequently, it presents the main implications for practice: while the findings show that PI can play a supportive role in the innovation area (e.g. R&D, product development, design), this impact may depend on the use and formality of PI. A loose integration of PI in the innovation process can possibly facilitate product innovation, also of a radical kind.

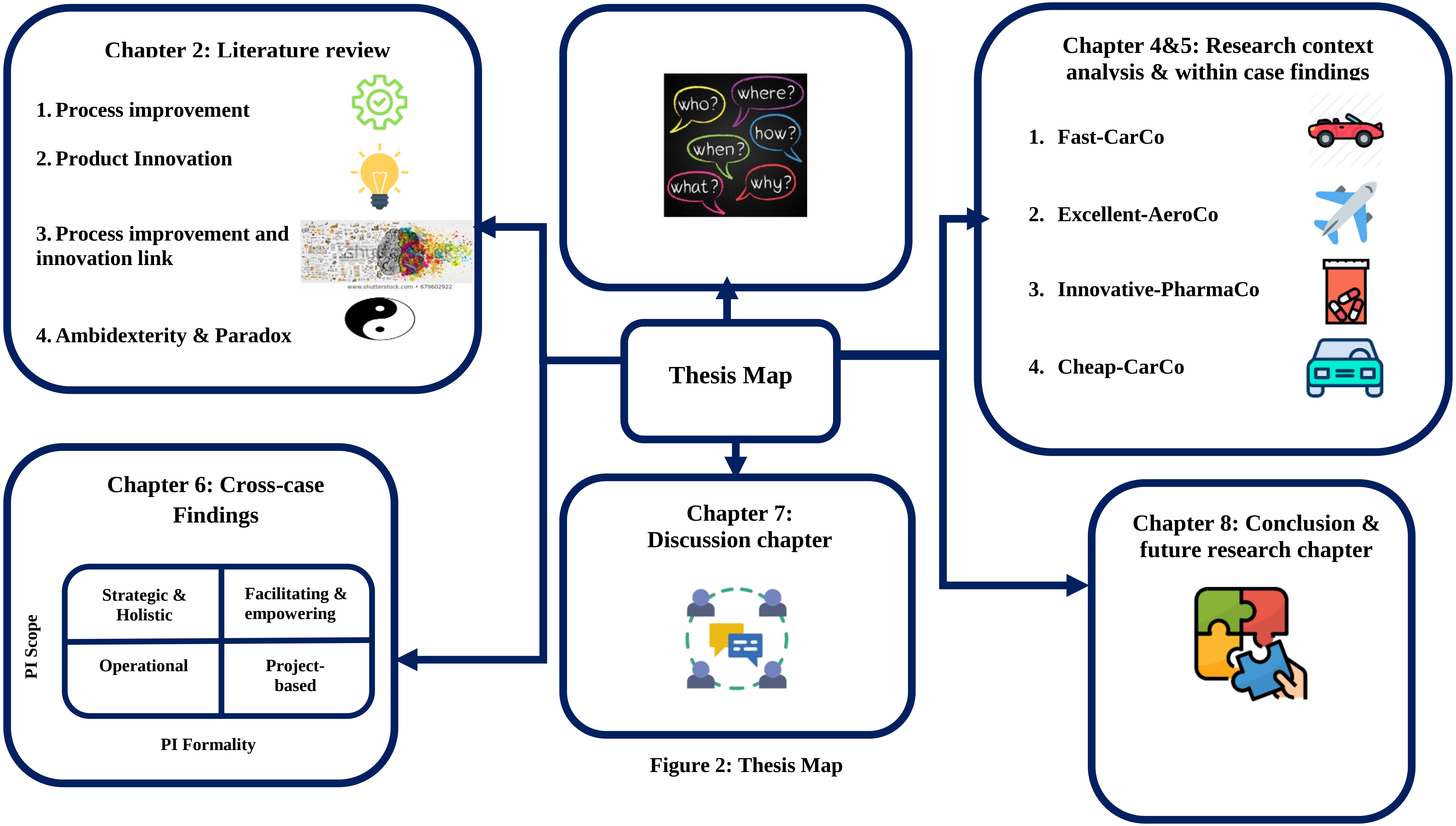


Figure 2: Thesis Map

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter provides a critical review of the literature with respect to PI, innovation, paradox and ambidexterity. An overview of the evolution, definitions, approaches, effects and criticisms for each stream is presented. This is followed by an in-depth review highlighting the main theoretical arguments regarding the interplay between PI and product innovation. The chapter concludes by summarizing the unanswered theoretical questions which inform the main research question of this thesis.

2.2 Process improvement

2.2.1 History and evolution of process improvement

For decades process improvement (PI) approaches has attracted a significant attention from both academic and practitioners. "Process" generally refers to "a sequences of tasks and activities" (Garvin, 1998, p.33). In an operations management context, process has been defined as "an arrangement of resources that produces some mixture of products and services" (Slack et al., 2010, P.663). "Improvement" is the act of incrementally and continuously modifying existing processes, tasks, activities or products (Gendron, 2013). Therefore, PI is a systematic effort to continuously simplify, streamline and align business processes to ultimately create value for customers and improve organizational performance. PI as a term has been used in two main ways in the literature. First, as an operational practice (Bateman and David, 2002) whereby, for instance, PI has been connected to general "enhancements in operational processes; e.g. improving a chair manufacturing process so that less raw material is consumed or reducing the cycle time from proposal to delivery of an insurance policy" (Anand et al., 2009, p. 454). Second, it has been associated with various approaches such as lean, six sigma, TQM and BPR (Slack, 2017, Slack et al., 2013). (See table 1)

Table 1: Process improvement approaches- Selected definitions

Process improvement approaches	**Definition**
Lean	- Lean: "is an operations strategy that prioritizes flow efficiency over resource efficiency (Modig and Ahlstrom, 2012, p.117). - *Lean thinking*: it can be "summarised in five principles: precisely specify value by specific product, identify the value stream for each product, make value flow without interruptions, let the customer pull value from the producer, and pursue perfection" (Womack and Jones, 1996, p. 10). - *Lean production* is an integrated system that "encompasses a wide variety of management practices, including Just-in-Time (JIT), quality systems, work teams, cellular manufacturing, supplier management, etc." (Shah and Ward, 2003, P.129). - *Lean management* "is a managerial approach for improving processes based on a complex system of interrelated socio-technical practices" (Bortolotti et al., 2015, P.182).
Six Sigma	- "an organized, parallel-meso structure to reduce variation in organizational processes by using improvement specialists, a structured method, and performance metrics with the aim of achieving strategic objectives" (Schroeder et al., 2008, P.540).
Total quality management	- "TQM is an approach to improving the quality of goods and services. At its foundation are the goals of continuous improvement of all processes, customer-driven quality, production without defects, focus on improvement" (Flynn et al., 1995, P. 1327).
Theory of constraints	- The theory of constraints "is a multi-faceted systems methodology that has been developed to assist people and organisations to think about their problems, develop breakthrough solutions and implement those solutions successfully" (Mabin and Balderstone, 2003, P. 568)
Business process reengineering	- Reengineering is "the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements is critical, contemporary measures of performance, such as cost, quality, service, and speed" (Hammer and Champy, 2001, P. 32). A business process is "a collection of activities that takes one or more kinds of inputs and creates an output that is of value to customer" (Hammer and Champy, 2001, P. 35)

The interest in improving processes, operations and organizational performance can be traced back to the contributions of early management scholars (Voss, 1995). This was reflected in the writings of Adam Smith and Fredrick Taylor, Edward Deming and of more recent scholars (e.g. Modig and Ahlstrom, 2012, Netland and Powell, 2017, Schroeder et al., 2008, Shah and Ward, 2007, Sousa and Voss, 2002, Womack et al., 1990). Adam Smith, in his book "*An Inquiry into the Nature and Causes of the Wealth of Nations*" (1776), highlights that nations' economic growth is rooted in labour's productivity. He emphasizes that task specialization improves labour productivity which, ultimately, leads to economic growth. Fredrick Taylor proposed standard procedures to improve workers' productivity; indeed, his well-known "scientific management principles" advocated the use of "one best way" of doing work to maximize the number of workers' outputs at the minimum time, cost and effort (Taylor, 1911). This was followed by Frank and Lillian Gilbreth who studied "work to eliminate inefficient time-and body-motions" (Robbins et al., 2011, P.27).

Considering management practice, in 1927 Henry Ford introduced his "philosophy and the basic principles underlying the revolutionary Ford production system" (FPS) in *Today and tomorrow* (Shah and Ward, 2007, p.787). Drawing on the tenets of Taylorism, Ford invented the moving assembly line that reduced the number of hours required to build a car from more than twelve hours to less than three (Ford-Media-Center, 2013). This was followed by the start of quality management in Shewhart's work on the application of statistics in controlling processes in the 1930s and 1940s (Voss, 1995, p. S17). Between the 1940s and 1970s, Toyota (Toyoda) Motor Company and the Toyota production system (TPS) were developed. TPS is characterized by just-in-time as a key production method which aims to save costs by producing the needed units and quantities at the needed time (Modig and Ahlstrom, 2012). The interest in improving production efficiency, productivity and maintaining product quality led to the development of the principles of quality management by Edward Deming in the 1980s. The promise of quality control and management attracted firms to adopt quality control principles. For instance, in 1984, Motorola – an electronic and communication systems company – developed six sigma, a method to improve and control processes, pursuing the goal of having almost no defects in manufacturing (Schroeder et al., 2008) (see figure 3).

During the same period the expression "lean production" was coined by Womack, Ross and Jones in their book *The machine that changed the world* (1990) which highlights the advantages of the Toyota production system. Following that, process improvement and management gained increasing popularity among academics and practitioners alike. In the 1990s, many well-known companies[2] adopted PI and quality management approaches, including General Electric, Honeywell, 3M, American Express and Ford (Benner and Tushman, 2003, Swink and Jacobs, 2012). The popularity of PI approaches was accompanied with an increase in the number of

[2] While the adoption of PI may have negatively affected the performance of some of these companies in the past few years, their implementation of PI in the 1990s contributed to increasing the popularity of these approaches.

excellence awards and certificates such as ISO9000, the Shingo Prize for Excellence, the British Quality Foundation Excellence awards in the United Kingdom, the Malcolm Baldrige National Quality (MBNQA) Award in the United States, and the European Foundation for Quality Management (EFQM) award in Europe (Benner and Tushman, 2003, Sousa and Voss, 2002).

Many of the early contributions on productivity, efficiency, specialization and standardization have shaped the evolving conceptualizations of PI. For example, while most early research focus on control, efficiency and operational improvement (Womack et al., 1990), later research considered learning and behavioural aspects of PI (Bessant et al., 2001, Choo et al., 2007a, Modig and Ahlstrom, 2012, Sitkin et al., 1994). With the introduction of the concept of continuous improvement (CI) – “a systematic effort to seek out and apply new ways of doing work i.e. actively and repeatedly making process improvements” (Anand et al., 2009, p.444) - and the emergence of a bottom-up approach for improvement in the 1990s, a shift in the focus of the literature from quality control (QC) to more comprehensive approach known as total quality management (TQM) was made (Voss, 1995). Indeed, research started to emphasize the crucial role that human resources and behavioural practices play in attaining the benefits of TQM adoption (Gil-Marques and Moreno-Luzon, 2013). Similar trends can be seen in relation to lean manufacturing and management where initial research was tool-focused (Hines et al., 2004), whereas recent research has considered both tools and behavioural aspects (Bortolotti et al., 2015). For instance, the book *The machine that changed the world* focused has been criticized as “there is not a single quote from the people who work within the system” (Mehri, 2006, p. 25). However, in later research various authors have stressed the importance of the behavioural and learning effects of lean, with Jones (2014) arguing that lean is “a path or a journey of individual and organizational learning and leads to more challenging and fulfilling work for those involved” (Online source).

The distinction between a predominant focus on technical aspects versus one that encompasses both technical and behavioural ones has been termed differently in the literature: “soft” and “hard” in relation to lean; “core” and “infrastructure” in TQM and quality management; and “methodological” and “contextual” in the context of six sigma (Bortolotti et al., 2015, Choo et al., 2007a, Naor et al., 2015, Shah and Ward, 2003, Zeng et al., 2015) (See table 2).

Table 2: Technical and behavioural aspects of PI

Author	Technical	Behavioural / relational
Core/ Infrastructure (Naor et al., 2008) (Naor et al., 2015)	• Quality information • Process management • Product design	• Top management support • Workforce management • Supplier involvement • Customer involvement
Hard/ soft (Zeng et al., 2015)	• Process management • quality information	• Small group problem-solving • Employee suggestions • Task-related training for employees
Hard/ soft (Bortolotti et al., 2015)	• Equipment layout for continuous flow • Just in time delivery by suppliers • Kanban • Setup time reduction • Statistical process control • Autonomous maintenance	• Top management leadership for quality • Supplier partnership • Small group problem solving • Continuous improvement • Training employees • Customer involvement
Methodological/ Contextual (Choo et al., 2007a)	• Employ common metrics • Adhering to step-wise problem solving • Analysing with a set of tools	• Providing support through leadership • Ensuring resource availability • Setting challenging work • Building trust

Another important development in both theory and practice relates to the diffusion of PI usage across industries and organizational functions (Benner and Tushman, 2002, 2003). The adoption of PI started in the automotive industry and then it transferred to other industries such as aerospace and consumer electronics and more recently in service industries such as healthcare and banking (Netland and Powell, 2017, Samuel et al., 2015). Also, the success of PI in improving performance led to the diffusion of various PI approaches from manufacturing units to other areas in the organization such as product development (Karlsson and Ahlstrom, 1996b, Ward, 2007). As this happened, the diffusion of PI attracted criticism from innovation and strategy scholars concerning its incompatibility with innovation management processes (Benner and Tushman, 2002, 2003). The next sections will expand on these themes by discussing the conceptualization, similarities and differences between PI approaches, the adoption and maturity of PI usage and, finally, the effects of and criticisms made to various PI approaches.

- **1760-1840**
  - Industrial revolution: The use of machines in manufacturing processes
- **1776**
  - Adam Smith introduces the concept of the "division of labour" in his book "The Wealth of the Nation"
- **1911**
  - Scientific management & time and motion studies
  - Fredreck Taylor, Frank Gilbreth and Lillian Gilbreth
- **1913**
  - Henry Ford: Assembly line and T-model
- **1920**
  - Statistical process control pioneered by Walter Shewhart
- **1927**
  - Henry Ford outlines the production philosophy underlying the Ford production system in "Today and Tomorrow" (Shah and ward, 2007)
- **1931**
  - PDSA (plan, do study, act) cycle of problem-solving
  - Walter Shewhart
- **1940-1970**
  - Development of the Toyota production system, called also just- in-time (JIT) by Ohno, Shingo and Toyoda
- **1960-70s**
  - Development in computing and increasing focus on production planning and control (Voss, 1995)
- **1980s**
  - Edward Deming principles of quality management
  - Popularity of quality management: Dominated by the concept of quality control
- **1984**
  - The Goal for Eliyahu Goldratt
  - Theory of constraints
- **1986**
  - Motorola introduces the six sigma approach for process improvement
- **1990**
  - "The Machine that Changed the World" by Womack, Roos, and Jones
  - The term "lean production" coined, to describe the Toyota production system
- **late 1980s-90s**
  - Total quality management: Including the principle of continuous improvement
- **1993**
  - Business process reengineering
  - Hammer and. Champy publish "Reengineering the Corporation: A manifesto for Business Revolution"
- **1995**
  - General Electric CEO Jack Welch adopts six sigma as a key part of the company
- **2000s-present**
  - Large number of books, academic and practicioners' articles written on various PI approaches as discrete approaches

Figure 3: Timeline of the critical contributions to PI evolution

2.2.2 PI as distinct approaches vs PI as a "bundle"

Since PI approaches have diverse roots and have emerged at different points in time (Slack et al., 2013, Slack, 2017, Schroeder et al., 2008, Womack et al., 1990, Ittner and Larcker, 1997), a considerable amount of research has focused on specific groups of principles, tools and techniques (Swink and Jacobs, 2012, Danese et al., 2018). While this has led to the development of prescriptive guides for implementing specific PI approaches (Benner and Tushman, 2003, Sitkin et al., 1994), treating PI approaches as distinct, independent ones can be problematic for several reasons.

First, in both theory and practice *it is difficult to distinguish between various PI approaches*. For example, while several researchers have defined TQM in a broad way as including process management together with leadership, benchmarking, product / device design, employee relations, suppliers' quality management, etc. (Zu et al., 2008, Jayaram et al., 2010, Kaynak, 2003), some lean scholars have considered TQM, as well as six sigma and TOC, as constituent parts of lean (Shah and Ward, 2003). Also, for some researchers process management includes six sigma, TQM, etc. rather than the reverse (Benner and Tushman, 2003). Moreover, while various scholars have argued that six sigma is different from other PI approaches (e.g., Pande et al., 2000), others have considered it as a repackaging of quality management (Dalgleish, 2003).

Second, *PI approaches rarely operate in isolation* (Ittner and Larcker, 1997) . Over time, organizations - in particular product-based ones - have adopted different PI approaches (Swink and Jacobs, 2012). According to Zilber (2006), using practices, technologies and initiatives for a long period of time creates a learning effect and embeddedness of the newly adopted practice. Therefore, disentangling certain practices from their context may be inappropriate (Hackman and Wageman, 1995, Ittner and Larcker, 1997) as the characteristics of various practices create a distinctive approach (Voss, 1995). Additionally, many researchers have suggested that PI concepts are based on learning (Bessant et al., 2001, Hines et al., 2004); therefore, examining the impact of a single PI approach can be inaccurate as the approach would interact with other ones (Swink and Jacobs, 2012, Ittner and Larcker, 1997).

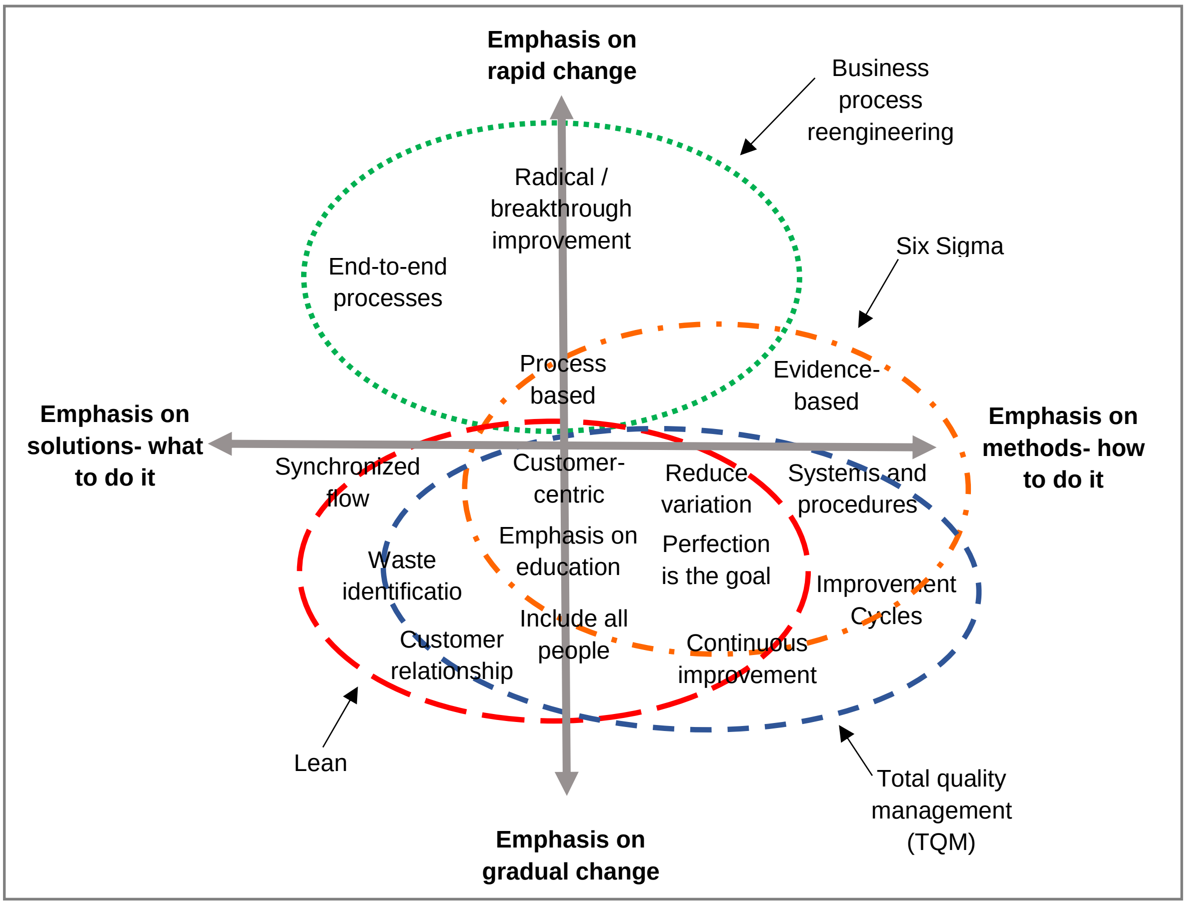
Third, over the years, different quality and PI concepts started to encompass various practices and tools that were not originally considered part of PI (Sousa and Voss, 2002). This can be due to two main reasons: first, the use of PI in non-manufacturing areas and sectors (e.g., product development and/or services) (Sousa and Voss, 2002). For instance, several learning practices have been proposed in addition to total quality control practices particularly in dynamic contexts (Sitkin et al., 1994). Second, advocates of PI approaches, consultants, practitioners and excellence award institutions have tried to repackage many PI approaches by adding tools unrelated to PI to make them more sellable (Sousa and Voss, 2002).

Despite the dominant approach of researching PI approaches individually, some scholars and practitioners have recently considered the integration of various PI approaches (Danese et al., 2018) for example under the banner of "lean sigma", but this perspective is still relatively uncommon.

2.2.2.1 Similarities and differences between PI approaches

Advocates of each approach promote it as best practice to improve organizational performance (Nave, 2002). As a result, studies on TQM, lean, TOC and six sigma have often been conducted separately, and many scales have been developed separately for each approach. This adds complexity to the concepts and creates the illusion that these techniques are incompatible and contradict each other (Nave, 2002). In fact, they are similar in many ways (Slack et al., 2013). For instance, "Lean shares the same scientific approach to the analysis of work with many improvement methodologies, like BPR, Six Sigma, and TQM" (Jones and Womack, 2017, p. 7). Also, Schroeder et al. (2008) found that "the philosophy and tools/techniques of Six Sigma are strikingly similar to prior quality management approaches" (p. 537). Indeed, PI approaches appear to share three main principles. First, all of these approaches are customer-centric (Slack et al., 2013). For example, "the critical starting point of lean thinking is value" (Womack and Jones, 1996, p. 16), which is defined according to the ultimate customers' needs (Modig and Ahlstrom, 2012). TQM also prioritizes a customer focus (Westphal et al., 1997, Fuentes-Fuentes et al., 2004, Zu et al., 2008), and six sigma aims to reduce variation and defects to satisfy customers (Andersson et al., 2006, Gutierrez et al., 2009). Second, these approaches use iterative cycles of continuous improvement (Slack et al., 2013), even though the cycles have different names - DMAIC (Define-measure-analyse-improve-control) in six sigma (Zu et al., 2008, Schroeder et al., 2008, Nair et al., 2011, Nave, 2002) and PDCA (plan-develop-check-act) in others. Third, improvement processes require involving everyone in the organization (Westphal et al., 1997, Nave, 2002, Slack et al., 2013). Other common elements between TQM, lean, six sigma and TOC are summarized in table 2.

At the same, TOC is said not to require total participation in all occasions (Nave, 2002), and six sigma, lean and TQM are process-oriented (Slack et al., 2013, Bhuiyan and Baghel, 2005), whereas TOC is system-oriented (aims to improve the system as a whole). These approaches also vary in their main assumptions and focus. For example, lean prioritises flow efficiency (Modig and Ahlstrom, 2012), TOC focuses on elevating constraints and improving the overall system, and six sigma aims to reduce variation (Nave, 2002, Drohomeretski et al., 2014). Also, they differ in whether the emphasis is on "what" to improve or "how" to improve. For instance, lean emphasizes "what" to change in the process by defining non-value-added activities to improve flow efficiency. On the other hand, TQM and six sigma focus on the "how" to improve through the PDCA or DMAIC cycle (Slack et al., 2013, p. 597). Moreover, PI approaches can vary from a focus on continuous improvement (TQM, lean, six sigma and TOC) to one on radical improvement (BPR[3]) (Benner and Tushman, 2003, Slack et al., 2013, Ittner and Larcker, 1997) (see Figure 4). Table 3 and Figure 4 illustrate the main differences and similarities between different PI approaches.



Adapted from: (Slack et al. 2013)

Figure 4: PI approaches on two dimensions of improvement

[3] Business process reengineering was not empirically examined in this thesis.

Table 3: Comparison of PI approaches

<table>
<tr><th></th><th>Lean</th><th>Six sigma</th><th>TQM</th><th>TOC</th></tr>
<tr><td>Purpose / main goal</td><td>Increase flow (Modig and Ahlstrom, 2012)</td><td>Reduce variation and defects (Schroeder et al., 2008)</td><td>Improve quality (Westphal et al., 1997, Hackman and Wageman, 1995).</td><td>Improve system performance (Mabin and Balderstone, 2003)</td></tr>
<tr><td>Improvement cycle</td><td>1. Identify value
2. Define the value stream
3. Flow
4. Pull
5. Perfection
(Womack and Jones, 1996)</td><td>1. Define
2. Measure
3. Analyse
4. Improve
5. Control
(Schroeder et al., 2008)</td><td>Structured problem-solving processes can include different tools such as: Cause-and-effect diagrams, Pareto diagram, statistical process control charts (Westphal et al., 1997, Hackman and Wageman, 1995)</td><td>1. Identify constraint
2. Exploit constraint
3. Subordinate processes
4. Elevate constraint
5. Repeat cycle
(Nave, 2002)</td></tr>
<tr><td>Common elements (Slack et al., 2013)</td><td colspan="4">• Continuous improvement
• Improvement cycle
• Process-oriented
• Customer-centricity
• End-to-end processes
• Include everyone
• Develop internal customer-supplier relationship
• Perfection is the goal
• Reduce process variation
• Waste identification
• Synchronized flow
• Emphasize education and training
• System and procedures</td></tr>
<tr><td>Common antecedents/ enablers</td><td colspan="4">➢ Top management support (Choo et al., 2007a, Schroeder et al., 2008, Karlsson and Ahlstrom, 1996b, Zu et al., 2008).
➢ Organizational culture (Schroeder et al., 2008, Naor et al., 2008, Anand et al., 2009).
➢ Resources (Choo et al., 2007a, Zu et al., 2008).
➢ Trust (psychological safety)
An environment characterized by trust creates psychological safety in which people are more willing to take risks, explore and learn from failure (Choo et al., 2007b, Choo et al., 2007a)</td></tr>
<tr><td>Common consequences / outcomes</td><td colspan="4">➢ Knowledge creation
Knowledge creation can result from balancing the methodological (tool-based) and the contextual (behavioural) techniques of a comprehensive quality management programme (Choo et al., 2007a).
Also, it can be enabled by creating an environment that maintains trust and psychological safety (Choo et al., 2007b)
➢ Customers' satisfaction (Drohomeretski et al., 2014, Nave, 2002).
➢ Reduce variations and error (Drohomeretski et al., 2014, Nave, 2002)
➢ Performance (organizational, business, financial and operational performance) (Zu et al., 2008, Naor et al., 2008, Schroeder et al., 2008, Drohomeretski et al., 2014, Shah and Ward, 2003, Jacobs et al., 2015, Shafer and Moeller, 2012, Mabin and Balderstone, 2003).
➢ Product and / or process innovation (Kim et al., 2012, Benner and Tushman, 2002).
➢ Productivity (Drohomeretski et al., 2014, Nave, 2002).</td></tr>
<tr><td>Reason of adoption</td><td colspan="4">➢ Institutional pressures (Zbaracki, 1998, Voss, 2005, Yeung et al., 2006, Braunscheidel et al., 2011).
➢ Efficiency / technical reasons (Westphal et al., 1997, Zbaracki, 1998).</td></tr>
</table>

2.2.3 PI adoption

Organizations adopt PI approaches for various reasons. Initially, thanks to its implementation by well-known organizations - such as GE, IBM, Toyota and 3M - many companies introduced PI approaches to improve their operational performance (Benner and Tushman, 2003, p.242). In the context of hospitals, Westphal et al. (1997) found that "early adopters, motivated by technical efficiency gains from adoption […] in contrast, later adopters, experiencing normative pressure to adopt legitimate quality practices, appear more likely to mimic the normative model or definition of TQM adoption implemented in other hospitals [organizations]" (p.387).

Various authors interested in the implementation of PI focused on specific tools and practices (Kaynak, 2003, Schroeder et al., 2008, Shah and Ward, 2003) (see table 4) related to waste elimination, customer-orientation and shop-floor management; for example, 5S were associated with operationalizing lean (Womack and Jones, 1996) and drum buffer rope scheduling was associated with TOC implementation (Inman et al., 2009). Customer focus, teamwork, continuous improvement, top management support, and product design were considered as TQM-related practices (Flynn et al., 1994, Kaynak, 2003). However, this literature is either descriptive or prescriptive in nature (Sitkin et al., 1994) and there was no attempt to develop a broader theory for process management or improvement (Benner and Tushman, 2003, p. 239). Similarly, Bessant et al. (2001) have identified three problems in the literature on continuous and process improvement: first, the behavioural aspects of PI were often missing in the literature; second, research was mainly prescriptive and "it tends to assume a correlation between exposure to tools … and CI, and neglects the other elements of behavior building"; third, it deals with PI as a binary rather than learning process (Bessant et al., 2001, p.68). The problem in the fixation on prescriptive tools, practices and procedures is that it limits the transferability and the applicability of PI in different contexts (Modig and Ahlstrom, 2012). For instance, "Toyota developed its methods and tools within the large-scale manufacturing of cars. This resulted in the designing of tools and methods for a specific context and environment and not necessarily for other contexts" (Modig and Ahlstrom, 2012, p. 88). Thus, narrowly focusing on PI as discrete approaches may lead to neglecting the variations in the form of PI adoption in varied contexts (Westphal et al., 1997).

Another stream of research has considered the breadth of the adoption of PI in different industries. Initial empirical research was completed in the manufacturing sector; however, later studies have been conducted in service sectors (Danese et al., 2018). For instance, it can be noticed that since the term lean production was coined by (Womack et al., 1990), many studies were conducted on Toyota. In the late 1990s and 2000s, PI usage expanded to other sectors such as aerospace, electronics and service-based companies (Samuel et al., 2015). However, most research has been narrowly focused on the production unit or factory within the studied organization (Shah and Ward, 2003). While recent research has considered the adoption of PI at the organizational level (e.g., Kim et al., 2012, Marodin et al., 2018), less has been done to understand the application of comprehensive PI approaches across the organization (Marodin et al., 2018).

Nonetheless, some scholars have considered the implementation of PI within an new product development (NPD) environment (Rossi et al., 2017, Ward, 2007). This research has predominantly considered the introduction of lean in NPD, often in the context of Toyota (Marodin et al., 2018). Overall, within this stream of literature, researchers have investigated the impact of PI adoption on NPD performance in terms of speed, quality and efficiency. For instance, Sun and Zhao, (2010) found a positive relationship between TQM and NPD speed. Tuli and Shankar (2015), also found that lean product development improves NPD speed, and product quality. Also, Dalton (2009) reached a similar conclusion and suggested that TOC enables continuous innovation by assisting innovators in identifying bottlenecks in the innovation process. In addition to the research that considered the impact of PI adoption in manufacturing or product development on performance, a few studies have considered the impact of PI approaches in both product development and manufacturing on performance. For example, Marodin et al. (2018) considered the mediating role of lean product development on the impact of lean manufacturing on business performance. While the research on the adoption of PI in manufacturing and NPD has been informative in terms of clarifying the impact of PI adoption on performance, how PI is used in different areas in organizations and the varied uses of PI in different environments remain relatively unexplored.

Table 4: PI Elements

PI techniques	Clear distinction between Hard/Soft	Elements	Supportive literature
Six Sigma	Yes (Choo et al., 2007a, Choo et al., 2007b)	Structured method	Zu et al. (2008), Schroeder et al. (2008), Nair et al. (2011)
		Structured roles (using improvement specialist)	Zu et al. (2008), Nair et al. (2011)
		Meso-structure	Schroeder et al. (2008)
		Statistical tools (six sigma focus on metrics)	Zu et al. (2008)
		Teamwork	Gutierrez et al. (2009)
		Psychological safety	Choo et al. (2007b), Nair et al. (2011)
		Customer orientation	Schroeder et al. (2008)
		Employees participation (involvement)	Nave (2002)
TQM / Quality management	Yes Naor et al. (2008), Zeng et al. (2015)	Customer focus	Zu et al. (2008), Jayaram et al. (2010)
		Training	Kaynak (2003)
		Leadership/top management support	Zu et al. (2008), Kaynak (2003)
		Employees relations (employees' involvement, workforce management)	Zu et al. (2008), (Kaynak, 2003, Jayaram et al., 2010)
		Process management	Zu et al. (2008), Kaynak (2003), Jayaram et al. (2010)
		Supplier quality management / supplier's relationship	(Zu et al., 2008, Kaynak, 2003)
		Product / service deign	Zu et al. (2008), Kaynak (2003), Jayaram et al. (2010)
Lean	Yes Bortolotti et al. (2015)	Customer involvement	Shah and Ward (2007)
		Supplier involvement	Shah and Ward (2007)
		Employee involvement	Pakdil and Leonard (2015), Shah and Ward (2007), Shah and Ward (2003), (Fullerton et al., 2013, Slack et al., 2013)
		Continuous improvement	Slack et al. (2013), Shah and Ward (2003), Bortolotti et al. (2015)
		Waste minimization	Slack et al. (2013), Hines et al. (2004)
		TQM practices	Shah and Ward (2003), Shah and Ward (2007)
		Flow	Shah and Ward (2007)
		TPM	Shah and Ward (2003), Shah and Ward (2007)
		HRM practices	(Shah and Ward, 2003)
Theory of Constraint (TOC)	Separate it into philosophy and technical	Logistics	Inman et al. (2009)
		Thinking processes	Rahman (1998), Inman et al. (2009)
		Performance measurement	Inman et al. (2009)
		PDCA	Nave (2002), Rahman (1998)

2.2.4 Effects of PI approaches

The increasing popularity of various PI approaches in organizations (Benner and Tushman, 2003, Schroeder et al., 2008) and the success and failure stories reported by the media have attracted the attention of many researchers. Consequently, an important stream of research relating to the consequences of adopting various PI approaches has developed. The existing literature can be classified into three main streams relating to the effects of PI. First, the majority of studies have considered the impact of various PI approaches on operating performance in terms of improving efficiency, quality, and/or overall productivity (Jacobs et al., 2015, Swink and Jacobs, 2012, Shah and Ward, 2003, Marodin et al., 2018, Drohomeretski et al., 2014). Within this stream, some researchers have looked at the impact of the adoption of PI and excellence related certificates such as ISO 9000, Shingo EFQM, on organizational performance (Benner and Tushman, 2002). Even though PI advocates promoted PI approaches as beneficial for the organization in terms of increasing efficiency and improving quality and customers' satisfaction (Benner and Tushman, 2003), there is no clear consensus regarding the impact of PI on performance as the empirical research results have been inconclusive so far (Kaynak, 2003, Sousa and Voss, 2002); this can be traced back, at least in part, to differences in the context and operationalization of PI.

Second, other scholars have considered the effects of PI on innovation[4] (Benner and Tushman, 2002, 2015, Kim et al., 2012), knowledge creation (Choo et al., 2007a) and product development performance (Helander et al., 2015, Salomo et al., 2007) including NPD speed (Sun and Du, 2010) and efficiency (Browning and Sanders, 2012). Empirical research regarding the impact of PI on innovation has reached mixed results as well, as some authors have found a positive relationship between PI approaches and innovation (e.g. Kim et al., 2012) while others have found the opposite (e.g., Benner and Tushman, 2002)

A third stream of research suggests that the main value of PI is not only in its operational but also in its social and behavioural impacts (Swink and Jacobs, 2012, Schroeder et al., 2008). This research suggests that PI implementation creates a learning environment for employees to create new knowledge (Choo et al., 2007a, Naor et al., 2008, Swink and Jacobs, 2012), facilitates collaboration and the development of shared vision (Gutierrez et al., 2009) , affects employees' motivation (de Treville and Antonakis, 2006) and creates a working environment that is based on

[4] Section 2.4 presents a detailed review on the impact of PI on innovation

trust (Choo et al., 2007b). This stream argues that for capturing the benefits of PI, its deployment should not simply focus on the tools and technical practices; rather, it should consider both the tools and behavioural practices. This includes the adoption of both the hard/core/methodological and the soft/ infrastructure/contextual practices of various PI approaches (Bortolotti et al., 2015, Choo et al., 2007a, Shah and Ward, 2003, Zeng et al., 2015). For example, Naor et al. (2008) found that "infrastructure quality practices have a greater impact on manufacturing performance than core quality practices" (P. 693). In doing so they stressed the significance of the soft and the human-oriented practices of quality management in creating a sustainable competitive advantage.

2.2.4.1 Critique of PI approaches

While many scholars have advocated the use of PI approaches, others have criticized them for many reasons. First, for some authors PI approaches do not meet their promised outcomes of improving a company's performance (Benner and Tushman, 2003, Swink and Jacobs, 2012, Schroeder et al., 2008). Some scholars have questioned the value of investing in PI and whether the benefits of adoption exceed the cost (Benner and Tushman, 2003), arguing that the adoption of PI requires substantial investments from companies in allocating resources, conducting training for employees, hiring specialists and changing structures (Swink and Jacobs, 2012, Schroeder et al., 2008). For instance, it has been noted that over a four-year period, GE spent around 1.6 billion dollars on six sigma (Swink and Jacobs, 2012). At the same time, despite this considerable cost, it was argued that the returned value of its deployment was not as promised and, in fact, in some cases PI adoption led to detrimental effects (Benner and Tushman, 2003). Another example relates to the use of six sigma in 3M, which, it has been argued, restricted its innovation performance. Indeed, between 2004 and 2007, 3M's rank in the Boston Consulting Group's Most Innovative Companies list dropped from number 1 to number 7, and several commentators attributed this decline in innovative performance to the use of six sigma (Hindo, 2007).

Second, PI approaches have been criticized for disregarding employees' needs (Mehri, 2006, Koukoulaki, 2014). By observing the Toyota production system for three years, Mehri (2006) concluded that lean production has a substantial human cost. In particular, he stated that the implementation of lean has a negative effect on workers' wellbeing and safety. The fast pace of the production line burdened workers and exposed them to dangerous working conditions. Over time, these conditions tightened workers' professional skills and led to a decrease in their quality of life (Mehri, 2006). The adverse consequences on employees were attributed to certain PI tools and sometimes in relation to specific industries. For instance, JIT, waste minimization and process intensification appear to increase stress and strain levels between workers (Koukoulaki, 2014). These harmful effects were evident in the automotive industry but not in other sectors. Conversely, other PI practices such as employees' empowerment and self-managed teams appear to have a positive influence on workers' health (Koukoulaki, 2014).

Third, the success of different PI approaches in a production environment - in terms of increasing efficiency and improving productivity - has led to the expansion of PI adoption beyond production units to other functional units, including product development, and innovation and knowledge management areas (Benner and Tushman, 2003, Staats et al., 2011). This expansion of PI has attracted criticism from strategy and innovation scholars, arguing that PI approaches are rigid practices that do not align with innovation development needs (Adler et al., 2009, Benner and Tushman, 2002, Benner, 2009). For example, Benner and Tushman (2003) suggest that the use of PI in the product development environment severely constrains creativity and drives incremental at the expense of radical innovation[5].

Other scholars have adopted a less extreme view and have suggested that the negative impact of PI depends upon the degree of its usage. For instance, de Treville and Antonakis (2006) conclude that "lean production job design may engender worker intrinsic motivation" (p.99); however, excessive leanness may demotivate employees. Others highlight the impact of other contingencies in shaping the effect of PI (Sousa and Voss, 2002) such as the company's structure (Benner and Tushman, 2003), environmental uncertainty (Sitkin et al., 1994) and sector (Staats et al., 2011). For example, by studying the lean journey of an IT Company, (Staats and Upton, 2011) conclude that lean principles can be applicable to certain types of knowledge work areas, i.e., lean principles can be effectively used in IT or engineering, but they can be detrimental in areas where innovation and experimentation are needed.

[5] Section 2.4 discusses the literature arguments concerning the impact of PI on innovation

Operations management scholars have traced these detrimental effects to three causes. First, some elements of PI approaches were not implemented, especially the "soft" ones (Choo et al., 2007a): for instance, early implementations of lean were tool-focused (Modig and Ahlstrom, 2012) while the behavioural (Hines et al., 2004) and cultural aspects were neglected (Pakdil and Leonard, 2014, Bhasin, 2013, Martinez-Jurado et al., 2013). Second, these approaches are context-sensitive (Sousa and Voss, 2002, Swink and Jacobs, 2012). Many contingency factors can play a role in the success of improvement initiatives including the organizational culture, top management support and the availability of resources (Karlsson and Ahlstrom, 1996b, Zu et al., 2008, Choo et al., 2007a, Schroeder et al., 2008). Third, organizations adopt PI approaches for different reasons; some to improve efficiency and performance (technical reasons) (Westphal et al., 1997, Zbaracki, 1998), others to facilitate change and learning (Choo et al., 2007a, Braunscheidel et al., 2011). Others adopt them because of institutional pressures (Zbaracki, 1998, Westphal et al., 1997, Braunscheidel et al., 2011). The reason for PI adoption may shape the achieved results.

2.2.5 PI maturity

One stream of research has attempted to evaluate the maturity of PI usage in organizations (Bessant et al., 2001, Nightingale and Mize, 2002, Silva et al., 2014, Shingo prize). Maturity is reflected by the organizational experience in using PI (Schroeder et al., 2008, Swink and Jacobs, 2012). Previous research has used different measures to evaluate the extent and the degree of adoption of different PI approaches. Most of all, this research considers maturity in production areas. For example, Hopp and Spearman (2004) used continuous improvement, waste elimination, pull production, variability reduction and buffers swapping to measure leanness. Alternatively, other authors, such as Jacobs et al. (2015), simply used the number of years of usage to measure the degree of six sigma adoption. While some of these measures are operational such as reduction of set up time, shorter lead times, reducing variation and zero defects (Li et al., 2005, Fullerton et al., 2014, Karlsson and Ahlstrom, 1996a), others are behavioural, such as employee involvement and empowerment, supplier relationships, customer involvement, and continuous improvement (Sanchez and Perez, 2001, Karlsson and Ahlstrom, 1996a, Malmbrandt and Åhlström, 2013, Fuentes-Fuentes et al., 2004, Naor et al., 2008, Shah and Ward, 2007, Doolen and Hacker, 2005). However, some constructs and variables appear to be common, such as continuous improvement, employee involvement, waste minimization, customer orientation and process orientation (Slack et al., 2013, de Treville and Antonakis, 2006, Karlsson and Ahlstrom, 1996a, Fuentes-Fuentes et al., 2004, Fullerton et al., 2014, Naor et al., 2008).

Other scholars have proposed a more comprehensive approach for assessing PI maturity. For instance, Bessant et al. (2001) developed generic architypes, a CI maturity model that represents an evolutionary model for developing CI capability in the organization. The model consists of five stages ranging from "CI interest" in level 1 to "CI capability" in level 5. The elevation from one stage to another involves learning and mastering the practices associated with the current stage and adding new CI related practices. Overall, the CI capability maturity model acts as a CI assessment model and road map for developing CI capability. Table 5 presents the stages of CI maturity proposed by Bessant et al. (2001).

In a similar vein, research has suggested that PI maturity can be evaluated through the breadth and depth of PI usage in the organization. Netland and Ferdows (2016) define PI maturity – in the context of lean programmes – as the breadth and depth of lean implementation in a plant; breadth means "how widely the lean principles have spread in different parts of the plant—that is, how many areas, departments, teams, operators, and other entities in the plant have started to implement the lean program" (p. 1107). Depth reflects "how thoroughly these entities are applying the lean principles" (p. 1107). Accordingly, the ultimate performance benefit of PI usage can be captured by using PI across functions and at the enterprise level (Jones and Womack, 2017, Marodin et al., 2018).

Table 5: CI maturity

CI level	Characteristics behaviour patterns
Level 1- pre-CI; interest in the concept has been triggered – by a crisis by attendance at a seminar, by a visit to another organization, etc. – but implementation is on an ad hoc basis	Problems are solved randomly; no formal efforts or structure for improving the organization; occasional bursts of improvement punctuated by inactivity and non-participation; solutions tend to realize short-term benefits; no strategic impact on human resources, finance or other measurable targets; staff and management are unaware of CI as a process.
Level 2- Structured CI; there is formal commitment to building a stream which will develop CI across the organization	CI or an equivalent organization improvement initiative has been introduced; staff use structured problem-solving processes; a high proportion of staff participation in CI activities; staff has been trained in basic CI tool; structured idea-management system is in place; recognition system has been introduced; CI activities have not been integrated into day-to-day operations.
Level 3- Goal oriented CI; there is a commitment to linking CI behaviour, established at 'local' level to the wider strategic concerns of the organization	All the above plus formal deployment of strategic goals; monitoring and measuring of CI against these goals; CI activities are part of main business activities; focus includes cross-boundary and even cross-enterprise problem-solving.
Level 4- Proactive CI; there is an attempt to devolve autonomy and to empower individuals and groups to manage and direct their own processes	All the above plus CI responsibilities devolved to problem solving units; high level of experimentation.
Level 5- Full CI capability; approximates to a model learning organization	All the above plus extensive and widely distributed learning behaviour systematic finding and solving problems and capturing and sharing of learning; widespread, autonomous but controlled experimentation.

Adapted from Bessant et al. (2001)

2.3 Innovation

2.3.1 The Conception of Innovation

"Innovation is a broad term with multiple meanings; it draws on theories from a variety of disciplines" (Crossan and Apaydin, 2010, P. 1165). The foundation of the concept of innovation come from economics and management. The economic perspective concerns the macro impact of innovation on the economy market and industry (OECD/Eurostat, 2018). Schumpeter (1934) - who proposed the first influential definition for innovation - associated it to "economic development" and defined it as a new combination of productive resources. His work defined five specific cases: Introduction of new products, new production methods, exploration of new markets, conquering of new sources of supply and new ways of organizing business" (mentioned in Hidalgo and Albors, 2008, p. 114). The management perspective examines the market positioning impact of innovation, and the generation and development of innovation.

Since then, a considerable amount of research has been conducted on innovation, its conception, types, degrees, and development processes (Andriopoulos et al., 2018, Beverland et al., 2016, Danneels and Kleinschmidt, 2001, Garcia and Calantone, 2002, Cooper, 2008). Innovation can be in products, processes, ideas, services, manufacturing processes, management practices or business models and in other aspects of the organization (Trott, 2012, Crossan and Apaydin, 2010). Table (6) presents various types of innovation

Table 6: Types of innovation

Type of innovation	Example
Product innovation	The development of a new product or improved product
Process innovation	The development of a new manufacturing process
Organizational innovation	A new venture division, a new internal communication system; introduction of new accounting procedures
Management innovation	TQM systems; BPR
Production innovation	Quality circles; just-in-time (JIT) manufacturing system: mew production planning software
Commercial / marketing	New financing arrangements, new approaches of interacting with customers (e.g., direct marketing), brand
Service innovation	Internet-based financial services

Adapted from (Trott, 2012, p. 15)

This thesis focuses on product innovation. Product innovation is defined as "a new or improved good or service that differs significantly from the firm's previous goods or services and that has been introduced on the market" (OECD/Eurostat, 2018, p.70). Various terms has been used to capture different degrees of innovation (Danneels and Kleinschmidt, 2001) such as radical/incremental (Atuahene-Gima, 2005), explorative/exploitative (Benner and Tushman, 2015, Andriopoulos and Lewis, 2009, Jansen et al., 2006), disruptive/sustaining (Christensen, 1998) and continuous/discontinuous (Birkinshaw et al., 2007). Some of these typologies have been used interchangeably; for example, explorative and exploitative innovation terms have been often used to refer to incremental and radical innovation in the context of product innovation (He and Wong, 2004).

Garcia and Calantone (2002) suggest two additional concepts to distinguish between incremental and radical innovation. "From the macro perspective, 'innovativeness' is the capacity of a new innovation to create a paradigm shift in the science and technology and/or market structure in an industry". From a micro perspective, "innovativeness is the capacity of a new innovation to influence the firm's existing marketing resources, technological resources, skills, knowledge, capabilities, or strategy" (p. 113). This research examines product innovation at the micro level (firm level) and from the firm's perspective. Table 7 shows different definitions of radical and incremental innovation.

Table 7: Radical and incremental innovation definitions

Authors	**Radical product innovation**	**Incremental product innovation**
Chandy and Tellis (1998)	"Radical innovations involve substantially new technology and provide substantially greater customer benefits per dollar, relative to existing products" (Chandy and Tellis, 1998, p. 476)	"Incremental innovations involve relatively minor changes in technology and provide relatively low incremental customer benefits per dollar" (Chandy and Tellis, 1998, p. 476)
Garcia and Calantone (2002)	Innovation that result in discontinuities on both a macro (world, industry or market level) and micro level (the firm and customer level) (p. 120)	"Products that provide new features, benefits, or improvements to the existing technology in the existing market" (p.123)
Dewar and Dutton (1986)	Radical innovation requires "high degree of new knowledge" (p. 1422)	Incremental innovation requires "low degree of new knowledge" (p. 1422)
Olson et al. (1995)	Radical innovation involves "the development of new technologies" (p. 52)	"Incremental innovation is about changing an existing product" (p. 52)
Sivadas and Dwyer (2000)	Radical innovations "are new-to-the-world, pioneering products that represent technological breakthroughs" (p. 38).	"Incremental innovations refer to improvements and revisions to existing products and additions that supplement a company's existing product lines" (p. 38)

Considering the distinction between incremental and radical product innovation, researchers have used similar terms to refer to different degrees of innovation (Garcia and Calantone, 2002). For instance, some scholars use the term radical innovation to refer to the changes in a company's technology, whereas others use the ambiguous term "really new" to refer to similar degrees of innovation (Garcia and Calantone, 2002). Overall, despite inconsistencies in terminology, there is a consensus on the use of the market and technology dimensions to differentiate between incremental and radical product innovation (Danneels and Kleinschmidt, 2001, Garcia and Calantone, 2002, Souder and Jenssen, 1999, Swink, 2000). While the market dimension refers to the degree in which a product is different from an existing one in terms of satisfying customers' needs, the technology dimension refers to the degree of change in the technology being used (Chandy and Tellis, 1998) (see table 8). Accordingly, radical innovation is about producing new products that "incorporate substantially different technology from existing products and can fulfil customer needs either significantly better than existing products, or address different types of needs which could not be fulfilled at all with existing products" (Herrmann et al., 2007, p.93). Incremental innovation is about improving existing products that enable firms to operate efficiently and deliver better value for customers (O'Reilly and Tushman, 2004, p. 76).

Table 8: Innovation classification

		Customers' needs fulfilment	
		Low	High
Newness of technology	Low	Incremental innovation	Market breakthrough
	High	Technology breakthrough	Radical innovation

Adapted from (Chandy and Tellis, 1998, p.476)

2.3.2 Tensions between incremental and radical product innovation

Pursuing both types of innovation is important; however, there is a tension between the processes and practices leading to incremental or radical innovation (Atuahene-Gima, 2005, Benner and Tushman, 2003, Tushman and Oreilly, 1996, Grover et al., 2007). This due to the differences between both types, in terms of the required attitudes toward risk and change (Dewar and Dutton, 1986, Bessant et al., 2014), need of resources (Gupta et al., 2006), knowledge management processes (Tushman and Oreilly, 1996), customer preferences (Danneels, 2003, Andriopoulos and Lewis, 2009), and required capabilities (Benner and Tushman, 2003). For example, radical innovation requires developing new capabilities, incremental innovation requires exploiting current capabilities (Benner and Tushman, 2002). Table 9 presents additional antecedents for incremental and radical innovation. The following section will discuss the interplay between exploration and exploitation.

Table 9: Examples of the antecedents for incremental and radical product innovation

Antecedents	Radical Product Innovation	Incremental Product Innovation
Capabilities	Exploration (He and Wong, 2004)	Exploitation (He and Wong, 2004)
Organizational learning	Generative learning (double-loop learning) "occurs when the organization is willing to question long-held assumptions about its mission, customers, capabilities, or strategy. It requires the development of a new way of looking at the world based on an understanding of the systems and relationships that link key issues and events" (Slater and Narver, 1995, p. 64).	Adaptive learning (single-loop learning) "…involves learning for improvement which primarily serves to perfect existing competencies and maintain the status quo" (Herrmann et al., 2007, p. 100).
Cross-functional collaboration	Cross-functional collaboration (CFC) is essential for product innovation (Beverland et al., 2016, Brettel et al., 2011). However, it is not clear whether it can trigger radical and incremental innovation differently.	
Trust / psychological safety	"This psychologically safe atmosphere likely encourages risk taking and exploration, which tends to create knowledge characterized by innovative solutions, improved team ability, and abundance of ideas" (Choo et al., 2007b, p.447).	-
Employees' Involvement	Process and product innovation are significantly related to the degree to which employees are involved. Also, employees that have a direct contact with customers are expected to be more creative and generate new ideas (Andries and Czarnitzki, 2014).	
Connectedness	Connectedness and social relations can enable organizations to pursue both radical and incremental innovation (Jansen et al., 2006).	
Centralization	Centralization reduces non-routine problem-solving; therefore, it negatively affects exploration and radical innovation (Jansen et al., 2006). However, Dewar and Dutton (1986) found that decentralization is not a significant predictor for radical innovation.	Centralization does not support exploitative innovation (Jansen et al., 2006).
Absorptive capacity	Forés and Camisón (2016) found that "firms that combine their internal knowledge base with knowledge from external sources can obtain a positive impact on radical innovation performance" (p. 844).	Absorptive capability has a positive effect on incremental innovation performance (Forés and Camisón, 2016).
Internal knowledge creation	"A firm must exploit some level of its current competencies to leverage its new competencies to develop radical innovations" (Atuahene-Gima, 2005, p. 79).	Incremental innovation can be enhanced by knowledge accumulation capabilities (Forés and Camisón, 2016).
PI	PI approaches hinder exploration, risk-taking and experimentation that require radical innovation (Benner and Tushman, 2003)	PI approaches have a positive effect of incremental innovation (Benner and Tushman, 2003).

2.3.2.1 Tensions between exploration and exploitation

Scholars have studied the tension between incremental and radical innovation through the lens of exploration and exploitation where incremental innovation was associated with exploitation and radical was connected with exploration (Andriopoulos and Lewis, 2009, Jansen et al., 2006). According to several authors, 'exploration' is based on trial and error, learning, novelty and increasing variation (Atuahene-Gima, 2005, Andriopoulos and Lewis, 2009). It includes "experimentation", "flexibility", "discovery" (March, 1991, p.71) which can lead to the creation of radically new products, while an incrementally improved product can be developed through exploitation which is based on variance decreasing activities and continuous problem-solving (Atuahene-Gima, 2005, Grover et al., 2007). Exploitation is associated with "refinement" and "efficiency" (March, 1991, p.71). Table 10 shows the differences and similarities between radical-incremental innovation and exploration-exploitation.

Table 10: Relationships among Constructs

Dimensions	Exploitation – Exploration	Radical – Incremental Innovation
Definitions	**Exploitation** • Involves local search that builds on a firm's existing technological capabilities (Benner and Tushman, 2002). • It is related to production, refinement, efficiency, execution (March, 1991). • “Refers to the tendency of a firm to invest resources to refine and extend its existing product innovation knowledge, skills, and processes. Its aims are greater efficiency and reliability of existing innovation activities’’ (Atuahene-Gima, 2005, p.62). • Influences the organization’s incremental innovation through improving current competence (Andriopoulos and Lewis, 2009, He and Wong, 2004).	**Incremental (Exploitative) innovation** • Involves improvements in existing components and architectures and build on the existing technological trajectory (Benner and Tushman, 2003). • Associated with technological innovation activities that aim to improve existing products, market position, routine, practices and technologies (Crossan and Apaydin, 2010, Cardinal, 2001, Dewar and Dutton, 1986, Olson et al., 1995, He and Wong, 2004).
	Exploration • Involves more distant search for new capabilities (Benner and Tushman, 2002). • Related to experimentation, risk-taking, and innovation (March 1991). • “Refers to the tendency of a firm to invest resources to acquire entirely new knowledge, skills, and processes. Its objective is to attain flexibility and novelty in product innovation through increased variation and experimentation” (Atuahene-Gima, 2005, p.62). • Fosters radical innovation through creating new competence (He and Wong, 2004) and discovering new opportunities (Andriopoulos and Lewis, 2009).	**Radical (Exploratory) innovation** • Involves a shift to a different technological trajectory (Benner and Tushman, 2002). • Associated with technological innovation activities that aim to create a new product or enter a new market (He and Wong, 2004). • Represents fundamental changes and a clear departure from existing practices and technologies in the organization (Crossan and Apaydin, 2010, Cardinal, 2001, Dewar and Dutton, 1986, Abernathy and Clark, 1985).
Differences	• Exploration versus exploitation “should be used with reference to a firm’s ex-ante strategic objectives in pursuing innovation” (He and Wong, 2004, p. 485). • Exploration and exploitation are organizational learning approaches that affect organizational performance by creating different types of technological innovation (radical and incremental) (He and Wong, 2004).	• Incremental versus radical innovation ‘’is often used in an ex-post outcome sense’’ (He and Wong, 2004, p. 485). • Technological innovation is grounded in exploration and exploitation (He and Wong, 2004). • Radical and incremental innovation represent the magnitude of an innovation which is one of the dimensions of evaluating innovation as an outcome (Crossan and Apaydin, 2010). • Innovation as an outcome can result from different internal drivers such as knowledge and resources (Crossan and Apaydin, 2010).
Commonality of use	Exploitation versus exploration parallel incremental versus radical innovation (Beverland et al., 2015) and many innovation scholars who have examined product innovation have used these terms interchangeably (Jansen et al., 2006, Jansen et al., 2009, Crossan and Apaydin, 2010, Benner and Tushman, 2003).	

In general, firms tend to focus on one type of innovation and neglect the other by developing the mind-set and routines that support either exploration or exploitation (Grover et al., 2007, Andriopoulos and Lewis, 2009). However, scholars have highlighted the importance of both for organizational adaptation, learning and technological innovation (see, e.g., Gupta et al., 2006). Indeed, a sole focus on exploration or exploitation can lead to negative consequences. While exploration enables radical innovation and high return, it is associated with high risk, volatility, and uncertainty in returns (March, 1991). It "often leads to failure, which in turn promotes the search for even newer ideas and thus more exploration, thereby creating a 'failure trap'" (Gupta et al., 2006, p. 695). On the other hand, "exploitation often leads to early success, which in turn reinforces further exploitation along the same trajectory" (Gupta et al., 2006, p. 695). Therefore, overemphasis on exploitation can lead to "stagnation and failure to discover new, useful directions" (March, 2006, p. 205), thereby creating a "success trap" (Gupta et al., 2006, Grover et al., 2007).

Given this tension and because of the importance of pursuing radical and incremental innovation simultaneously, management scholars have looked at different mechanisms for managing the trade-off between both types. These antecedents can be related to structure, culture, strategy (Raisch and Birkinshaw, 2008, Gupta et al., 2006, Jansen et al., 2009), social context (Gibson and Birkinshaw, 2004), and performance and process improvement (Benner and Tushman, 2002, Kim et al., 2012). While some researchers have found that this tension can be managed and radical and incremental innovation can be triggered through the same mechanisms (Cardinal, 2001, Dewar and Dutton, 1986), others have found the opposite (Jansen et al., 2006, Dewar and Dutton, 1986). Moreover, many of these studies have focused on the role of the formal (centralization, and formalization) and informal (connectedness and social relations) control mechanisms in managing the tension between radical and incremental innovation. Other research has considered the role of process management techniques in managing it (e.g., Benner and Tushman, 2002, Kim et al., 2012). Processes that can "combine high levels of efficiency with the flexibility to evolve and improve over time" (Adler et al., 2009, p. 100) can lead to balancing exploitation and exploration. Therefore, more insights can be gained about managing the tension between different types of innovation by considering a process improvement perspective (Adler et al., 2009). Section 2.4 presents a detailed review for the literature on the impact of various PI approaches on product innovation.

2.4 PI and innovation[6]

2.4.1 Overview

When considering the interplay between PI approaches and incremental and radical product innovation, authors have conceptualized PI in two main ways. This distinction is not only important from a theoretical point of view, but also from an empirical one, as authors adopting a control-oriented view of PI have tended to find that PI impedes product innovation - in particular radical innovation - whereas those adopting a learning-oriented view have concluded the opposite. The main premises of the two perspectives are summarized in Table 11. This section examines the two perspectives, identifying their main conceptualizations, definitions, PI attributes and practices used, theoretical and empirical arguments over the link between PI approaches and product innovation, and main areas of tensions and agreement.

Table 11: Premises of the control-oriented and learning-oriented perspectives

	Control-oriented perspective	**Learning-oriented perspective**
Conceptualization	PI approaches are efficiency-oriented practices that are based on discipline, conformity and adherence to existing rules, formalization, reduction of variation, standardization, and exploitation of existing knowledge	PI approaches are means to create an environment that fosters collaboration, learning, openness, trust, knowledge creation, exploitation and exploration
Practices/ attributes	Focus on the "hard" aspects (tools and techniques) such as process management, waste minimization, statistical process control and structured methods	Encompasses both "hard" and "soft" aspects such as employee involvement, teamwork, human resource management practices and leadership
Impact on innovation	PI approaches may enable incremental innovation, but hinder radical innovation because of standardization and reduction of slack (Benner and Tushman, 2002, Benner and Tushman, 2003, Parast, 2011)	PI approaches enable both radical and incremental product innovation through continuous improvement, employees' involvement and process management (Asif and de Vries, 2015, Kim et al., 2012, Zeng et al., 2015, Antony et al., 2016)
Main differences	• The control perspective considers the hard aspects of PI as rigid and inherently in contradiction with risk-taking, experimentation and exploration, which are required for product innovation, especially radical. • The learning perspective considers the hard aspects as enablers for innovation since they provide a sense of clarity, assist companies in maintaining stable goals, help understand customer needs and reduce time-to-market. The soft aspects contribute to create a learning environment which, in turn, supports radical product innovation.	

[6] This section is based on a systematic literature review paper on the impact of PI approaches on product innovation. Details on the systematic literature review method and papers selection process are available from the author.

2.4.2 Control-oriented view

This perspective considers PI approaches mainly as sets of efficiency-oriented practices that are based on discipline, conformity and adherence to rules, formalization, reduction of variation, standardization, and exploitation of existing knowledge (Benner and Tushman, 2002, Benner and Tushman, 2003, Lopez-Mielgo et al., 2009, Prajogo and Sohal, 2004, Prajogo and Sohal, 2001). For example, Benner and Tushman (2003) suggest that "process management, based on a view of an organization as a system of interlinked processes, involves concerted efforts to map, improve, and adhere to organizational processes" (p. 238). Similar to process management, continuous improvement is also seen as aiming to reduce variability, minimize waste and ensure conformity, using, for example, "Plan, Do, Check, Act" (PDCA) cycles and Statistical Process Control (SPC) (Moreno Luzon and Valls Pasola, 2011). Considering quality management, several authors, such as Naveh and Erez (2004), have also argued that the implementation of practices and tools, such as ISO 9000, result in a culture of "attention to detail" that values standardization and conformity to existing rules.

2.4.2.1 Control-oriented view: PI and innovation

The control-oriented view is mainly based on the "hard" aspects (i.e., tools and techniques (See e.g., Bortolotti et al., 2015, Zeng et al., 2015) of PI such as process management, waste minimization, statistical process control, collecting and reporting information, structured methods for problem-solving and interaction with customers (Benner and Tushman, 2003, Perdomo-Ortiz et al., 2006, Martinez-Costa and Martinez-Lorente, 2008).

Scholars that adopt such a view have criticized the effectiveness of PI approaches, arguing that they can impede product innovation, especially radical, for three main reasons (Benner and Tushman, 2003, Benner and Tushman, 2015). First, these approaches aim to reduce variation in processes (Benner and Tushman, 2002), whereas radical innovation requires variation-increasing activities and slack resources (Atuahene-Gima, 2005, Troilo et al., 2014, Helander et al., 2015). Second, PI approaches often rely on standardization and formalization to maintain improvements and stability (Zeng et al., 2015). However, standardization may impede flexibility, creativity and innovativeness (Zeng et al., 2015). Third, the customer-centric element of PI approaches can trap organizations in improving their existing products instead of creating radical new ones (Sadikoglu and Zehir, 2010, Slater et al., 2014, Slater and Narver, 1998). The emphasis on the existing products establishes “a focus on easily available efficiency and customer satisfaction measures” (Benner and Tushman, 2003: 239), which go against radical innovation and penalize adaptation and long-term goals (Adler et al., 2009).

In addition to the above theoretical arguments, several empirical studies provide support for the control-oriented view. For example, Benner and Tushman (2002) found a negative relationship between process management and radical innovation. Also, Leavengood et al. (2014) found that quality-oriented firms are risk-averse and focus on meeting current customer needs instead of targeting new customers; therefore, they “deliberately choose not to pursue innovation” (p. 1136). According to Parast (2011), six sigma projects enhance incremental innovation by emphasizing efficiency, variance reduction and serving current customers; however, they are “not very effective in dynamic environments, where the rate of technological change is dramatic” (p. 45). Also, Salomo et al. (2007) found that in highly innovative projects, PI activities can impose rigidity and prevent project managers from reacting quickly to internal and external changes. Mehri (2006) has identified that lean, through *kaizen* and waste minimization, has a negative effect on employees’ creativity and their potential to innovate. Similarly, (Staats et al., 2011) argues that it is possible to apply lean on knowledge work, but not everywhere, especially if tasks require innovation and experimentation, which will be negatively affected.

2.4.3 Learning-oriented View

Authors adopting this perspective regard PI approaches as sets of learning-oriented practices that aim to create an environment that fosters collaboration, learning, openness and trust (Gil-Marques and Moreno-Luzon, 2013, Gutierrez Gutierrez et al., 2012, Choo et al., 2007b, Hung et al., 2010, Moreno Luzon and Valls Pasola, 2011, Moreno-Luzon et al., 2014, Perdomo-Ortiz et al., 2006). For example, Gutierrez Gutierrez et al. (2012) consider six sigma as an organizational learning process that stimulates knowledge absorption by allowing process management and teamwork. According to Kim et al. (2012) quality management is a “holistic management philosophy” that consists of interrelated practices including process management, employee relations, training, leadership, supplier quality management, customer relations, quality data and reporting, and product and service design (p. 296). Also, these authors emphasize the importance of investing in various quality management practices to generate “a creative synergy among individual practices” and lead to innovative performance (p. 305). Additionally, Hung et al. (2011) stress that TQM is more than a set of tools, as it “can also promote a culture of sharing, trust, openness, and innovation when supported by top management, employee involvement, continuous improvement, and customer focus” (p. 223). Also, Moreno Luzon and Valls Pasola (2011) suggest that, by creating a “mistake acceptance culture” instead of a “blame culture”, TQM can promote ambidexterity (i.e., the ability to exploit current capabilities and explore new ones) and creativity (p. 938). For Perdomo-Ortiz et al. (2006), quality management and continuous improvement practices “are considered to be a forerunner in the accumulating of innovation capability and, consequently, innovating practices and routines are considered to be determined by the good practice deriving from quality management” (p. 1170). Also, Zeng et al. (2015) support this argument by stressing that quality and product innovation are not “a matter of trade-off, but they can coexist in a cumulative improvement model with quality as a foundation” (p. 216).

2.4.3.1 Learning-oriented view: PI and innovation

The learning-oriented perspective relies on both “hard” and “soft” aspects (Bortolotti et al., 2015, Zeng et al., 2015) such as employees’ involvement, teamwork, human resource practices, leadership, training and people management (Martinez-Costa and Martinez-Lorente, 2008, Choo et al., 2007b, Abrunhosa and Sa, 2008).

Scholars that have adopted this perspective argue that PI can support product innovation, both incremental and radical (Schulze et al., 2013, Kim et al., 2012, Hung et al., 2011, Prajogo and Sohal, 2006). From a theoretical point of view, this perspective regards PI approaches as sets of principles and practices that create a fertile environment for innovation (Pekovic and Galia, 2009, Prajogo and Sohal, 2001). For example, these approaches use iterative cycles of continuous improvement (Santos-Vijande and Alvarez-Gonzalez, 2007), which can create a learning-oriented culture based on trust, openness and sharing (Hung et al., 2011). Indeed, many PI approaches highlight the importance of involving employees in decision-making and in the improvement process (Prajogo and Sohal, 2001). This provides employees with a sense of responsibility, engagement and ownership (Slack et al., 2013, Moreno Luzon and Valls Pasola, 2011), which enhance their creativity and their capacity to innovate

(Gil-Marques and Moreno-Luzon, 2013). Moreover, “control in process management is likely to assist firms to maintain stable goals, to reduce product development time, and to meet customer needs in both existing and emerging markets” (Kim et al., 2012: 304). Process management can also improve the product development process performance by reducing time-to-market (Dalton, 2009, Kim et al., 2012, Tuli and Shankar, 2015).

Empirically, Prajogo and Hong (2008) found that TQM can be implemented effectively in an R&D environment and have a positive impact on both product quality and innovation. Also, Schulze et al. (2013) reveal that value stream mapping facilitates “feed-forward learning” in new product development processes (p.1146). Sethi and Sethi (2009) conclude that “quality orientation does not adversely affect product novelty in cross-functional product development teams” (p. 206). Similarly, Pekovic and Galia (2009) emphasize the importance of a “well-established quality system” to improve innovation performance (p. 829).

Explicitly considering hard and soft aspects of PI, Prajogo and Sohal (2004) found alignment between “the mechanistic elements of TQM with quality performance and the organic elements with innovation performance” (p. 443), where the “mechanistic elements” reflect the hard aspects and the “organic elements” reflect the soft ones. Abrunhosa and Sa (2008) found that TQM principles have a positive effect on incremental technological innovation. However, this positive effect can be reduced by the lack of maturity of the improvement initiatives and the dominance of a “mechanistic model” (the “hard” aspects of PI). Antony et al. (2016) drew a similar conclusion, but their results indicate that lean six sigma “does have the potential to influence radical/breakthrough innovation” (p. 124). Moreover, Gil-Marques and Moreno-Luzon (2013) highlight the importance of TQM human resources management (HRM) practices in changing the culture toward “exploitation” and “exploration”, and found a positive effect of the TQM HRM practices on both incremental and radical innovation. Hoang et al. (2006) found that TQM has a positive effect on companies’ innovativeness and emphasize the importance of TQM practices, such as leadership, people management, process and strategic management, as means to foster innovation. Also, Wiengarten et al. (2013) have identified that “seven practices closely related to TQM, namely visionary leadership, internal and external cooperation, learning, process management, continuous improvement, employee fulfilment, and customer satisfaction have a significantly stronger impact on operational performance in companies characterized by a high level of innovativeness” (p. 3055). Kim et al. (2012) found that quality management practices through process management enable radical and incremental product and process innovation. According to them “information and knowledge in a set of routines accumulated through process management help firms establish a learning base and facilitate innovative and creative activities” (P. 303). Santos-Vijande and Alvarez-Gonzalez (2007) reinforce the argument that TQM can enable innovativeness; however, they found that the impact of TQM on innovation culture is stronger in stable environments than in turbulent ones. Moreno Luzon and Valls Pasola (2011) found that TQM is a supportive platform for creating radical and incremental innovation. Also, Martinez-Costa and Martinez-Lorente (2008) stress the importance of TQM in creating an environment that supports innovation.

Other scholars have considered the effect of PI approaches on the speed and performance of the new product development (NPD) process. For example, Dalton (2009) argues that a theory of constraints approach could help improve NPD processes by creating a culture of continuous innovation and by helping identify bottlenecks in the innovation process. Sun and Zhao (2010) found that TQM is positively related to NPD speed. Also, Tuli and Shankar (2015) argue that lean can improve NPD process performance in terms of quality, time to market, and risk management by aligning people and processes towards a common goal.

In summary, two main perspectives emerge from the literature. Authors adopting a control-oriented view tend to find that PI approaches may enable incremental innovation, but hinder radical innovation (Benner and Tushman, 2002, Benner and Tushman, 2003, Parast, 2011, Salomo et al., 2007). Conversely, scholars taking a learning-oriented perspective find a positive relationship between PI approaches and both incremental and radical product innovation (Asif and de Vries, 2015, Kim et al., 2012, Zeng et al., 2015, Antony et al., 2016).

2.4.4 Control-oriented vs. Learning-oriented View

This review of the literature on the interplay between PI and product innovation further reveals that there are seven principal themes on which scholars appear to diverge. These are: Capabilities, customer orientation, formalization, attitude toward risk, availability of slack resources, continuous improvement and employee involvement.

Capabilities. PI approaches encourage stability, variation reduction and process control by applying various statistical techniques to maintain efficiency in a process. This, in turn, leads to capability exploitation (Benner and Tushman, 2003), which aligns with incremental innovation, but is said to hinder exploration and experimentation that are required for radical innovation (He and Wong, 2004, Benner and Tushman, 2002). This standpoint is consistent with the view that exploitation crowds out exploration (Brunner et al., 2010). On the other hand, according to a learning-oriented perspective, investing in process enhancement "aids firms in fostering creative thinking" and "establishing a learning base" (Kim et al., 2012: 304). Here, PI approaches are seen to enable both capability exploitation and exploration, which, in turn, align with incremental and radical innovation (Gil-Marques and Moreno-Luzon, 2013).

Customer orientation. There is consensus that customers are the critical starting point of any improvement process (Sadikoglu and Zehir, 2010, Westphal et al., 1997, Womack and Jones, 1996). However, the benefits and drawbacks of customer involvement have been long debated in the innovation literature (see, e.g., Andriopoulos and Lewis, 2009). Indeed, some innovation management scholars have argued that a high degree of customer orientation can trap the organization in satisfying its current customers, instead of guiding it towards new ones (Benner and Tushman, 2003). Consequently, tight customer orientation has been considered to hinder radical innovation (Andriopoulos and Lewis, 2009). On the other hand, rather than considering customer-orientation as a barrier to radical innovation, authors adopting a learning-oriented perspective regard customer-orientation as a means to meet and exceed current and future customers' needs (Prajogo and Sohal, 2001), therefore leading to product innovation, both incremental and radical.

Formalization. Some scholars who have adopted the control-oriented view (e.g. Benner and Tushman, 2003, Benner, 2009) state that formalization and standardization - which result from process management - are important to sustain improvement processes, but act as barriers to radical innovation since they can impose rigidity and hinder creativity which are required for radical innovation. However, researchers adopting a learning-oriented view have found that control and standardization are crucial for both incremental and radical product innovation

(Moreno-Luzon et al., 2014, Kim et al., 2012). According to them, standardization can provide structure and clarity of goals for the NPD process which, in turn, assist companies in maintaining and exceeding current and emerging customers' needs (Prajogo and Sohal, 2001: 546). This result confirms the findings of Jansen et al. (2006) in the innovation literature whereby rules and procedures are not detrimental to exploration and, therefore, to radical innovation.

Attitude towards risk and tolerance of failure. For several authors, the focus of PI approaches on improving flow and value creation by eliminating non-value adding activities (Helander et al., 2015), errors and variation (Schroeder et al., 2008) can hinder radical innovation, which is based on trial and errors and risk taking (Atuahene-Gima, 2005, Dewar and Dutton, 1986). However, others have emphasized that PI approaches can be characterized by tolerance of mistakes (Moreno Luzon and Valls Pasola, 2011), are not dominated by risk aversion (Santos-Vijande and Alvarez-Gonzalez, 2007: 523) and can create an innovation-oriented culture that encourages exploration (Gil-Marques and Moreno-Luzon, 2013).

Slack resources. From a control-oriented view, slack resources can be considered non-value-added activities and, therefore, should be eliminated in order to improve efficiency (Benner and Tushman, 2003, Benner and Tushman, 2015). On the other hand, radical innovation requires extra resources to develop new products and eliminating waste may inhibit it (Troilo et al., 2014). Even though the link between slack resources and innovation was not discussed clearly in the studies adopting a learning-oriented view, some scholars have examined aspects related to it. For example, according to Kim et al. (2012), efficiency-orientation that results from reducing non-value-added activities in the process "plays a significant role in completing a radical project on time and budget" (p. 300). This view is consistent with Nohria and Gulati (1996) who found that there is an inverse U-shape relationship between the availability of slack resources and innovation because having too little slack discourages experimentation and having too much slack "breeds complacency and a lack of discipline that makes it possible that more had projects will he pursued than good" (p. 1260). Therefore, the discipline that results from the PI principle of reducing the non-value-added activities might not necessarily be a barrier for radical innovation.

Continuous improvement and employee involvement. Scholars who have adopted the learning-oriented perspective consider these two additional dimensions, which are both positively associated with innovativeness. According to them, the iterative learning process of continuous improvement creates a culture that encourages knowledge-sharing, trust, openness, employees' involvement and participation in decision-making. This environment also fosters a sense of ownership and encourages knowledge creation and innovation (Gil-Marques and Moreno-Luzon, 2013, Moreno Luzon and Valls Pasola, 2011).

The main diverging aspects of the control-oriented and learning-oriented perspectives on the link between PI approaches and innovation are summarized in Tables 12 and 13.

Table 12: Links between PI and product innovation from a control-oriented Perspective

Perspective / Dimensions	**View of PI**	**Incremental Product Innovation**	**Radical Product Innovation**
Capabilities	Exploits current knowledge	Is aligned with exploitation and therefore potentially enabled by PI	Depends on exploration, which is often at odds with exploitation and therefore hindered by PI
Customer orientation	High customer focus	Potentially deriving from tight coupling with customers	Requires loose coupling with customers
Formalization	Increases formalization and standardization	Rules and procedures make existing knowledge explicit and processes more efficient; this may enable incremental innovation	Standardization may impede flexibility, creativity and innovativeness which are required for radical innovation
Attitude toward risk and tolerance of failure	Risk-aversion PI aims to reduce variation and errors	Typically, does not require high risks to be taken	Requires taking risk and tolerating failure
Slack resources	Reduces waste and therefore slack	May be enabled by efficiency-orientation and slack reduction	Requires the mobilization of extra resources to develop novel capabilities and incorporate new technology and therefore is in opposition with PI

Table 13: Links between PI and product innovation from a learning-oriented perspective

Concepts / dimensions	View of PI	Incremental Product Innovation	Radical Product Innovation
Capabilities	Enables both exploration and exploitation	Is aligned with exploitation	Depends on exploration
Customer orientation	High customer focus	Encourages organizations to seek a better way to meet and exceed customers' requirements by introducing both incremental and radical product innovations	
Formalization	Increases standardization through process management	Process management assists firms in maintaining stability, reduce time-to-market and improve product development process performance, which enable different degrees of innovation	
Attitude toward risk and tolerance of failure	Creates a risk acceptance culture	PI approaches can create an innovation-oriented culture that is not dominated by risk aversion, thereby supporting both incremental and radical innovation	
Continuous improvement	Is based on iterative cycles of continuous improvement	CI creates a culture of trust, openness and learning that encourages knowledge creation and innovation	
Employees involvement	Creates a culture that encourages employees' involvement and empowerment.	Product innovations are positively related to employee involvement. Also, employees that have a direct contact with customers are expected to be more creative and generate new ideas	

2.5 Ambidexterity and Paradox

2.5.1 Evolution and definitions of ambidexterity

Over the past two decades a sizable amount of literature has emerged around the concept of ambidexterity (Birkinshaw et al., 2016). The term "organizational ambidexterity", coined by Duncan (1976), refers to the notion that innovative activities should be separated from non-innovative ones and proposed the use of a dual structure to meet the different requirements of the initiation and implementation stages of NPD. The use of the concept was renewed by March (1991), who stressed the importance and the difficulties in pursuing "exploration" and "exploitation" in organizations. Focusing solely either on exploration or on exploitation can lead to "self-reinforcing patterns" (Raisch and Zimmermann, 2017, p.3) as organizations pursuing only exploration might "suffer the cost of experimentation without gaining many of its benefits". On the other hand, engaging solely with exploitation can trap organizations in "suboptimal stable equilibrium" (March, 1991, p. 71).

Since then, the concept of organizational ambidexterity was discussed at various research streams including, organizational learning (Levinthal and March, 1993, March, 1991), technological innovation (Abernathy and Clark, 1985, Benner and Tushman, 2003, Dewar and Dutton, 1986, He and Wong, 2004), strategic management (Raisch and Birkinshaw, 2008), organizational design (Duncan, 1976, Gibson and Birkinshaw, 2004, Jansen et al., 2009, Tushman and Oreilly, 1996) and marketing (Beverland et al., 2015). (See table 14).

Table 14: Literature Streams Related to Organizational Ambidexterity

	Exploitation	Exploration	Tensions
Organizational Learning	• Single-loop learning • Knowledge through existing routines • Refinement Implementation	• Double loop learning • Knowledge through experimentation • Search • Variation	Old/ New
Technological Innovation	• Incremental Innovation • Minor adaptations of existing products and business concepts to meet existing consumer needs	• Radical Innovation • Fundamental changes leading to new products or business concepts to meet emergent consumer needs	Capability /Rigidity
Organizational Adaptation	• Convergence • Alignment	• Revolutionary/ Discontinuous Change • Radical transformation	Continuity/ Change Chaos/ Inertia
Strategic Management	• Induced Strategy Processes • Initiatives within current scope • Build on existing competencies • Static efficiency	• Autonomous Strategic Processes • Initiatives outside current scope • Build on new competencies • Dynamic efficiency	Leverage/ Stretch
Organizational Design	• Mechanistic Structures • Centralization • Hierarchy	• Organic structures • Decentralization • Autonomy	Efficiency/ Flexibility

Adapted from Papachroni et al. (2015, P. 74)

2.5.2 Relationship between the pole and paradox perspective

Authors investigating the concept of organizational ambidexterity have tended to frame the argument to operationalize the main constructs in two different ways. For some, exploration and exploitation are the two opposite ends of a continuum (Lavie et al., 2010) and managers are confronted with two mutually exclusive sets of options (Farjoun, 2010, Smith and Lewis, 2011). For instance, Abernathy (1978) introduced the notion of the "productivity dilemma" and states that productivity-enhancement cannot coexist with adaptability and innovation activities. In contrast, other scholars argue that exploration and exploitation are separate (orthogonal) concepts, rather than two ends of a spectrum. According to this view pursuing more exploration-related activities does not necessarily mean engaging in lower levels of exploitation and vice versa (Birkinshaw and Gupta, 2013). In a similar vein, paradox theorists have advocated a fundamental shift in organizations from an *either/or* to a *both/and* perspective. In this context, paradox denotes a "persistent contradiction between interdependent elements" (Schad et al., 2016, p.10). It concerns "how organizations can attend competing demands simultaneously" (Smith and Lewis, 2011, p. 381) instead of examining separately the conditions under which a certain set of activities (e.g., innovation, flexibility, exploration) or another set of activities (e.g., standardization, efficiency, exploitation) can be effective.

2.5.3 Managing and dealing with tensions (contradictory goals)

Even though paradoxes cannot be resolved, research suggests various approaches for managing competing demands in organizations. Poole and Van.de.Ven (1989) describe four ways to deal with paradox in organizations: acceptance (keeping and living with tensions), spatial separation, temporal separation and synthesis. Subsequent research has drawn on this studies and suggests various approaches for managing tensions in organizations (Raisch et al., 2018, Schad et al., 2016). Broadly speaking these approaches can be classified into three main categories: Separation, integration and a combination of the two (Raisch et al., 2009, Schad et al., 2016). In relation to *separation,* extant research in ambidexterity suggests spatial separation as a solution for managing conflicting goals (Raisch and Birkinshaw, 2008). In this case, two units exist in the organization: One focuses on explorative activities and the other on exploitative ones (Tushman and Oreilly, 1996). Similarly, other scholars have proposed the introduction of parallel structures. This includes having a parallel team or project who undertake explorative activities alongside regular ones (Raisch and Birkinshaw, 2008). Another type of separation – temporal - involves cycles of exploration and exploitation that happen sequentially over time (Eisenhardt et al., 2010).

Integration entails concentrating on complementarities (Schad et al., 2016). For example, building on Ghoshal and Bartlett (1997), Gibson and Birkinshaw (2004) introduce the concept of "contextual ambidexterity" and suggest that the tension between alignment and adaptability can be managed in one unit by creating a context that builds on trust, empowerment, discipline and stretch, that allows individuals to pursue different contradictory goals. Similarly, by conducting a case study on the

Toyota production system, Eisenhardt and Westcott (1988) explain how Toyota leaders managed the innovation and excellence tension by finding a novel approach to have no inventory while, at the same, reaching customers on time at the lowest cost. This method was later known in operations management literature as just-in-time (JIT) (Modig and Ahlstrom, 2012).

Third, some studies suggest a combined approach where separation and integration reinforce each other. For example, Andriopoulos and Lewis (2009) have found that design firms could manage nested innovation tensions through a multilevel virtuous cycle of integration and separation. Also, Adler et al. (1999) provide a comprehensive description of a combination of various strategies for managing the tension between efficiency and flexibility in Toyota, including meta-routines, switching, partitioning and job enrichment.

This stream of research also stresses the importance of managing tensions at different levels in organizations (Andriopoulos and Lewis, 2009, Kassotaki et al., 2018): senior management (Smith and Tushman, 2005), middle management (Burgess et al., 2015), across functions (Beverland et al., 2016) and at the front line.

2.5.4 The use of the Ambidexterity and Paradox literature in this thesis

This thesis uses the ambidexterity and paradox literature in four main ways: first, as a framing to position the research in relation to the wider debate around managing contradictory goals in organizations. Second, some terminologies -such as conflicting / complementary, integration/ separation from this literature were adopted in this thesis to help to articulate how the interplay between PI and incremental and radical product innovation gets managed. Third, while the ambidexterity and paradox literature were not used to theorize from the data to theory- in the meaning of identifying specific tensions -such as exploitation and exploration, etc.- that the research informants face, instead, the whole debate about PI usage in organisations and its effect on innovation outcomes is considered as tension by itself. This is because under the notion of the productivity dilemma, the literature of ambidexterity has discussed the challenge of using productivity-enhancing activities (such as PI) and maintaining adaptability and innovation. Moreover, the literature on ambidexterity and paradox has discussed the interplay between various contradictory goals (also regarded as tensions), that was associated with both PI and innovation, and their management. In particular, this literature asks questions related to whether organizations are able to pursue contradictory goals such as efficiency vs flexibility, standardization vs creativity, stability vs change, alignment vs adaptability; and how tensions can be managed. Therefore, drawing on the literature of ambidexterity and paradox is indeed suitable for exploring the interplay between PI and product innovation (their activities and associated practices) and its management. Finally, drawn upon the emerged empirical findings in relation to the interplay between PI and product innovation, potential insights were made to the literature on managing contradictory goals in organizations. Future research on ambidexterity and paradox can build on these insights and explore them further.

2.6 Summary of literature review and research question

This chapter has reviewed the main arguments in the previous literature with respect to PI, innovation, ambidexterity and paradox. The review shows that the topic of PI is controversial. There are contradictory arguments regarding the benefits and usefulness of PI usage in organizations. Overall, two main arguments exist in the literature: one adopts a control-oriented view of PI approaches - which views PI as rigid, efficiency-oriented practices that focus on standardization, formalization, exploitation and control and, thus, leading to incremental innovation but hindering radical innovation. On the other hand, other scholars view PI as a set of learning-oriented approaches that facilitate learning, collaboration, creativity and innovation. Moreover, empirical research shows inconclusive results concerning the impact of PI approaches on innovation, and some of the ways in which PI affects innovation have been overlooked.

The literature on ambidexterity and paradox concerns managing contradictory and conflicting goals in organizations. Overall, it suggests that divergent goals could be managed through integration, separation or a combination of the two. Therefore, the ambidexterity and paradox literature provide an appropriate lens for understanding and managing the interplay between PI and product innovation.

Drawing on the paradox and ambidexterity literature, this study aims to explore the interplay between PI and incremental and radical product innovation. Toward this aim, it addressed two main questions:

(1) *What are the factors that plays role in shaping the interplay between PI and incremental and radical product innovation?*
(2) *How do organisations manage the interplay between PI and incremental and radical product innovation related activities and what effect it leads to?*

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter presents the research methodology starting from the philosophical stance, research design and theoretical sampling criteria, followed by the data collection method and process, data analysis procedures, research ethical consideration and it concludes with the procedures that were taken in relation to the qualitative research assessment criteria.

3.2 Philosophical stance

The philosophical stance of the researcher can be described by her ontological and epistemological positions. Ontology refers to the question of existence. There are two views of ontology: objective and subjective. While an objective ontology suggests that reality exists independent of human cognitive abilities and perception, a subjective ontology suggests that reality is an output of human cognition and therefore that there is no reality "out there". Epistemology concerns our knowledge about reality. "An objective view of epistemology presupposes the possibility of theory-neutral observational language - in other words, it is possible to access the external world objectively" (Johnson and Dubcrley, 2000, p.162). A subjective view of epistemology rejects this perspective and argues that knowledge is theory-laden and subjective (Johnson and Dubcrley, 2000, Ramoglou and Tsang, 2016).

The researcher believes that reality exists independent of the researcher's perception, which is referred to as an objective ontology. However, our access to reality is subjective (subjective epistemology). This position aligns with the realism stance (see table 15) which bridges between the positivist and the social constructivist by acknowledging "the existence of a reality that is independent of our perceptions of it" (Welch et al., 2011, p.748). However "our comprehension of reality as theory-laden and subjective, and social phenomena as concept-dependent (in other words, constituted by the meanings we attach to them)" (Welch et al., 2011, p.748).

A typical question for a realism stance is: "what produces a certain change?" (Welch et al., 2011, p.748). In other words, it is concerns with identifying the mechanisms and factors that contribute to the creation of a certain phenomenon in its context.

Table 15: Ontological and epistemological stances

Dimensions	Empiricism	Constructivism	Realism
Ontology	The world exists objectively "out there," with an emphasis on material existence. Things that exist must be empirically observable. Causation is indicated by the constant conjunction of empirical events.	The idea of an objective world is an illusion; reality is ultimately reducible to social constructions. There is no single way the world is or can be. Agents can willingly create their own realities as long as they regard them as real.	The world exists objectively, albeit in various modes of being. The real is broader than the domain of the empirically observable. Tendencies are unobservable and operate trans-factually.
Epistemology	What can count as scientific knowledge must be based on sensory experience, testable by observation and experiment. The objectivity of research outcomes requires the elimination of subjective interpretations.	Contradictory interpretations of external reality can be equally valid. There are no objective criteria for assessing the truthfulness of some categories of knowledge claims, particularly those that relate to social or cultural knowledge.	We can know the world indirectly. Our observations are theory laden and fallible. We may use our imagination in explaining phenomena, but reality imposes constraints on what should be accepted as plausible knowledge.

Adapted from Ramoglou and Tsang (2016P. 413)

In the context of this thesis, the realist philosophical stance implies that organizations, their processes and practices exist independent of the researcher's perception; however, the knowledge of this reality is shaped by the perception of the researcher, her theoretical bases and the research context. Therefore, PI approaches are not context-free tools, but they are context-sensitive mechanisms that shape and are shaped by the context - industry, functional area, organizations - that they are implemented in.

A qualitative multiple case study approach aligns with the assumption of the nature of reality (objective ontology) and the knowledge about reality (subjective epistemology) (Bergen, 2007) and with the purpose of this research in seeking an explanation of a certain phenomenon by identifying the used mechanisms in their contexts. The following sections will elaborate on the research design and the data collection process.

3.3 Research design

This research adopted a qualitative multiple-case study method to elaborate and identify the mechanisms which organizations use to manage the interplay between PI and innovation. Using a case study is appropriate for addressing the research question for different reasons: first, this research attempts to explore "how" and "why" PI can play different roles in organizations and "how" it can act as an enabler or barrier for innovation. The case study design is appropriate for addressing "how" and "why" questions (Yin, 2009). Second, similar to many concepts in operations management (Voss, 2009), different PI approaches consist of both human and physical aspects of the organization. This adds further complexity to the phenomena of the interplay between these approaches with innovation as it includes many dimensions that need to be explored. The case study design is "one of the most powerful research methods in operations management" (Voss et al., 2002, P. 195), as it is suitable for exploring complex phenomena in multiple settings. Third, the main interest of this research is to gain an in-depth understanding of the role of the use of PI in facilitating or hindering the generation of product innovation in practice and using case study research design enables the researcher to gain in-depth understanding of the phenomenon in its natural setting (Yin, 2009). Finally, according to the results of the systematic literature review[7][8] for the articles that discussed the relationship between different PI approaches and product innovation, 61% of the reviewed 57 articles used a quantitative method and only 21% used a qualitative method.

3.4 Theoretical sampling criteria

The theoretical sampling strategy was used to identify the appropriate site for this research. The case sampling strategy aimed to achieve maximum variation across cases "to obtain information about the significance of various circumstances for case process and outcome" (Denzin and Lincoln, 2011, p. 307). Therefore, three main criteria were used to identify the appropriate sites of this research. First, given the

[7] The full systematic literature review paper is available from the author
[8] Multiple versions of this paper were presented in various conferences including EurOMA, IPDMC and BAM

focus of this research on product innovation, the studied companies had to be product-based. Second, all of the chosen companies should be large ones (with 250 full-time employees or more), since previous research shows that large companies are more likely to implement PI approaches such as lean (Shah and Ward, 2003). Third, to elaborate on the conflicting arguments found in the literature and to explore how organizations manage the interplay between PI and innovation, two dimensions were used to purposefully sample the case organizations: the extent of PI usage and the degree of product innovativeness. While these criteria were identified at the beginning of the sampling phase, further validation of the initial assessment of the chosen firms was sought during the data collection and analysis process. Overall, PI characteristics were derived in three ways, starting from the breadth of PI usage across the organization (Marodin et al., 2018, Netland and Ferdows, 2016). According to Sousa and Voss (2008), the degree of use of a practice can be reflected in "the intensity (breadth and depth) of the implementation" (p. 709). Moreover, recent research suggests that only those companies that use PI approaches such as lean across the organization could exploit its full potential (Marodin et al., 2018, Jones and Womack, 2017, Netland and Ferdows, 2016). Second, key informants were asked regarding the use of PI in the organization. Third, the CI maturity level criteria, which were proposed by Bessant et al. (2001) (see section 2.2.5), were used to validate the identified degree of PI usage in the case organization.

The degree of product innovativeness was evaluated in relation to both market and technology, consistent with other authors (e.g. Danneels and Kleinschmidt, 2001, Chandy and Tellis, 2000, Chandy and Tellis, 1998). Therefore, a product that displays new technology, knowledge or capability and satisfies new customers was identified as a radical innovation. Conversely, instances where current technology, knowledge or capability was used, and the product satisfied existing customers, were identified as incremental innovations. In order to derive this, informants were asked to provide examples of recent products and classify them as incremental and radical.

In addition to the above criteria, other evidence of a company's innovativeness and level of PI implementation was used such as awards (excellence, quality awards and innovation awards), certificates, number of patents and other available evidence.

3.4.1 Sampling selection process[9]

The process to identify suitable companies started at the end of February 2016. Different channels were used to contact product-based organizations in different industries in the UK. However, before starting contacting the organizations to seek access, certain assumptions were made to ensure that the sampling criteria were met and the case organizations were selected purposefully rather than randomly (Eisenhardt, 1989a, p.540). For instance, since the focus of the research is on organizations that use PI and produce products, only large product-based organizations were contacted. In relation to the variation in PI intensity and in product innovativeness criteria, companies from various industries were approached, since previous research suggests that industries have adopted PI at a different point in time banking (Netland and Powell, 2017, Samuel et al., 2015) and thus the likelihood to find companies with different degrees of PI might exist in various industries rather than one industry. The same applied to the variation in product innovativeness.

Consequently, after determining the appropriate list of companies that can be contacted, various databases were used to collect the contact information of product-based companies based in the UK. First, the Warwick Business School (WBS) alumni database, the WBS alumni database consists of contact information of WBS graduates who work in industrial and academic institutions. A contacts database which includes the name of the company, name and role of the informant, contact information (emails or telephone numbers), and links to the informants' LinkedIn accounts, was developed. This contact database was developed by the researcher to track the contacted companies' informants, set email reminders and identify the status of the company in terms of access (approved, decline, no answer). Seventy emails were sent to people in different companies in the first round, this led to 13 declines, 55 no answers and two positive responses from people in two different companies, the first one was from Hartridge Ltd, an automotive supplier based in the UK; however, the initial discussion via e-mail showed that the company was not appropriate for this research due to its small size and lack of implementation of PI approaches. The second company was the Mini-Cooper Company in Oxford. A visit to the manufacturing facility and an interview with the plant project leader was conducted. While this is a

[9] Pseudonyms were used to refer to the studied organizations for confidentiality reason at request of the participating organizations.

large company that uses PI, it was not appropriate to conduct this study as its facilities such as R&D, engineering, and strategy areas are not based in the UK.

Given the lack of responses from the people contacted initially, follow-up e-mails were sent to those which remained unanswered. Also, in parallel, LinkedIn was used in two ways to identify the research companies and find a gatekeeper. First, through sending an InMail message and, second, through adding people to the researcher's LinkedIn network. InMail limits messages to 15 per month. Two rounds were undertaken and, therefore, 30 InMail (private) messages were sent. These messages led to two positive responses. One from the New product innovation-Concept design leader at Dyson UK, who suggested having a conversation before confirming his company's participation; a lot of postponements occurred to this call between July 2016 until January 2017 and the response was that they would contact the researcher if they could provide sufficient access. A second company showing interest was GKN Driveline UK; however, they were in the process of restructuring the company and they would not be available until July 2017. The contact was kept for future reference. However, given the time constraint of the PhD research, the search for appropriate sites was continued.

In August 2016, a positive response was received through the WBS alumni database from the Business development director at Excellent-AeroCO. Excellent-AeroCO was identified as an appropriate company for this research as the discussion with the Business development director and the initial two interviews (see section …) showed that it has a high degree of PI usage in addition to Excellent-AeroCO being an industry leader in terms of product innovation.

In parallel to data collection in the first company (Excellent-AeroCO), further companies were approached. At an automotive sector presentation in November 2016 , two companies showed interest in participating in the research: Ford UK and Fast-CarCo. Pilot interviews were conducted in both companies and both were identified as appropriate sites for the research. However, due to lack of response from Ford UK gatekeeper, Ford was later dropped from the research. Subsequently, Fast-CarCo became the second company selected for this research.

In the same period of November 2016, two more companies showed interest in participating in the research: Cheap-CarCo UK and Siemens UK. An interview was conducted with the director of Cheap-CarCo and also identified as an appropriate site for the research. Regarding Siemens UK, an initial joint telephone interview was conducted with the head of open innovation and the head of business excellence. Consequently, Siemens UK was identified as an appropriate site for the research. However, one month later, they dropped from the research as they were unable to make a suitable commitment.

Moreover, various institutions were contacted to share the research invitation letter with their members such as the British Quality Foundation, the Institute of Mechanical Engineers (IMechE), the Lean Enterprise Academy and the EEF manufacturer. This approach did not lead to any positive responses.

In addition to the above method for approaching targeted companies, the PhD supervisors were involved in providing contacts, support, suggestions and advice throughout the case sampling. Consequently, through using the supervisors' contacts, access to the fourth company was secured. This company is Innovative-PharmaCo. Two initial face-to-face interviews were conducted, and these showed that Innovative-PharmaCo was suitable as the fourth site for the research as it uses PI and is an industry leader in terms of product innovation.

Ultimately, four companies were selected for matching the theoretical sampling criteria. These companies are: Fast-CarCo, Excellent-AeroCo, Innovative-PharmaCo, and Cheap-CarCo UK. The selected four companies are large product-based firms based in the UK. Nevertheless, they vary in terms of their degree of product innovativeness and the extent of PI usage. Coding of the initial interviews confirmed that the targeted companies match the sampling criteria (see table 16). Table 17 summarizes the main criteria and figure 5 illustrates the relative position of the selected companies. Also, chapter 4 provides a detailed description of the research context.

Table 16: Illustrative quotes to validate the theoretical sampling

Sampled companies	Identified sampling criteria	Illustrative quote
Fast-CarCo	High extent of PI implementation	- "Continuous Improvement methodology is used throughout the business to improve operating efficiency and remove non-value-added work" (Internal document, 2016, p. 29). -According, to the head of business excellence Fast-CarCo uses a bundle of PI approaches *"We use plenty of these things all available, people pick whatever they want to"*.
	Relatively high degree of product innovativeness	Fast-CarCo develops and produces varying degrees of innovative products. This was evident through the examples of product innovation that were given by the informants. For example, the [product] car was considered as a radical innovation by the head of business excellence because it provides *"...new set of customers and new space*".
Excellent-AeroCo	High extent of PI implementation	Excellent-AeroCo has used a bundle of PI approaches and has different dedicated teams for PI. Moreover, PI is used across the company. For example, the head of the production system said about the scope of PI implementation: *"I do know that all parts of our organization are using process improvement. And we're all getting the results that we want to. I think the biggest difference with process improvement between the three areas [manufacturing, R&D, Engineering], is the pace"*.
	Relatively low degree of product innovativeness	Despite Excellent-AeroCo currently developing new radically innovative technologies which are the ultrasound and autonomous shipping technologies, the main focus of Excellent-AeroCo in the past 20 years was on improving and developing different variations of the [current product]. For example, the head of engineering strategy and enterprise architecture said: *"so give or take,* Excellent-AeroCo *has had variants of the same product for the last 20 years. So we have one basic architecture of how the gas turbine works and we improve it and we improve it and we make it Lean and we polish it and it gets really, really good"*.
Innovative-PharmaCo	Low extent of PI implementation	*"And I think, again, maybe this is where I think the pharmaceutical industry is a bit lacking in terms of process improvement, even though it's been implemented, you can never see Innovative-PharmaCo as a company. You know, we are lagging behind industries like automobile, even food industry, or any of those industries; you know, we're not on the same level of approaching process improvements like the other industries are"* (product introduction lead, Innovative-PharmaCo).
	High degree of product innovativeness	Innovative-PharmaCo has varying degrees of product innovation - both radical and incremental - for example, the Malaria vaccine is considered as radical innovation because it is new to Innovative-PharmaCo and *"...never any company done that"* (new product introduction lead).
Cheap-CarCo UK	Relatively low extent of PI implementation	According to the chief programme engineer at Cheap-CarCo: *"It's [six sigma] certainly used in Cheap-CarCo. There isn't really a formal process for process improvement, other than there's a recognition it's required, but we don't have Six Sigma black belts across the business"*
	Relatively low product innovativeness	Cheap-CarCo's products seem to be not highly innovative compared to Fast-CarCo or other automotive companies as the main market of Cheap-CarCo is price sensitive. According to the head of advanced product creation: *"...the challenge for us in the vehicles that we are selling in [developing country] and those other markets, it's very price sensitive"*.

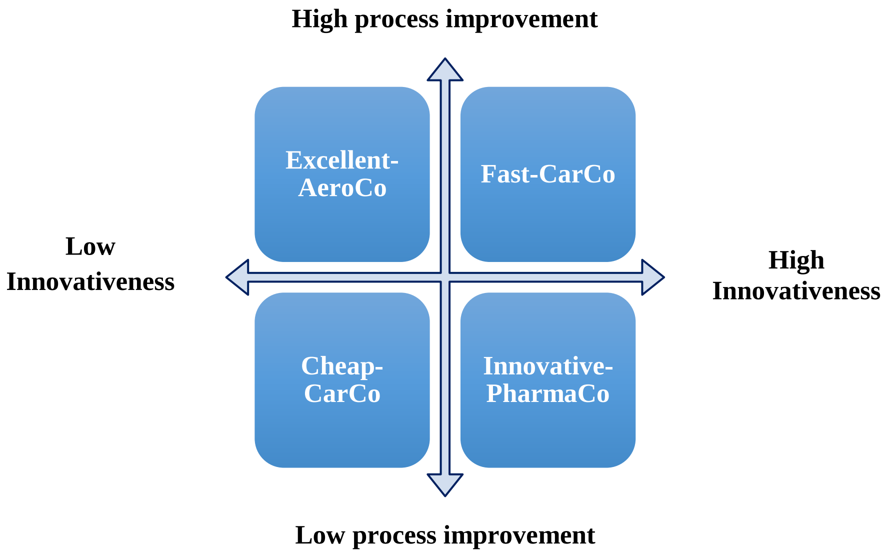


Figure 5: sampling Matrix

Table 17: Research context and sampling criteria

		Fast-CarCo	**Excellent-AeroCo**	**Innovative-PharmaCo**	**Cheap-CarCo**
Description	***Main Business***	To design, innovate, engineer, manufacture, market and service premium vehicles, parts and accessories, sustainably, in a global market place	A pre-eminent engineering company focuses on world-class power and propulsion systems	To create, discover, develop, manufacture and market pharmaceutical products, including vaccines, and health-related consumer products	To design and engineer vehicles
	Sector/ Industry	Manufacturing/ Automotive	Manufacturing/ Aerospace	Manufacturing/ Pharmaceutical	Manufacturing/ Automotive
Main Similarities	***Size***	Large (38,000 employees)	Large (49500 employees)	Large (99,500 employees)	Large (60,000 employees)
	Time-to-Market	Relatively long (5-7 years)	Long (7 - 12 years)	Long (12- 15 years or more)	Relatively long (between 5-7 years)
	Degree of regulations	Relatively high	High	High	Relatively high
	Length of PI usage	Using PI approaches for more than 15 years.	Using PI approaches for more than 15 years.	Using PI approaches for more than 15 years.	Using PI approaches for more than 10 years.
Main differences	***PI usage***	High - Using PI across the organization	High - Using different PI approaches	Low - Using PI only in manufacturing	Low - Using PI mostly in the manufacturing

		where appropriate - Using different types of PI approaches and practices- such as lean, six sigma, TQM, etc. - There is a clear awareness of PI across the company even in the R&D area.	such as lean, six sigma, TQM, across the organization - Having a formal process for PI - Having dedicated teams for facilitating PI implementation	- Using different PI approaches (lean & six sigma). - There is no formal program for PI - There is no awareness of PI across the company except in manufacturing	area and as projects in engineering - Using different PI approaches (mostly six sigma, lean, TOC) - Does not have a formal process for PI - Does not have dedicated teams for facilitating PI implementation
	Product innovativeness	Relatively high. - Have different types of product innovation both incremental, and radical	Relatively low. - Mostly focused on improving the current product (incremental product innovation)	Relatively high. - Have different types of product innovation both incremental, and radical	Relatively low. - Mostly focused on improving the current product (incremental product innovation)

3.5 Data Collection Method and Process

3.5.1 Interview protocol development process

Multiple methods, such as semi-structured interviews, documents and research diary and reflections, were used to collect data (Voss et al., 2002). Data collection consisted of the following: the interview protocol was developed based on the literature and on the three preliminarily informal interviews. The purpose of these informal interviews was to gain a sense of the context and types of PI methods used. Table 18 shows the sources of the initial list of the interview questions. Subsequently, the initial interview protocol was refined through pilot testing and by reviewing it with an expert in the field. Finally, refinement of the list of interview questions continued after the first few interviews in the data collection process and additional questions were added. Figure 6 shows the process of developing the interview protocol. The final list of the interview questions is presented in Appendix B.

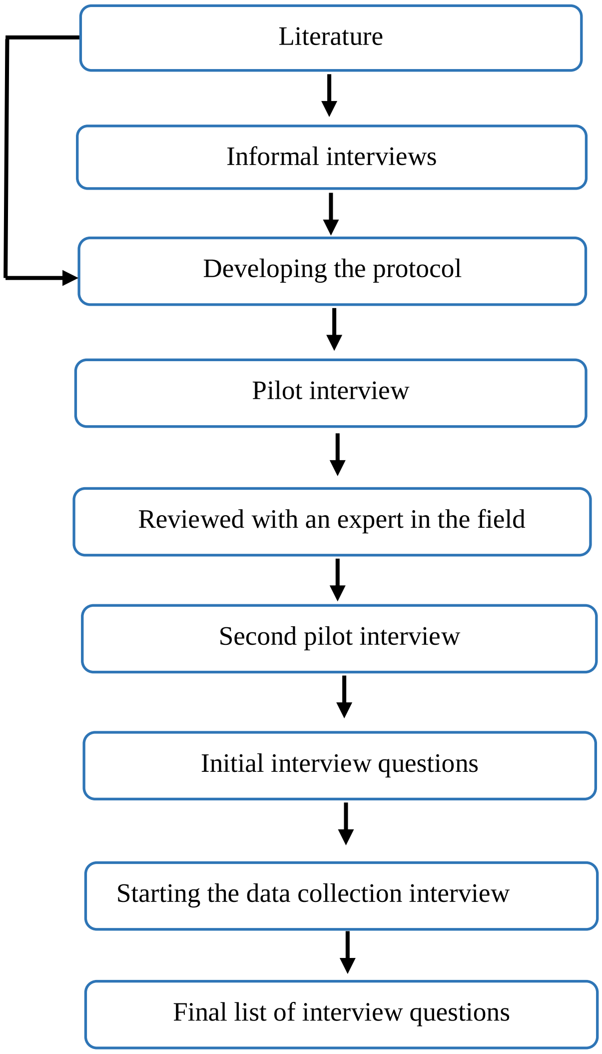


Figure 6: Interview protocol development

Table 18: List of initial interview questions and related sources

No	List of interview questions	Objective / reason	Source / related citations
1.	What PI approaches do you use in your company? *Probes: Have you implemented lean, six sigma etc.?*	Types of PI approaches	Researcher
2.	Why do you use them?	Reasons for adoption	(Zbaracki, 1998, Voss, 2005, Yeung et al., 2006, Westphal et al., 1997)
3.	Who is responsible for improvement in your company?	The implementation / use of PI across the company	(Pakdil and Leonard, 2014, Shah and Ward, 2003, Slack et al., 2013)
4.	Do you use these approaches everywhere in the company or only in certain departments or units?	The implementation of PI across the company	Informal interview
5.	How do you use them (lean, six sigma…)? *Probes: What are the practices that you use in implementing PI approaches?*	PI approaches implementation (hard/soft)	(Modig and Ahlstrom, 2012)

6.	To what extent are employees involved in decision-making and improvement processes?	The soft side of PI	(Pakdil and Leonard, 2014, Shah and Ward, 2003, Slack et al., 2013)
7.	What are the main challenges your company faces in implementing these approaches (lean, six sigma, etc.)?	Challenges (factors that affect the implementation of PI)	Informal interview Pilot interview
8.	What are the main problems caused by the use of PI approaches, if any?	Consequences of PI	(Benner and Tushman, 2003, 2015)
9.	Could you talk me through new product development or innovation processes?	Innovation processes / NPD processes	Discussion with an expert in the field
10.	Could you give me examples of product innovations in your company (incremental vs radical)? *Probes: Are your innovations more radical or incremental?*	Different types of product innovation	Discussion with an expert in the field
11.	Do the activities that lead to radical product innovation co-exist with the activities that lead to incremental product innovation?	The interaction between different types of product innovation	(Gupta et al., 2006, Jansen et al., 2009, Birkinshaw and Gupta, 2013, Benner and Tushman, 2003)
12.	What is the impact of PI approaches on innovation and new product development? (positives and negatives) *Probes: Do you think PI has an impact on research and development, design or engineering?*	The interaction between PI and product innovation	(Benner and Tushman, 2002, 2003)
13.	Do you have a formalized NPD process?	Formalization in NPD	(Cooper, 2008)
14.	Does having a standardized process / operation affect your company's ability to innovate? *Probes: How?*	The interaction between PI and product innovation	(Zeng et al., 2015, Benner and Tushman, 2003, 2002, Adler et al., 1999)

3.5.2 Data collection process

Data collection proceeded over a 15-month period between August 2016 and November 2017[10]. Table 19 summarizes the data sources for each case. Semi-structured interviews were used as the primary source for this research. However, the other sources of the data enriched the understanding of each case context.

3.4.2.1 Semi-structured interviews

A total of 44 semi-structured interviews were conducted in the four companies. Figure 7 shows the number of interviews over the data collection period. The interviews were conducted with informants from different functional specialisms (strategy, R&D, engineering, design, marketing, and manufacturing). A snowballing technique was used to ensure meeting the "information-rich key informants" (Patton, 2002, p. 237). Each interview lasted for one hour on average. Two informants were

[10] Appendix A presents the participants invitation letter

interviewed twice; two other informants were interviewed jointly upon their request. Forty-two[11] out of 44 interviews were audio-recorded and transcribed. Field notes were taken throughout the research in order to capture the ideas and impressions as they occur (Eisenhardt, 1989a). The anonymity of the informants was kept both in the main data collection and in the pilot and informal interviews. The interviewing process continued until theoretical saturation was achieved. This was evident through the lack of novelty of information that was derived from the last interviews.

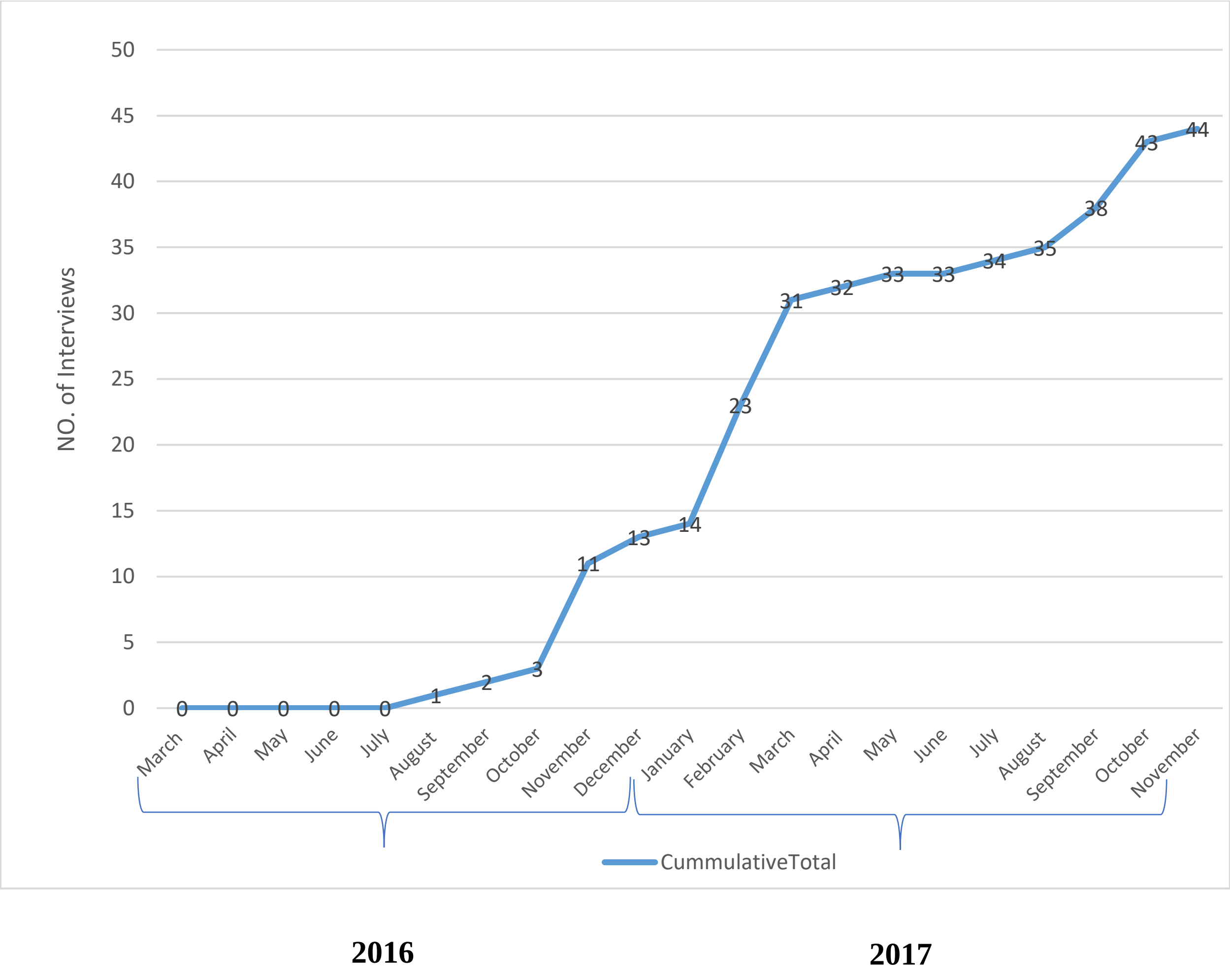


Figure 7: Data collection phase

3.4.2.2 Document analysis

In addition to semi-structured interviews, relevant documents were collected from each case organization. A total of 72 online and internal documents were gathered,

[11] Two interviews were not audio-recorded based on the informants' request

including: PI reports, annual reports, strategic plans, product development process templates, awards-related documents and performance management objectives. Table 19 presents the collected internal and online documents.

Table 19: Interviews and relevant documents

Company	Number of conducted interviews	Number of collected documents (external / internal)
Fast-CarCo	**17 interviews** • Process excellence & improvement senior manager in marketing and sales (marketing and sales) • Master black belt in engineering (two interviews) (engineering) • Technical specialist vehicle dynamics systems (product development) • Head of research and technology strategy (research) • Head of marketing communications director (marketing/ communication) • Business planning senior manager in marketing (strategy/ marketing) • Experiential marketing director (marketing) • Business manager of the global CRM and customers' insights (Marketing/ customers relations) • Product marketing manager (marketing) • Director of business excellence (strategy) • Competitive and market intelligence manager (strategy) • Product creation delivery system project manager (joint interview) (product development and design) • process planner (joint interview) (product development and design) • Lead engineer (engineering) • Business transformation principal (strategy) • Purchasing transformation director (Strategy / purchasing and Human resources)	**Internal documents (8 documents)** • Excellence and strategic priorities document 2016 • Technology creation and development system process • Innovation process template • Research centre brochure • Global CRM & customer insights organization chart • Global marketing business priorities • Quarterly review document for experiential marketing • End of year performance review for the head of business excellence in marketing and sales **Online documents (2 documents)** • Fast-CarCo Annual report 2016 • Fast-CarCo financial report 2016 **Total: 10 documents**
Excellent-AeroCo	**10 interviews** • Global head of continuous improvement (Central/ manufacturing) • Head of continuous improvement in engineering (engineering) • Head of the production system (Central / manufacturing) • Technology lead - innovation unit (Research/ technology) • Head of improvement (central/ strategy) • Head of lean transformation team (central) • Method and capability director (strategy) • Head of product development system (product development) • Head of innovation team (central/ Research) • Head of engineering strategy and enterprise architecture (design and engineering)	**Online documents (10 documents)** • Full year results 2016, 2015, 2014 • Business model 2016 • Excellent-AeroCo strategy 2016 • Excellent-AeroCo strategic report 2016 & 2015 • Annual report 2015, 2016 • Company profile 2015 • Patents (Amadeus database) **Internal documents (1 document)** • Slides on PI and problem-solving techniques **Total: 11 documents** • Other related documents: 15 external / 12 Financial times publications and 3 other sources • 4 industry-related documents (Excellent-AeroCo)
Innovative-PharmaCo	**10 Interviews** • Fund director, Immunology Innovation Fund (Strategy / R&D)	**Online documents (31 documents)** • Innovative-PharmaCo magazine SWOT analysis (2008-2012) (10 issues)

	• New product introduction lead (NPI) (product development) • Director of , strategy, operations and finance, Rare Diseases (R&D) • Director of portfolio management (Strategy) • Global commercial lead (commercialization) • Project director, Rare Diseases (R&D) • Manufacturing unit manager (Manufacturing) • Medicine supply chain leader (Manufacturing) • Director, of inhaled drug product design and development (product development) • External consultant	• Company profile (2012-2016) (9 issues) • Annual reports (2008, 2010, 2012, 2013, 2015, 2016) (6 documents) • Annual summary-strategic priority (2008, 2009, 2013) (3 documents) • Annual report-pharma • Annual report-vaccine • Innovative-PharmaCo drug development process • Case study on the accelerating delivery and performance **Internal documents (3 documents)** • Strategic objectives-rare diseases / R&D • R&D key performance indicators- 2017 • R&D Governance and internal rate of return overview **Total: 34 documents**
Cheap-CarCo UK	**7 interviews** • Chief programme engineer (engineering) • Principal engineer (engineering) • Head of advanced product creation (two interviews) (Product development) • Head of digital (technology/ research) • Head of design (design) • Head of propulsion & innovation (engineering / strategy)	**17 documents (1 internal document and 16 Online documents):** • Annual report (2008-2016) • Awards & achievements (2011-2014) • Future strategies &plans (next level in connectivity, design, driving experience, fuel economy) • Sustainability report 1 internal document: innovation process

3.6 Data Coding and Analysis Process

Data analysis was conducted in parallel with data collection. Data were analysed within and between cases through a multi-stage iterative process which included several rounds of coding, categorization, and refinement using the NVivo software. (`See Table 20). While the process is described in a linear process for simplicity, it was iterative in practice (see coding structure in Appendix C Table 36). The analysis was broadly conducted in seven stages:

Stage 0: Researcher reflections and interview checklist

This stage acts as a data analysis preparation stage. The researcher wrote initial reflections on each interview shortly after finishing it. The interview checklist consists of the main topics that were discussed in the interview, the connections between the topics discussed and the research question, similarities and differences between different interviews. Similarities and differences between the initial discussed topics and the literature.

Stage 1a: First round of coding

The open-coding process was iterative. Interview transcripts were coded using NVivo software. First order codes were used to code the interviews for each case sequentially, starting with Excellent-AeroCo, then Fast-CarCo, then Innovative-PharmaCo and finally Cheap-CarCo. In this first order coding, NVivo codes or descriptive sentences were used to "adhere faithfully to informants' terms" (Gioia et al., 2013, p. 20). Some of the codes were deductive as terms were derived from the literature, e.g., "employees' involvement". Other codes emerged from the data, e.g., "improvement bundle".

Stage 1b: Categorization and mapping

This started by grouping first-order codes into general topics. These include PI, innovation, link between process and innovation, collaboration, performance measurement and management, problem-related topics, capabilities and market related topics and, finally, context specific aspects (this consists of descriptive codes for each company). Subsequently, the researcher searched for similarities and differences between codes under each topic. Consequently, sub-categories emerged under the main identified topics (main categories). For example, codes that were grouped under "PI" topic were classified into WHAT PI approaches are used? WHAT does it mean? HOW is PI implemented? WHO is responsible for PI? WHERE PI is used? etc. The same type of classification was used for innovation, e.g., WHAT types of innovation, HOW innovation is conducted and generated, WHO is responsible for innovation, and so on. The "Link between PI and innovation" category consists of what informants said about the relationship between PI and product innovation, and organizational tensions that need to be balanced according to the informants. Then, mind maps were used to compile and visualize the main categories, sub-categories and codes. Finally connections were built between the identified categories.

Stage 2: Research context analysis

This stage aimed to analyse the research context characteristics for each of the case organizations in terms of the extent of PI usage and the degree of product innovativeness. Different criteria were used to define the degree of PI usage including the breadth of PI in the organization, the informants' descriptions of the use of PI in their organizations and other available evidence including, for example, quality- or excellence-related awards. The degree of product innovativeness was derived from the examples of product innovation that were given by the research informants in each of the case organizations. Informants were also asked to classify their organization's product innovativeness as either incremental or radical.

Stage 3: Within-case analysis to identify the main themes within each organization

The first round of analysis was initiated by an in-depth reading of the transcripts for each of the case organizations separately to allow "the unique patterns of each case to emerge" (Eisenhardt, 1989a, p.540). Initially, first order codes were used to identify the characteristics of PI approaches in each organization - where they were being used, by whom and how – as well as product innovation characteristics, including the types of products and the new product development process. After identifying the main characteristics of PI and innovation through the first order coding, a detailed description was written for each case.

Stage 4: Cross-case comparison

Through the second round of analysis the main similarities and differences between the case organizations were identified. By comparing the findings from the four companies, it was clear that PI approaches were deployed differently, especially in terms of scope and formality, and the degrees of innovation also varied. Moreover, each organization appeared to use different mechanisms to manage the interplay between PI and innovation (e.g., performance measurement, training, structure) and to conceive such interplay differently. By comparing the main themes across cases, the second order codes and the aggregate dimensions were derived. Appendix C presents the coding and data structure.

Stage 5: Identifying configurations for managing the interplay between PI and innovation

The emerging coding structure was used to build tentative relationships between the identified second order codes. These relationships were refined multiple times through discussions, research presentations and writing. Through iterations between findings and the relevant literature, four configurations for managing the interplay between PI and innovation in each case organization emerged. These include: (1) "strategic and holistic" approach in aerospace; (2) "facilitating and empowering" approach in Fast-CarCo; (3) "operational" in Pharma; and (4) "project-based" in Cheap-CarCo. Chapter 5 describes each configuration in detail.

Stage 6: Exploring the interaction between various elements of the configurations

A final round of analysis was conducted to explore the interaction between various characteristics of each configuration (PI deployment characteristics, innovation outcomes, organizational features, the viewed interplay between PI and innovation). At this stage, the proposed approaches for managing contradictory goals in the ambidexterity literature - integration and separation - were used to describe the interaction between PI and innovation in each of the emerged configurations. Chapters 4, 5, and 6 present the detailed descriptions of the research findings.

Table 20: Analysis stages and emerging themes

		Findings				
Analysis stages	**Description of the stage**	**Excellent-AeroCo selected emerging themes**	**Fast-CarCo selected emerging themes**	**Innovative-PharmaCo selected emerging themes**	**Cheap-CarCo selected emerging themes**	**Emerging themes (main findings at each stage)**
Stage 1: Research context analysis (identifying the context characteristics)	Using the interview transcripts and collected documents to identify the following: *-The extent of PI approaches implementation:* • Based on the training programmes • Breadth of PI implementation • Types of used PI approaches and practices *-The degree of product innovativeness:* • Based on the market and technology dimensions of product innovation	*-High in PI implementation:* • Using PI across the organization • Having a formal process for PI • Having dedicated teams for facilitating PI implementation *-Relatively low product innovativeness:* • Mostly focused on improving the current product (incremental product innovation)	*-High in PI implementation:* • Using PI across the organization where appropriate • Using different types of PI approaches and practices • There is a clear awareness of PI across the company even in R&D area *-Relatively high product innovativeness:* • Have different types of product innovation both incremental, and radical. Also, Fast-CarCo have a variation of other types of innovation	*-Low in PI implementation:* • Using PI only in manufacturing • There is no formal programme for PI • There is no awareness of PI across the company except in manufacturing *-Relatively high product innovativeness:* • Have different types of product innovation both incremental and radical	*-Low in PI implementation* • Using PI only in manufacturing and some initiatives in engineering • Does not have a formal process for PI • Does not have dedicated teams for facilitating PI implementation *-Relatively low product innovativeness* • Mostly focused on improving the current product (incremental product innovation)	Common themes: • Companies vary in the degree of PI usage • The degree of product innovativeness varies between the case organizations

Stage 2: Within-case analysis- (a) describing: PI characteristics and usage (b) Innovation characteristics (c) Exploring the link between PI and innovation	First-order coding to identify the following: (a) **PI characteristics** • What PI approaches are used? • Why are PI approaches used? • Who is responsible for PI? • How PI is implemented (practices and mechanisms) • Outcomes barriers for PI *(b)* **Product innovation** *characteristics* • What are the types of product innovation? • How are incremental and radical product innovation generated? (idea generation, processes and mechanisms) • Who is responsible for generated product innovation? (sources of innovation) • Challenges and enablers for product innovation **(c) The interplay between PI and innovation (as informants see it)**	**(a)PI characteristics' themes:** • PI as a set of different approaches: uses more than one PI approach at the same time. However, each approach is used differently • PI approaches are used across the companies. However, PI usage varies within the company and between functions • Everyone is responsible for PI. However, there are dedicated teams for facilitating and monitoring PI used across the company • PI training is mandated • Employees' involvement in PI is formally reviewed • PI approaches are used both in their behavioural and hard (tools) aspects **(b)Innovation characteristics themes**	**(a)PI characteristics' themes** • PI as a set of different approaches: uses more than one PI approach at the same time. However, each approach is used differently • PI approaches can be used across were appropriate • PI usage is not mandated on people in the organization • People are empowered to improve their processes in the way they find appropriate • PI training is not mandated on people in the organization **Innovation characteristics' themes** • Overall uses similar process	**(a)PI characteristics' themes** •More than one PI approach used in the manufacturing area •PI usage is confined to the manufacturing area •There is a lack of communication and collaboration between manufacturing, R&D and commercialization areas. There is a friction between these units **Product innovation characteristics** • The process of producing incremental and radical innovation is the same at the execution stage but different at the idea generation stage **Link between PI and product**	**(a)PI characteristics' themes** •More than one PI approach is used in the manufacturing area. Six sigma is the dominant approach •Using PI on projects in engineering •PI is not used in design and digital innovation areas **Innovation characteristics' themes** •Incremental and radical innovative technologies separate from each other at the development stage but both types of technologies have similar deployment process **(C)Link between PI and product innovation (informants view)** •PI can enable incremental but hinder radical innovation	**Common themes**: • PI as a bundle of approaches • The scope of PI implementation varies between the studied organizations and the PI implementation maturity varies within companies • The responsibility of PI implementation varies between the studied organizations • Feeling pressure to balance opposite outcomes and mechanisms • Overall, similar processes are used to manage incremental and radical product innovation. • Informants' view regarding the link between PI and product innovation varies between companies • Employees autonomy in generating and developing their ideas vary between companies • The alignment between functional units vary between the case orgnaizations

	(d) Organizational features (managerial, structural)	• Overall uses similar process for both radical and incremental innovation • Radical and incremental innovative ideas require a different ways of problem framing **(c)Link between PI and product innovation (informants view)** • Generally speaking, PI approaches are regarded as enablers for product innovation • Some people perceive PI as a barrier for product innovation (in particular radical) **(d)Organizational features** • Identifies different outcomes and mechanisms that needed to be balanced • Having performance measurement and objectives for PI and innovation	for both radical and incremental innovation • Radical innovation teams can be separate from the current one if needed **(C)Link between PI and product innovation (informants view)** • PI seen as an indirect facilitator to innovation **(d)Organizational features** • Having process-oriented structure which facilitates collaboration • Employees have the flexibility to develop their ideas • Balanced performance measurement objectives	**innovation (informants view)** • PI and innovation are conducted in two separate areas • PI is disconnected to product innovation because they are in different places **(d)Organizational features** • Silos: misalignment between units and functional areas • Employees have the flexibility to develop their ideas	• Need to convince people to ignore the process **(d)Organizational features** • Innovation and improvement championships	

		• PI and innovation specialized teams				
Stage 3: (a) Cross case comparison	Identifying main similarities and differences between the case organizations	*Main Differences:* a. The case organizations manage the interplay between PI and innovation differently (1) Excellent-AeroCo uses a strategic and holistic configuration (2) Fast-CarCo uses a facilitating and empowering configuration (3) Innovative-PharmaCo uses an operational configuration (4) Cheap-CarCo uses a project-based configuration These four emerging configurations vary in: PI dimensions (formality of PI, scope of PI, PI usage), Viewed interplay between PI and innovation and the organizational mechanisms (managerial and structural) *Main Similarities:* a. PI as a bundle of approaches b. PI is Multi-Dimensional				
Stage 3: (b) Exploring the interplay between PI and innovation at the NPD level	Exploring the reasons behind the divergence in the viewed interplay between the case organizations	a. The interplay gets managed through “integration” under the “Strategic and Holistic” and under the “Facilitating and Empowering” configurations and through “separation” under the “Operational” and “project-based” configurations b. When and how PI is used in the NPD play role in shaping the interplay between PI and innovation				

3.7 Research Ethics

The researcher took several steps to ensure research ethics; first, as part of the doctoral programme at WBS, the researcher attended a workshop on research ethics before starting with the field-work in order to familiarize herself with ethical considerations early in the research process. Second, the researcher signed the research ethics form at WBS. WBS “is committed to ensuring that the research conducted by its staff and students maintains the highest possible standards of integrity and respects the dignity, rights, safety and well-being of participants” (WBS research ethics form); therefore, research students must obtain the appropriate ethical approval for their research. Third, the informants’ names and information were kept anonymized and companies’ documents, interviews transcripts and audio-records were stored on the researcher’s password protected personal computer. Fourth, the researcher signed a formal non-disclosure agreement with one of the companies (Fast-CarCo) and informally agreed with the other three companies on maintaining anonymity and confidentiality of the companies and informants’ documents.

3.8 Research Quality Evaluation Criteria

To maximize the quality and rigour of the research data, different steps were taken during the research design process, data collection and, analysis. Table (21) presents the actions that were taken to meet the quality criteria in terms of four commonly used tests: (1) construct validity, (2) internal validity, (3) external validity, (4) reliability (Yin, 2009).

Table 21: Actions taken to meet the validity and reliability criteria of case research

Test	Case study tactic	Phase of research in which tactic occurs	Action taken in this research
Construct validity	• Use multiple sources of evidence • Establish a chain of evidence • Have key informants review draft case report	• Data collection	• Triangulation of data sources (interviews, document analysis). • Informants from different functional specialisms were interviewed. • Transparency of the coding process and chain of evidence.
Internal validity	• Do pattern matching • Explanation building • Address rival explanations • Use logic models	• Data collection • Data analysis	• An iterative process of coding, categorization and refinement was undertaken during the data analysis process. • Verified through adopting various informants' perspectives. • Comparing the research findings with theory when needed.
External validity	• Use replication logic in multiple case studies	• Research design	• Multiple case study was used. • Studying companies from multiple industries.
Reliability	• Use case protocol • Develop a case study database	• Data collection • Data analysis	• Companies' databases were developed during the case sampling process. • Each company's information was kept separate in a different folder in NVivo software. • Well-designed interview protocol. • Pilot the interview protocol with an expert in the field. • Enhanced by directly taken field notes after conducting the interviews. • Maintaining transparency in the analysis process.

Source: This table is a modification of the original work of Yin (2009, p. 41)

CHAPTER 4: RESEARCH CONTEXT ANALYSIS

4.1 Introduction

This chapter provides a detailed description for each case organization including a brief introduction to each company's core business, degree of PI usage and product innovativeness. It concludes with the positioning of each company in the sampling matrix (please refer also to Tables 16 and 17, and Figure 5 in Chapter 3).

4.2 Case 1: Fast-CarCo

4.2.1 Overview, mission and core business

Fast-CarCo is a global automotive manufacturer, based in the UK, and with a new owner since 2008. Its main business - as Fast-CarCo describe it - is "to design, innovate, engineer, manufacture, market and service premium vehicles, parts and accessories, sustainably, in a global market place" (Internal Document, 2016, p. 2). Fast-CarCo is built around a merger of two automotive companies, Company A and Company B. Under the current ownership, Fast-CarCo has experienced great growth in terms of size, revenue, investment, retail volume, and the number of manufacturing sites. It is currently the largest automotive company in the UK with around 40,000 employees. Moreover, its revenue increased from £6.5bn in 2009/2010 to £21.9bn in 2014/2015. Fast-CarCo operates in eight sites in the UK: three manufacturing plants, two advanced design and engineering centres, an engine manufacturing centre, special vehicle operation and advanced research centre (Annual Report, 2016, p. 8). In these eight sites, Fast-CarCo develops and produces different vehicles to 153 markets around the world (Annual Report, 2016).

The overall purpose of Fast-CarCo is to deliver "Experiences Customers Love, for Life" (internal document, 2016, p. 1). It delivers this purpose through three main pillars: first, put the customer first, second, deliver more great products faster, third, environmental innovation. This is supported by "four foundations: 'Engaged Passionate People', 'Transformed Cost Structure', 'Business Excellence' and 'Global Growth'" (internal document, 2016, p. 1). And through its main values of "'Integrity', 'Understanding', 'Excellence', 'Unity', and 'Responsibility'" (internal document, 2016, p. 29).

4.2.2 Degree of product innovativeness

Innovation is one of the key pillars of the Fast-CarCo strategy. Fast-CarCo has "the highest investment in R&D compared to other automotive companies" (Annual Report, 2016, p. 10). It is one of the winners of the innovation award from the Institution of Engineering and Technology in 2014. Fast-CarCo developed its technological capabilities both internally and externally through collaboration and partnership with IT companies such as Intel and universities including the University of Oxford, University of Cambridge, University of Warwick, and University College London in the UK and Massachusetts Institute of Technology in the US. These collaborations assist Fast-CarCo in being up-to-date with the recent technology and developing smart, connected, clean, desirable and capable vehicles.

Fast-CarCo offers a variety of products in its portfolio. It consists of a range of product lines including Premium, Sport and Lifestyle. The research informants were asked to classify the innovativeness of Fast-CarCo products into radical and incremental through giving examples of both types. These examples showed that Fast-CarCo has a range of innovative products. For instance, some products such as [product] was described by the lead engineer

> *"…the [product] convertible was the first SUV convertible by Fast-CarCo and by anybody else to begin with. Now that took innovation to take into account, aerodynamics, stability of the vehicle as it began to speed off with such a large car and the top half was taken off when the roof was taken down. So, that took a lot of innovation in terms of even climate control. How do you control the climate of the vehicle when there's no roof…?"*

Other examples of radical and incremental innovation that were given by the informants include Lane Keep Assist in the [product] that is considered as a radical innovation since *"…that is using new technologies, radar and camera systems, to identify when a vehicle is being put in a hazardous situation and can alert the driver before an incident or accident occurs"* (Senior Manager for Operational Excellence in Marketing Sales and Service). *[Product]* was described as radical innovation by the process planner in Fast-CarCo since it is the first fully battery-operated car and this is a new technology to Fast-CarCo. According to the product innovation and development systems manager, incremental innovation can occur through adding new features to the vehicles.

In addition to radical and incremental innovation classification, Fast-CarCo informants added two other categories of product innovation, the first using current technology for new purposes, for example the New [product] that was launched in 2016 was described, by the Senior Manager for Operational Excellence in Marketing Sales and Service, as an innovative product since in the *"New [product] existing technology is being used for a new purpose".* The second concerns styling, by making the product more appealing, which was described as *"…refreshing car…adding gloss and glitter… it looks refreshed, it does not give customers anything new in terms of technical function but it looks pretty*" (Product Innovation and Development Systems Manager).

Overall, the various types of innovative products that Fast-CarCo produced reflects that it is capable of producing both incremental and radical innovation frequently.

4.2.3 Degree of process improvement usage

The automotive sector is a pioneer in the use of different PI approaches such as lean, six sigma, etc. Fast-CarCo uses different PI tools and practices such as PDCA, DMAIC, FMEA, SPC, process mapping / flowcharting, TICs, IPS, Kaizen and lean methods, etc. (internal document, 2016, p. 27). (See table 22 for a description of the used PI tools and practices). "Continuous Improvement methodology is used throughout the business to improve operating efficiency and remove non-value-added work" (internal document, 2016, p. 29). Fast-CarCo communicates and shares best practices, including PI, across the company through different portals such as the 'Fast-CarCo way'. Fast-CarCo Way is a business-wide initiative that was established in 2014. Its main purpose is to "bring together and improve the business excellence mechanisms which establish and control our ways of thinking, behaving and working. It includes all Fast-CarCo corporate and operational policies, key work systems, processes, procedures, templates, standards, etc., and it is accessible globally via the Fast-CarCo Portal" (internal document, 2016, p. vii). Fast-CarCo portal acting as a library that collect the improved processes from various parts of the organization, including processes for strategy (SCDS), technology development (TCDS), product creation (PCDS) and others. Each process in Fast-CarCo has a process owner who is responsible to improve it.

Additionally, Fast-CarCo uses PI across the business and at different departments. As the Head of Business Excellence explained:

> "*It's across the business. Everyone uses PI to improve their processes. What tools they use are all different".*

However, the degree of the embeddedness of continuous and PI varies across function, according to the director of operational excellence in marketing and sales:

> *"in Manufacturing, there is a long-established ethos for continuous improvement. In places like Marketing, Sales and Service, that is less well-embedded…"*

Overall, Fast-CarCo uses PI approaches across the organization, thus, this research considers Fast-CarCo as high in PI usage.

4.3 Case 2: Excellent-AeroCo

4.3.1 Overview, mission and core business

Excellent-AeroCo, as it describes itself, is an engineering company focused on world-class power systems (Annual Report, 2016). It is one of the largest aero engine in the world. It operates in more than 50 locations and has customers in 150 countries. Excellent-AeroCo was established in 1884, and currently it has 50,000 employees around the world. 16,526 of Excellent-AeroCo's employees are engineers (Annual Report, 2016), with the following distribution: 46% in design, 20.8% in manufacturing, 9.9% services, 9.8% electrical and 13.5% others.

Excellent-AeroCo's main business is to provide and support "integrated power systems" (Annual Report, 2016). It consists of various businesses, the largest one in term of its percentage contribution to revenue is Aerospace.

The vision of Excellent-AeroCo is to provide "'better power for a changing world' and to '...to be the market leader in high-performance power systems where [our] engineering expertise, global reach and deep industry knowledge deliver outstanding customer relationships and sustainable solutions'. Excellent-AeroCo aims to achieve this through '…focus on differentiated, mission-critical power systems which create high barriers to entry in our chosen markets, leverage world-leading engineering, operational and customer service excellence to drive growing market shares, capture long-term aftermarket value and deliver profitable growth'" (Excellent- AeroCo website).

4.3.2 Degree of product innovativeness

The aerospace sector is one of the R&D-intensive sectors (UK Commission for Employment & Skills -aerospace infographic, 2013). The use of new manufacturing technologies and materials like "additive manufacturing and composites have been identified as of major strategic importance" in the Aerospace industry in the UK (UK Commission for Employment & Skills Report, 2013).

Excellent-AeroCo is the largest aero engine manufacturer in the UK. In 2016, Excellent-AeroCo invested more than £1.2 billion on R&D to satisfy current and future customer needs. A recent company publication shows that there is a continuous increase in R&D expenses between 2009 and 2016. The investment in future technology as a percentage of sales increased by 8% in 2016. This growth is due to the rise in expenditure on three large engine programs. (Strategic Report, 2016, p.9).

Excellent-AeroCo coordinates its research both internally and externally: Externally through collaborations with academic and industry partners which help to "bridge the gap between early research and industrial application, with a focus on developing new manufacturing processes and technologies" (Annual Report, 2016, p.41); internally, through three different ways: first, dedicated innovation teams across the business. Each business has its *"own innovation teams…., and they can be relatively large, maybe eight or ten people"* there is *"a central team with coordinates all the innovation activity across the whole business, so it's not just those at [UK], it's Germany, America, Singapore, India"* (technology lead in the innovation team).

Second, the innovation portal is shared with all employees across the business. The innovation portal "*is a piece of software that actually any and all of our 55,000 employees can access…Some people spend a lot of time on the portal, but it's there and they can just go and have a look, and if they think they can contribute, they can add an idea or they can comment upon an idea that's already in there, so we get people to develop things for us, and that's worked quite well"* (technology lead in the innovation team, Excellent-AeroCo).

Third, running an innovation challenge encourages participation and sharing best practice and ideas from different parts of the business. For example, as described by the technology lead at Excellent-AeroCo:

> *"a challenge that said we need new aerospace technology for gas turbine engines, anyone from Marine would just look at it and go, it's Aerospace, I'm not interested, and the Nuclear guys would look at it and go, well, that's Aerospace. So, you lose 70% of your brainstorming population, and only the Aerospace guys look at it, and they've already been looking at the problem for 30 years; so, actually, they're probably not going to come up with the answer. The Nuclear guys are, oh, yes, we deal with high temperatures. Have you thought about this? And the Marine people might go, yes, we get high temperatures in our engines, and this is what we… and suddenly you get lots of inputs in lots of different areas, and it's that cross-pollination that's absolutely critical. That's our experience, actually, and we've got some interesting statistics now that shows the spark of innovation will generally come from outside of the area that's got the problem, maybe two thirds of the time"*

Excellent-AeroCo offers a range of products, the process of producing an aero-engine takes a long time and follows highly regulated stages, and this process is described by the head of continuous improvement in engineering as follows*:*

> *"… essentially it is staged processes so we have a number of different stage processes that we go through, business proposal to concept to detailed definitions through…ultimately into the production phase. So, we run a gated review process on that…. deal with process and that traditional set of design, review your PDA, your CDA and then ultimately into production so it follows the traditional product introduction lifecycle model".*

Excellent-AeroCo products vary in innovativeness. One of the examples given about radical innovation is the ultrasound technology as it has *"more radical things like brand-new fan technology…and in terms of the architecture and the way that engine is configured"* (head of continuous improvement in engineering). And the product family is considered as incremental innovation by the head of continuous improvement in engineering:

> *"…the [product] family that will be incremental so at the time we had what we called EP packages so enhanced performance packages so you know that of the [product] will be launching an EP package …which will have incremental technology improvement added into it."*

Overall, Excellent-AeroCo focuses on producing incremental innovative products.

4.3.3 Degree of Process improvement usage

The aerospace industry is ranked the second industry in the UK with respect to the use of PI approaches. Excellence and process and performance improvement are key priorities in Excellent-AeroCo as well. Currently 42,000 employees are involved in different improvement activities, supported by 700 continuous improvement facilitators (Annual Report, 2016, p. 11)

Excellent-AeroCo uses various PI tools and practices (see table 22 for a description of the used PI tools and practices). It has used different PI approaches throughout the years. In the last 11 years, it has launched formal transformation programmes for PI approaches that focus on "simplifying the organisation, streamlining senior management, reducing fixed costs and adding greater pace and accountability to decision making" (Strategic Report, 2016, p.10). One of these is a business-wide engineering efficiency programme called E3 that was launched in 2016 (Strategic Report, 2016). E3 stands for "embedded engineering excellence". This programme focuses on: 'efficiency and effectiveness', 'provide additional capacity with minimal cost', and 'leverage existing programmes around high performance culture and lean' (Excellent-AeroCo full year results presentation, 2016, p.9).

The formal transformation programmes for PI are managed by different dedicated teams such as lean transformation enterprise which has: *"…a strategic and coaching role with the intention that [w]e support the organisation to transform more towards what I would describe as a true Lean"* (Head of Lean Enterprise Transformation), the production system which is *"…a Lean system to try and get everyone to work in a better way"* (head of the production system) and continuous improvement functions that facilitate continuous PI in different areas and businesses.

Additionally, Excellent-AeroCo runs different PI trainings such as green belt, black belt, yellow belt, master black belt, Kaizen, Lean, etc. PI training is usually followed by PI project and coaching activities to ensure that trainees can use PI after training. Some of this training focusses on creating and changing the culture in Excellent-AeroCo, these are run by the production system and aim to create a performance improvement mind-set and culture. This training is used as a reflective mechanism, especially when employees try something new. The aim of this type of training is to ensure that employees reflect on their own experience, performance, how this impacts others and how to control the results. As described by the head of the production system:

> “*that’s all about mind-set, that you can control the results from the things that… the actions that you take and the thinking that goes on. So, you can change your thinking and it will change your actions, which change your results”.*

In summary, Excellent-AeroCo follows a systematic approach toward PI and uses PI across the business, this research regarded Excellent-AeroCo as an organization that uses PI to a large extent.

4.4 CASE 3: Innovative-PharmaCo

4.4.1 Overview, mission and core business

Innovative-PharmaCo plc is “a major global healthcare group which is engaged in the creation, discovery, development, manufacture and marketing of pharmaceutical products, including vaccines, over-the-counter medicines and health-related consumer products” (Annual Report V4, 2016, P. 236). Innovative-PharmaCo was formed through a merger between two companies in 2000.

It is a large company with around 100,000 employees around the world. It operates in 87 manufacturing sites and serves more than 150 markets (Annual Report V4, 2016) in 57 countries. Innovative-PharmaCo has three world-leading businesses: pharmaceutical, vaccine, and consumer healthcare. The pharmaceutical business “discovers, develops and commercializes medicines to treat a range of acute and chronic diseases” (Annual Report, 2016, p.22). The pharmaceutical business portfolio currently offers a wide range of innovative and improved drugs in respiratory disease and HIV, and the focus of research is “across respiratory, HIV and infectious diseases, immuno-inflammation, oncology and rare diseases” (Annual Report, 2016). The vaccines business “has the broadest portfolio of any company, with vaccines for people of all ages – from babies and adolescents to adults and older people” (Annual Report V2, 2016, p. 30). The consumer healthcare business “develops and markets products in Wellness, Oral health, Nutrition and Skin health categories” (online document). Innovative-PharmaCo has seven global power brands under the consumer healthcare businesses including some of the most trusted and best-selling brands in the world” (online document).

Innovative-PharmaCo has four main strategic priorities: “grow: ‘Grow a balanced business and product portfolio, centred on our three global businesses’, Deliver: ‘Deliver more products of value to offer improved treatment for patients, consumers and healthcare providers', Simplify: 'Simplify the way we operate to reduce complexity, increase efficiency and free up resources to reinvest in the business or return to shareholders, wherever we see the most attractive returns', and Responsible business: 'Being a responsible business, as how we deliver success is as important as the results we achieve'" (annual report, 2016, p. 7).

The pharmaceutical industry is highly regulated. The product development from concept to launch follows a prescribed four phases and gates that are determined by the Food and Drugs Agency (FDA). This process takes around 12 to 15 years. Figure 8 presents the development phases for a drug.

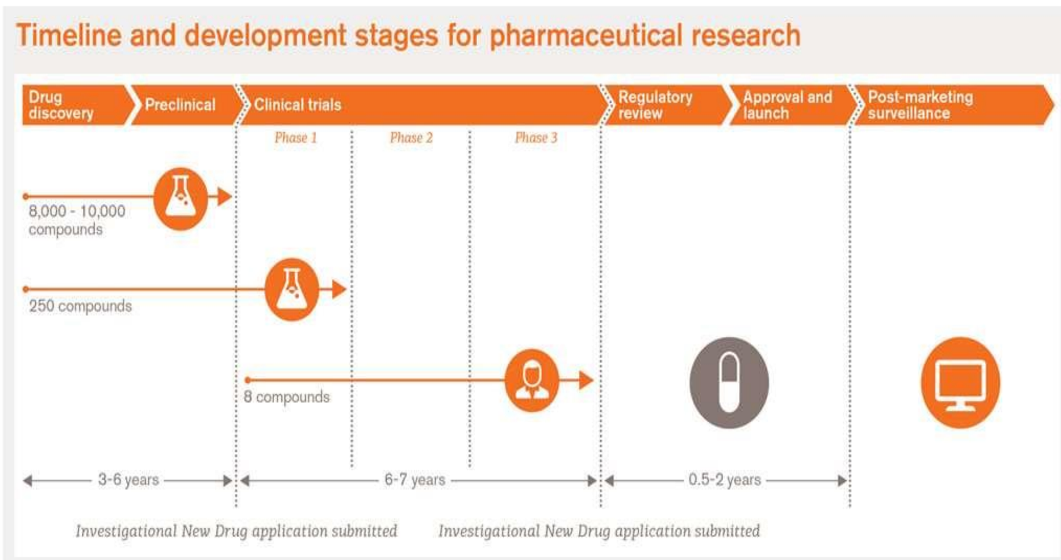


Figure 8: Product development stages / phases in pharmaceutical Research - Adapted from the Innovative-PharmaCo website

4.4.2 Degree of product innovativeness

The pharmaceutical industry is an R&D intensive industry. Underpin Innovative-PharmaCo invested 3.6 billion on R&D in 2016. Innovative-PharmaCo R&D investments are focused on six areas: Immuno-inflammation, HIV/infectious, respiratory diseases, vaccines, oncology, and rare diseases (Annual Report, 2016).

Innovative-PharmaCo obtain their innovation insights via different sources both internally and externally: Internally through its employees; and, externally through collaborations and partnerships with academic institutions, biotech, NGOs and other institutions (Annual Report, 2016). These partnerships allow Innovative-PharmaCo to develop and gain access to knowledge and new areas of science and develop innovative products (Annual Report, 2016).

Innovative-PharmaCo has different innovative products that range from incremental to radical innovation. For example, the Respiratory portfolio of products is considered as incremental innovation since many of the new products in the respiratory portfolio are created through a combination of existing products and *"building on previous knowledge and expanding on combined in the same area"* (global commercial lead). [Product] for Asthma patients is one of the examples of respiratory products which was considered by the new product introduction lead as incremental innovation as well "…*this is very much incremental in terms of we are becoming better in dealing with patients with this type of disease or illness…*" Also, the [product] was considered as incremental innovation as "…it can have a combination of two or just one different type of product" (new product introduction lead). Regarding examples of radical innovation, the malaria vaccine was considered as a radical innovation since it is new to Innovative-PharmaCo and *"…never any company has done that"* (new product introduction lead). Another example of radical innovation is the gene therapy and bioelectronics products since they are new areas for Innovative-PharmaCo.

Overall, the various types of innovative products that Innovative-PharmaCo produced reflects that it is capable of producing both incremental and radical innovation frequently.

4.4.3 Degree of Process improvement usage

Innovative-PharmaCo seeks to reach simplicity and optimization in its operations through "restructuring, investment and modernization to improve profitability and efficiency" (Annual Report, 2016). Its incremental annual saving reached £1.4 billion with 9.3% improvement in the operating profit margin in 2016 (Annual Report, 2016). Moreover, Innovative-PharmaCo has gained the British Quality Foundation BQF Business Excellence Award in 2013.

Innovative-PharmaCo uses lean, six sigma and various PI tools and practices (see table 22 for a description of the used PI tools and practices). It has a programme called GPS (Innovative-PharmaCo production system), which is an internal system focussing on

Gemba with the purpose of reducing waste and becoming more efficient in the manufacturing area. There are teams in Innovative-PharmaCo that assess each site's maturity in terms of the GPS aspects. In addition to the GPS, quality insurance procedures are used in product development processes to maintain product quality. According to the new product introduction lead:

> *"…as we [product development] develop our product we use a quality-by-design philosophy, it is looking at how we can build quality within our products".*

Nonetheless, Innovative-PharmaCo is lagging behind other companies in the automotive and aerospace industries in its journey of using PI since PI approaches are used in the manufacturing area rather than across the entire company. Moreover, Innovative-PharmaCo R&D, manufacturing, and commercialization areas seem to be disconnected and operate in silos as *"…the focuses of the R&D and [manufacturing] are very different… and they are not well aligned" and "…R&D, manufacturing and commercial always had a bit of friction"* (new product introduction lead).

Overall, the use of PI in Innovative-PharmaCo is confined to manufacturing and not used in other areas in the business.

4.5 Case 4: Cheap-CarCo[12]

4.5.1 Overview, vision and core business

Cheap-CarCo Global is "a leading global automobile manufacturer with a portfolio that covers a wide range of cars, sports vehicles, buses, trucks and defense vehicles" (online document). It was established in 1945 as part of the [Conglomerate group]. Cheap-CarCo Global is one of the largest automotive companies, with 60,000 employees. It has different design, research and development centres in the UK, Italy, Korea and India. One of these centres is based in the UK, which is a "Centre of excellence for automotive design and engineering, Cheap-CarCo UK Centre provides research and development principally for Cheap-CarCo Global but also for selected partners in the automotive industry". The UK centre was established in 2005 and it has more than 300 employees (online document).

[12] Cheap-CarCo Global is an international organization. Data used in this thesis were collected from Cheap-CarCo's UK centre for research, design and engineering. However, interviewees who are associated with the manufacturing area were met.

The vison of Cheap-CarCo's UK centre is "As a high-performance organization, we are, by FY 2019: The preferred choice for customers in delivering excellence, efficiency and value in design and engineering solutions, achieving sustainable financial performance, and delivering exciting innovations" (online document). To achieve this, Cheap-CarCo bases their values on 'integrity, 'teamwork', 'accountability', 'customer focus' and 'excellence' (online document).

4.5.2 Degree of product innovativeness

Cheap-CarCo runs an innovation competition to develop innovative ideas that can be used in vehicles later. Cheap-CarCo runs this competition once a year, in which they ask for involvement from everyone in the company to share their ideas. The competition runs as follows: first, employees are invited to participate in the competition with their ideas; these ideas can range from improving the process or the way of developing a new technology for vehicles. Second, participants present their ideas and people vote for the best one to progress to the next stage. Third, the finalists form a team to develop the idea or pass it to someone else for further development "*…because the person who comes up with the idea might not be the best person to take it forward…might only be happy to initiate an idea but some have to take it forward" (principle engineer and head of the innovation facilitation team).* Fourth, after forming teams the finalist gets some guidance *"on how to build up further their ideas… what they are going to do what risk and where, what the opportunities are and where, etc." (Principal engineer and the head of the innovation facilitation team).* Fifth, the teams present their ideas and projects to the senior management in Cheap-CarCo and to the headquarters of Cheap-CarCo Global. The winning team is given the time and money to develop the idea and put it into practice.

In terms of product innovation, Cheap-CarCo's products do not seem to be highly innovative compared to Fast-CarCo or other automotive companies as the main market of Cheap-CarCo is price sensitive. However, at Cheap-CarCo, they are in the process of developing new technologies. One of the examples that was given by the chief programme engineer at Cheap-CarCo was:

> *"…a radical technology area we're developing is autonomous, self-driving vehicles at the moment. That's radical, in terms of it will completely change the market in the next five to 20 years. A more incremental level of change might be let's say fuel economy* improvement

of vehicles…. When we're deploying technologies that have already been identified and developed, so we're not creating new technologies, we're just deploying what's already there. Whereas, on the autonomous side, we're having, we are doing genuine research and then testing which technology solutions work best".

Overall, Cheap-CarCo focuses on producing value products and predominantly incrementally innovative ones.

4.5.3 Degree of Process improvement usage

The automotive sector is highly mature in terms of the use of PI approaches. Cheap-CarCo uses six sigma and lean to a certain degree, and PI approaches are used to a lesser extent compared to other automotive companies (see table 22 for a description of the used PI tools and practices). However, Cheap-CarCo UK is on the journey of using it in its design and engineering. According to the chief programme engineer at Cheap-CarCo:

"Six Sigma is used. I wouldn't say it's particularly widespread".

According to the principal engineer and head of the innovation facilitation team,

"…having look at process improvement we do a lot of six sigma work, lean work …looking at …here is not too much do with process improvement as working out …point but we feed that back through the DFMEA and the design guidelines that's the whole implied process or technology creation processes which takes a number of tools to feed that back in".

Based on the above-mentioned informant's description, Cheap-CarCo does not use PI approaches to a great degree.

Table 22: Selected examples of PI tools and practices in the case organizations

Case organizations	Tools (hard)	Behavioural practices (soft)
Fast-CarCo (Sources: internal document, Interviews)	DMAIC, PDCA, FMEA, SPC, Kanban, visual management, six sigma, 5 whys	Kaizen, employee's involvement in PI (responsibility for PI), continuous improvement
Excellent-AeroCo Sources: internal document, Interviews)	DMAIC, value stream maps, 8Ds, visual management	Cultural changing programs, kaizen, employee's involvement in PI, training
Innovative-PharmaCo (Sources: Interviews)	5whys, problem solving tools, Kanban, DMAIC, 5S	Employees involvement in PI (in manufacturing)
Cheap-CarCo (Sources: Interviews)	DMAIC, TOC	Not available

CHAPTER 5: WITHIN-CASE FINDINGS

5.1 Introduction

Having identified the main business and general PI and innovation characteristics in Chapter 4, this chapter focuses on each case organization - Fast-CarCo, Excellent-AeroCo, Innovative-PharmaCo, and Cheap-CarCo - and discusses the main identified themes in relation to PI deployment, innovation development and process characteristics. The perceived interplay between PI and innovation and organizational features were analysed in each case organization. The next chapter compares the within case themes across cases.

5.2 Case 1: Fast-CarCo

5.2.1 Process improvement characteristics themes:

5.2.1.1 Process improvement as a set of different approaches

> *"The problem is to just only focus on one of those [PI approaches] to be the answer to everything, and you know that's not the case – it can't work like that" (competitive and market intelligence manager, Fast-CarCo)*

Given the importance of PI, Fast-CarCo currently uses a variety of approaches including: lean, six sigma, TQM, 8D, design for six sigma, etc. For example, the head of business excellence in Fast-CarCo stated:

> *"Do we use just any one of them [PI approaches] in Fast-CarCo? No. We have plenty of these things, all available"*

Various of the company's events and changes have contributed to the creation of a PI bundle, including mergers, changes in ownership, leadership preferences, and periods of growth and recession (see Figure 9). The initiation of PI usage in Fast-CarCo was evident before the merger of Company A and Company B. In the early 1990s, when TQM gained popularity between organizations as an effective production practice, Company-A adopted TQM in different areas of the business. As described by an employee who used to work with Company-A at the time of TQM adoption in design and engineering:

> "*A long time ago, 30 years ago, I was involved in total quality management rollout at Company-A, in fact, when we first started to realize there was a better way of managing quality, and I was one of the initial wave of process improvement leaders that was trained.*

We were the primary source, effectively, we were trained by the external company, and then we were disseminating the message".

Company-A and Company-B were merged by Fast-CarCo previous owner, another multinational automotive company known for having highly structured processes, high quality and relatively inexpensive cars. During that period, Fast-CarCo used to have a common management structure, processes and practices with its owner. This resulted in adopting many practices from the parent company. For example, after the merger, the quality director at Fast-CarCo-first-owner brought six sigma to Fast-CarCo. As the master black belt in engineering in Fast-CarCo elaborated:

"*We started using six sigma about 2000, I think, when we were part of [Fast-CarCo first-owner], because when they owned [Company-A], we had a common set of working, a common management structure, and [Fast-CarCo first-owner]* wanted *to [use it]"*

At the time of the financial crisis in 2008, Fast-CarCo started to use lean for cost saving (field notes from the interview with the Fast-CarCo-way director) and this resulted in downsizing the company. For example, the business transformation principal stated:

"We went through the financial crash, 2008 probably to 2013, and the workforce shrunk down to circa 10-11,000 people".

During that period, Fast-CarCo was sold to a second firm, which is also the current owner. This company has a completely different style of leadership compared to the first owner. Rather than having centralized processes and practices, it follows a flexible, decentralized and empowered approach, which allows Fast-CarCo the flexibility to use its own set of PI approaches. Around 2012, several good practices taken from each PI approach - lean, six sigma, TQM and others - were combined under the "*Fast-CarCo*-Way". The head of business excellence in marketing and sales further explained the role of the "Fast-CarCo-way":

"The Fast-CarCo Way will tell you everything from how to design a car to how to operate a photocopier [...] It's trying to promote and provoke process thinking and process improvement, but it's not a mechanism for doing process improvement"

Between 2013 and 2017, Fast-CarCo experienced fast growth in the number of products sold, markets reached, and product lines. Also, the number of employees increased from around 11,000 to 38,000 (head of business excellence in sales and marketing, Fast-CarCo). This growth attracted highly qualified employees who brought new skillsets, practices and approaches to the Fast-CarCo toolbox. With time, this enlarged the toolbox in Fast-CarCo aims to encompass various PI approaches from which employees can select what is needed and more useful. For example, the business transformation principal described:

> "*The tool box is much bigger and so people can now dip in and out and choose what they want to use and use it depending on their own skillsets*".

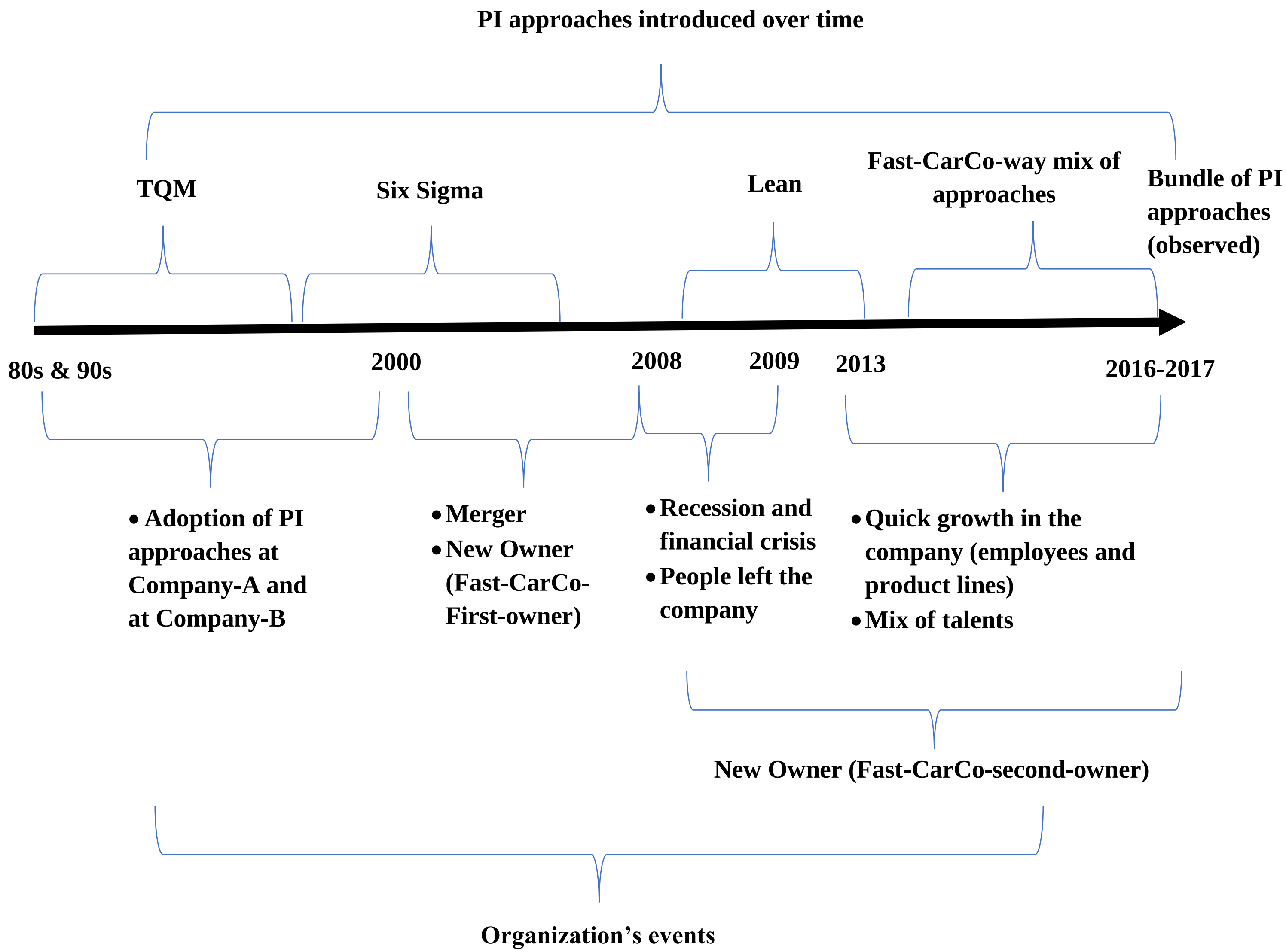


Figure 9: Adoption of PI in Fast-CarCo over time

5.2.1.2 Pervasive scope of Process improvement

Another important feature of PI deployment in Fast-CarCo is the breadth of PI usage. PI approaches are used across the business and in different areas, including R&D, engineering, manufacturing and product development (see Table 23). For example, according to the purchasing transformation director:

> "*Most of the functions, whether it's engineering, finance, HR, purchasing, quality, will have lean six sigma expertise*".

However, the use of PI varies between functional units in terms of the type of tools and approaches used, the frequency of using PI and the degree of flexibility in the process. For example, while both engineering and design uses similar approaches to PI, the deployment of PI in design tends to be more flexible and less structured compared to engineering. As explained by the Product Creation Delivery System Project Process Manager

> *"Within design, it's, I think, a bit more flexible but they use a similar kind of approach but it's maybe not as structured as the way that it's done in the core engineering areas".*

Moreover, PI usage tends to be more explicit and evident in manufacturing and implicit and based on using the thinking of PI in transactional areas. For example, the competitive and market intelligence manager described the use of PI in the manufacturing area:

> "*So if you go to a factory site for example, then you will see the kanban boards and the boards they use for reporting where they are. I think the process runs all the way through, so the whole of manufacturing"*

However, in other areas:

> *"When you start to get out into the broader areas of the business, it's a lot harder to use six sigma in its, you know, purest, formal sense. But I think there's lots of an element of [that] the mindset that you can take on board and help to drive less tangible process improvements" (Product Creation Delivery System Project Process Manager, Fast-CarCo).*

This variation in PI usage across areas appears to be due to three main reasons: first, functional requirements and PI maturity. PI tends to be more mature (used frequently) in areas that are characterized by measurability, repeatability, and process-orientation such as manufacturing, rather than in areas that are more ambiguous such as R&D and marketing. The head of business excellence in marketing and sales elaborated the difference:

“Manufacturing is an industrially-engineered organization. So every person has a job sheet, timed to the second that tells them what tools to use, in which order, which parts to fit, in which order. Monitoring, measuring, performance and achievement is really easy, and then outcome measures are dynamic. You can go to the production line at any time and see how many they should have built, how many they have built, and what they’re likely to build at the end of the shift…When you move away to the more transactional areas of the business, like marketing and sales and so forth, there are no, or there are fewer dynamic operational measures. So daily sales are known, weekly sales, monthly sales, they’re known. But the activities to generate and realize those sales are not measured, monitored in the same way as they are in manufacturing”.

Second, the adaptive use of PI to the area that it is implemented in. Fast-CarCo aligns the used PI approach and the structure of the processes with the area’s requirements. For instance, the use of DMAIC in the product creation area tends to be more flexible and aligns with the local needs. The product creation and development system process and project manager elaborates on the use of six sigma in this area:

“So there were lots of opportunities for doing problem definition, but we wouldn't necessarily then go through a measure, analyse, improve, control in that really rigorous and structured way, particularly for a business process”.

This adaptation to the local context was evident also in the translation of the concept of waste in the implementation of lean. In this environment, creativity, ideas and employee involvement are value added elements and, thus, employees should be given the flexibility needed to innovate. According to Technical specialist vehicle dynamics systems at Fast-CarCo:

“*It’s 7+1, isn’t it, the waste. I did actually do a quick infographic that I shared with some of my colleagues, because pretty well every one of them you can actually equate to the product creation environment as well. So things like overproduction, that’s where we actually do more than is necessary to do the job. So people, if they’ve done a piece of work and the outcome is a solution to that piece of work, all you need to know is the bones of what they did and what the outcome was. So if somebody starts writing a weighty 30-page report, that’s actually overproduction. if you’re not utilising your people correctly […] you know the seven wastes. They said seven plus people. And actually the thing that I spoke about where you’re not using creative people for doing creative work, that counts as the eighth waste for me”.*

Third, the mangers’ perspective and leadership rhetoric affected PI use. For instance, while PI is officially deployed in the marketing area in Fast-CarCo, PI usage is not supported in the marketing leadership rhetoric since PI is seen as less applicable to marketing. For example, the head of business excellence in sales and marketing said:

“When you get into the marketing and sales space, there is a lot of focus on process, kind of at ground level. But it’s not something that you hear in the vocabulary and dialogue of the senior leadership”.

On the other hand, in purchasing and human resources, PI is considered as an essential part. PI tools are incorporated in the departments' daily activities and performance reviews. The Purchasing transformation director elaborated:

> *"And, we have a philosophy, which I call here, Do Your Job, and, basically what that means is three things. One, everybody needs to understand their job, and the way they understand their job is through clarity on the process. Then they need to do their job, so, they need to be… they need to have the skills, the training, the tools, and the capacity, to do the job. And, if anybody isn't doing their job, the feedback is immediate. So, straightaway. We don't wait till the performance review, or the end of the day, or the end of the week. If we see through our performance metrics or through our people's performance, that the job is not being done, well then, the feedback is immediate, because we're very, very clear on what the process is. So, we have this team and centrally, we're developing a team of about 30… It's sort of building up".*

Table 23: PI deployment in functional areas

Functional area	**PI deployment**
Research	• Uses lean through the visual factory and six sigma tools to maintain rigour in the technology development process • PI deployment is less structured than in other areas • Employees are involved in improvement decisions • PI gets used when needed
Design, product development & engineering	• Design use of PI is less structured than engineering • Uses six sigma and lean including DMAIC but in a less structured way
Manufacturing	• Uses PI to a larger degree • PI is an essential component of the unit's culture
Marketing	• There are PI representatives including a business excellence specialist • Some of the marketing teams have submitted their improved processes to the shared portal (Fast-CarCo-way). However, the use of processes and PI is less accepted by the senior managers

5.2.1.3 Voluntary and informal Process improvement

Given the importance of various PI approaches and the appropriateness of each approach in different situations, Fast-CarCo advocates a rather informal approach for using PI. For example, the head of business excellence noted:

> "*So they all have their own place. As long as they're able to solve a problem. And we know that all these tools have certain benefits and that's why we don't mandate that you better use this".*

For instance, there is no centralized team that is responsible for deploying PI. Instead, employees are empowered to improve their own processes, and the decision over which PI approach to use is voluntary. Similarly, PI training courses are available but not mandatory. For example, the head of business excellence explained:

> *"We say, okay, these are all the tools. You want knowledge on the tools, Google it, find it. You want knowledge on the tools, yes. There is a central place where we store all of these*

things. That is there. You learn about all these tools. But for process improvement, if you want to do that, you understand your problem. Apply any one of the tools. Improve".

Similarly, the competitive and market intelligence manager said:

"We don't have big process improvement teams who go out and improve processes on other people's behalf. What we've got are people like master black belts and there's a business process improvement team, the business excellence team, who look more at the business processes".

Training is also available, but not mandatory. As the purchasing transformation director described:

"But, it's not, shall we say, a mandatory training. People can volunteer to go on it."

PI competency (measured as the number of accredited employees) varies between areas. One would expect areas like manufacturing and engineering to have a higher level of PI accredited employees; however, in Fast-CarCo, other areas such as research, finance, human resources and purchasing have a high level of PI competency. For instance, in human resources everyone is trained in PI and has participated in writing the standards of their jobs. As the purchasing transformation director said:

"A lot of the work that's done there is quite industrial, it's quite transactional by its nature. And so it lends itself very well. So, all the people upstairs [HR] have been trained, shall we say, in process improvement, so they have all written… The people who are doing the jobs have written the standard and they have skills matrices. So, you know, here is a list of people and here are all the jobs, and I think in each area is about 40 different jobs, and the people who do the jobs have written the job standards to go alongside the process. And we have stand up meetings every morning whereby we look at the work that needs to be done during the day, who's available to do it, and then the work is allocated"

Fast-CarCo follows this informal approach for PI in order to drive employees' engagement, create a sense of ownership and hold employees accountable for doing PI. For example, the Product Creation Delivery System Project Process Manager explained:

"*And then part of that is trying to get the right level of engagement developed in the process. Because, if they're engaged in it and they can see how it's evolved and how much better it is and they're being involved in fixing it, they will be more of a champion to it."*

Moreover, this approach makes employees feel more accountable for PI. For example, the Product Creation Delivery System Project Process Manager elaborated:

"*Your core team has got to be made up of the people who operate or own the process and the process expert needs to be a facilitator and a coach; not the person who actually goes and solves the problem because the people who are going to own that process when you leave are the ones who've got to feel accountability for it. And if they haven't been part of the decision-making process and part of the project process, they won't feel accountable when* *you leave; they'll feel that you are accountable for it so they won't feel that they need to continue to do it"*

Overall, this informal approach for PI was associated to improvements in employees' productivity and morale, as argued by the purchasing transformation director:

"And that delivered for us when we implemented that about two years ago. That delivered a 30% improvement in our capacity and about a 20% productivity improvement"

5.2.1.4 Responsibility and accountability of Process improvement

While everyone in Fast-CarCo are responsible for improving their processes, accountability varies between different areas of the business. For instance, in the manufacturing area, there is a clear ethos and interest in PI, where everyone is responsible and accountable for its deployment. For example, the head of business excellence in sales and marketing described the responsibility of PI in the manufacturing area:

"So if you talk to the folks in manufacturing, absolutely they will say that quality is everybody's responsibility, and train to do their jobs in a more effective, more efficient way. Everybody has a responsibility to contribute ideas".

However, in non-manufacturing areas, the process owners (process managers) hold the ultimate responsibility and accountability for PI. Yet, employees can initiate and get involved in improving the processes that they operate in. The head of business excellence elaborated:

So, if I own the process, it is my responsibility to go and improve, not someone else's responsibility. Someone else is responsible for some other process. So it's process owners but, by and large, if I work on any of the processes where I'm not an owner, I can say this part needs improvement and the concerned owner will pick it up and say, okay, let's improve it…But the responsibility should sit and sits with the process owner, whoever is having final authority on that process".

Additionally, this gets supported with PI experts who help in facilitating PI in different functions if needed. These facilitators are accredited PI experts, who can run PI training and help in conducting PI projects such as the six sigma black-belt, green-belts, business excellence and transformation teams. For example, in the research area there are people who can support the use of PI if needed; as the head of research said:

"So six sigma, there'll be a number of green belts and a number of black belts that are there to help if you want. Not everybody is trained on all of the six sigma techniques, or lean. But there are people around to help, should they want or need help. And we've got a six sigma function itself, and that's what we do. We would draw upon their experience".

5.2.2 Innovation characteristics themes

5.2.2.1 Innovation development process[13]

In Fast-CarCo the new product development process is structured and documented. Yet, the process of creating and developing current and new products tends to differ from each other especially in the idea generation and discovery stages. As the competitive and market intelligence stated:

> *"There are different processes, depending on what sort of a car it is. Whether it's a brand new model, or just an update*".

The new product development process starts at the idea generation stage. Ideas for new projects get generated from internal and external sources including (innovation process, internal document) multiple sources in the company and from various milestone projects in collaboration with university research students. For example, the head of business excellence in sales and marketing in Fast-CarCo articulated the difference between incremental and radical innovations idea sources:

> "*So incremental innovation tends to come from two sources: learning from problems that you're solving with your existing technology and seeing what competitors are doing around the same technology space. If you then look at what the research teams are doing here for Fast-CarCo, they are working with research students, trying to find the next new technology, the next new way of using existing and emerging technologies. They're trying to find the things that nobody's done before. And so, from that perspective, their research is much more forward-thinking"*

Initially, these ideas get reviewed and prioritized in terms of budget discussions in the manufacturing quarterly quality circles (innovation process, internal document). Consequently, the prioritized project ideas pass to the exploratory research stage. Exploratory studies get conducted for multiple projects, each takes around six months. These include both initial technology studies and ethnographic marketing research. These studies focus on checking the market acceptance for certain technology and product concepts. For example, the competitive and market intelligence manager described the difference between radical and incremental innovation from a marketing point of view:

> *"There's a different process, absolutely. So if, for example, we're doing a model year change for a car, we wouldn't do as much research on that car, we wouldn't do an ethnographic study, we might not even do a product clinic. We might just do an early buyers' study. So, once it's been launched, talk to customers who've bought it and find out what's good, what*

[13] This section provides a generic description of the research and product development processes in Fast-CarCo based on the collected internal documents and the informants' descriptions. The actual process is more complex and consists of multiple sub-processes, milestones, feedback loops and stakeholders.

could be improved. If it's a brand-new product, like the [X-New] for example, the first electric car from Fast-CarCo. we would do everything to understand that car, and the target market for it. From ethnographic stuff at the beginning, through to full blown product clinics, confirmation clinic".

At this stage various ideas get reviewed. For example, the product marketing manager described the idea selection process for new cars from a marketing point of view:

When you go to research if it's an all new car, we don't just research one idea. So, when we researched [previous radically innovative product], we had four different themes. And you have to tell yourself they are all equally valid. And intentionally, you construct the research in a way that they are all presented in an equal way, that they are all the same colour, you see them all from the same angles, the discussion guide that's presented to you. So, they are all equally good ideas.

After that the ideas move to the technology creation and development system (TCDS), a loosely structured and rigorous process for developing new technologies. This is a multi-stage process which involves multiple stakeholders, group finance, marketing, sales, manufacturing, engineering, design, at each decision gate. This process generates application-ready technologies and concepts. Six sigma is used on occasions in the TDCS process to test the rigor of the new technologies. For instance, the head of research at Fast-CarCo elaborated:

"And I think in terms of fault diagnostics and analysis, Six Sigma is a pretty powerful tool. For us in developing new technologies where those new technologies are exhibiting failures that we can't work out, we might have ten things on the bench and come in the following morning and two have stopped. And why? Why have they, when the others are okay? So Six Sigma is useful for that sort of thing"

On completion, the project gets handed over to the design, the engineering, and product development teams in the product creation and development system (PCDS). This process includes prototyping followed by the production process. For instance, the head of research described the TCDS and the involvement of various stakeholders:

"*So again, every gateway. Do sales and marketing want this? Can they sell it? Do finance have the money to take it through? Can purchasing actually buy it? You know, is there somewhere we can go to buy it? Do engineering still want to take it if we get to CR? So these are all key stakeholders that, again, every gateway, they have to sign. So when we come to a gateway, we're pretty solid. There's evidence behind every deliverable, that evidence is being peer reviewed by somebody independent.*

Despite the involvement of various stakeholders from various functions in Fast-CarCo, the difference in the research and manufacturing area perspectives on the required standards leads to various interpretations on the products' requirement. Manufacturing, looking for manufacturability and feasibility of the product, and R&D

looking for the innovative and latest technology. For instance, the business transformation principal explained this tension through the example of the car sensor.

> *"So as we move to a more electronic based car, there are sensors everywhere. Everything's got a sensor on it right and it feeds back to some sort of control unit and to some extent. And within the research world, people think, and the perception is, is that we need to make these sensors smaller, lighter… But they end up becoming more and more fragile. So, this continuous improvement world is make this smaller, lighter, more insignificant etcetera. Compare his world with the guy that's actually got to fit this sensor then just safer. I think there was something like 12 sensors fitted to the exhaust. So the guy manufacturing, this big steel pipe comes down and he's got to fit these sensors? And he's got like 90 seconds to fit them and they're handed and they're different, you know, and they're fragile. But what does he do? He puts his hand in the box and takes a handful of sensors out. So, six of them are already broken. And then he screws one in and he tightens it up. And because it's made of ceramic, it cracks. So that's another three broken".*

Also, the marketing communication team get involved in releasing the new products to customers at the pre-assigned date. This includes advertisement, events, preparing brochures and catalogues. Due to the difference in the type of work between the marketing and engineering areas, tensions may occur in the handover process from the engineering department to the marketing one; for instance, the marking communication director explained:

> *"Just the other day we had something where the engineers changed a torque figure of an engine, they changed an engine. For them it's on a spreadsheet and they just change a number, for us it was four days before we were about to reveal the car […] We had to rework every single asset, but for them it was just, well 'I'm just changing [a figure], We haven't revealed the car yet, it's one figure. What's the problem? I'm just changing it on my spreadsheet'. We need to say, no, no, no, that's massive implications for us you know"*

5.2.3 Link between Process improvement and product innovation (informants view)

5.2.3.1 Process improvement seen as indirect facilitator or irrelevant to innovation

Informants in Fast-CarCo expressed the benefits for using PI either for their area of work or for the organization as a whole. These benefits range from improving the way of working in a certain function to improving customer satisfaction. However, PI was not seen as directly beneficial and an enabler for innovation. Instead, PI was considered as an indirect facilitator for innovation; through operating around processes, standardization and through using a structured problem-solving approach. For instance, PI helped in maintaining rigour in the technology development process, facilitating collaboration between stakeholders, providing a structure for the product development process, preventing errors, and reducing time to market. For example, the master black belt in engineering noted:

"… The impact of using process improvements means you get improved customer satisfaction, you speed up time to market, and you improve the way you work… It should, if you do it correctly, give yourself more opportunity to innovate. You should reduce your costs, ultimately, and become a more profitable and successful business".

Also, for example, the purchasing transformation director elaborated the benefits of PI for innovation in purchasing:

"*One of the things that we've done through the lean six sigma work is identify strategic activities, operational activities, and transactional activities. And, from a business model standpoint, that has enabled us to be innovative, in terms of our organization design"*

Many benefits of PI were expressed in relation to certain areas or stages in the product development process. For instance, PI was said to provide rigour for the research process as elaborated by the head of research:

"Otherwise, we are spending company money developing things that have very little chance of progressing. So, it's a balance, really. And that's why [technology development process] has been developed over many years, is to try and provide that balance [between rigour and flexibility]".

Additionally, the benefits of PI to innovation was expressed through the use of standardization and processes. For instance, PI is seen as essential for creativity. The head of business excellence explained:

"So creativity and standardized work can work together, hand in hand. It's not that you just leave everything open and create a chaos and say, okay, let creativity come from anywhere. So, standardized work is important but creativity can be within different parts of it. They go hand in hand, actually. It's interplay of both".

Table 24 presents illustrative quotes for the benefits of PI for innovation.

Table 24: Perceived benefits of PI for innovation in Fast-CarCo

Benefits of PI	**Illustrative quotes**
Maintain rigour and prevent errors	• "*I would say that at those early stages, yes, it would be important. As I said earlier, if you find out at these stages, at some level of these stages, you can reduce your costs by finding errors by almost 70%. So, the earlier you do them, the better". (Lead engineer)*
Provide a structure for change Avoid chaos	• "*You want tools, techniques [PI], etc., so that you put a certain structure to it. It only puts a structure to problem solving".* (Head of business excellence) • "*Because if everything is free, then it'll be pure chaos. And maybe something great comes out of that pure chaos but it may not be too effective. So, it is good to have a standardized process. At least certain major steps and then, within that, you can let creativity thrive. And then when you go through that, then you will have feedback loops which will say, okay, probably this I should have done earlier. Now that is a process improvement to make the standardized work even more standardized. And improve that".* (Head of business excellence)
Allow time for innovation	• "*I think if you put standardized process into routine activity, it would give people the mental capacity to be able to think about innovation. In a non-standardized organization, people are so caught up in trying to think, how do I do whatever it is that's right in front of me now".* (Head of business excellence in sales and marketing) • *"Anyone can pick up something and do it, which also works. But in today's world where everyone has become so busy and occupied that you start going and finding best practices of what has worked somewhere else. And if you put that framework, you do less of that thinking on the framework but do more of the thinking on the real content". (Head of business excellence)*

5.2.4 Organizational features: Structural & managerial features

5.2.4.1 Process-oriented structure

Due to the fast growth in the number of employees and product lines, several years ago Fast-CarCo moved from being a functional organization to a more process-oriented organization. As described by the competitive and market intelligence manager:

> *"For example, we had – in 2007/8 – 14700 people within the business […] today we have something like 43000 people within the company […]. And we have moved from 150000 cars to 700000 cars. So it's a big increase […] which is to me a sign that we're very complex in that […] it's moving from one type of company to another type of company".*

Currently the structure of Fast-CarCo is based on multiple interlinked processes. For instance, there are processes for strategy, leadership, research, product development, marketing, IT and other areas (see table 25). For example, the competitive and market intelligence manager said:

> *"We've changed towards that model over the last few years now. So the functions are still functions. They still do marketing and sales, and engineering and manufacturing, and so on, of corporate strategy. But we all work to different parts of the process now".*

However, the level of structure, and process flexibility varies between processes and functional area. For instance, to keep room for creativity and innovativeness, the processes in the research and design areas tend to be less formalized and loosely structured compared to those in the engineering and manufacturing areas. For example, the head of research described the structure in the engineering process:

> "*Even more structured, because you're bringing tens of thousands of parts together that have to be released on time with suppliers all over the world that then have to bring their parts to the production facility so that they can all be assembled on time, bearing in mind there's a new car coming off every 20 or 30 seconds. The processes are incredibly tight".*

On the other hand, the research and design processes are more flexible. For example, the technical specialist vehicle dynamics systems, product creation elaborated:

> *"I think the R&D area and the design area are less driven by process, which is what enables them to be a bit more radical in their thinking. There are certain milestones, because we need to know when they're going to deliver, but in terms of the way they go about creating it, my perception is they are less constrained"*

Overall, the change from functional to process-oriented organization was beneficial for Fast-CarCo in many ways: First, it provides a formal structure for change and growth. For example, the competitive and market intelligence manager said:

> *"the benefits that it gives is that there is a formalized structure for change, and conditions the decision-making mind – the heads of the business – into providing time for this".*

Second, the use of a structured process in the research area helped in providing a sense of direction and clarity for employees, in particular, the technology and product development process takes many years which make it hard for the research employees to see their contributions. The head of research elaborated:

> *"We tended to do the right things, but it wasn't in any formal framework. So one of the things that I decided to do was try to set this framework in which, hopefully, all of the researchers can understand where their work contributes to the greater good of the business. Because it's very difficult for them sometimes. They're working on a new technology or a new feature, and they may be working with a development partner or even the university, and it's years from production. It's possibly even years from being handed over to engineering".*

Despite the benefits of the use of processes, the acceptance of working on processes varies between different areas in the company. For example, some areas like engineering prefer working on processes more than other functions like marketing. For instance, the CRM manager described the difference between the two groups in term of the acceptance of operating on processes:

> *"I think it depends on the type of person you are, and the culture of that part of the organization. I think when you say the word process to a group of marketing people, they kind of go, put their fingers in their ears, 'la, la, la, la' don't like process, 'oh it's going to take away my creativity'. If you say it to engineers, oh they, you know, they're going to be more like, so I love a process, oh yes, and we can improve in this area, and that area".*

This different level of process acceptance can be traced to the functional priorities, type of work and measurability. For example, the head of business excellence in marketing and sales elaborated:

> *"Marketing and sales folks will tell you that they are creative, that they are… they're involved in social science, it's not engineering, it's not operations and, therefore, it can't be tightly defined and tightly controlled. And in the more creative aspects of what they do, that's true…You know, so it's very much… people are busy being busy doing their jobs".*

Table 25: Fast-CarCo main processes

Main processes in Fast-CarCo	Illustrative quotes
SCDS (*Strategy Concept Development System***) for strategy**	• *"… a process called SCDS – Strategy Concept Development System – which starts with what is the world out there? Investigates and tests, analyses where we are as a business. Does the SWOT analysis and other analyses. Feedback to the senior management in a process that says, this is where we're going right, this is where we're going wrong. This is what it takes, these are the deltas that need to be addressed. We suggest that these questions are the ones that we really need to address. We have a piece of time, in which to properly describe those problems, and then feed back to them to say this is what we think the problems are, here's the analysis around that. This is what we propose to do in terms of timing, and benchmarking". (*Competitive and market intelligence manager, Fast-CarCo)
TCDS (*Technology Creation and Deliverance System***) for research**	• *"Our main process is called TCDS, so that stands for Technology Creation and Deliverance System. So TCDS is a gateway process. So we start off with TKO (Technology Kick-Off) and then we hand over, normally to engineering. So then it goes into engineering, and that's a different process".* (Head of research, Fast-CarCo*)*
PDCS (*Product Creation and Deliverance System***) for product creation and development**	• *"PCDS, which stands for Product Creation and Deliverance System. So we deliver technologies and features, Engineering deliver vehicles. So P means product, which is the vehicle"* (Head of research, Fast-CarCo) • *"So the product creation and delivery system isn't a process in itself, it's a framework within which sits at a whole… Well, thousands of business processes that deliver a product from one end, from concept, through to the other end, which is the first production vehicle to roll off the line in manufacturing".* (Product Creation Delivery System Project Process Manager, Fast-CarCo)
SIPOC (*Supplier, Input, Process, Output, Customer***) for various functions**	• "*We have our quality department, and we have our finance department, and we have our HR department. And what we try to do within Fast-CarCo is identify what we call key work systems, which are high level processes, which will go across the functional boundaries, and we ensure that… We have a process called SIPOC, S stands for supplier. So, if this is the process, let's say for the purchasing of a component, you basically go, Supplier, Input, Process, Output, Customer"*. (Purchasing transformation manager, Fast-CarCo)

5.2.4.2 Managerial mechanisms

People in Fast-CarCo expressed the pressure to balance different outcomes such as incremental and radical innovation, and growth and continuous improvement. For example, the business transformation principal argued that:

> *"We try really hard to do improvement and innovation and make the best possible components that we can".*

Stemming from Fast-CarCo's current strategic priorities for excellence and innovation, different managerial mechanisms have been taken to drive both goals. For instance, employees are given the flexibility to start new projects. As the head of research explained:

And the reason I say that is if we kick off a project that says we have a problem, but we get to TS and we say we can't find the solution, we tried, there is a process behind this that goes that way, called our milestone process. So if we have a problem that doesn't have a solution, we can create a milestone project. A milestone project just says, give me some money, give me some time, and I want to really, really try and find just one solution".

Moreover, in line with this, the dynamic in the automotive industry is changing in various ways. This includes the development of the driverless car and the shift in customer attitude toward car ownership from car owning to car sharing. To cope with these changes, Fast-CarCo created an independent start-up company focusing on mobility service for customers. The marketing communication manager explained the role of this unit:

"And basically what their role is, to go out and look at businesses that are cutting-edge, looking at what the customer needs of... Not tomorrow, but probably in slightly further than tomorrow, and particularly if you like the, not obvious things. So not so much what was the car, physical metal, meant to look like, but what kinds of services do they need".

These managerial strategies get supported by regular performance management reviews, and a rigorous performance measurement system and excellence initiatives. For example, Individual objectives are associated with both excellence and growth goals. For instance, the CRM manager in Fast-CarCo has objectives such as "efficient and effective sales support", "optimization of every touch point" to meet the Fast-CarCo goal for excellence and PI and other objectives such as, "electrification", "future customers' experience" and "future portfolio" represent the growth goals for Fast-CarCo (internal document).

In addition to the use of the performance objectives, various excellence (including PI) initiatives are being used to support the company's goals in pursuing growth and continuous improvement. One of these is LEAP (Leadership, Efficiency, Agility and Performance), a business transformative initiative which aims to drive cultural change in the company. LEAP "is under way to drive a step change in performance across six major work streams: (1) Market Equation, (2) Product Design Cost, (3) Material Cost, (4) Manufacturing Cost, (5) Quality/Warranty Cost, (6) Fixed Cost Containment & IT, with each work stream having multiple initiatives" (internal document).

Table 26 presents Fast-CarCo coding table

Table 26: Fast-CarCo coding table

Aggregate dimension	Second order coding	First order coding
PI characteristics	**PI bundle**	*Uses more than one PI approach*
		Reasons behind the bundle
	PI formality	*Voluntary*
	PI responsibility	*Everyone*
	PI scope	*Pervasive*
	PI usage	*Adaptive use across areas*
Managerial-related mechanisms (features)	**Balanced performance objectives**	*Performance objectives: Operations excellence*
		Performance objectives: Future-oriented
	Entrepreneurial orientation	*Employees' autonomy and flexibility to initiate new projects (LEAP, milestone projects in research)*
Structural-related mechanisms (features)	**Process-oriented structure**	*SCDS, TCDS, PDCS, SIPOC*
Innovation development process characteristics	**Radical and incremental innovation processes**	*same processes, but have the flexibility to allocate a specialized team for new products (if needed)*
Perceived Interplay between PI and innovation	**Managers' perception of the association between PI and the product innovation related activities and its potential impact on innovation**	*PI as indirect facilitator (Complementary)*

5.3 Case 2: Excellent-AeroCo

5.3.1 Process improvement characteristics themes

5.3.1.1 Process improvement as a set of different approaches

Excellent-AeroCo uses more than one PI approach such as lean, six sigma, kaizen, and others. Each is used differently. For instance, six sigma is used as a data-driven problem-solving tool and lean is used for streamlining processes. For example, the head of continuous improvement in engineering described the different uses of lean and six sigma in Excellent-AeroCo:

> *"If we got waste and you want to be more efficient take a lean type approach the use of kaizen or lean event which are facilitating by lean type people or if we got specific problem or quality investigate or something where you do root cause investigation where you got data we expect six sigma green belt black belt type approach so it is kind of mix in terms of what process improvement activities".*

This set of PI approaches was developed over time for two main reasons (see figure 10): First, the history of PI usage. In the past, Excellent-AeroCo used to have a process excellence programme that mainly focused on six sigma and the technical aspects of PI. For example, the head of the lean transformation team in Excellent-AeroCo recalled:

> *"Our process excellence programme, as it was called a number of years ago, was probably more focused on… in the last 10 years, 10 years or so ago, it was probably a bit more six sigma-focused, a bit more specific, very, kind of, I would say quite technical".*

Several years ago, management in Excellent-AeroCo realized that despite the extensive use of PI tools and the large number of PI-specialized people the company, Excellent-AeroCo was not getting the intended outcomes from using PI. Therefore, decided to change the culture through running different initiatives such as lean transformation, lean improvement for everyone and the cross-functional production system. These initiatives aimed to embed lean thinking in the business and to engage employees in PI. For example, the head of the production system explained this shift in PI focus in Excellent-AeroCo from purely technical-focused to both behavioural- and technical-focused:

> *"Three years ago, we recognized in [Excellent-AeroCo], we had lean and we had improvement systems already, but we were challenging how well they were being deployed and the results that we were getting from them, and when we looked, the analysis into those, we found out they weren't as good as they needed to be, so we still had performance gaps in our organization… But our gaps were all about round the planning side and the governance and the people, and engaging the people".*

While this shift indicated a change the company's culture toward PI, it did not undervalue the importance of the technical element of PI. Instead, this behavioural change aimed to exploit the benefits of the PI technical competency in Excellent-AeroCo. For example, the head of lean transformation team elaborated:

> *"But that's not to say that, you know, the sort of highly technical full six-sigma approach isn't important, and it absolutely is. I think when you look at design for six sigma or some of our highly… more highly technically specialist areas of engineering, then many times the problem-solving requirements we'll need will mean we need to use a highly technical problem-solving kit, which might be more six sigma and may rely on a much more forensic data analysis and hypothesis testing. And I think, there, six sigma's very, very relevant. And we must not lose that skill-set in our more cultural transformation".*

Therefore, Excellent-AeroCo currently uses a "blended approach" which consists of both lean and six sigma as described by the head of continuous improvement in engineering:

> *"Traditionally we kind of grew up with a six sigma event we did a lot of work to train black belt to train green belt get that six sigma approach into problem solving you're actually getting data and using that to fix problems. More recently we are talking more of a focus on lean; that's not to say that six sigma didn't work, it's just another element of process improvement so we do a lot more of what we describe as lean events or kaizen events where we get teams together to use value stream mapping and other lean tools and techniques to*

take wastes out of processes and get things working more effectively. So, we kind of use a blend…"

The second reason that contributed to the development of the blended PI approach is the adaptation of PI to the area that it is used in. This adaptation brought new characteristics to the bundle. For example, rather than using six sigma in the office environment in Excellent-AeroCo, simpler problem solving tools such as process mapping and kaizen events are used. For example, the head of the lean transformation team talked about the adaptation of PI approaches to the transactional areas:

"I would suggest many times most of our business problems, bearing in mind that most people in [Excellent-AeroCo] are working in offices, not in highly technical roles, most of those problems require a much more simple problem-solving mind-set and a much more simple and accessible problem-solving toolkit. And so there, maybe, it's more about focusing on waste elimination or flow and maybe some simple mapping techniques would be a great place to start".

Similarly, given the need for maintaining flexibility and rigour in the product development area, lean is mixed with agile. For instance, the head of the product development system elaborated:

"So in the early stages of product development, our approach is, I would say, an adaption of lean that is really built around building agility into the processes that iterate our designs and iterate the validation processes on those designs very quickly to gain as much learning and insight as we can and take that insight and build that into some subsequent iterations".

Third, attracting diversity of thinking styles. In the past Excellent-AeroCo used to appoint top-class creative people and this list led to generating many creative ideas that could not be implemented. Therefore, as a consequence they recruited more delivery-oriented people. For example, the head of engineering strategy and enterprise architecture in Excellent-AeroCo described that:

"*In the past, Excellent-AeroCo recruited only the top 1%, the very, very top of the classes. And, as a consequence… I'm talking 20 years ago. As a consequence, they ended up with a whole population of high flyers, driven people who couldn't deal with the mundane things of delivery. And, as a consequence, they were only interested in crisis and excitement and adrenaline. And so, again, it was back to balance, finding the right balance".*

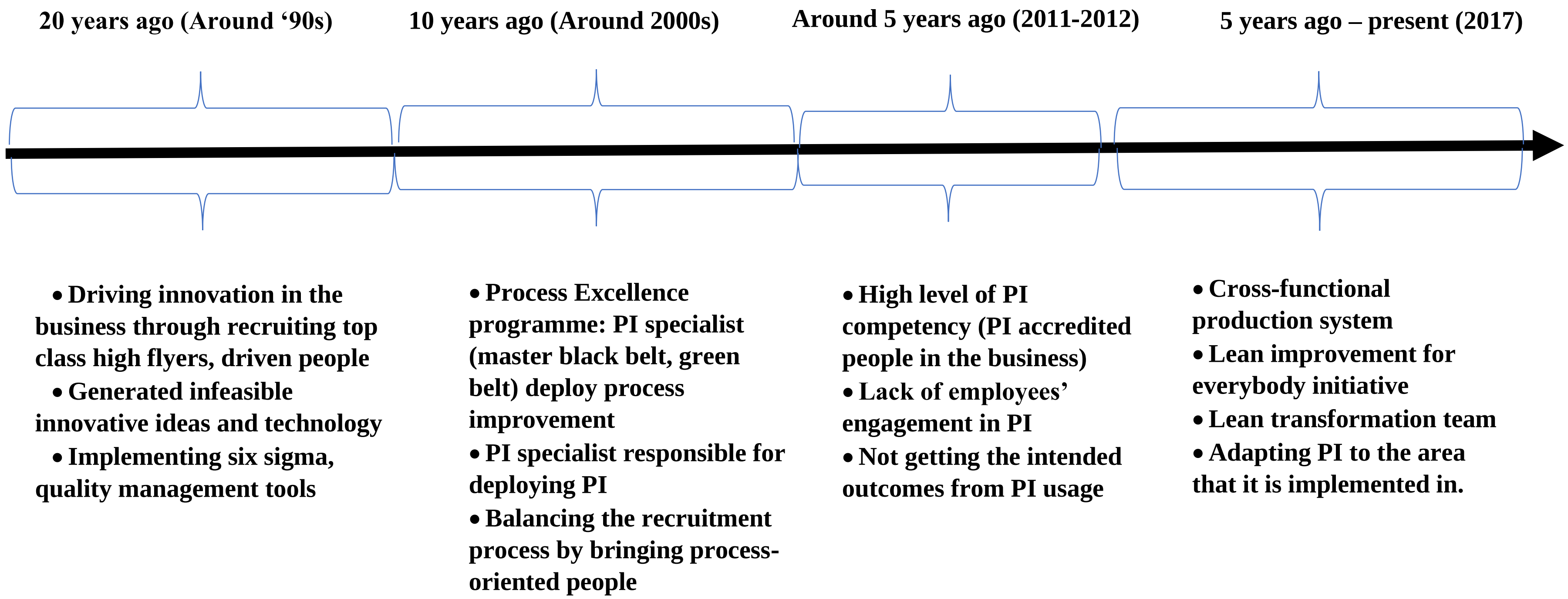


Figure 10: PI usage timeline at Excellent-AeroCo

5.3.1.2 Pervasive scope of Process improvement

In Excellent-AeroCo, PI approaches are used across the organization, in all of its businesses and functions (manufacturing engineering, product development, design, etc.). For example, the head of the production system described the cross-functional ownership of the production system in the organization:

> *"The production system is cross-functional, so it's not just the improvement function, which is pushing this into the business, saying you need to get better. The production… the improvement function owns some of it, but not all of it. So planning and control is a function. They own a bit. They have an accountability for some of it. Manufacturing and engineering has some, purchasing has some, HR has some. You know, everyone. All the different functions own a little bit".*

However, despite the holistic use of PI in Excellent-AeroCo, different areas in the business have different levels of PI maturity (the level of competency in using PI approaches, the number of PI events, and the number of years in using PI). For example, the global head of continuous improvement described the spread of PI usage in Excellent-AeroCo:

> *"We are about 52 thousand people in Excellent-AeroCo and each is different, broken into five sectors civil, aerospace, defence aerospace, marine nuclear and aerospace, power system. Each of those has its own set of black belts employed within their sectors […] engineering, HR, quality, etc., those functions also have business improvement footprints that vary in their maturity".*

Similarly, the head of continuous improvement in engineering described the level of maturity within the design and engineering areas:

> *"I think in terms of the design department, it is variable; some areas are very mature, do loads of process improvement, loads of lean events, regularly... driving improvement through investigations. Some areas are less mature, just depend on the areas they interface with, so I would say probably people in the areas of engineering that directly interface with operations and manufacturing it is a little more mature and in some of the areas research and technology are less mature".*

Different factors contributed to the variation in PI maturity within Excellent-AeroCo. This includes the history of PI use in the area, the pace of the activities in different functions, and the adaptation of PI to the local context. For example, the head of continuous improvement in engineering emphasized the importance of adapting PI to the engineering area through using the appropriate PI tools:

> *"We got much careful in how we translate. So it is relevant for engineers equally the [types of] wastes, we use value stream mapping…. I think all the tools are absolutely relevant just having practitioners are able to translate the messages and make those connections for engineers from the manufacturing into things around data or around knowledge creation around training and skills …the talent of process improvement and lean are universal".*

5.3.1.3 Process improvement usage is expected

Currently, Excellent-AeroCo uses PI as a company-wide approach where everyone is expected to use PI. This was evident through: Their performance evaluation system, the mandated PI training for employees and LIFE (lean improvement for everyone) initiative. In relation to the performance evaluation system, employees' involvement in PI gets evaluated by their direct manager. For example, in the engineering area there is a formal tracking process for people's involvement in PI activities. For example, the head of engineering strategy and Enterprise Architecture explained:

> "*We have an engineering quality department that tracks… So every year, every the employee has to perform a lean activity".*

Similarly, the head of the production systems:

> *"We've got an IT system called My Learning, which everyone… if there's anything mandated that people need to do…when you've done your improvement project, you fill in like a confirmation. It's very quick to do. And your manager affiliates it".*

In that respect, employees are mandated to join various PI training programs, and to incorporate PI in their jobs afterwards. For example, the head of the production system elaborated:

> *"We then do mandated training, so what we recognized is, dependent on your role, there is some training that you need to have upfront. Because obviously learn by doing is 70% of the way that we learn. But unless it's up here [mind], you can't pull from that library, and you will struggle. So what we need to make sure is that the people have had the training so that they can pull from that library, so that they can then learn by doing".*

Moreover, every employee on the shop-floor must use the value stream map. For example, the head of the production system said:

> "*We mandate value stream-maps on the shop floor, and it's the first thing the teams all do to understand what they need to do to improve they'll… we actively encourage value stream maps all the time, and then the value stream map will obviously mean collecting a load of data and understanding who the customers are and what the most important bits are".*

Finally, as a part of the LIFE initiative, employees at Excellent-AeroCo are required to get involved at least in doing one improvement; for example, the head of continuous improvement in engineering described this initiative:

> *"Currently, every employee should be involved in doing some kind of improvement activity it can be… Something that is really, really small, just take out [waste] …in early life or be something you know is big like green belt project or black belt project or something more significant. We are trying to get everyone engaged".*

However, despite the cross functional ownership of PI and the availability of the central PI teams, the department leaders play a big role in encouraging people's involvement in PI in their area. This creates a challenge for the holistic and shared approach of PI in the business, as some leaders are more involved in PI than others. The head of the lean transformation team explained:

> *"I would contend that, if one's line manager or manager is asking questions on a daily or weekly basis about how the performance of the team is going and what's stopping it working as well as we'd like it, are we hitting our KPIs, if we're not, what problems have we had, you know, what kind of issues have come up recently and which techniques have we used to solve the problems, what have we learned? You know, if we've got this basic kind of coaching mind-set coming from our managers and leaders, then I think we have a highly developed mature organization that will be… every employee will be accessing and choosing to improve and solve problems regularly. And I'm not… I don't think we have got that everywhere. We certainly do in some areas of the business".*

5.3.1.4 Everyone is responsible for Process improvement

Informants in Excellent-AeroCo distinguished between accountability and responsibility of PI. In terms of accountability of PI tools and techniques there are specialized teams that facilitate and monitor the implementation of PI such as the continuous improvement team which has representatives across the business and in different functions. For example, the global head of continuous, improvement elaborated:

> *"We have a structure within the business where we got heads of continuous improvement within each of the sectors; each of those heads have an organization within their business where they have appropriate levels of resource, delivering specific improvements".*

The main focus of the continuous improvement is to check the compliance for the regulations; for example, the head of the transformation team said:

> *"So we have a lead for that function [continuous improvement function], globally, and that individual's role is about… and the team that she leads, is about developing the group, so we have a [Excellent-AeroCo] management system, which is a set of mandatory processes that keep us safe from a regulatory point of view, a legal point of view, and from a business efficiency point of view".*

Another specialized team that facilitates and monitors PI in Excellent-AeroCo is the production system. The production system is cross-functional system that consists of three main elements. One is people, plan, process, plant. For example, the head of the production system described the main role of the production system:

> *"So the production system which I own and I created has got four elements. It's got… we call it People, Plan, Process, Plant. So we make sure that we've got the infrastructure to be able to do what we need to do. We make sure we've got the tools and the processes and that they are simple and easy for people to use and understand, and accessible. We make sure that we have got people engaged, so that we've trained them, we've communicated to them and we've engaged them in the right way. And then we make sure that we've got the plan and the governance to be able to make sure that it's going to be sustained. So that's what we… those four elements, and there's then things below them. That's what we call the production system".*

Third is the lean transformation team, which aims to drive lean in the company and across units. As the head of the lean transformation team described the role of his team:

> "*…the intention that we support the organization to transform more towards what I would describe as a true lean".*

However, despite having specialized teams for PI, informants emphasized that everyone is responsible for doing improvement at Excellent-AeroCo. As section 5.3.1.1 explained, in recent years Excellent-AeroCo has changed its approach toward PI deployment by shifting the focus from being purely technical and tool focused (through the use of six sigma) to a more behavioural focus (through introducing lean across the business). For example, the head of the production system explained the reasons behind this change:

> *"Because what we've found is, previously, we had an improvement called the Journey to Process Excellence, and that was purely pushed from business improvement. And they were just trying to get everyone to do it their way, and it didn't work, because there was no engagement and… but this, the production system, is owned cross-functionally, so it's everyone working together to do their bit. The… where we're trying to get to is everybody… improvement is everyone's responsibility".*

5.3.2 Innovation characteristics themes

5.3.2.1 Innovation development process

Operating in a highly regulated industry, Excellent-AeroCo tends to follow the same process for producing incremental and radical technologies. However, the way Excellent-AeroCo manages the early stages of generating incremental and radical technologies differs. For example, the radical technologies require more flexibility in the beginning of the product development process. The head of the product development systems explained:

> *"And the technologies, before they go onto customer sponsored projects tend to be demonstration products where we enable freer thinking to mature the concept and radical or rather agile iterations of experiments that are conducted to verify the concepts. So they may be rig tests, they may be analyses that we do, they may be other forms of verification that we employ. But we gradually move those new concepts into an environment that is much more totally controlled and conforms very much with the scriptures of the regulators in our industry that quite rightly demand standards and safety and so on that absolutely have to be met. But it is very much driven by where you are in the lifecycle and the purposes of the programs that we run".*

Ideas for new technology come through collaboration with universities and other partners such as suppliers. Early stages of radical technology require broader ways of problem framing. While radical innovation tends to have and requires a broad way of framing problems, incremental innovation does not require broad problem framing. For example, the technology lead said:

> *"It's the way you formulate the original challenge or the original problem. If you just say, how do we make bigger blades, then you narrow down, perhaps, the scope. Whereas if you take… like say if you took that back and, actually, well, you're not worried about bigger blades, what we want is more thrust, and then you suddenly open up… So if you're looking at bigger blades, you might get a disruptive innovation, or you might get radical innovation. I think the odds are more likely it will be incremental. Whereas if you took that back and said, how do we get more thrust? Someone might come up with something quite radical that said, well, actually, you don't want a jet engine, you want something entirely different. So it may be not so much the process, it might be how you pose the problem".*

In the technology and research areas various problem solving tools are used, such as TRIZ, the Six Hats, Scamper and Edward De Bono, to facilitate the brainstorming process (technology lead, Excellent-AeroCo). There are six sigma specialists available in research area if needed. However, PI is discouraged at the discovery stage as it is considered as a constrained way of thinking. The technology development process hands over development-ready technologies to the product development system. The technology readiness level gets tested through a systematic process to check the risk of the new technology to check if there is any harm on the customers or on Excellent-AeroCo. The product development system is an enterprise system that is connected to two main value streams, the customer enterprise and the production system; for example, the head of the product development system described:

> *"The product development system is what we call an enterprise system. We have a number of those within our business that serve key value streams in our business […] the product development system works closely with the other enterprise systems as we develop products but it also provides, if you like, product surveys, information, all kinds of deliberate rules that are handed over to our production system and are handed over to our customer and services system".*

The PDS develop products that are ready to manufacture with "*all of the associated information and training and how you service the product and all those kinds of things. You know, and really, our aim is to provide a service ready solution to the customer and services system" (head of the product development system).*

The product development system consists of two main stages. Early stages consist of iterative and agile processes for concept realization and later stages for product realization where products are developed and made ready for production. According to the head of the product development system:

> *"So if you imagine our product development lifecycle, the earlier stages, whether that's in the very early concept stages or even in the product realization stages where we're starting to produce physical product, we are very much looking to speed things up and gain learning".*

In these stages, then, this process feeds the learning from the early and later stages of iterative processes into concurrent processes to develop production-ready and service-ready products. During these iterative processes, six sigma and lean are used to progress the concepts and the technology faster and to ensure learning throughout the process. For instance, as the head of the product development system described:

> *"And we do apply six sigma and zero defects mentality into that production solution with the aim that we exit the product development process with true six sigma capability, zero defects capability and a truly service-ready solution for business solutions, not just technical solutions, for the customer and services".*

5.3.3 Link between Process improvement and product innovation (informants' view)

5.3.3.1 Process improvement approaches as enablers for product innovation

At Excellent-AeroCo, informants' views of the interplay between PI and innovation were assorted. While the majority of the informants regarded PI approaches as enablers for innovation, others expressed the opposite. The former views PI as beneficial for various reasons: First, through eliminating the non-value-added activities in the process, PI can provide people with more time to spend on innovative ideas. For example, the head of engineering strategy and enterprise architecture in Excellent-AeroCo said:

> *"If you don't make the delivery aspect as efficient as possible, then you don't create the time for people to stare at the window and think. So lean is essential to innovation but maybe not in the way of making innovation, itself, lean".*

Second, PI approaches do not affect idea generation, they only provide a structure to the innovation process; for example, the global head of continuous improvement said:

> *"I don't see process excellence and six sigma and process control is limiting… So, no I don't see that process improvement limiting innovation. It just provides a structure for allowing those ideas and revolutions to progress quicker not to say … can't use innovation …because it should not cut the ideas it should just provide a structure of those ideas to progressing through the regulations that are required in order to get those ideas to progress".*

Moreover, the head of the lean transformation team has a similar opinion regarding the impact of using standards on innovation*:*

> *" And so I personally don't believe that should be a problem insofar as I think it [standardization] is good to… you know, we need to innovate in our kind of world, definitely, but I think innovating in a structured way is helpful, so if we have standard processes for*

innovation, then we should be able to innovate in an efficient manner. It doesn't mean you have to do things the same way every time, but I think applying standard innovation approaches in a rigorous kind of way is a good thing to do".

Fourth, PI helps reduce time to market; for example, the head of continuous improvement in engineering in Excellent-AeroCo said:

"It immediately springs to my mind so for me is a business to remain …in one of the… getting products to the market quickly… one of the things that you need to capture earlier is how do you make sure that as you go faster you capture all the learning and embed it back to the rest of the process and to the future demand. So we are not just going faster and not learning. You know the global is becoming more and more competitive the time to market is becoming quicker and quicker so we have to improve to stay competitive in my opinion".

Fifth, innovation and improvement use the same purpose. For example, the head of the production system said:

"You're kind of doing exactly the same thing. You're looking for a better way. You know, innovation is we're looking for a better way to do it, or a different way of working. And an improvement mind-set, again, you're looking for exactly that same thing. Is there a better way of us doing it? Is there a different way of us doing it? Can we do it with less waste? Can we do it cheaper? Can we do it to a higher quality level? You know, can we do it faster? You know, innovation is then… is part of that solution, isn't it? So, you're using a lot of the same tools to get to that same end goal".

Notwithstanding the majority of Excellent-AeroCo informants consider PI as an enabler for innovation, others argue that PI is inapplicable for the innovation processes and can stifle creativity and innovation. For example, the technology lead elaborated:

"But you just have to be careful, because continuous improvement is a very constrained way of thinking [...] I think continuous improvement, by its very nature is probably incremental. So, if that's all you did, the danger is all you ever get is incremental innovation. Which may be okay. And then, if a competitor has been a bit more radical, they could put you out of business very quickly".

5.3.4 Organizational features

5.3.4. Managerial and structural mechanisms

People in Excellent-AeroCo expressed the need to balance different outcomes such as balancing continuous improvement and innovation goals. These two goals are managed in Excellent-AeroCo through different mechanisms; first, through having balanced performance objectives. These objectives are managed in Excellent-AeroCo through a formal review process to encourage people to get involved in either improvement or innovation activities. For example, the technology lead said:

"if you removed all the performance metrics around six sigma, continuous improvement, lean, and innovation, I'd be very surprised. There would be very little happening across the business, because why would you?"

The second is having multiple specialized teams that facilitate PI and innovation. For example, there are several PI teams that facilitate PI in the company such as the continuous improvement team, the production system and lean transformation team. These teams facilitate and monitor the use of PI in the business. In addition to PI facilitator teams, Excellent-AeroCo has a centralized innovation team that supports the business and units in the organization through providing them with the required tools, techniques, running innovation workshops and training, organizing innovation challenges and teaching creative problem-solving techniques. For example, the head of innovation described the role of the innovation team as:

> "*…support the businesses across aero, marine, power systems, all businesses, in being more innovative. Which is helping them come up with new ideas, giving them tools, techniques, but also providing mechanisms for them to be more creative. Bringing them together with a crowd-sourcing approach".*

Third, part of the role of the specialized teams is to run various types of training' programmes for both innovation and others for PI qualifications. For example, the technology lead elaborated:

> "*So what's desirable, whether it was continuous improvement or innovation… so there will be something, and everyone has something around training, as well, because we're always trying to continuously improve the staff across the board, so there's always a training line item on there for everyone".*

Also, the head of the innovation team described the innovation training in Excellent-AeroCo:

> *"So currently we're reactive in training everyone. So if somebody asks us, you know, could we get training on a creativity technique? You know, I want to learn more about innovation, whichever aspect, we might make sure that someone either from this team or someone from this innovation network goes to talk to them and figures out what kind of support is needed".*

Fourth, balancing innovation and improvement goals achieved in Excellent-AeroCo through varying the level of PI maturity across the company and through adapting PI approaches to the functional needs, in particular, into the more creative areas. The head of the product development system describes their approach in balancing standards and innovation:

> *"I think the design of the product development system has been thought about quite carefully in that you can definitely see potential risks if you standardize, over-standardize things or if you don't have a structure that enables you to bring in innovation and turn them into standards. But you can have a conflict between standardization and innovation. The design of the product development system takes the lean concept of standard approaches, standard work and uses to make sure against a current standard way of working, that everybody knows what that standard is and that people have been trained very well in that standard approach".*

Finally, through having balanced teams that consists of balanced skill sets. For example, having process-oriented team members and others who are more creative. For example, the head of engineering strategy and enterprise architecture said:

> "*We have a large element of diversity in the company. We talk about diversity. And diversity is not just about male and female or LGBT, plus, it's about diversity of thinking styles".*

Appreciating diversity in teams' thinking styles is essential in areas such as product development, design and engineering. This is because distinguishing productive and creative time, innovative and wasteful ideas, will depend upon the managers' knowledge about their team members' skills and abilities. For example, the head of engineering strategy and enterprise architecture in Excellent-AeroCo elaborated:

> *"So, you've got an engineer who is working away and he's staring out into space or she is staring out into space. You are in a position where you might say to them, we need to deliver the current engine and you're wasting time on that. And they might tell us, but I was just about to invent the next generation".*

Thus, the role of managers is crucial in distinguishing and allowing space for employees' creativity and, as a consequence, this may determine the type of innovation that gets produced eventually. As the head of engineering strategy and Enterprise Architecture in Excellent-AeroCo emphasized:

> *"If you have someone who is very, very processed or radiated just doing things regimented and you haven't determined, shown in the past any spark of creativity, then I would suggest the manager may be tended to think that's a processed person and if they're staring into space, that's something wrong. Whereas someone who is maybe more creative and very little focused on delivery may actually go, well these people need space to think. So it's a human issue… The challenge is that you can't always tell if that's waste or creativity. And so it comes down to the judgement of the person, the manager, [and] the director, to say to this person, through a period of time you'll form opinions about the capabilities of your staff".*

Table 27 presents Excellent-AeroCo coding table

Table 27: Excellent-AeroCo coding table

Aggregate dimension	Second order coding	First order coding
PI characteristics	**PI bundle**	*Uses more than one PI approach*
		Reasons behind the bundle
	PI formality	*Expected*
	PI responsibility	*Everyone*
	PI scope	*Pervasive*
	PI usage	*Adaptive use across areas: Translating PI through Varying PI usage across areas*
Managerial-related mechanisms (features)	**Balanced performance objectives**	*Performance objectives for PI*
		Performance objectives for innovation
	Balanced training	*Training for PI*
		Training for innovation
Structure related mechanisms (features)	**Balanced specialized teams**	*Teams to facilitate PI*
		Teams to facilitate innovation
Innovation development process characteristics	**Radical and incremental innovation processes**	*Same processes*
Perceived Interplay between PI & innovation	**Managers' perception of the association between PI and the product innovation related activities and its potential impact on innovation**	*PI as enabler (complementary)*
		Conflicting

5.4 Case 3: Innovative-PharmaCo

5.4.1 Process improvement characteristics themes

5.4.1.1 Process improvement as a set of approaches in the manufacturing area

Innovative-PharmaCo has been using PI approaches for more than 15 years. Their deployment and usage of PI have changed over time (see figure 11). Between the early 2000s and 2008, PI was used in R&D and manufacturing (published paper on Innovative-PharmaCo) [14]. During this period of time, both lean and six sigma were used in Innovative-PharmaCo R&D.

PI is well established in the Innovative-PharmaCo manufacturing area as some of the plants have been using PI since the 1990s. PI usage has led to significant improvement in the operating performance in the manufacturing unit. The interest in using PI in R&D started in 2003, with the aim of reducing cost and inefficiency, time to market and improve productivity (published paper on Innovative-PharmaCo).

[14] This paper was published in 2009, in a peer-reviewed academic journal by previous workers in Innovative-PharmaCo who described the implementation of PI in R&D at that time. For confidentiality reasons, the full reference was not mentioned in the reference list.

Various PI approaches and tools were implemented including lean thinking, six sigma, TOC, Kaizen, five-whys, waste elimination, value stream mapping and others (published paper on Innovative-PharmaCo). PI expertise was shared from the manufacturing units by using the PI training materials and being supervised by PI experts (master black belts, green belts) from manufacturing (published paper on Innovative-PharmaCo). Between, 2003-2007 PI implementation in R&D was supported by the senior management in R&D and the accreditation schemes. For example, the director of strategy, operations and finance, at Innovative-PharmaCo Rare Diseases recall:

> *"It goes in trends, right? So I remember when I first joined [around 2004], everybody wanted to be a lean sigma person, and then it kind of faded away".*

However, around 2008, the R&D PI specialist left the company and the use of PI stopped in R&D. This was in parallel with the change in R&D leadership which aimed to drive innovation in the company. The new R&D leadership drove internal entrepreneurship in R&D which allowed employees the flexibility to generate and develop their ideas. Since 2008 until 2017[15], PI approaches have been used only in manufacturing units. Various PI approaches are used in the manufacturing unit such as lean, six sigma, Kanban, kaizen five-whys, etc. For example, the Medicine Supply Chain Leader described the use of PI:

> *"In terms of techniques we use a number of lean sigma type tools and processes to effect the change. ... Problem-solving, five-whys in particular, Kanban and so on and so forth including other businesses".*

Within manufacturing the use of PI evolved over time. For instance, initially, when PI was first implemented in manufacturing, experts (specialist and PI accredited employees) were responsible for PI deployment. However, placing responsibility of implementing PI on the experts only did not lead to the intended performance benefits of using PI. Non-expert employees were not committed to the use of PI due to the lack of engagement. Therefore, Pharma's manufacturing approach has changed by involving everyone in manufacturing in PI. For example, the manufacturing unit manager described this change:

> *"Ten years ago, it was mainly those experts who were lean six sigma experts who would take projects and lead them through to completion on behalf of production [....] What's changed in the past three years is now they're implementing a Innovative-PharmaCo production*

[15] Empirical data collection period was held between 2016-2017

system which is like the Toyota production system, […] and the emphasis on that has been 'everyone in the factory does that, you don't have to be a lean six sigma person'".

Currently, due to inefficiencies in R&D and product development, and the appointment of a new CEO in March 2017, there is an attempt to re-spread PI outside manufacturing to other areas in the business. The new CEO set three main strategic pillars for Innovative-PharmaCo's future direction: Innovation, performance and trust. The performance strategic direction involves using PI in the company. For example, the manufacturing unit manager elaborated:

"I think it is happening. There are a few reasons for that. Our new CEO was appointed I think at the beginning of 2017. She's got basically three key pillars: Innovation, performance, and trust. Everything is being aligned behind innovation, performance, and trust. […] Performance-wise, she is, and the corporate executive team are, trimming down processes, cutting waste out of business processes".

Lean is considered more appropriate to be used in non-manufacturing areas. Therefore, Innovative-PharmaCo is currently in the process of spreading lean through adapting lean concepts to the non-manufacturing areas. For example, the manufacturing unit manager explained:

"In the last three years, Innovative-PharmaCo has been actively trying to spread, I would say, not as much six sigma but more lean principles into some of the functional processes and business processes: Reduce waste, implement performance management and problem-solving, and standards outside of the factory. It's very high level, but it is something the company's actively been doing, which I think is good…"

Overall, the changes in leadership in Innovative-PharmaCo as whole, and in R&D, has influenced the types of PI approaches used and deployed in the company.

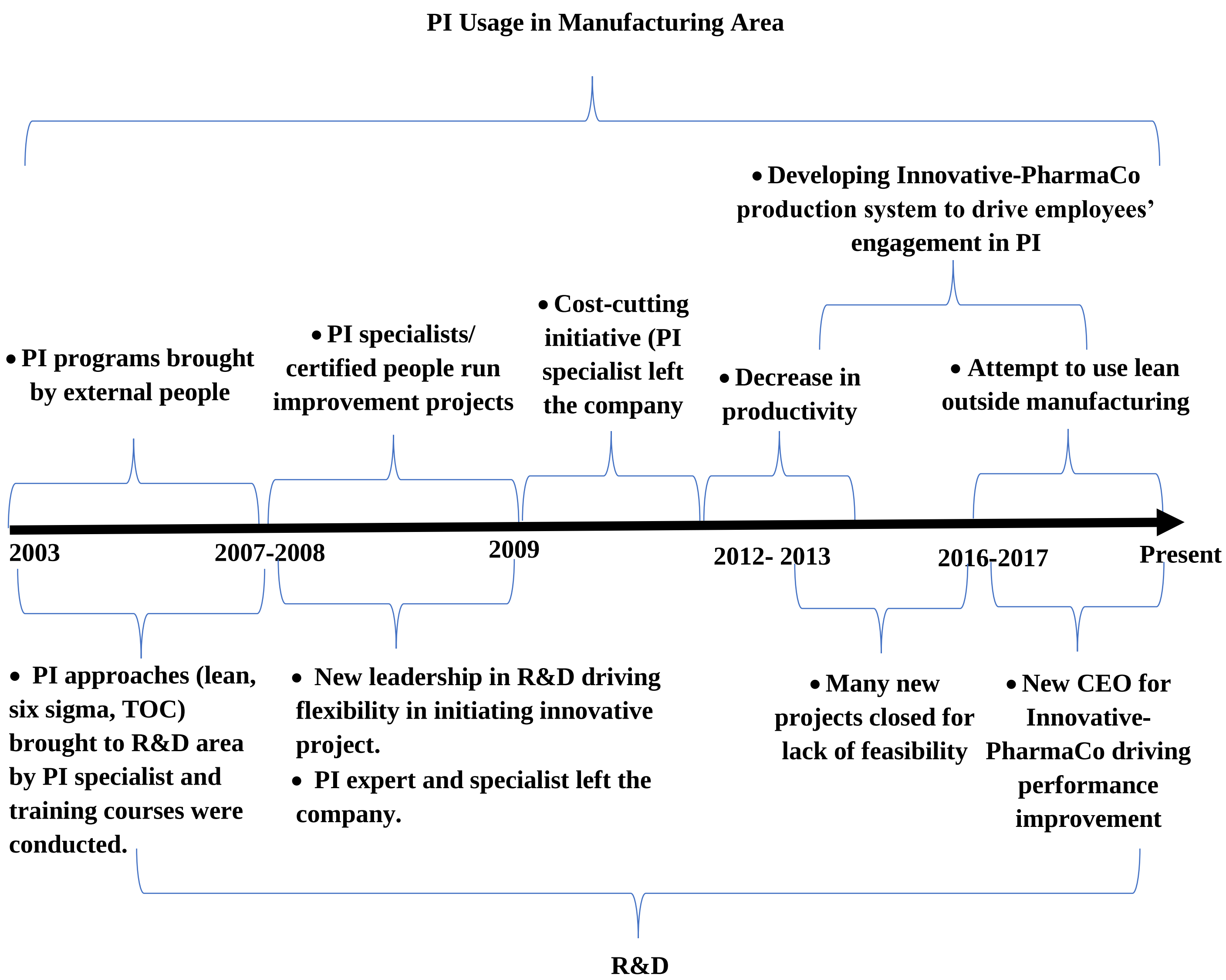


Figure 11: Timeline of PI usage in Innovative-PharmaCo

5.4.1.2 Confined and expected Process improvement in manufacturing

To comply with the regulatory requirements, PI is heavily used in the manufacturing environment which characterized by standardization and process-orientation. Therefore, PI is considered as an essential part of the culture. For instance, the director of inhaled drug product design and development explained:

> *"I would say they are used much more purposefully in the [manufacturing] environment. So, the business will be aware of these tools and the approaches that can be used. But in a manufacturing environment they are found essential in the culture".*

In the past, the PI specialist, and accredited employees were responsible for driving PI. However, several years ago, there was a shift in Innovative-PharmaCo's manufacturing toward employees' engagement in PI deployment. As a part of this change, employees are getting incentivized to use PI through their performance measurement system. For example, shop-floor employees' involvement in PI gets annually reviewed by their manager. For instance, the manufacturing unit manager elaborated:

> *"If they [operators] didn't do one [problem-solving through PI], and they sat down with their manager at the end of the year, they probably weren't going to get their full bonus rating. It was incentivised to do at least one, and the people who wanted to go above and beyond did more. And that was one way to create the culture and get people excited about, 'hey, we can do this', whereas before that, I think the operators just viewed it as 'we just push buttons and we load the materials onto the machine and we don't improve things, other people improve things, and we just come in and this is what we do'".*

Consequently, this change helped in engaging employees in PI deployment and created a sense of ownership between them for their own processes. For instance, the manufacturing unit manager explained:

> *"And that changed things, I think made it much more engaging for people, that they felt ownership of their area, the process, and what they were doing, and they felt more supported as opposed to… we tried… we would say, the operators are the most important people, they're the drivers, they're driving it. Everyone else, the managers, should be taking a lead from what the operators need to succeed".*

On the other hand, PI is confined to the manufacturing area and seen as inapplicable to other areas in the business such as R&D. The focus in R&D is different from manufacturing. While, the aim in manufacturing is to drive excellence, efficiency, standardization, and optimization in processes, the R&D area relies on individualized work that is based on scientific discovery, which does not fit with the application of PI.

For example, the new product introduction lead described the difference between the manufacturing and R&D areas:

> *"No, I would say less, probably a bit less. So, yes, again, because the focus is slightly different, where it's not necessarily always about efficiency or optimization, the focus might be slightly less in product development. However, the different philosophies that they're applying, you know, obviously does help with improvements in the way they develop things, but it's not necessarily something that is done and will help the commercial side of things, if you know what I mean, just because the focus is so different".*

Not only is PI seen as inapplicable for the R&D area, it is seen as a possible barrier for creativity if used in the R&D environment. For example, the fund director of the immunology innovation fund expressed:

> *"The problem I have with a lot of these business efficiencies is they look very nice on a sheet of paper and I have seen them try to implement it across something like R&D and it doesn't… It works, to… It doesn't really work, per se, and so I've seen them try to adapt principles from engineering or manufacturing, such as six sigma, et cetera, and bring that type of thinking into an R&D environment".*

Thus, PI is not considered as a strategic priority in R&D and is not heard in the leader's rhetoric. For example, the global commercial lead described the lack of leaders' interest in using PI and standard efficient processes:

> *"I think the main reason is the leadership not being bought into this kind of concept".*

5.4.2 Innovation characteristics themes

5.4.2.1 The process of producing radical and incremental innovation

The process of producing incremental and radical innovation tend to be similar as the pharmaceutical industry is highly regulated. The drugs discovery and development process is regulated by the Food and Drug Administration (FDA). This process consists of four different stages (see figure 12). The first stage is the drugs discovery and the pre-clinical stage, which takes between 3-6 years. This stage includes researching, discovering and identifying molecules that are appropriate to treat a specific disease. For example, the new product introduction lead described this stage:

> *"So, obviously, if there is a need for treating a specific disease state, a bunch of scientists will look at 1,000-plus or 20 or how many hundreds of thousands of different molecules, and they'll start looking at... and, basically, try and find the right molecule that will treat a*

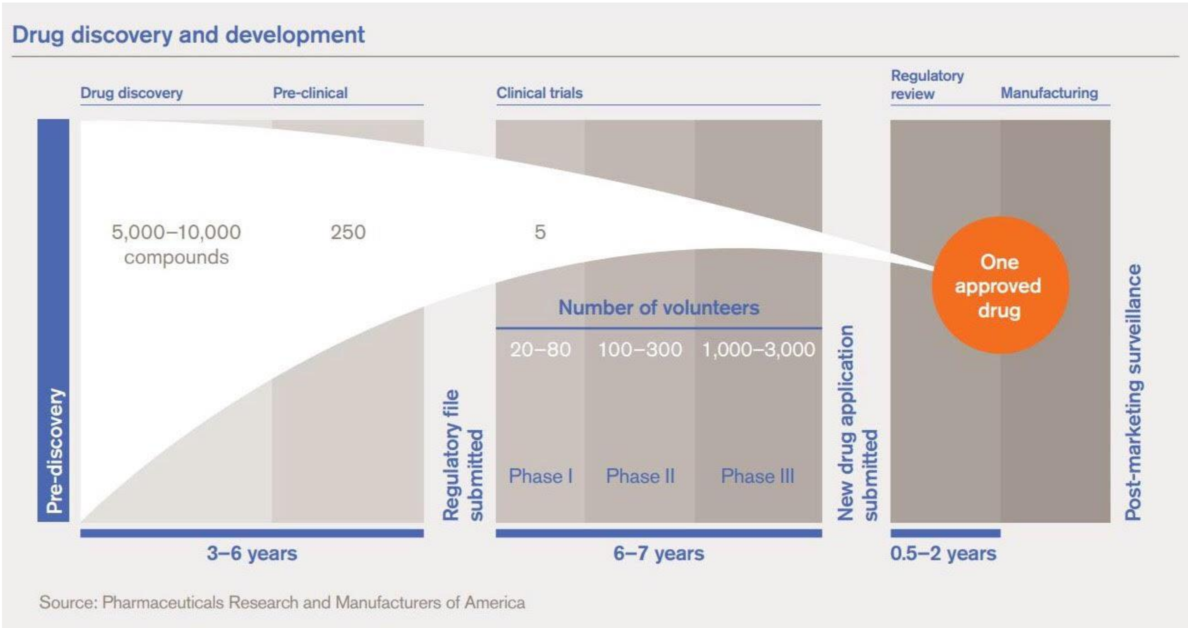
specific disease. Once they think they've got something, it goes into what they call a Phase One clinical trial".

The second is stage two which is the clinical trial stage. This stage is the longest in the drugs discovery and development process as it takes around 6-7 years. This stage consists of three main phases, that include laboratory work, many studies for testing the treatments, animal trials and human trials. In each of these phases, the FDA regulations need to be checked. For example, the new product introduction lead describes phases one to three:

- ***For Phase 1**: "So it would have gone through various animal studies and things like that. It will go to kind of the first trial in human and kind of Phase One, so you've cracked one, and it basically it says whether the molecule is safe, whether it's treating what they'd like to treat".*
- ***For Phase 2**: "And then, after that, if it's successful, it will then start moving into a Phase Two clinical trial. So, this is kind of a bit more patients, maybe in a different couple of areas in the world, so different types of population groups. And then they will assess different things while in the Phase Two stage. Sometimes those could be trying to determine what is the right dose. Again, safety is important, so they'll see whether there's any toxicity or any toxicology concerns. Phase Two can be various different types of studies".*
- ***For Phase 3**: "And then kind of after that it goes into a Phase Three clinical trial, so then you're really starting to produce way more of the product. And this is obviously if the Phase Two was successful and you can basically show that it's superior, it's safe; it's producing a desired effect with minimal adverse effects, adverse symptoms. Phase Three studies can look again at various different things, and they can be what they call either blinded or masked, or they can be open label, or they can be double-masked, or double, you know, open."*

Third, is the commercial stage which includes regulatory review and manufacturing of the product. This stage is the shortest in the drugs discovery and development process as it might take between 0.5-2 years. For example, the new product introduction lead described this stage:

"Finally, then, you kind of go into your commercial phase. So then you need to file, so you need to basically apply for the licence to produce the product and to register. So you register the product, so in each market, so the US will have the FDA, you register with them. They will do various inspections. They'll review your file, they'll look at data, they'll look at your active pharmaceutical ingredients; they'll look at the drug; they'll look at all the analytical methods and testing and all of that, all your GMP systems, chemistry, manufacturing and controls around the product, so it's quite a lengthy document. You know, so it's a lot of data, a lot of stuff you've got to approve".



Adapted from the Innovative-PharmaCo annual report 2018

Figure 12: Drug discovery and development process

Operating in a highly regulated industry, Innovative-PharmaCo tends to follow the same process for producing incremental and radical innovative products. For example, the project leader in R&D explained:

> *"The process is more or less the same. How you execute the process, so, you know, it can get to a very granular level. If you just look at what I've described, that's the process of doing a phase one, phase two, phase three study. You finish one, you move onto the next one, you finish the next one and then you start the next one, right. Eventually you get to the regulatory people. There's a lot of talks, how did you accelerate your development plan?"*

However, although the process of producing incremental and radical innovation is similar, informants suggests that radical and incremental innovation tend to be different in three main aspects: The source of the idea, the risk investment and the type of environment needed to incubate radical innovation. For example, the new product introduction lead explained:

> *But, yes, in my view, I think it's slightly different. I think it takes a different type of innovation mindset, innovation culture to bring incremental and radical types of innovations or products or whatever. I think when you have a radical innovation, you know, you are really challenging and really almost going completely the opposite as what people might think. So, yes, it's a bit of a difficult question but, I think in my view, I think they're different and they come about in different ways. […] But, yes, I think it takes different types of people* and also

different types of cultures and different types of environments to either produce incremental or a radical innovation, so…"

Given the newness of radical innovation to the company, the investment risk for radical innovation tends to be higher than that for incremental innovation. For example, the director of portfolio management elaborated:

"We have a sort of phased differential development which essentially means that some things due to their prioritization, will have more early, upfront at risk investment in them versus others".

In relation to the innovation source, incremental innovation tends to come from within the organization whereas radical innovation tends to be generated externally through collaboration with external partners. For example, the global commercial lead explained:

"But for me it's also having the courage to look outside, looking externally. And I think sometimes I get the impression that we are very inward looking within [Innovative-PharmaCo]. There are great examples of success, now and in the past, absolutely. And it is good to learn from them sometimes".

Overall, because of the regulatory constraints, Innovative-PharmaCo uses a similar approach to develop different types of products.

5.4.3 Link between Process improvement and innovation

5.4.3.1 Process improvement seen as more applicable at later stages of the NPD process

Through their accounts, informants emphasized that PI approaches are inapplicable in research and product development and more applicable in the manufacturing area and production units. Thus, PI gets isolated from the innovation processes and gets deployed only in manufacturing.

The product development process in Innovative-PharmaCo takes around 15 years and the manufacturing unit (where PI is used) gets involved at the end of the NPD process in the last 0.5-2 years. As mentioned earlier (section 5.4.1.1), PI gets used in manufacturing units only, at the same time, R&D - where innovation gets developed - and manufacturing are misaligned. These dynamics were reflected in the informants' views of the interplay between PI and innovation. For example, many informants see PI as more applicable at later stages of the drugs development processes (manufacturing stage) and not applicable at early stages (R&D). For example, the fund director of the immunology innovation fund explained:

> *"I've seen them try to adapt principles from engineering or manufacturing, such as six sigma, et cetera, and bring that type of thinking into an R&D environment. And it works better at the later stages of clinical development but as you move earlier in the pipeline and earlier in discovery, they become less relevant and actually, they just become a hindrance because it's all about the creative spark and the creative spark doesn't go very well with a structured template and process".*

Additionally, PI is considered as beneficial for innovation at later stages for reducing time to market, driving efficiency in the production process, helping preventing problems, and avoiding chaos through standardization. For example, the new product introduction lead noted:

> *Obviously, process improvement is always looking for, you know, reducing waste and making sure that we've got, obviously, timelines and it's keeping the end-to-end supply chain going…. Our products are quite key, because patients need their medicine. So if there's a gap in the supply chain or there's a stock out or shortage, that's massive for any pharmaceutical company. You know, you can't just stop. So all of that helps with the end-to-end supply chain that's making sure that patients – and that's how we talk about our customers – our patients get their very, very important medicine. […] you know, the stress it's [shortage of medicine] causing patients is significant, you know. We're talking about people that are sick. So the process improvements indirectly actually help that".*

In addition, to the benefits of PI at later stages of the NPD process, PI is seen a compatible with incremental innovation. For example, the new product introduction lead elaborated:

> *"Because when we look at process improvements, we're looking at very small steps, small step changes, because if you make anything… If you make any large step changes, you can potentially impact the product quality or the final product spec or, you know... So, typically, they will tweak things here and there. So, for me, process improvement is probably more aligned to incremental innovation than it will be to radical innovation".*

Overall, since PI is seen as more applicable in manufacturing and not applicable in early stages of product development (e.g., R&D), PI and innovation are separated from each other and, thus, PI can be considered as irrelevant to innovation.

5.4.4 Organizational features

5.4.4.1 Silos between functions

In Innovative-PharmaCo different functions seem to be disconnected from each other. For example, R&D and manufacturing have minimum communication. As described by the new product introduction lead manufacturing, R&D and commercialization are disconnected:

> *"R&D and manufacturing and commercial will always have a friction; you know there will always be some friction".*

This silo and the separation between functions can be traced to different reasons: First, the differences in mind-set and culture between different areas. For example, the director of inhaled drug product design and development described that:

> *"The mind-sets of the two organizations [R&D and manufacturing] are very, very different. It's good and bad in both".*

In the manufacturing area, there is a focus on standardization, compliance and efficiency; however, this is not the case in the R&D area as the focus is on innovation and standardization gets avoided where possible. For example, the director of inhaled drug product design and development described the difference between R&D and manufacturing areas:

> *"Some of that is down to the nature of the work for instance, in a manufacturing environment the work is highly repetitive and standardized, in R&D we like to think it's much more individualized".*

Also, the new product introduction lead made a similar note on the differences in the mind-set between manufacturing, R&D and commercialization and he described the misalignment between R&D commercialization and manufacturing:

> *"I think it's more of a cultural thing rather than technology or… You know, I think, really, it's a cultural mind-set. It's the way we do things, it's the way we approach things. It's the way R&D's focus and the commercial focus and the manufacturing focus mainly doesn't necessarily always align and there's not a lot of alignment there".*

Second, the difference in performance priorities. For instance, performance measurements in R&D prioritize the advancement of science and the product's safety.

However, in the manufacturing area, performance measurement emphasizes the manufacturability of the products. For example, the director of inhaled drug product design and development elaborated:

> *"So, those performance indicators in the manufacturing world are staring you in the face. I think in an R&D environment you're trying to measure the quality of ideas, in a way, you're measuring the quality of a design…. One way to look at this is that if I'm designing a product, I need that product to be, first and foremost, safe and effective when a patient takes their medicine. So, that is my priority. I need it to be, then, something that we can manufacture robustly and cost-effectively. I need it to be something that is commercially attractive and environmentally responsible. You've got a number of things to trade off then in designing the product, it's not just about how easy it is to manufacture, whereas in manufacturing it's only about how easy it is to manufacture".*

Silo and misalignment between functions, cause problems in Innovative-PharmaCo as this challenges PI initiatives' success and leads to inefficiencies in the product development process. In particular, the inefficiencies in R&D processes create delays in the development and the production of products (drugs). For example, the manufacturing unit manager described:

> *"I know that ten years ago some of the processes that were coming out of R&D were so terrible, that there was so much waste in manufacturing, and then we would have to spend years and years and years trying to improve the process".*

Given the importance of bringing different areas together, improving the interface between manufacturing and R&D and reducing the inefficiencies in product development, there is an attempt to get the manufacturing involved earlier in the drugs development process. For example, the manufacturing unit manager stated:

> *"I have worked closely with R&D on commercializing new products, there's a big push to have manufacturing involved earlier to help build that process in a sustainable way. I think that's getting better and I can see it a little bit".*

Moreover, functions are more aligned in some units in Innovative-PharmaCo. For instance, in one of the respiratory products sites, there is a close collaboration between R&D, manufacturing and commercialization. For example, the new product introduction lead described this site:

> *"So I've worked for different companies, and I think each company has got its own challenge. I guess the site I'm working at, what makes it quite unique, and you don't always see this,*

you do get it here and there, is that we are co-located with R&D, you know, so we're very close. We have very close collaboration; our respiratory products, all the developed work is done actually on the commercial line".

Also, the rare diseases unit in the R&D area has its own in-house commercialization department. This helps in aligning the research and commercialization needs in this unit. For example, the director of strategy, operations and finance, at Innovative-PharmaCo Rare Diseases described:

> *"It's unique in the [Innovative-PharmaCo] structure, because we have R&D and commercial integrated in one unit. Whereas most other parts of the [Innovative-PharmaCo] we have the R&D that studies a therapy area. You know whether it's respiratory, or psychology, or whatever. And then the commercial organization is somewhat separate. So the global commercial, right? So there's global commercial, and then there's commercial in each country which is the money-making…"*

5.4.4.2 Entrepreneurial-orientation: Used and unused ideas

Across Innovative-PharmaCo, people at the manufacturing area are encouraged to improve their own processes and have the autonomy to suggest new ideas. People's ideas and suggestions are considered as an essential part of both the improvement and innovation processes. For example, the medicine supply chain leader elaborated:

> *"Place those ideas as waste? No. I mean ideas are always helpful from an innovative point of view anyway, they're always helpful from a learning point of view regardless of whether they're actually implemented or not".*

Moreover, this autonomy of people in Innovative-PharmaCo is not limited to improvement activities but also connected to generating new ideas for innovation. For example, the portfolio management director described that:

> *"I think there is an attitude. I think if somebody had an idea about something there's very much the right environment for that to be sort of taken on-board".*

Moreover, people in Innovative-PharmaCo R&D are encouraged to generate new ideas and they get supported in implementing their ideas. They are given incentives, resources, and budget to deploy their ideas. If the ideas were appropriate and meet the regulatory constraints, employees have the opportunity to receive innovation awards. For example, as a project director in R&D described:

> *"So, I've been asking some internal people, you know, how do we generate new ideas and opportunities to bring the idea forward. And, you know, the feedback I got from the R&D*

scientists was yes, of course. And then I looked at our internal website and there's loads of awards, processes, incentives to encourage people to bring in ideas".

Since 2008, there has been an increase in the openness and freedom that are given to employees in the R&D area. This is due to the change in leadership which aims to drive innovation in the company. For instance, the global commercial lead mentioned:

"I think it was 2008, before my time. And he [manager] was very much of the view and is still of that view that he wants to leave complete freedom and independence for the scientists to create. And that's what permeated through the company in terms of mustering that kind of innovation to freedom."

At that time people had the freedom to open new discovery performance units (DPU). These are independent units that allow people to implement and test their ideas. For example, the global commercial lead explained:

"But when I joined in 2011, the organization was in a situation where they had basically created a significant large number of small units which are innovation generating. What they call Discovery, DPUs, Performance Units. Because DPUs, they open up the opportunity for any individual that has an idea and wants to test that, to basically go and do it. And create a little more enterprise. Without any guidance from any ... market constraints and also any kind of guidance or key areas of focus of commercial opportunity within 10, 12 years. It's basically the time it might take for a track to materialize".

However, this freedom was not without disadvantages as this led to the development and implementation of many innovative projects that neither fit with the capabilities of Innovative-PharmaCo nor with the market needs and cannot be commercialized at the end. For example, the global commercial lead elaborated:

"They started to realize that ideas and projects were coming out of this approach, a vast number of those. But the reliability of a number of those projects, or these tracks, was limited from a commercial point of view. And sometimes also knowledge within the organization because many of the projects were going into areas where they had not had the expertise before"

Moreover, this led to very novel and innovative products ideas' which were not feasible. For example, the global commercial lead explained:

"I think it has led to more innovation for sure. But not necessarily innovation that could be executed, if that makes sense? So there were great ideas of new areas to explore in terms of, for example, [x] areas and mechanism faction's target, near target. Very new, very novel. But then when tried to either take them into legal trials or there was a marketable opportunity or a willingness to potentially pay the cost of those therapies, it was reliable but it was not feasible".

However, after 2013 there was a realization that some of the products were not successful and this led to reorganization of the way in which R&D is managed. For example, the global commercial lead explained:

> *"Yes, that's what happened in 2013 for sure. I think between 2008 and 2013, there was this explosion of ideas. And then in 2013, it was the realization that they were not materializing and that led to the oncology business being sold to [pharmaceutical company], to a large number of DPUs being stopped. And then resources being refocused".*

However, often, the unused idea and projects were not considered as a waste; for example, the manufacturing unit manager described that:

> *"We would never say an idea is waste, I think we would just say there are many ways to solve a problem. Just because we didn't choose that option, we still think it's valuable that we got… that people were putting through ideas. Having ideas come through, even if you get ten ideas and you only pick one, it's a good lead indicator of are people engaged and are they trying to help, right?".*

Indeed, the autonomy that was given to employees at Innovative-PharmaCo led to the generation and the development of new innovative but unfeasible ideas. Thus, it is important to maintain a balance between freedom and feasibility when considering new products. Table 28 presents Innovative-PharmaCo coding table.

Table 28: Innovative-PharmaCo coding table

Aggregate dimension	Second order coding	First order coding
PI characteristics	**PI bundle**	*Uses more than one PI approach*
		Reasons behind the bundle
	PI formality	*Expected in manufacturing*
	PI responsibility	*Not everyone (only in manufacturing)*
	PI scope	*Confined/ isolated to manufacturing*
Structure related features / mechanisms	**Silos between functions**	*R&D, manufacturing, commercialization disconnected*
Managerial related features / mechanisms	**Entrepreneurial-orientation**	*Employees' autonomy and flexibility to initiate new projects (DPU)*
	Performance objectives	*PM trigger tensions between functions (R&D and manufacturing)*
Innovation development process characteristics	**Radical and incremental innovation processes**	*Same processes*
Perceived interplay between PI and innovation	**Managers' perception of the association between PI and the product innovation related activities and its potential impact on innovation**	*PI regarded as irrelevant to innovation (more applicable at the later stages of NPD process)*

5.5 Case 4: Cheap-CarCo

5.5.1 Process improvement characteristics themes

5.5.1.1 Process improvement as a set of approaches

Cheap-CarCo uses more than one PI approach, such as six sigma, lean, theory of constraints (TOC), design for six sigma. For example, the head of propulsion and innovation stated:

> *"We use all of those tools from time to time in elements".*

Each approach is used differently and for different reasons. For example, TOC is considered as a good approach for understanding customers' needs; six sigma is good for maintaining rigour and reducing variation in the process; and lean is used as a broad concept of meeting standards and targets. Despite various PI approaches being used in Cheap-CarCo, six sigma is the most dominant approach.

Different reasons have contributed to the creation of the bundle of PI approaches. First, the industry in which Cheap-CarCo operates. The automotive sector is the pioneer in implementing PI and it has a long history of using different PI approaches. Therefore, PI became the industry best practice that different automotive companies adopted at different times in their history.

The second reason is more specific to Cheap-CarCo. Most people in Cheap-CarCo have a long working experience in other automotive companies, such as Toyota, Honda, Fast-CarCo among others, which have a long history in the use of PI. Therefore, most people in Cheap-CarCo were exposed to different PI approaches throughout their career and they brought this knowledge to Cheap-CarCo. Consequently, this mix of talents has contributed to the creation of a PI bundle in Cheap-CarCo. For example, the head of advanced product creation and lean facilitator explained:

> *"You learn from your peers and colleagues and in an environment like this where you've got people who have come from a whole different host of organizations that have all had similar but different experience, you can learn quite a lot from each other".*

Third, benchmarking. In general, benchmarking of good practices is widely used in the automotive sector. Cheap-CarCo collaborates with other automotive companies and learns from their experience in PI. Therefore, Cheap-CarCo is benchmarking and learning the usage of PI from other automotive companies. The head of advanced product creation and lean facilitator explained:

> *"It [Cheap-CarCo] also has the benefit of owning [Automotive Company]. [Automotive company] came through their own maturation of lean experience".*

5.5.1.2 Not using a formal and systematic approach for Process improvement

Compared with other automotive companies, Cheap-CarCo uses PI at a lower degree. However, within Cheap-CarCo, the use of PI approaches is more dominant in manufacturing compared to other areas such as engineering, design, research and digital innovation. For example, in engineering in Cheap-CarCo, PI usage is not systematic and different PI projects have been conducted from time-to-time. For example, the chief programme engineer elaborated:

> *"..., it's probably not systematic or consistent in the approach the business takes, which is often... which can often be typical of where Cheap-CarCo is with its process development. So room for improvement".*

In the design and digital innovation areas, however, PI approaches are not used at all. For example, the design area uses processes for different stages of product definition and has deliverables to achieve, yet, PI approaches are not used. For example, the head of design described PI usage:

> *"So for instance like nobody in design, in the department actually, you know, uses that system for instance but I know that the rest of the company does, you know, to help define the product from their points of view".*

There are many reasons behind the lack of PI usage in Cheap-CarCo in general and in design, engineering and product development in particular. First, lack of competencies and trained people. Despite many people being knowledgeable in PI, not many people are six sigma or lean trained. Therefore, other problem-solving tools are used, instead of six sigma or lean. The chief programme engineer explained:

> *"Some people are on the continuous improvement projects who have no six sigma training at all, they're just using their common sense and normal problem-solving skills, so what I'm saying is there's not a systematic strategy for six sigma or any other type of problem resolution".*

Second, PI applicability. In some areas, PI approaches are seen as not applicable and a barrier for creativity. For example, leaders in the design area see PI as a systematic and linear tool that does not fit with the creativity required for design. However, design requires an iterative process and, therefore, needs to provide a space for designers to be creative. For example, the head of design elaborated:

> *"But I've gone to the training for it myself and the more I thought about it I felt like it's far too compartmentalized and far too, you know, it's like this is the process, it's A, B, C, D, E. And I felt like once you apply that it becomes too regimented".*

Nonetheless, PI is seen as more applicable in repetitive environments and in places where measurements can be used, such as manufacturing. Therefore, given the small size of some teams in design and product development in Cheap-CarCo, PI is considered as inapplicable given the diversity in the type of work that employees do in these areas. For example, the head of propulsion and innovation explained:

> *"The people who can look around and say we're all doing the same job is quite a small number. If you put them in the context of our colleagues over in [developing country] where instead of 250 people, they've got 4,000 people in engineering, you obviously see bigger teams quite quickly and hierarchical management, which would allow you to say, 'right, everybody at this level works to one process' because it's important, that there are so many of them, they have to work to a single process".*

5.5.1.3 PI is the responsibility of leaders

While many people in Cheap-CarCo acknowledged that improvement is the responsibility of everyone, it is not necessarily for people to use PI approaches. However, senior leaders and the head of quality have the ultimate responsibility for deploying PI in Cheap-CarCo. The chief programme engineer explained:

> *"Only inasmuch as a more senior person probably feels they've got more of a remit to make a decision in terms of what needs to be solved or what the priorities are. A more junior person probably doesn't have a view or can't take decisions on prioritization. That's probably the key difference, but everybody has a responsibility to improve the processes that they deal with on a daily basis".*

Moreover, there is no central group responsible for facilitating PI in the company; as the head of digital stated: *"I'm not aware that Cheap-CarCo has a group, has a process improvement department".* Instead, PI approaches can be deployed as projects for solving certain problems, if needed. The decision behind using PI or not depends on the individual competency. For instance, PI accredited employees (e.g., master black belt, green belt) are more likely to use PI to solve problems and manage processes. However, untrained people might use other approaches. For example, the chief programme engineer elaborated: *It's more down to individuals' ability just to follow their own instincts or training"*.

The main reason behind the lack of a central systematic approach for PI is that there is no need to apply a systematic approach for PI usage and PI training. For example, the head of advance product creation and lean facilitator in Cheap-CarCo argued that companies in the automotive sector in general, and in Cheap-CarCo in particular, do not need a central systematic approach for any PI practices as PI is embedded in the company:

> *"So if you go to the NHS, the hospitals, maybe some of the banking environments, you'll find that there are people there who go on university courses or courses which are accredited by consultancies to get formal training in lean. And you'll find that in those places. You don't find that so much in the automotive world because typically it came from there, so you learned it from osmosis rather than formal, being taken out of your environment to go to a specific course in lean".*

5.5.2 Innovation characteristics themes

5.5.2.1 The processes of managing incremental and radical technologies are different

Overall, Cheap-CarCo products are seen as mostly incremental, low-cost products that are not high-tech compared to other automotive companies. However, currently there is an attempt to develop highly innovative products in term of design and technologies. For example, the head of advanced product creation and lean facilitator described the types of cars that Cheap-CarCo produce:

> *"Cheap-CarCo is typically a relatively low-end car manufacturer: We make cars that are very simple, not very feature-rich".*

Two different processes are used in Cheap-CarCo to develop incremental and radical technologies. For developing incremental technologies or improve current ones, a new product introduction (NPI) process is used. This process has standard, well-defined and clear stages to develop previously used technologies. However, radical technologies are currently developed through [process], which is a process that was recently adopted from another automotive company. [Process] is a loosely managed, well-defined, and flexible process to develop and test new technologies. For example, the chief programme engineer described the two processes:

> *"it's called NPI, which is the delivery process for deploying new products and deployment of, let's call it, existing technology. That's typically used on every vehicle that [Cheap-CarCo]*

launches, it goes through the [process] process. And any customer feature, if you want an electronic park brake or, say, automatically-dimming headlights, which is available technology and you've just got to deploy it, like go through the NPI process, and that's very well defined. And very clear, very explicit in terms of what it wants. If we're developing new technology, we have the… it's a [automotive company] process that we use, called [process], for Technology Creation and Development System. So we use that".

Despite the process of developing radical and incremental technologies being different at the development stage, the same process is used for both types of technologies at the deployment stage as this stage requires efficient processes, meeting targets and does not require creative thinking. For example, the chief programme engineer explained:

"In the deployment process, you don't want innovation. What you want is delivering an output within the specified timescale within a specified budget, without any error states, and then precisely meeting your customer requirements. So you don't want new innovation, new ideas and creativity creeping in. You actually want to remove those sorts of error states so that you have a clean delivery".

5.5.2.2 Innovation challenges

Informants in Cheap-CarCo expressed some of the challenges they face in relation to innovation development. First, creating affordable yet innovative cars. In this respect, some informants stressed the need to consider both the emotional and rational sides of the products. The emotional side of the purchase is associated with the visual aspect and brand of the car and the rational side is connected with the affordability and functionality of the car. This creates a tension for Cheap-CarCo as it is operating in the value-automotive-segment, where cost is the main driving force for customer purchase. Therefore, Cheap-CarCo has a tension to produce a product that is appealing and highly featured whilst, at the same time, being affordable for customers. For example, the head of design expressed the importance of considering the emotional and the rational sides of the customers' purchase when designing cars:

"So that emotional, that rational and emotional side of design is really the first thing that a designer needs to understand to create a product that is competitive".

Indeed, Cheap-CarCo needs to stay up-to-date with the changes in technology and customers' preferences. For instance, the head of design stressed the importance of market research for product design:

"You know, and all those things can inform you in terms of… So, so that sort of benchmarking measuring the market, measuring the customer, that all has to be done before you actually start designing".

Second, balancing personal drives and business needs in creative areas (such as product development and design). As section mentioned earlier, (Section 5.5.2.1), Cheap-CarCo attempts to drive innovation in the business through running innovation and improvement initiatives and through allowing flexibility for employees to pursue their ideas. While this flexibility helped in generating innovative ideas, it sometimes led to infeasible ideas that do not match with the business needs. Additionally, this creates a tension for leaders in being rigorous in selecting the right ideas without demotivating employees. For example, the head of design highlighted this tension:

> *"It's a balance. You have to kind of fulfil, you know, the objectives of the company and the product but, at the same time, you know, satisfy your own creative expectation. That's a challenge, you know".*

5.5.3 Link between Process improvement and innovation (informants' view)

5.5.3.1 Process improvement can enable incremental but hinder radical innovation

Most informants in Cheap-CarCo regarded PI as an enabler for incremental innovation and a barrier of radical innovation for different reasons: First, PI is seen as inapplicable to the areas where innovation happens, e.g., design, digital innovation and some parts of engineering. For example, the head of design sees PI as a linear and rigid approach that does not fit with the creativity required in design. For instance, the head of design explained:

> *"No. No. I actually discourage it because like I said I find it I find it it's too engineering-based and it stifles creativity".*

Moreover, processes are considered as a barrier to change and the development for new technologies. For example, the head of digital expressed his challenge in convincing people in Cheap-CarCo to leave the process and think differently.

> *"So, I have difficulty in trying to persuade quite a lot of the time. Say to people, put those processes to one side, ignore them for this particular application that we're working on, this business opportunity that we're working on, you're going to have to trust me that we will get to this point in your process quicker, potentially more efficiently, potentially not quite so efficiently but you're going to have to trust what I'm doing".*

Second, PI is seen as more applicable at later stages of the technology development process. For example, Using PI at the development stage of innovation (design, engineering and product development) can act as a barrier for innovation. However, deploying PI at later stages (e.g., manufacturing) can support innovation. Nevertheless, this viewed applicability of PI may vary depending upon the used PI approach. For instance, while design for six sigma (DFSS) is appropriate to be implemented early in the process, shortly after the technology discovery stage, using operations' six sigma at early stages of product development is not applicable and can be considered as a barrier for radical innovation. For example, the chief programme engineer explained:

> *"Design for six sigma, I think, is more of the front-end of the six sigma process. But even so, that's not about innovation and creativity, that's about once you've defined your idea or defined what it is you want to do, then following a fairly rigid methodology to ensure that you introduce that new idea in a way where you avoid failure modes. So even design for six sigma is not about creative thinking, it's about introducing change in a controlled way, I would suggest… the design for six sigma approaches, yes. But I would very much distinguish design for six sigma from operational continuous improvement six sigma.".*

Third, using process does not fit with innovation. According to some informants, innovation needs freedom and flexibility; however, using processes for innovation can stifle innovation and discourage creative people. For example, the head of propulsion and innovation expressed his disagreement with restricting creative people with processes:

> *"People who've novel ideas, creative ideas, things that dare to be different, a lot of them are somewhat undisciplined people. I think it's the left brain/right brain thing going on. Anyway, I think when you've got these right-brained guys, the worst thing you can do is say, 'oh, you've got to follow this checklist'".*

5.5.4 Organizational features

5.5.4.1 Cross functional tension and collaboration

In Cheap-CarCo, the design and engineering functions seem to be in tension. For example, designers are passionate about designing products that are attractive, highly featured and appealing to the customer. However, engineers are concerned about the feasibility of the products, and meeting quality standards. For example, the head of advanced product creation and lean facilitator describes the difference between the two groups:

> *"So, you've got two groups of people that are very passionate, one group with a set of data and analysis and hard stuff, and the other group with a lot of aspiration about how a thing should look for it to be attractive, for it to be appealing to the market".*

Also, the head of design explained the difference between the designers and engineers in terms of their views and interests:

> *"If you take two communities of designers and engineers, designers will always want to design a Ferrari, and engineers will always want to give you a square box with wheels on".*

The divergence in perspectives between the two communities results in tension in relation to the type of product that is needed to be produced. For example, the head of design elaborated:

> *"It's just a challenge around the design intent of the guys who design these vehicles; they want to keep as much of their design as they possibly can. But the engineers have to apply feasibility to that, and sometimes what you draw can't be engineered, so there has to be some adjustment. But that's the normal, kind of, iterative process".*

Throughout their accounts, informants explained how the undertaken changes in the interaction between the two communities and the closeness in location were essential to improve the relationship between design and engineering. In particular, informants emphasized the importance of the regular interface between both parties' in bridging their perspectives. These daily conversations between designers and engineers helped in aligning them together. The head of design elaborated on the continuous interface between design and engineering:

> *"So, for instance like we are in one building and we have engineering, you know, with us in the same… They're not in the design studio but they're in the same building and they are coming into design and we are going into engineering and we have meetings every day. And it's, you know, it's almost like the left-hand side of the brain is talking to the right-hand side of the brain".*

Additionally, informants stress the role of the performance metrics in resolving the tension between the two communities. Design and engineering share the same performance objectives. This sharing helps in aligning the views of both communities toward the benefits of the whole business and customers rather than individual areas. For example, the head of design explained:

> *"Both communities have got the same metric in the sense of they all have to do what they need to do within the timeline which is given by the programme timing to achieve start of production, start of sales. So that's given by the client company, the parent company. What we have to do in engineering and design is meet that timeline within budgetary constraints".*

Overall, aligning the views of design and engineering areas and managing the interface between them, helps in creating products that are appealing to customers which, at the same time, can be manufactured. Therefore, this helps in balancing the product feasibility and attractiveness tension. For example, the head of advanced product creation elaborated:

> *“So we have to make sure that the design doesn't run too far ahead of the engineering. The design is always in front of the engineering, but the engineering needs to come along to confirm that design is doable. If that design isn't doable, then you can't show it to anybody”.*

Indeed, the tension between design and engineering persists despite the efforts in aligning both communities.

5.5.4.2 Initiatives to drive innovation and improvement

Despite Cheap-CarCo’s products being highly innovative, Cheap-CarCo runs an initiative to drive innovation in the company and encourage employees to participate in innovation activities. Toward this aim, four approaches are currently used in Cheap-CarCo to improve people’s engagement in innovation. First, over the past two years, Cheap-CarCo has started to run an annual innovation challenge (competition) which aims to encourage people to get involved in innovation and improvement. The innovation challenge consists of several stages. First, all employees get invited to participate in the competition and share their improvement or innovation ideas (e.g., new technology). Then, shortlisted people present their ideas in front of their colleagues and senior managers in Cheap-CarCo and then the audience votes for the best ideas. After that, the finalists form into teams and develop their ideas further. Finally, the finalist teams present their project to the senior management. The winning team gets provided with money and resources to develop and pursue their projects. For more details on the innovation challenge in Cheap-CarCO, please refer to section 4.2.4.2.

The second involves allowing people the space to innovate. For example, in the design area, people are given the time and flexibility to learn new things. For instance, designers are encouraged to attend courses at the design school, going to tradeshows either in the automotive or non-automotive sector (e.g., fashion, furniture etc.). Also, designers are given the budget to pursue their ideas. For example, the head of design elaborated:

> *"I mean there is always a kind of advance design sort of future product budget and sort of space that's given to designers. And we have sort of an area within the design department which is kind of, you know, brainstorming and ideating, you know, we should be doing this or we should be doing that. And then if it's a good idea then you put it forward to management. It's a kind of, you know, innovation, you know, workshop. Designers have to be given that space".*

Similarly, the digital innovation team has the complete freedom to pursue their idea. For example, the head of digital argued:

> *"You know, so we present that to them. If internally they're not interested in doing it, then I have complete freedom to do it independently".*

Second, not imposing processes on areas that require flexibility such as digital innovation and design areas. For example, in the digital innovation area, people are encouraged to challenge the process and come up with new mobile applications that fit with the market needs. For example, the head of digital explained his approach:

> *"So, I would, I always encourage people to be innovative and creative in what they do and how they do it and just challenge the processes at every single opportunity that they have, you know. It's healthy".*

However, while the flexibility that is given to employees in creative areas (such as design) helped in generating innovative ideas, it sometimes led to infeasible ideas that do not match with the business needs. For example, the head of advanced product introduction explained:

> *"So, waste would be if we let the designers design without constraining them with what's technically feasible. So, it's the balance. If we constrain them too much, every car looks the same and it looks horrible."*

Certainly, informants emphasized the importance of balancing feasibility and creativity in selecting the best ideas to progress to final product. Table 29 presents Cheap-CarCo coding table.

Table 29: Cheap-CarCo coding table.

Aggregate dimension	Second order coding	First order coding
PI characteristics	**PI bundle**	*Uses more than one PI approach*
		Reasons behind the bundle
	PI formality	*Individual choice (no formal approach)*
	PI responsibility	*Senior leaders*
	PI scope	*Not everywhere (dominant in manufacturing and on projects in engineering)*
Managerial related (Mechanisms) features	**PI and Innovation enabling tools**	*Internal innovation competitions*
Innovation development and process Characteristics	**Radical and incremental innovation processes**	*Different processes for current and new technologies*
Perceived Interplay between PI & innovation	**Managers' perception of the association between PI and the product innovation related activities and its potential impact on innovation**	*PI as more applicable in early stage in NPD process*

CHAPTER 6: CROSS-CASE FINDINGS

6.1 Introduction

The previous chapter discussed the main themes in relation to PI usage, innovation management and the interplay between PI and innovation within each case; this chapter compares the main themes across the case organizations. The cross-case analysis was conducted in two stages: the first section compares the main similarities and differences between the case organizations at the organization level. Two themes were identified as common between cases: (1) PI as a bundle of approaches, (2) PI maturity varying within the organization. However, the case organizations differ in some other aspects: PI scope, PI formality, PI responsibility, and the organizational mechanisms that are used for managing the interplay between PI and innovation. Following the analysis at the organizational level, a second stage of cross-case analysis was conducted at the NPD level. This highlights the importance of PI usage at different stages of the NPD, the capacity to adapt PI approaches, and the ways in which middle and senior managers view the interplay between PI and innovation. This section concludes with a description of each configuration.

6.2 Cross-case analysis: Comparing the main similarities and differences across case organizations

6.2.1 Process improvement as a bundle of approaches

In all organizations more than one PI approach was used. Moreover, different organizational events and other factors contributed to the emergence of "bundles" of PI approaches (see Table 30). A key one relates to mergers, acquisitions. As discussed in section 5.2.1.1, this is evident in the case of Fast-CarCo. Resulting from a merger of two automotive organizations and moving between two different owners with divergent leadership styles, Fast-CarCo adopted different PI approaches at different points in time. Consequently, these changes and the resulting learning process have led Fast-CarCo to create its own set of PI practices (the so-called "Fast-CarCo way").

Second, leaders' and managers' preferences played an important role too. For example, in Innovative-PharmaCo, R&D leadership in 2008 drove openness toward innovation by allowing employees the flexibility to start new innovative projects and develop their ideas. In the same period, different PI specialists left the company and PI initiatives were stopped in the R&D area (see section 5.4.1.1 for more details). In Fast-CarCo, six sigma was brought to the company based on the preferences of the quality manager at that time (around 2003-2007).

Third, the creation of a PI bundle depended on the area it is implemented in. While this factor contributed to the use of PI bundles in all case organizations, it was particularly evident in firms that used PI to a larger degree (Excellent-AeroCo and Fast-CarCo). For instance, in Excellent-AeroCo PI was adapted to the product development area, for example by mixing lean with agile. Blending the two approaches allowed the product development area in Excellent-AeroCo to pursue speed and flexibility goals.

Finally, the growth in the number and diversity of employees' employees' skills and competences. For example, while Cheap-CarCo does not use PI to a large degree, many employees had experience in the use of PI from their previous jobs. Thus, people who worked in other companies brought the knowledge and skills to Fast-CarCo and added to its skill-set.

Table 30: Factors that affected the creation of PI bundles

Main factors	Main organizational events
Change in leadership and leadership style	• Change in the company's leadership (Fast-CarCo) and functional unit leadership (Innovative-PharmaCo) • Leader preference (Innovative-PharmaCo, Fast-CarCo)
Mergers	• Merger between companies (Innovative-PharmaCo, Fast-CarCo)
Growth / reduction of number of employees	• Employees' skills and competencies (Cheap-CarCo, Fast-CarCo) • PI experts leaving the company (Innovative-PharmaCo, Fast-CarCo)
Strategic change priorities	• Culture change: Excellent-AeroCo new direction to drive lean and creating a culture of CI across the company • Excellent-AeroCo changes in the recruitment process
Previous companies' experience with using PI	• Previous success of using PI (Fast-CarCo, Excellent-AeroCo) • Appreciating the benefits of each approach (Fast-CarCo, Excellent-AeroCo; Cheap-CarCo)
Trend in the industry and external events	• Financial crisis (Fast-CarCo, Excellent-AeroCo and Innovative-PharmaCo)

6.2.2 Process improvement maturity and usage vary across functions within the organization

It is apparent that the use and degree of PI maturity varies between functions and organizations. In all cases the manufacturing area is more mature in the use of PI compared to other areas in the business (e.g., R&D and design). However, the main difference between the organizations that use PI to a greater extent (Fast-CarCo and Excellent-AeroCo vs. Innovative-PharmaCo and Cheap-CarCo) is that PI is used in all areas in the organization but with varied use across the organization. For example, the head of business excellence in marketing and sales in Fast-CarCo explained:

> "*However, there's variability across the functions as to how well those teams permeate into their broader organization".*

The variation in PI maturity can be due to different reasons. For example, the areas that are more process-based (e.g., manufacturing) tend to be more mature in the use of PI compared to the areas that are not driven by processes (e.g. marketing, R&D). For example, the head of advanced product creation and lean facilitator in Cheap-CarCo articulated:

"Lean six sigma is very much, you will see in [Cheap-CarCo] across the manufacturing space, you will see six sigma methodology... you know that if, statistically, you have to have data points, normally 25 to 30 data points before you can make a judgement that wasn't working in the design space".

Similar patterns were found in Fast-CarCo. As described by the competitive and market intelligence manager:

"If you go to a factory site, for example, then you will see the Kanban boards and the boards they use for reporting where they are. I think the process runs all the way through, so the whole of manufacturing and logistics… really is quite involved in process improvement all the way through".

Also, the head of continuous improvement in engineering in Excellent-AeroCo elaborated:

"In terms of the design department, it is variable; some areas are very mature, do loads of process improvement, loads of lean events, regularly driving improvement through… some areas are less mature and just depend on the areas they interface with".

Second, PI was regarded as more or less applicable in some areas/functions. For example, the lack of perceived applicability of PI to R&D or product development led to not using PI in these areas in Innovative-PharmaCo and Cheap-CarCo. For example, the new product introduction lead in Innovative-PharmaCo stated:

"Lean and six sigma is still a big part of our [manufacturing] system, which is the internal [Innovative-PharmaCo] production system… I would say less [in product development], probably a bit less. So, yes, again, because the focus is slightly different, where it's not necessarily always about efficiency or optimization, the focus might be slightly less in product development".

The third reason behind the variation in PI maturity within the organization is the possibility to adapt PI to the different areas. Adaptations were evident in the cases where PI was used to a larger degree (Excellent-AeroCo and Fast-CarCo). For example, in Excellent-AeroCo there are different variants and elements of the production system which are cross-functionally owned. There are operations, supply and office variants and each is used in different environments according to the suitability of the variant for the functional needs. For instance, the head of continuous improvement in engineering elaborated:

"We've got something called the production system which has been developed in [Excellent-AeroCo] which is a sort of framework for improvement; we've got three variants of that we use across we've got manufacturing variant, purchasing, supply chain variant and office variant and the office variant is applicable to all of engineering…. Again, it takes all the principles of good process improvement theories, gets activities to just make them relevant to the office environment".

In Fast-CarCo, the use of PI is less structured in R&D, design and product development than in manufacturing and engineering. The product creation and development system manager described:

> *"Within design, it's, I think, a bit more flexible but they use a similar kind of approach but it's maybe not as structured as the way that it's done in the core engineering areas".*

6.2.3 Process improvement deployment varies between the case organizations: PI formality and scope

The findings show that the deployment of PI in organizations involves multiple dimension in addition to PI tools. Previous research suggests that the implementation of PI in organizations encompasses the use of different practices including the technical and behavioural. However, the cross-case analysis shows that there are two further important dimension: PI formality and PI scope. Table 31 summarizes the meanings and categories of each dimension.

Table 31: PI deployment dimensions

PI Dimensions	Sub-dimensions / categories
PI formality: Involve the degree to which PI usage is documented in the organization or not.	• **Expected formality**: Involves considering PI as part of the company's overall direction, everyone in the organization/area is expected to get involved in the use of PI, monitor employees' involvement in PI. • **Voluntary PI formality**: Means that PI usage is left to people's choice. In other words, people in the organization have the autonomy to use PI or not where appropriate.
PI Scope: Reflects the spread of PI usage in the organization and across units and functions.	• **Pervasive scope:** PI is used everywhere in the organization including the innovative areas (e.g., R&D, product development, design and engineering). • **Isolated or confined scope**: Indicates that PI is used in only one area/unit/function in the organization (e.g., manufacturing) and rarely used in other areas (e.g., R&D, product development).

It is not surprising that the case organizations deploy PI approaches differently. However, one would expect that the case organization that use PI to a larger degree (Fast-CarCo and Excellent-AeroCo) or the one that uses PI to a lower degree (Innovative-PharmaCo and Cheap-CarCo) follow a similar approach for deploying PI in the organization. On the contrary, different levels of PI formality were observed. For instance, PI usage in Excellent-AeroCo is expected; however, in Fast-CarCo, PI usage is voluntary and based on employees' choice. PI is the main priority in Excellent-AeroCo. PI has been used for a long period of time and many people are trained in different PI programmes. However, several years ago, it was noticed that there is a need to engage all employees in the company in PI usage. Consequently, in an effort to embed PI in the way of working in Excellent-AeroCo and in engaging employees in using PI, various PI programmes were initiated, and PI was used as a company-wide strategy that involves everyone. Accordingly, PI formality is expected in Excellent-AeroCo. For example, the head of the production system in Excellent-AeroCo elaborated:

> *"So, you know, you can't rely on 6% of your organization to do all your process improvement. So, we've got to move away from that mind-set and more of get everybody involved. And we measure that, so we do something called Lean Improvement for Everybody. So, our target is 100%. We want every single person to do an improvement".*

Similar to Excellent-AeroCo, in Fast-CarCo, PI is used with a pervasive scope but voluntary formality (i.e., left to people's choice). This can be due to the current leadership approach in the company. In the past, prior to 2008, Fast-CarCo was owned by a different owner; at that time, Fast-CarCo adopted the processes and standards of its parent company. However, the current company uses a more flexible approach in managing its subsidiaries by, for example, allowing the autonomy for Fast-CarCo to use its own processes. Following the current leadership spirit, Fast-CarCo created a central portal/toolbox "Fast-CarCo way" that collects different PI approaches, improved processes from different functions and various best practices. This toolbox is available to everyone in the company to select the appropriate PI approach when needed without imposing any specific approach to be used by people. For instance, the head of business excellence in Fast-CarCo, elaborated:

> *"So, we have not kind of mandated, like General Electric said, everything has to [adopt six sigma]. Everyone uses six sigma, this is the standard. Over here we have said, use six sigma, use 8D, use lean, use Kaizen, use whatever you want to…There is no embargo on that".*

On the other hand, in Innovative-PharmaCo and Cheap-CarCo, PI usage is isolated/confined to one area but with different formality. For instance, Pharma's use of PI approaches is confined to the manufacturing area with expected formality in manufacturing. This can be due to two main reasons: First, PI approaches are seen as inapplicable outside the manufacturing area and as a barrier for innovation. Therefore, PI is not used in R&D and product development areas. Second, PI is considered as an ethos in the manufacturing area and employees are expected to use PI to maintain rigour in the production process and to ensure compliance to regulations. The director of inhaled drug product design and development in Innovative-PharmaCo elaborated:

"I think [manufacturing], our manufacturing environment, particularly in a highly regulated manufacturing environment, everything has to be standardized".

In Cheap-CarCo PI usage is more dominant in the manufacturing area but it follows a voluntary formality in engineering, design and product development areas. Overall, Cheap-CarCo lags other automotive companies in the use of PI as it is less mature. Currently, PI is used on occasions and when needed, outside manufacturing. Thus, the usage of PI depends on the employees' competencies in the use of PI. For example, the head of propulsion and innovation stated:

"We use all of those [PI] tools from time to time in elements".

The voluntary use of PI in engineering and product development areas in Cheap-CarCo can be due to two main reasons: First, employees in these areas are aware of PI and are competent in using it. For example, the head of advanced product creation and lean facilitator explained:

"So what I've learned in the time I've been in [Cheap-CarCo] is that because this is an organization that's predominantly made up of people who've been elsewhere in the automotive industry... Not exclusively, but predominantly. Most of the people that work within this facility and the designers who work within the other facility have come from organizations where there has been quite a substantial element of lean already embedded within the way that they work. So they've all got different experiences depending upon which company groups they came from, but there isn't anything within lean that is new to anybody in this building because they've seen it or they've had some exposure to it in their previous experience".

Second, PI is used informally in Cheap-CarCo as PI is seen as inapplicable for innovation processes. For instance, the head of propulsion and innovation stated:

"There are limits to how we can contribute to the overall process, and within the more local things like innovation and new idea development, those, at least to my way of thinking, aren't… they're not very easily described in language which allows you to use some of the more systematic process improvement tools".

6.2.4 Organizational mechanisms for managing the interplay between Process improvement and innovation

Various organizational factors seem to play a role in managing the interplay between PI and innovation. These factors were grouped into managerial and structural -related factors. Managerial-related factors include training, performance objectives;

meanwhile, structural-related factors include cross-functional integration and silos, specialized teams.

Overall, more than one type of mechanism is used in each company. However, in Excellent-AeroCo and Fast-CarCo there is more focus on the managerial mechanisms to manage the use of PI and the development of innovation in the organization. In both cases, the managerial mechanisms were supported with structural-related ones. For example, Excellent-AeroCo uses three main mechanisms to enhance the impact of PI on product innovation. First, conducting balanced training programmes. For instance, there are training programmes for PI and others for innovation. These training programmes are conducted at the company level. For instance, the technology lead at Excellent-AeroCo described:

> "*So, what's desirable, whether it was continuous improvement or innovation… so there will be something, and everyone has something around training, as well, because we're always trying to continuously improve the staff across the board, so there's always a training line item on there for everyone".*

Second, having balanced performance objectives at the company level. For instance, Excellent-AeroCo seeks the balance between improvement and innovation through having performance objectives for PI and others for innovation at the company level. These objectives are managed in Excellent-AeroCo through a formal review process to encourage people to get involved either in improvement or innovation activities. For instance, the technology lead said:

> *"And actually, employees in general have an objective. So, everyone has objectives as part of your role around innovation, be it continuous improvement or true innovation, a large innovation type thing. So everyone is encouraged at some level to get involved, every employee."*

Similar to Excellent-AeroCo, Fast-CarCo uses performance objectives to support both improvement and innovation. However, in Fast-CarCo the performance objectives are balanced at the individual level. Thus, employees have performance objectives that are future-oriented and current business-oriented. For instance, the marketing communications director described his performance objectives:

> *"So we're always trying to get a mix in objectives of what should we be doing to do the basics well, and then where next is the business trying to head?"*

The second mechanism that Fast-CarCo uses is the balance between an empowering approach for PI and process-orientation in the company. For example, Fast-CarCo has moved from an organizational structure that is based on functions to a structure that is based on processes. Therefore, there are processes for leadership and strategy, finance, HR, research, product development and manufacturing, etc. However, despite the tendency toward using processes in different parts of the organization, Fast-CarCo follows PI voluntary formality for people in the company and this allows maintaining the rigour from processes and the flexibility through people empowerment.

However, in the other two cases, Innovative-PharmaCo and Cheap-CarCo, there are more dominant types of mechanisms (managerial, structural-related). For instance, Innovative-PharmaCo focuses more on structural-related mechanisms. For example, in Innovative-PharmaCo improvement and innovation goals get balanced through using PI and innovation in two structurally separate areas. For example, innovation is mainly located in the R&D area and PI is more dominant in the manufacturing area. For instance, the director of inhaled drug product design and development, in Innovative-PharmaCo described the differences between the manufacturing and R&D areas in terms of their main focus:

> *"I think that having come back from the [manufacturing] environment, like I say, the [manufacturing] environment and R&D are chalk and cheese, and that's partly cultural, it's a mind-set difference, rather than being a necessary difference".*

Cheap-CarCo focuses on managerial mechanisms to drive both PI and innovation, first, through allowing the space for people to generate new ideas and innovate. This was evident in the annual innovation challenge that is run to encourage employees to participate in generating and developing new ideas either for improving processes, improving current products or generating new ones. The head of propulsion and innovation elaborated:

> *"It was really to try and inspire people to say, follow your process, because the rewards for your company could be very good. But that's an incentivized innovation challenge which has a sort of merit award at the end of it which says, if your team idea or your individual idea is successful, then you get to form a team to start some work on it and you get some budget to do that".*

Also, this for managing innovation includes using PI on occasions and when it is needed based on individual competency (certified in PI or not) and choice. For example, the chief programme engineer elaborated:

> *"Whilst there are projects to improve certain processes, there's not a blanket".*

6.2.5 Perceptions of the interplay between Process improvement and innovation

The perceived interplay between PI and innovation vary between the case organizations. While the most informants in Excellent-AeroCo suggested that PI is an enabler for innovation, few informants suggested that PI approaches are inapplicable to the innovative and R&D areas. This variation becomes evident when comparing these two quotes from the head of the production systems and the technology lead in Excellent-AeroCo.

> *"I don't see how you can be innovative if you don't have that improvement mind-set. I think they go hand-in-hand".*

On the other hand, according to the technology lead in research are:

> *"Well, how would you apply lean? In what way? This is where it gets difficult. […] Now, in what context would you apply that to R&D? If you were trying to minimize waste, you'd have to quantify that in terms of R&D; what is the waste? You know, it's not the same as if you were making a component and you've got to produce 50 components out of each piece of metal. Well, can you make it 53?"*

In Fast-CarCo, PI approaches are seen as indirect facilitators through the use of processes, and standardizations that facilitate collaboration. For instance, the competitive and market intelligence manager said:

> *"And the necessity to work together […] Otherwise without it, what you're left with is individual areas trying to put change in, and if they're really open, or they're doing something for the business, it may not be for their particular function. In that it is known and understood that what we're trying to do for the whole business. It [the use of processes] drives collaboration".*

Others view PI as irrelevant to innovation; for example, the head of research in Fast-CarCo conceptualizes PI as a set of tools that are irrelevant to innovation:

> *"…I think just a tool to use and when appropriate. I don't think we innovate any more for them and I don't think we innovate any less for them. I just see them as a tool."*

However, due to the strong silo between manufacturing and R&D, in Innovative-PharmaCo PI is regarded as irrelevant for product innovation because the two are separate structurally and in location. For example, the director of inhaled drug product design and development in Innovative-PharmaCo described the differences between manufacturing and the R&D areas as:

> *"The [manufacturing] approach would be to use those standardized processes and aim to continually improve those processes. In [manufacturing] it's all about standardization, in R&D, I think we're much more likely to try and avoid standardization as much as possible".*

In Cheap-CarCo, also, informants suggested that PI approaches are more applicable at later stages of product development rather than early stages as the use of structured approach in the early stages could stifle innovation. For instance, the principal engineer elaborated:

> *"In the early stages you need to enable the idea to grow with some broad guidelines rather than you've got to improve XYZ by this date, ABCD by this date….. Because then people don't get involved and then get engaged".*

Despite the general consistency in the viewed interplay between PI and innovation within each company, there are some variations. Therefore, the next section presents the second stage of cross-case analysis that focuses upon the differences in the viewed interplay within and between each of the case organizations. Table (32) summarizes the main themes between the case organizations.

Table 32: Cross case comparison table

Theme	Second order code	Excellent-AeroCo	Fast-CarCo	Innovative-PharmaCo	Cheap-CarCo
		First order code			
PI as a bundle of approaches	*Uses more than one PI approach*	Mostly lean, six sigma, TQM, Kaizen, 8D, TOC	Mostly lean, six sigma, TQM, process redesign, five-whys	Mostly lean, six sigma	Mostly lean, six sigma, TQM, TOC
PI dimensions	*PI Formality*	Expected	Voluntary	Expected in manufacturing	Voluntary
	PI Scope	Pervasive	Pervasive	Isolated/confined in manufacturing	Isolated
Interplay between PI and innovation (Majority view)	*Managers' perceptions of the association between PI and the product innovation related activities and its impact on innovation*	PI viewed as enabler	PI viewed as indirect facilitator	PI viewed as irrelevant for innovation	PI impact on innovation contingent to NPD stage
Mechanisms for managing the interplay between PI and product innovation related activities	*Management-related mechanisms*	- *PI usage*: PI adapted to the area that is used in. - *Management systems*: Balanced performance objectives for both PI and innovation, balanced training (PI and innovation training, knowledge sharing portal) - *Structural mechanisms*: Dedicated teams	- *PI usage*: PI adapted to the area that is used in. - *Management systems*: Entrepreneurial orientation: flexibility to start new projects, balanced performance objectives for both PI and innovation - *Structural mechanisms*: process-oriented structure	- *PI usage*: PI not used in R&D and in product development - *Management systems*: Entrepreneurial-orientation: flexibility to start new projects - *Structural mechanisms*: PI and innovation happen in separate locations	- *PI usage*: PI not used in R&D and in product development - *Management systems*: Innovation and improvement championships

6.3 When and how Process improvement is used in NPD

Through comparing the perceived interplay between PI and innovation across the case organization, it was observed that the interplay can be considered as either "conflicting" or "complementary" depending upon two main factors: PI usage dimensions (scope, formality and usage) and the stage of the NPD (discovery, development, deployment). Table 33 (A-D) summarizes PI and innovation viewed interplay, PI usage and the associated mechanisms at different stages of the NPD in each organization. (See table 37 in Appendix D for illustrative quotes for the interplay at the NPD level).

6.3.1 Discovery stage of NPD (idea generation)

This stage involves the generation and selection of ideas that will eventually become a product. This includes the technology development process in automotive and Excellent-AeroCo and early stages of drugs development in Innovative-PharmaCo. Through analysing the informants' responses on the interplay between PI and product innovation, it becomes clear that informants' responses vary between the studied organizations at this stage. For example, while in Fast-CarCo PI is seen as a supportive mechanism for innovation and, therefore, the interplay between PI and innovation was described as "complementary", in Innovative-PharmaCo and Cheap-CarCo, however, PI is considered as inapplicable for the areas involved in the early process of NPD (such as the R&D function) and PI is seen as a barrier for creativity; therefore, the interplay between PI and innovation was described as "conflicting".

The main reason behind these variations between the companies is the way in which PI is used in the organization. For example, in Fast-CarCo, at the discovery stage in the research function, PI is adapted to the area through using PI to maintain rigour, facilitating collaboration and creating a trust environment through encouraging employees to participate in improvement decisions. Therefore, PI is seen as a facilitator for the idea generation process. However, in Cheap-CarCo and Innovative-PharmaCo PI is not used in R&D and early in the product development environment. In Excellent-AeroCo, which uses PI across the organization (pervasive PI scope), the views of PI applicability at the discovery stage vary between idea generation and selection of the appropriate idea. For example, at the idea generation stage, PI is considered as conflicting with innovation since

PI is seen as a constrained way of thinking. On the other hand, at idea selection, PI plays the role of gatekeeper which filters the ideas and selects the most rigorous to pursue. This involves identifying value-adding and non-value-adding ideas that have the potential to be successful.

6.3.2 Development stage of new product introduction

This stage involves departments like product creation, product development, design and engineering. People's responses regarding the interplay between PI and innovation vary between companies at this stage. While PI is considered as a facilitator for innovation at this stage and the interplay between PI and innovation is seen as complementary in Fast-CarCo and Excellent-AeroCo, in Innovative-PharmaCo and Cheap-CarCo PI is considered as a barrier for creativity and therefore as "conflicting" with innovation. These differences in the viewed interplay can be traced to the variation in the use and characteristics of PI in the four companies. For example, at this stage in both Excellent-AeroCo and Fast-CarCo, PI is adapted to the product development, design and engineering to maintain flexibility. This adaptation is through mixing lean with agile, using standardization in a loose manner and translating the meaning and types of "wastes" to these environments. Consequently, this adaptation of PI helps in providing structure for the product development, balancing flexibility and rigour, making PI relevant to people in design, engineering and product development and, therefore, allowing people a space and time to innovate. However, in Innovative-PharmaCo and Cheap-CarCo, PI is seen as a barrier for innovation at the development stage and inapplicable in design, and product development areas. This is because PI is seen as a rigid process which might limit flexibility and lead to a more incremental type of innovation. Therefore, PI is discouraged at the development stage and in the product development and design environments.

6.3.3 Deployment stage of new product introduction

This stage involves the production of products in the manufacturing and late engineering areas. These areas are characterized by high measurability, certainty and process-orientation. In the four studied companies, PI is seen as applicable, and essential to maintain rigour in these areas. Therefore, the interplay between PI and innovation at the deployment stage is seen as "complementary" rather than "conflicting". For example, at the manufacturing in Innovative-PharmaCo, PI is used to maintain rigour in the production process, meeting regulations and facilitating learning through providing people the autonomy to pursue their ideas and participate in improvement decisions. Similar to Innovative-PharmaCo in Cheap-CarCo, PI is considered as a facilitator and complementary to innovation. Here, PI is used as a controlling mechanism to avoid risk and maintain quality. In Excellent-AeroCo and Fast-CarCo, PI is seen as applicable and "complementary to innovation at this stage as well.

Table 33: Descriptions of the interplay between PI and innovation at different stages of the NPD (tables A-D)

A. Company A: Fast-CarCo

Table B- Company B: Fast-CarCo			
Dimensions	**Discovery/selection**	**Development**	**Deployment**
Conflicting (PI impact on innovation)	- Not applicable	- Not applicable	- Not applicable
Complementary (PI impact on innovation)	**Discovery and selection of ideas (research area):** - Maintain balance between flexibility and rigour - Individuals have the choice to use PI or not -*Rigour*: PI (six sigma) helps maintain rigour in selecting the ideas and in the technology development process. -*Collaboration*: PI (lean) facilitates collaboration through the use of visual management -*Trust*: Encourage employees to participate in PI	**Development (product development, design and engineering areas):** -PI makes NPD faster and more efficient -PI helps to maintain customers satisfaction -PI is adapted to area: For example, the types of waste are adapted to the product development environment -PI helps in maintaining rigour at the development stage	**Deployment (manufacturing and hard engineering):** -PI makes the process more efficient, rigour, meet customers' needs
Organizational features	**-Structure related**: Process-oriented structure that helps maintain rigour and integration between functions **-Managerial related:** PI platform (Fast-CarCo way) collects all the best practices that different functions and processes use, balanced performance measurement, entrepreneurial-orientation in research area		
PI usage	-Adapting PI to the area (in product development, engineering and design) -PI formality is voluntary and left to the individual choice		

B. Company B: Excellent-AeroCo

Table A- Company A: Excellent-AeroCo			
Dimensions	**Discovery/selection**	**Development**	**Deployment**
Conflicting (PI impact on innovation)	**Discovery of ideas**: - PI is a constrained way of thinking - Radical innovation requires broader problem framing	-Not applicable	-Not applicable
Complementary (PI impact on innovation)	**Discovery and selection of ideas:** - PI as a filtering mechanism - PI helps maintain rigour in selecting ideas	**Development:** - Adapting PI to the area - PI makes the innovation development faster and efficient - PI provide a structure for the NPD process - Balancing standardization and flexibility	**Deployment**: PI makes the process more efficient, rigour, meet regulations
Organizational features	**- Managerial-related:** Cross-fertilization of ideas, innovation portal, PI and innovation training and workshops, balanced performance objectives. **- Structural related**: Specialized teams that support PI and innovation		
PI usage	- Adapting PI to the area (in product development, engineering and design) - Varying levels of PI maturity across the organization and between departments - Definition of waste (when ideas and the time spent by the employees considered as a waste or not)		

C. Company C: Innovative-PharmaCo

Table C- Company C: Innovative-PharmaCo			
Dimensions	**Discovery/selection**	**Development**	**Deployment**
Conflicting (PI impact on innovation)	**Discovery and selection of ideas (research area):** -PI is not used at this stage and in the R&D environment -PI is seen as inapplicable in R&D - there is inefficiency in R&D	**Development (product introduction and development areas):** -PI is not used at this stage and in the product development environment - PI is seen as inapplicable for the innovation development process -PI is aligned with incremental innovation -using quality assurance method to maintain product quality	- Not applicable
Complementary (PI impact on innovation)	- Not applicable	- Not applicable	**Deployment (manufacturing):** -Rigour: PI makes the process more efficient, rigour, meeting regulations -Trust: Having an environment that encourages employees in participating in PI and have the autonomy to pursue their ideas
Organizational Features	**- Structure related**: R&D and manufacturing (where PI is used) are disconnected from each other **- Managerial related**: Entrepreneurial-orientation, portfolio management, collaboration with other partners		
PI usage	- PI is used in manufacturing only - PI is used to meet regulations and encourage people to participate in PI		

D. Company D: Cheap-CarCo

Table D- Company D: Cheap-CarCo			
Dimensions	**Discovery/selection**	**Development**	**Deployment**
Conflicting (PI impact on innovation)	**Discovery and selection of ideas (digital innovation area):** -PI is seen as inapplicable at this stage -Facilitate innovation through: 1. Encouraging employees to leave the process and trust their ideas 2. innovation & improvement competition	**Development (product development, design areas):** -PI is not used at this stage and in the product development environment -PI is seen as a rigid process -PI is inapplicable for design area	- Not applicable
Complementary (PI impact on innovation)	- Not applicable	**-** Not applicable	**Deployment (manufacturing and late engineering):** -Rigour: PI makes the process more efficient, and rigorous
Organizational features	**- Managerial related:** Empowering employees to use PI, lack of PI competency in manufacturing, PI and innovation initiatives (competitions) **- Structural features:** small design & engineering functions		
PI usage	- PI formality is voluntary and based on choice		

6.4 Toward a configurational view for managing the interplay between process improvement and product innovation

The previous section compared the case organizations in terms of their similarities and differences. Multiple factors seem to affect the interplay between PI and product innovation related activities. Some of these factors are related to PI deployment characteristics, organizational mechanisms (managerial/structural), the use of PI at the NPD stages and perceived of PI and innovation interplay by managers. These factors combine differently in each organization; as a result, four configurations for managing the interplay between PI and product innovation emerge. These are: “Strategic and Holistic” in Excellent-AeroCo, “Facilitating and Empowering” in Fast-CarCo, “Operational” in PharmaCO and “Project-based” in Cheap-CarCo. The four configurations emerged from the intersection of two main dimensions: PI formality (expected or voluntary), and PI scope and PI integration in the innovation processes (pervasive/integrated or confined/separated). In addition to the differences in PI characteristics, these configurations are different in their potential outcome and use mechanisms to manage the interplay between PI and product innovation related activities. This section compares the four configurations in terms of the main characteristics (PI formality, PI scope and level of PI and innovation integration), the main mechanisms used to manage the interplay between PI and product innovation related activities, and potential outcome in terms of the product innovation type the management approach might lead to (incremental product innovation focus/or incremental and radical innovation focus) (see figure 13 and table 34)

PI Scope & level of integration	Expected formality	Voluntary formality (individual choice)
Pervasive PI & integration	**Strategic & Holistic Configuration (Excellent-AeroCo)** **Characteristics** • *Pervasive PI & integration* • *Expected formality* **Outcome** • *PI as an enabler for innovation* • *Focuses on incremental product innovation (dominant)*	**Facilitating & empowering Configuration (Fast-CarCo)** **Characteristics** • *Pervasive PI & integration* • *Voluntary formality (individual choice)* **Outcome** • *PI as an indirect facilitator for innovation* • *Focuses on both incremental & radical product innovation*
Confined (dominant) PI & separation	**Operational Configuration (Innovative-PharmaCo)** **Characteristics** • *Confined (dominant) PI in manufacturing & separation* • *Expected formality in manufacturing* **Outcome** • *PI as irrelevant for innovation* • *Focuses on both incremental & radical product innovation*	**Project-based Configuration (Cheap-CarCo)** **Characteristics** • *Confined (dominant) PI in manufacturing & separation* • *Voluntary formality (individual choice)* **Outcome** • *PI is a barrier or contingent for innovation* • *Focuses on incremental product innovation*

PI Formality

Figure 13: Configurations for managing the interplay between PI & Product innovation

6.4.1 Strategic and holistic configuration

> *"We're quite good in [Excellent-AeroCo] speaking in one voice around 'this is what we want to do'. It can be challenging in implementation, but, certainly in terms of policy, it is lean. Lean is the way to go" (Head of engineering strategy and enterprise architecture)*

Excellent-AeroCo uses a strategic and holistic configuration for managing the interplay between PI and product innovation related activities. The main characteristics of this configuration are pervasive PI scope and expected PI formality. PI is considered as the current priority in Excellent-AeroCo as stated by the head of the production system:

> *"We're trying to move to a more standardized way of working…a standardized way of working is a more lean way of working".*

Overall, the interplay between PI (practices, tools, approaches) and product innovation (process, activities) is managed by integrating PI in the innovation processes and across functions. However, the level of integration varies between functions and at different stages of the product development process. For instance, in R&D, where ideas for new products are generated and selected, lean is integrated with innovation and problem-solving tools. At this stage lean is used as a filtering mechanism to distinguish useful from wasteful ideas. For example, the head of engineering strategy and enterprise architecture elaborated:

> *"We have an innovation website and we may get hundreds of ideas coming in every day. Where lean plays a part is spotting the good ideas and moving them efficiently to product. Where waste comes out is spotting the wrong one or spotting the right one and implementing it purely".*

PI is also adapted to the product development, design and engineering areas to maintain flexibility. This adaptation is achieved by mixing lean with agile and using standardization in a loose manner. This adaptation of PI helps to provide structure for product development, balancing flexibility and rigour, and allowing people space and time to innovate. For example, the head of continuous improvement in engineering articulated:

> *"We have to be careful in how we translate... I think all the tools are absolutely relevant just having practitioners who are able to translate the messages and make those connections for engineers from the manufacturing into things around data or around knowledge creation around training and skills."*

In addition to adapting PI, other organizational mechanisms are used. Some of these are managerial mechanisms including the use of formal training and balanced performance indicators and objectives (both PI and innovation-related). For instance, some areas in the business have more PI-related objectives and others have more of innovation-related ones. Aligning the performance objectives with PI and innovation not only supports the expected PI formality in Excellent-AeroCo, but also helps in maintaining employees' commitment toward PI and innovation initiatives. For instance, the technology lead explained:

> *"Employees in general have an objective. So, everyone has objectives as part of your role around innovation, be it continuous improvement or true innovation, a large innovation type of thing. So, everyone is encouraged at some level to get involved, every employee".*

Moreover, various types of training are used for different PI approaches including Kaizen and six sigma certifications. At the same time, other training is provided through innovation workshops. Structure-related mechanisms are also used in Excellent-AeroCo for managing the interplay between PI (practices, tools, approaches) and product innovation (process, activities) using specialized teams for facilitating PI usage and innovation development.

However, despite the efforts for maintaining flexibility through the adaptive use of PI and innovation related training and performance measurement, the extensive use of standardization seems to hinder employees' capacity to explore new ideas. Consequently, this appears to promote incremental innovation and to hinder radical innovation. For example, the head of innovation elaborated:

> *"I think if you have, say, 20,000 engineers that are used to operating within the boundaries of certain processes, they're forced to think in boxes. You know, how do you entice them to think outside of their box? They've never been trained for it. The people that live here and that work here and have been working here for 15 years, have always been told, think in the box. If you ask them to think outside of the box tomorrow, it's difficult because you're not playing to the strength of people".*

6.4.2 Facilitating and empowering configuration

> *"So, business excellence right now is as big a focus as product innovation, product design and product excellence" (head of business excellence in marketing and sales, Fast-CarCo).*

Fast-CarCo has a high degree of PI usage and high level of product innovativeness and follows a "facilitating and empowering configuration" for managing the interplay between PI and product innovation related activities. PI is used everywhere in the organization, in different functions (HR, finance, manufacturing, research, product development and engineering) with voluntary formality.

Under the facilitating and empowering configuration, the interplay between PI (practices, tools, approaches) and product innovation (process, activities) is managed by integrating PI and innovation-related activities. This is achieved through different mechanisms: the adaptive use of PI, PI voluntary formality and entrepreneurial orientation, process-oriented structure, and balanced performance indicators. As an example of adaptation, in R&D a lean visual factory tool is used to facilitate collaboration and six sigma is used to maintain rigour in the technology development process. The same is true with the product development area, where not using people's creativity is considered waste, a typical lean concept. According to the technical specialist in vehicle dynamics systems:

> *"If you're not utilizing your people correctly…, you know the seven wastes. They said seven plus people. And actually the thing that I spoke about where you're not using creative people for doing creative work, that counts as the eighth waste for me".*

Some years ago, Fast-CarCo moved to a process-based structure: for example, there are codified processes for strategy and leadership, research, HR, etc. These processes are improved and reviewed regularly and added to the shared portal. This process-oriented structure helps in maintaining rigour in the company. At the same time, using this configuration, Fast-CarCo facilitates an entrepreneurial-oriented environment by allowing employees to autonomously use PI, start new innovative projects in the research area, and separate teams to develop innovations. As another example, in 2016 Fast-CarCo launched a high-tech start-up company to develop app-based transportation solutions. This company has provided the autonomy and flexibility for developing new technologies. Additionally, Fast-CarCo uses performance indicators to balance excellence- and innovation-related goals. For example, forward- and backward-looking objectives are used as performance indicators in marketing teams (internal document, Fast-CarCo).

Overall the voluntary PI formality, the adaptive use of PI in the area, together with the autonomy and flexibility that is provided to employees could possibly facilitate the development of various types of product innovation. Here, PI acts as an indirect facilitator for innovation through maintaining rigour and structure for the technology and product development processes while, at the same time, allowing employees the flexibility to innovate. For instance, the Head of business excellence in sales and marketing described the benefits of using PI:

> "*If people know they have process, know they can rely on process to see them through any situation, that would give them the mental capacity to be able to sit back, take the kind of helicopter view of what they're doing and how they're doing it, and perhaps start to think in a more innovative manner about how could I get the same result differently? Or how could I get a different result? Or what are the different results might I want to get?"*

6.4.3 Operational configuration

> *"I think the focus from R&D and from [manufacturing] is very different. It's probably not as well aligned. Where R&D's focus is to have innovative products and better products that are, you know, first in class, they are new, they are different, […]. Whereas, [manufacturing], obviously, is focused on efficiency, you know, driving costs down, compliance to the regulators' requirements, so that's quite key for [manufacturing]" (Product introduction lead, Innovative-PharmaCo).*

Innovative-PharmaCo displays high product innovativeness and limited use of PI. Here, the interplay between PI and product innovation related activities is managed through the use of an "operational" configuration whereby PI is used only in manufacturing. At the same time, PI is a priority in that area; as a director in product design and development stated:

> "*PI is a religion in [manufacturing]"*

Under this configuration, the interplay between PI (practices, tools, approaches) and product innovation (process, activities) is managed through separation, as PI and innovation happen in different areas of the business and are disconnected from each other, as PI is considered inapplicable for the R&D and product development areas. For example, a director in product design and development argued:

> *"I would say our approach is night and day in terms of similarities".*

In R&D, employees are given the flexibility and resources to generate and develop new ideas. This entrepreneurial-oriented environment is created through flexibility that is given to employees in R&D and is seen as contributing to the development of different types of innovation (radical and incremental). However, this is not without disadvantages, as it creates inefficiencies and delays in the innovation process. Moreover, this flexibility has led to initiating projects that proved not feasible. For example, the global commercial lead explained:

> *"I think it has led to more innovation for sure. But not necessarily innovation that could be executed. … So there were great ideas of new areas to explore … Very new, very novel. But then when tried to either take them into legal trials or there was a marketable opportunity or*

a willingness to potentially pay the cost of those therapies, it was [not] reliable, it was not feasible. So, I think it generated a great idea more of which were not feasible for the organization".

Another contributor to this disconnection between manufacturing and R&D is the stage in which the manufacturing area gets involved in the innovation process. Manufacturing involvement is at the very end of the drugs development process (the last 2-0.5 years) while it takes around 15 years to develop a new drug. This late manufacturing involvement contributes to the separation between R&D and manufacturing and, therefore, the area in which PI is used in (manufacturing) areas that innovation is developed in (R&D and product development). Therefore, in Innovative-PharmaCo, when using "operational configuration" for managing the interplay between PI and innovation, PI is regarded as irrelevant for innovation as the two happen in two separate locations and are disconnected to each other.

6.4.4 Project-based configuration

"[Cheap-CarCo] obviously has embraced lean, but it hasn't had that longevity yet, so it's still learning. What it is doing, it recognizes the value of lean and can see from people who work in General Motors and Ford and Toyota, and it's been able to sort of pick pieces to start to mould its own version. Which it's doing" (head of advanced product creation and lean facilitator, Cheap-CarCo).

Cheap-CarCo displays low use of PI and focuses on improving current products. For example, the head of propulsion and innovation at Cheap-CarCo elaborated:

"[Cheap-CarCo] is typically a relatively low-end car manufacturer: We make cars that are very simple, not very feature-rich".

Cheap-CarCo uses a "project-based configuration" for managing the interplay between PI and product innovation-related. This configuration is characterized by isolated PI scope and voluntary PI formality. Here, PI is mainly used in the manufacturing area and occasionally in other areas including engineering and product development. Overall, the main mechanism that is used to manage the interplay between PI (practices, tools, approaches) and product innovation (process, activities) under this configuration is "separation", which is achieved through the flexibility that is given to employees, first by making the use of PI voluntary, and, second, by running improvement and innovation initiatives to encourage employees' engagement in innovation and PI activities. These initiatives aim to develop innovation and excellence in the company as Cheap-CarCo is developing its innovative and PI capabilities. For instance, the head of propulsion and innovation in Cheap-CarCo described the aim of the innovation challenge:

> *"That's an incentivized innovation challenge which has a sort of merit award at the end of it which says, if your team idea or your individual idea is successful, then you get to form a team to start some work on it and you get some budget to do that".*

In addition, Cheap-CarCo recently adopted a new technology development process from another automotive company. This process is used to develop new technologies that were not used before and another process is used to improve current technologies. By doing this, Cheap-CarCo started to separate radical from incremental innovation processes. Given the separation using a "project-based" configuration, informants in Cheap-CarCo view PI as more applicable at later stages (manufacturing) of the product development than at earlier stages (R&D, design and engineering.

Table 34: Configurations for managing the interplay PI and innovation

	Strategic and holistic	**Facilitating and empowering**	**Operational**	**Project-based**
Case organization	Excellent-AeroCo	Fast-CarCo	Innovative-PharmaCo	Cheap-CarCo
Scope of PI	Pervasive	Pervasive	-Isolated: Confined to manufacturing	-Isolated: Dominant in manufacturing and occasionally used in other areas
PI formality	Expected	Voluntary	Expected in manufacturing	Voluntary
Interplay management (How the interplay between PI and product innovation related activities gets managed)	Integration	Integration	Separation	Separation
How the interplay between PI and product innovation-related activities is viewed	-Overall PI is regarded as an enabler for innovation	-PI as indirect facilitator for innovation	-PI regarded as irrelevant to innovation	-PI is seen as applicable mainly in the back end of product development process and as a barrier in the front end
Mechanisms for managing the interplay between PI and innovation	- ***PI usage***: PI adapted to the area that is used in. - ***Management systems*****:** Balanced performance objectives for both PI and innovation, balanced training (PI and innovation training, knowledge sharing portal) - ***Structural mechanisms***: Balanced PI and innovation teams	- ***PI usage***: PI adapted to the area that is used in. - ***Management systems*****:** Entrepreneurial orientation: flexibility to start new projects, balanced performance objectives for both PI and innovation - ***Structural mechanisms*****:** process-oriented structure	- ***PI usage***: PI not used in R&D and in product development - ***Management systems*****:** Entrepreneurial-orientation: flexibility to start new projects - ***Structural mechanisms***: PI and innovation happen in separate locations	***PI usage*****:** PI not used in R&D and in product development - ***Management systems*****:** Innovation and improvement championships

6.5 Summary of the findings chapter

This chapter consisted of two main sections. In the first, the main themes that emerged by comparing the case organizations were identified. These include: PI as a bundle of approaches; varying degrees of PI maturity and usage within the organization; and, different configurations for managing the interplay between PI and innovation in each company. The second stage of cross-case analysis was conducted at the level of NPD to identify the mechanisms which each case organization uses to manage the interplay between PI and innovation. This section showed that PI is viewed as complementary for innovation in different functions and at different stages of NPD (discovery, development, deployment) in the case organizations that use PI to a larger degree (Fast-CarCo and Excellent-AeroCo) by adapting PI to the area that it is used in. However, PI is seen as conflicting with innovation in the early stages of NPD in Innovative-PharmaCo and Cheap-CarCo which use PI to a lesser extent.

Finally, this chapter concluded with a presentation of the four configurations for managing the interplay between PI and innovation: Strategic and holistic in Excellent-AeroCo, facilitating and empowering in Fast-CarCo; operational in Innovative-PharmaCo; and, project-based in Cheap-CarCo. These configurations vary in the characteristics of PI (formality and scope), the mechanisms used to manage the interplay between PI and innovation, and the potential outcomes in terms of product innovation.

Overall, the findings show that the interplay between PI and innovation are shaped by different factors, some are related to PI characteristics, PI usage at different stages of NPD, viewed interplay between PI and innovation and viewed applicability of PI, and organizational mechanisms for managing the interplay between PI and innovation. Also, the findings highlight that the impact of PI on innovation depends on how, when and where PI is used in the organization.

CHAPTER 7: DISCUSSION

7.1 Introduction

Previous research on tensions and paradoxes have explored the management of various contradictory goals in organizations. One of the areas that is debatable in the literature of strategy, OM and innovation, is related to the interplay between PI and innovation. Predominantly, prior research has focused on identifying the intensity of the relationship between PI and product innovation (Benner and Tushman, 2002, Kim et al., 2012), the mechanisms in which this interplay exists and how PI interacts with innovation have been overlooked. To address this issue, this thesis *explores the interplay between PI and incremental and radical product innovation.* In particular, it begins with the two main research questions: *(1) What are the factors that play a role in shaping the interplay between PI and incremental and radical product innovation? (2) How do organizations manage the interplay between PI and incremental and radical product innovation-related activities and what effect it leads to?* Through unpacking PI and innovation features at four case organizations, varying patterns of the interplay between PI and product innovation-related activities and its management were observed. Several important findings emerged: first, multiple factors shape the interplay between PI and product innovation, these include: PI deployment characteristics, organizational factors, perceived PI and innovation interplay by managers. Second, four different configurations for managing the interplay were proposed: “strategic and holistic”, “facilitating and empowering”, “operational” and “project-based” configurations (See figure 13 and Table 34). Each configuration has its associated mechanism and potential outcomes. Third, three aspects that reflect PI deployment were identified, namely, PI scope, PI formality, and PI usage. Fourth, depending on the configuration, in some cases PI and innovation-related activities co-exist and become integrated into the same place, in other cases they become managed through separation. Fifth, PI was identified as a bundle of approaches. The emerged findings open the black box of the interplay between PI and incremental and radical product innovation and clarify the link between the two (Benner and Tushman, 2002, 2003, 2015, Kim et al., 2012). Essentially, the research highlights the complexity of the interplay and suggests that it is configurational. In particular, it posits the importance of “where” and “how” PI is used (formality, scope and usage) rather than focusing solely on “what” elements (e.g., practices, tools) of PI to use when considering the potential impact on product innovation. Furthermore, moving beyond the factory by exploring the interplay and its management across the organization, this research unveils various characteristics of PI that were not evident in its traditional settings (manufacturing units). Specifically, the findings elucidate the context-sensitive assumptions in relation to PI (Modig and Ahlstrom, 2012, Netland and Powell, 2017, Sousa and Voss, 2008, 2002), and propose PI as a mutable concept that gets shaped by the use and context in which it is used. The discussion now moves beyond the findings to elaborate their relevance to debates on PI, and PI and product innovation literature. This section concludes with presenting learning points and reflections to the wider debate on managing contradictory goals in organizations.

7.2 Process improvement

7.2.1 Process improvement as a bundle of approaches

The findings of this research contribute to the conceptualization of PI approaches. A considerable amount of research has been conducted on PI approaches such as lean, six sigma, TQM and TOC, by considering them separately. For example, many researchers have studied lean practices Shah and Ward (2003), (2007), TQM (Kaynak, 2003, Flynn et al., 1994) or six sigma ones (Schroeder et al., 2008). However, in the literature, these approaches have been defined in various and often overlapping ways. For example, some authors defined TQM as a broad concept that includes leadership, product design, process management and employees’ relations (Kaynak, 2003, Flynn et al., 1994), whereas others considered TQM as part of lean (Shah and Ward, 2003, 2007). The same is true for process management: sometimes it is narrowly defined as an element of TQM, other times it is considered as a broad concept that includes six sigma, TQM and lean (Benner and Tushman, 2003, 2015). These overlaps between the conceptualization of varying PI approaches have created confusion over the meaning of PI.

Moreover, while researching PI approaches as discrete ones is good for construct validity (Sousa and Voss, 2002), setting boundaries between these concepts appears artificial in practice as this assumes that these concepts are unambiguously translated from theory to practice and between companies/areas as systems that have clearly defined boundaries (Zilber, 2006) and cannot be mixed together.

Researching PI approaches as discrete approaches can possibly be as a result of two main reasons: First, PI approaches have been developed at different points in time, have come from different roots and have different priorities (Slack et al., 2013, Slack, 2017). For example, lean focuses on improving the flow (Modig and Ahlstrom, 2012), six sigma prioritizes reducing variations and defects (Schroeder et al., 2008) and TQM focuses on improving the quality of the products (Westphal et al., 1997, Hackman and Wageman, 1995). Second, this can be due to the dominant perspective on PI approaches as efficiency-oriented practices that consist of tools (Bourke and Roper, 2017, Hines et al., 2004), without considering the interaction between PI and the context it is implemented in and the people that are using it.

Moving beyond the view of PI as distinct types of approaches, this research has reconceptualised PI as a bundle that includes different approaches such as lean, six sigma, TQM and TOC. As the findings suggest, this bundle evolves over time because of different factors and organizational events such as a company's history, leaders' preference, mix of talents, types of industry and the area in which PI is used (R&D, product development, manufacturing, etc.). Therefore, this research proposes that PI is a dynamic set of processes and practices that are shaped and reshaped over time by the context that they are used in. What emerges is therefore a bundle which blends together various characteristics of PI approaches that create company-specific or plant-specific approaches (e.g., Crute et al., 2003, Netland, 2013). While the proposed bundle conceptualization of PI aligns with the holistic view of PI approaches (as a comprehensive set of different practices rather than a single one) (e.g., Shah and Ward (2003; 2007), de Treville and Antonakis (2006), Kim et al. (2012)), this research departs from this view by abstracting PI as a holistic set of various approaches (lean, TQM, six sigma etc.), rather than a set of practices/tools (e.g., employees' engagement, top management support, DMAIC, Kanban etc.).

Therefore, this study advances previous research in three main ways. First, conceptualizing PI as a bundle of approaches leads to considering how PI is defined and implemented in organizations (Westphal et al., 1997), rather than imposing predetermined assumptions of what PI is. Second, this research has identified certain factors that have contributed to the creation of these bundles. These include leaders' preference, mergers and acquisitions, changes in ownership, changes in strategic priorities, growth and downsizing, etc. In this study, these factors were observed and recalled by the research informants; however, there might be others connected to other contexts. Previous research suggests that organizations adopt PI because of institutional pressures and efficiency reasons (Westphal et al., 1997, Zbaracki, 1998). Others stress the importance of leadership support for the implementation of various PI approaches such as lean, TQM and others (Naor et al., 2008). However, why attributes of PI bundles change over time and how various organizational events contribute to the deployment and creation of PI bundles have rarely been discussed. Therefore, these contributors to the creation of PI bundles point to the fact that different PI approaches are brought by various interest groups (e.g., leaders, PI specialist), at different points in time and through various organizational events. For instance, in Fast-CarCo, various organizational events have contributed to the expansion of the used PI toolset over time, including the deployment of six sigma based on FastCarCo-first-owner preferences, followed by the growth in employees' mix of skills and talents.

Third, different PI approaches are used in different areas in the case organizations. Most of the previous research has dominantly discussed the use of various PI approaches in production units and factories (Marodin et al., 2018). However, some research considers the implementation of certain PI approaches such as lean and design for six sigma in product development (Rossi et al., 2017, Ward, 2007). Nonetheless, previous research did not explicitly discuss whether a certain PI approach is more suitable in certain areas or in others. This research, instead, found that certain approaches are more applicable in specific units. For example, in Excellent-AeroCo, six sigma is more dominant in manufacturing and lean in people-oriented areas such as engineering and design. Since multiple areas get involved in innovation and given that various PI approaches are used in different areas, examining different PI approaches in isolation may not be helpful in exploring the interplay between PI and product innovation-related activities. In other words, the outcome cannot be explained by a single approach in one function given that multiple functions become involved in creating the innovation outcome (Ittner and Larcker, 1997, Swink and Jacobs, 2012).

In similar vein, the existence of the PI bundle suggests that detangling the effect of one specific PI approach (e.g. six sigma, lean) on performance can be inaccurate (Swink and Jacobs, 2012), because it is a part of a wider whole that is shaped by various PI approaches characteristics. As "Hackman (1983) argued: If our attempt to understand [performance] focuses on single causes, we are unlikely to generate a coherent understanding of the phenomenon. There are simply too many ways to get there from here, and the different routes do not necessarily have the same cause" (Ittner and Larcker, 1997, p. 530).

7.2.2 Expanding the dimensions of Process improvement deployment

By comparing the use of PI approaches in the case organizations -*Excellent-AeroCo, Fast-CarCo, Innovative-PharmaCo and Cheap-CarCo* - it was uncovered that PI usage is multi-dimensional and contextual. Key attributes include: PI scope (the spread of PI in the organization and across functions), PI formality (whether PI usage is left to individual choice or expected from people in the organization), PI usage (adapting PI to the local context that it is used in or not using PI) and PI tools/practices (including technical and behavioural elements). These dimensions qualify a central element in PI research: the managerial factors that shape the implementation of PI in organizations (Karlsson and Ahlstrom, 1996b, Netland et al., 2015)

In past studies, many researchers have identified different tools, practices, and scales for implementing PI in the organization such as DMAIC, Kanban, 5S, waste elimination, customer focus, employees' involvement, etc. (Kaynak, 2003, Schroeder et al., 2008, Shah and Ward, 2003, Bortolotti et al., 2015). In doing so, scholars in operations management have discriminated between hard (tools/techniques) and soft (behavioural) elements of PI (Bortolotti et al., 2015, Choo et al., 2007a, Zeng et al., 2015). Different terms were used in the literature to describe the behavioural and technical practices of PI such as core and infrastructure (Naor et al., 2008), methodological and contextual (Choo et al., 2007a) or socio-technical system (Shah and Ward, 2003). In doing so researchers have stressed the significance of considering both the technical and the behavioural elements of PI to get the ultimate benefit of PI implementation (Choo et al., 2007a, Naor et al., 2008, Swink and Jacobs, 2012). However, many of previous research were tool-focused (Hines et al., 2004, Modig and Ahlstrom, 2012). The findings of this research support previous research arguments that suggested that PI approaches are more than just a set of tools and highlighted the importance of the use of the behavioural practices in PI implementation.

However, the extensive focus on identifying PI practices and tools "neglected to examine variation in the form of adoption itself or in implementation" (Westphal et al., 1997, p. 366). And thus, aspects regarding: "how PI is used", "where is used", and "who will use PI" in the organization, were rarely noticed. This study addresses this through adding three different dimensions, namely PI formality, PI scope, and PI usage. While these dimensions may resonate with some of the concepts that were discussed in the literature, including- the "breadth" of lean in factory (Netland and Ferdows, 2016), the "top-down and bottom-up" approaches for lean implementation (Chay et al., 2015), and the concept of employees' involvement in PI implementation (Zeng et al., 2015)- the emerged dimensions differ in reflecting the deployment of PI across the organization and not simply in the production unit. Considering the deployment of PI beyond the factory is crucial in capturing the ultimate benefit from PI (Marodin et al., 2018) in creating better value for customers, and in improving business performance (Jones and Womack, 2017, Womack and Jones, 1994).

From a different angle, this research contributes to the debate around employees' participation in PI initiatives (Lam et al., 2015, Netland et al., 2015) by identifying PI expected formality-which associated with clear responsibility and accountability toward PI, dedicated teams, and performance measurement system- as a dimension that helps in achieving commitment between employees toward PI and in sustaining the improvement benefits (Holweg et al., 2018, Netland et al., 2015). For instance, through following an expected PI formality, *Excellent-AeroCo* and *Innovative-PharmaCo manufacturing* have maintained employees' engagement in PI initiatives.

Taken together, the various forms in PI deployment, in terms of the scope, formality, and usage dimensions may possibly explain the contradictory empirical findings on the impact of PI on organizational performance (Kaynak, 2003, Sousa and Voss, 2002, Netland et al., 2015, Fullerton et al., 2014). For Instance, if two organizations use the same tools but get deployed in different areas and in different ways, then the drawn outcome in terms of performance will be different.

7.3 The link between Process improvement & innovation literature

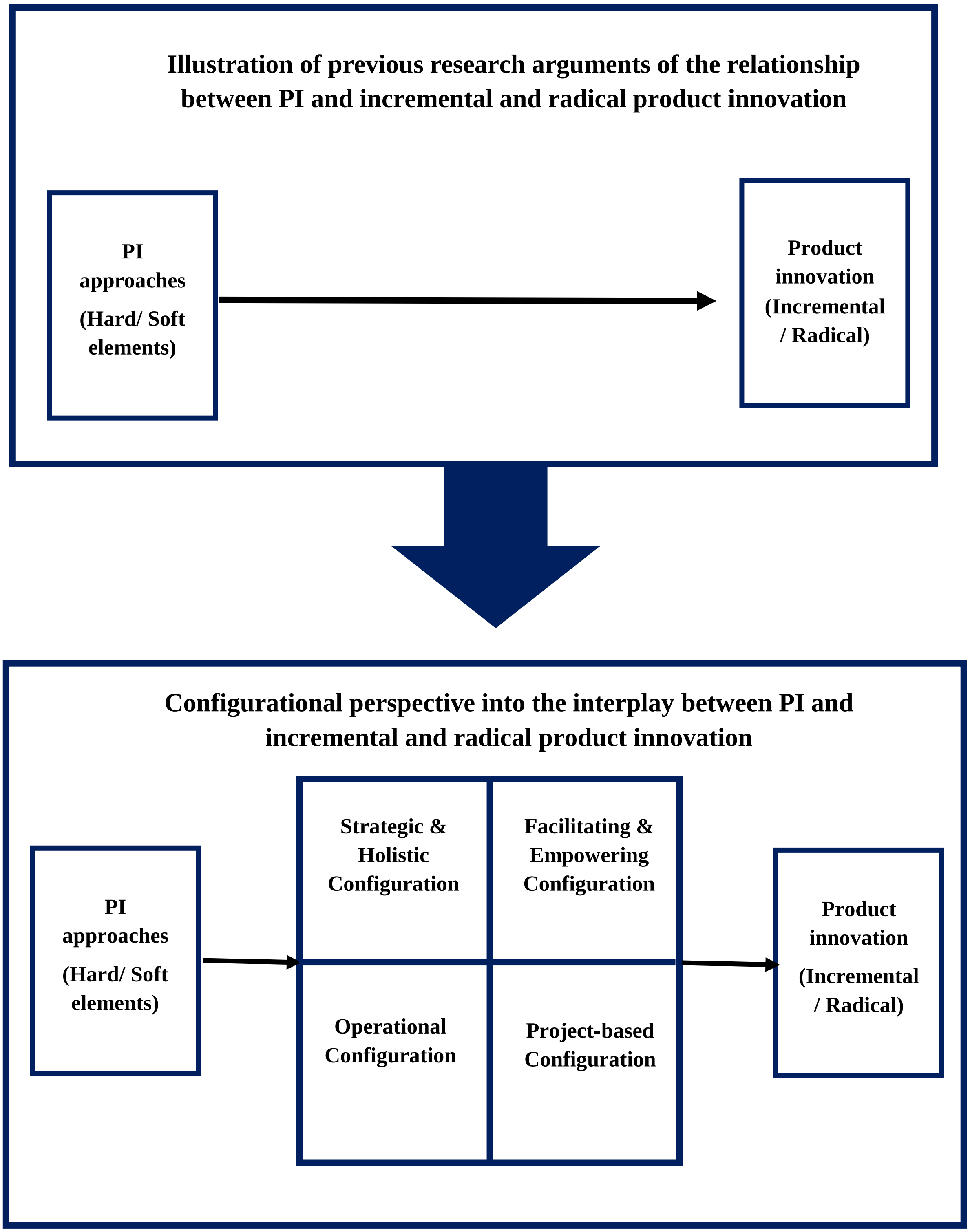
7.3.1 Configurational view for the interplay between Process improvement & product innovation

A sizable amount of research has been conducted on the relationship between different PI approaches and product innovation. The literature is divided into two main streams. The first stream of research, based in the operations management literature, argues that PI approaches are beneficial for organizations' performance and have a positive impact on innovation (Kim et al., 2012). This stream of research argues that PI helps in creating a learning environment that facilitates knowledge creation, exploration and both incremental and radical innovation (Gil-Marques and Moreno-Luzon, 2013, Gutierrez Gutierrez et al., 2012, Choo et al., 2007b, Hung et al., 2010, Moreno Luzon and Valls Pasola, 2011, Moreno-Luzon et al., 2014, Perdomo-Ortiz et al., 2006). On the other hand, strategy and innovation management studies have criticized productivity-oriented practices such as PI approaches (Abernathy, 1978). This stream argues that PI approaches are efficiency-oriented practices that drive rigidity, structure and standardization (Benner and Tushman, 2002, 2003, Lopez-Mielgo et al., 2009, Prajogo and Sohal, 2004, 2001). Therefore, PI approaches are seen as aligning with incremental innovation and stifling radical innovation (Benner and Tushman, 2003, Perdomo-Ortiz et al., 2006, Martinez-Costa and Martinez-Lorente, 2008). The first stream, therefore, advocates for a greater use of PI in organizations as this will improve productivity, efficiency and innovation. The second stream calls for reducing the use of PI, particularly in the non-manufacturing areas and in relation to innovation and product development processes.

The findings of this research depart from both of these streams and argue that the interplay between PI and product innovation related activities is configurational (Cardinal et al., 2019, Farjoun, 2010, Miller, 2017). In particular, the interaction between PI related activities and product innovation related ones depends on multiple factors and the used configuration ("strategic and holistic", "facilitating and empowering", "operational" and "project-based") (see figure 14). The identified typology suggests four manifestations of the interplay that vary in their scope and level of integration on one side and PI formality on the other. Moreover, these configurations differ in their associated mechanisms (PI usage, and managerial- and structure-related mechanisms) and potential outcomes (product innovation). Therefore, considering a greater use of PI as negatively related to product innovation, in particular radical innovation, may not be accurate. For example, if an organization is using the "operational" configuration in which PI is confined to the manufacturing area and separate from product innovation related activities, as in the case of Innovative-PharmaCo, then PI's effect on innovation is virtually unconnected. In other cases, where the "strategic and holistic" and the "facilitating and empowering" configurations are being deployed, PI is integrated in the innovation processes. Thus, in this case PI can act as an enabler or barrier for product innovation, depending on how PI is being used and its level of formality.

Thus, the findings of this research move beyond the intensity of the relationship between PI and innovation and suggest that the interplay is complex (Meyer et al., 1993). Accordingly, identifying the configurations of PI deployment and the interplay is a precursor to understanding the impact of PI approaches on product innovation. It helps in defining the multi-pattern of the interaction between constructs [PI and innovation] rather than focusing on the intensity of the examined interaction (Doty and Glick, 1994). Therefore, the findings of this research illuminate the underlying complexity of this relationship and propose more variety into the interplay between PI and product innovation and their related activities. The identified configurations and the different uses of PI in each one could possibly explain the contradictory arguments and the mixed empirical results in the literature (e.g., Benner and Tushman, 2002, Kim et al., 2012). In other words, the research findings suggest that the conflicting findings in the literature for the impact of PI approaches on innovation can be explained by the lack of understanding of different uses of PI and the varying patterns of PI and innovation interaction that could lead to different outcomes (Doty and Glick, 1994).

Figure 14: Illustration of the research contribution: Toward a configurational perspective of the interplay between PI and innovation



7.3.2 Dimensions that shape the interplay between Process improvement and innovation

This research has identified two main dimensions that characterize different organizational approaches for managing the interplay between PI and product innovation-related activities and its potential impact on product innovation. These are the *scope* and the *formality of PI*. These dimensions provide an important and missing element in PI usage and impact on innovation literature: A language that describes the use of PI in organizations and the interaction of PI with innovation. Taken together, these two dimensions can illustrate the ways in which organizations manage the interplay between PI and product innovation.

First, *PI scope (where PI is used)*: predominantly, in examining the impact of PI on product innovation, previous research has not been explicit regarding the location of PI deployment in the organization (Prajogo and Sohal, 2001, Kim et al., 2012)This can be due to the implicit assumption that PI approaches are dominantly used in the manufacturing units rather than various areas in the business. While some scholars investigated the use of PI in the NPD process- such as lean product development- (Helander et al., 2015, Sun and Zhao, 2010, Dalton, 2009, Tuli and Shankar, 2015), these studies usually focused on the impact of PI NPD on the innovation performance (e.g. in term of NPD speed), but its impact on product innovation was rarely considered. However, the findings of this research highlighted the crucial role of PI scope in shaping the potential impact of PI on product innovation as it determines whether PI is integrated or separated from the innovation processes. Without considering the locus of interaction between the two, the drawn impact of PI on product innovation might be misleading.

Second, *PI formality and usage (how PI is used)*: the importance of PI formality appears when comparing Excellent-AeroCo and Fast-CarCo, as both companies have a pervasive scope of PI and PI is integrated into innovation areas. However, Excellent-AeroCo follows a “strategic and holistic configuration” that involves expected PI formality. On the other hand, Fast-CarCo using an “empowering and facilitating configuration” which involves voluntary formality. In both companies, PI approaches are seen as facilitators for innovation. However, the standard and formal process in Excellent-

AeroCo seems to limit employees' capacity to explore new ideas. This is possibly because formal management approaches get perceived as controlling ones that hinder innovation (Amabile et al., 1996, P. 1162). Nevertheless, in Fast-CarCo, employees' autonomy was highlighted by informants as an important enabler for exploration and innovativeness. This is because the "autonomy around process fosters creativity because giving people freedom in how they approach their work heightens their intrinsic motivation and sense of ownership" (Amabile, 1998, p.82). Thus, in this case, autonomy is a key to creativity and innovation (Amabile et al., 1996).

In addition to the above, the findings highlight the importance of the intersection between how and where PI is used in the organization. This suggests that the use of PI (its tools and practices) in manufacturing and engineering is different from the use of PI in R&D and product development. For instance, DMAIC and lean gets used loosely in both R&D areas in Fast-CarCo and in product development in Excellent-AeroCo. This adaptive use of approaches (e.g. PI) to the local context is important to ensure their effectiveness, otherwise, the lack of practice adaptation can lead to negative consequences (Volberda et al., 2014). For instance, Canato et al. (2013) show that between 2000-2005, "3M implements standard DMAIC and DFSS procedures [six sigma tools], following the template popularized by Jack Welch and practised by Jim McNerney at General Electric" (p. 1734). Consequently, people in 3M perceive Six Sigma as a barrier and misaligned with the "fundamental and distinctive values of the organization (creativity, tolerance for mistakes, self-initiative)" and as a detrimental to innovation (Canato et al., 2013, p.1735). However, the findings of this research show that the adaptive use of PI help in facilitating an environment of trust, providing structure to the innovation processes and allowing a space for employees to innovate as it is the case in FastCarCo and Excellent-AeroCo. Thus, through adapting PI to the local context it is possible to "buffer the negative effect of structure on creativity" (Choo et al., 2007a, p.928), maintain flexibility and foster innovation. This is consistent with the stream of research that highlights the importance of PI in creating a learning environment for people to engage in exploration, innovation, and collaboration (Kim et al., 2012, Choo et al., 2007a).

Therefore, the findings qualify the previous research arguments that suggest that the impact of PI on incremental and radical product innovation depends on the implemented PI practices (technical and/ or behavioural practices) (Kim et al., 2012, Zeng et al., 2015, Antony et al., 2016 , Benner and Tushman, 2002). However, the findings emphasize that the potential impact of PI on product innovation (incremental /radical) depends on "where" and "how" PI is used in the organization rather than "what" elements to use. This means that PI can be used in various ways and thus, it has the potential to produce "dissimilar types of learning [explorative and exploitative] and knowledge" (Choo et al., 2007a, p.919). This, in turn, facilitates both incremental and radical innovation (Andriopoulos and Lewis, 2009, He and Wong, 2004).

7.3.3 Unpacking the interplay between process improvement and innovation

Previous research differentiates between the impact of hard and soft practices of PI on innovation (e.g., Kim et al., 2012). The soft practices concern "people and relations" and the hard practices are associated with "technical and analytical tools" (Bortolotti et al., 2015, P. 183). Some researchers argue that the soft and behavioural elements of PI are beneficial for facilitating innovation (Abrunhosa and Sa, 2008, Lin, 2009) others suggest that a combination of the two lead to better innovation performance (Bourke and Roper, 2017, Kim et al., 2012). Others focus on the hard side of PI (Benner and Tushman, 2002, 2003, Mehri, 2006, Parast, 2011) and differentiate the impact of PI on different types of product innovation including incremental and radical (Benner and Tushman, 2002, 2003). In this stream, PI is defined as practices that involve tools to maintain efficiency, standardization and adherence to processes and argue that process management initiatives, which include quality management and six sigma, can lead to incremental innovation and stifle radical innovation (Benner and Tushman, 2003).

Moving beyond the direction of the relationship between PI and product innovation, this research has revealed different factors that shape the interplay between PI and product innovation related activities, these include: PI usage (adapting or not using PI), the stage of the NPD process in which it is used (discovery, development, and deployment), and middle/ senior managers' views of the applicability of PI and the perceived interplay between PI and innovation.

The findings show that *the stage of the NPD* plays an important role in shaping the interplay and its impact on the product innovation. As the interplay at early stages of the NPD differs from those at later stages. For example, in Innovative-PharmaCo, PI is seen as inapplicable and a barrier for innovation; therefore, it is not used in the R&D and product development areas. It is used only in the manufacturing area for maintaining compliance to regulation. This finding illuminates the implicit argument of implementation that suggests the impact of PI is negatively associated with innovation when it is used at early stages in the NPD (e.g., discovery and selection stages). For instance, Benner and Tushman (2003) suggest that "as process management practices spread in an organization, the predominant measures of effectiveness are increasingly focused on speed, efficiency, and reductions in costs or waste. These dynamics lead to selecting innovations that leverage efficient, streamlined manufacturing or distribution processes or that utilize materials that are cost-effectively obtained from streamlined purchasing processes. Such innovations build on existing firm capabilities and tend to be closer to existing products" (p. 246). Others have found that PI approaches such as lean, when used in product development, "is positively correlated with the speed of the NPD" (Sun and Zhao, 2010, p. 351).

This research complements this argument by highlighting the importance of a second element - *the use of PI* at different stages of the NPD. This was clear in the case organizations that have a higher level of PI maturity (use PI to a larger extent). For example, in Excellent-AeroCo and Fast-CarCo, PI is adapted to the area that it is implemented in, for instance when PI is used in engineering, design, and product development areas in Excellent-AeroCo, PI is used in a way that is more relevant to people working in these areas. This finding qualifies the proposed coupling and decoupling of the methodological and contextual practices of six sigma that was proposed by Choo et al. (2007a); according to them "as contextual elements facilitate exploratory learning and methodological elements exploitative learning, loose coupling between these two sets of elements is likely to facilitate balancing of exploratory and exploitative learning" (p. 926). However, the research findings move beyond this idea of decoupling of the methodological (PI tools) and contextual (behavioural) practice and suggest a multi-use of PI through adapting PI to the stage of NPD. PI can play various roles in different areas and stages of the NPD. For instance, it can play the role of controller by providing a structure for the product development process, maintain rigour and meet regulatory constraints, a facilitator through allowing time and space for employees to spend time on innovation, and a gatekeeper by playing a role in filtering good ideas from wasteful ones. Therefore, the research brought forward the concept of PI adaptability in shaping the interplay between PI and product innovation-related activities.

Also, the findings highlight the crucial role of PI adaptation at the discovery and selection stage of innovation as the use of PI in these stages seems to make a difference between the meanings of waste. Distinguishing waste from non-wasteful ideas, and employees' time by managers, are crucial for drawing a line between waste and slack resources (Hill, 2018). As a consequence, these decisions lead to certain types of innovation as an outcome (Troilo et al., 2014). Radical innovation requires extra resources, experimentation and thinking time (Troilo et al., 2014). PI approaches have been criticized for reducing non-value-adding activities, eliminating waste and, therefore, reducing slack resources that are required for radical innovation (Benner and Tushman, 2003). The findings of this research contradict this argument and suggest that the possible negative impact of the process of eliminating waste depends upon "how PI is used" at the discovery and development stages. For example, through "adapting" PI to the area (e.g., R&D and product development) PI could be beneficial for innovation. Moreover, the positive and detrimental impact of PI in eliminating slack resources depends, in the first place, upon the ability of managers in distinguishing waste from slack that is required for innovation. This line of argument resonates with Nohria and Gulati (1996) who found an inverted U-shape relationship between the use of slack resources and innovation. Thus, it is important to reach a balance between too little and too much slack and, therefore, drawing a line between waste and slack resources. The use of PI is not a mindless process of following standards and deploying a plan, instead it is about learning and continuously challenging and improving the process to create better value for customers (Hung et al., 2011) and creating a learning environment that facilitates collaboration, knowledge creation and learning (Choo et al., 2007b).

The third element is the ways in which middle and senior managers view the applicability of PI. When it is regarded as inapplicable to the innovative areas, then PI is not used in areas such as R&D, design and product development. For example, in Cheap-CarCo the head of design viewed that PI stifles innovation and is, therefore, inapplicable to the design process. In other cases, PI is seen as a facilitator or irrelevant for innovation. For example, PI is used in innovation areas such as R&D in Fast-CarCo where PI is used as a facilitator to stakeholders' engagement and for maintaining rigour through the use of visual management and structured processes for technology development. This perspective aligns with the argument in the literature that stresses the role of managers in pursuing and running PI initiatives in the organization. Nevertheless, the findings illuminate that PI can used in the selection stages without being detrimental to innovation based on PI usage and the manager that is implementing it.

Taken together, the use of PI, the stage of the NPD, and the viewed applicability of PI and the viewed impact of the association of PI with the innovation activities by middle managers and senior leaders, shape the management of the interplay between PI and product innovation. Thus, this research illuminates that PI approaches are not necessarily detrimental for innovation (Benner and Tushman, 2003), but can play multiple roles in the NPD depending upon how PI is used. By adapting PI to the area that it is used in, it can be used to maintain rigour, compliance to regulation and, at the same time, be used to facilitate collaboration and learning. This argument supports the learning perspective that exists in the literature which argues that PI approaches create a learning environment that facilitate collaboration and knowledge creation (Gutierrez Gutierrez et al., 2012, Hung et al., 2011, Kim et al., 2012). In addition to the "use of PI" and the "stage of NPD", managers play a role in determining the potential impact of PI on the product innovation through distinguishing between waste, wasteful ideas and employees' time early in the NPD stage. Overall, this provides a nuance to previous research and contributes to explaining the mechanisms that shape the interplay between PI and innovation and its effect, therefore, it explains the missing "how" in the literature.

7.4 Beyond the Interplay between PI and Product Innovation: Reflections[16] on the ambidexterity and paradox literature

The final points relate to the original framing of this thesis, the research on managing contradictory goals in organizations. This section draws on the research findings and reflects on some of the assumptions and propositions that have been made by the research in this literature (Schad and Bansal, 2018, Schad et al., 2016, Smith and Lewis, 2011, Knight and Paroutis, 2017). Two main streams have been reflected on. First, the relationship between poles (sets of concepts that are considered as contradictory goals) (Lavie et al., 2010, Birkinshaw and Gupta, 2013, Gupta et al., 2006, Smith and Lewis, 2011). The literature on ambidexterity has often considered the interplay between two generic sets of concepts such as productivity-enhancing, standardization, efficiency, formalization, exploitation; and innovation, adaptability, flexibility and exploration, as dichotomic and in a dilemma (Benner and Tushman, 2002, 2003, 2015, March, 1991, Schad et al., 2016, Smith and Lewis, 2011, Lavie et al., 2010). In part, this is due to the underlying conceptualization of the relationship between these two poles of concepts as mutually exclusive and opposite to each other (Farjoun, 2010, Smith and Lewis, 2011). In the context of the productivity-dilemma, this can be due to the need for in-depth research for how productivity-enhancing activities interact with innovation and what kind of outcome this can lead to (Benner and Tushman, 2002, Kim et al., 2012). According to the dilemma perspective, organizations need to choose between either using PI or developing innovative products, in particular, radical types of innovation (Abernathy, 1978, Benner and Tushman, 2003). However, the research findings suggest that the relationship between these concepts can be not only conflicting but also configurational.

The configurational view of the interplay suggests that there are multiple factors shaping the relationship between productivity-enhancing activities and innovation. Indeed, there is more variety to the interaction between PI and product innovation-related activities than previously assumed. Instead, the relationship depends on the locus of interaction and "how" and "where" PI and innovation-related activities interact with each other. For instance, the emerged configurations suggest that in some cases PI gets used in

[16] This section draws upon the research findings to reflect on the literature on ambidexterity. These reflections can be explored with more depth by further research.

the areas where innovation is discovered and developed. However, in other cases, PI is used in areas where innovation is deployed (implemented) solely. For instance, through adopting the operational configuration at Innovative-PharmaCo, the use of PI approaches is confined to the manufacturing area and not implemented in other areas where product innovation is developed. Thus, PI usage is considered as disconnected from innovation in this context. In other cases, for example, in Fast-CarCo, PI is integrated across the organization and at the innovation discovery and development areas. Here, PI is regarded as a facilitator for innovation rather than a barrier; so, PI and innovation-related activities interact in a complementary manner. Therefore, the interplay is not necessarily conflicting (either/or relationship), but rather it can be complementary (both/and relationship) (Smith and Lewis, 2011). Accordingly, there is more complexity in relation to the interplay between productivity-enhancing activities and innovation and overlooking this variety risk by oversimplifying the complex reality of organizations (Cardinal et al., 2019, Farjoun, 2010, Miller, 2017).

Given that, the configurational view of the interplay between PI and innovation suggests that the interplay between various related poles such as exploration and exploitation, control and creativity, efficiency and flexibility, is more diverse than a simple dichotomy. Hence, the proposed view aligns with previous research that questioned the accepted unidimensional understanding of different organizational practices, such as bureaucracy, control systems and PI (Adler and Borys, 1996, Simons, 1995, Sitkin et al., 1994, Schroeder et al., 2008). Conversely, bureaucracy can be both enabling and coercive (Adler and Borys, 1996, Adler et al., 2009), control systems have a diagnostic use and an interactive use (Pešalj et al., 2018, Simons, 1995), performance information can have passive and purposeful uses (Micheli and Pavlov, 2017). Stability can foster change and vice-versa (Farjoun, 2010). While this thesis does not draw upon these precedents, the proposed configurational perspective of the interplay between PI and product innovation-related activities, shares with them the questioning of the either/or approaches toward managing various poles and calling for a richer view for tensions management (Farjoun, 2010).

The second stream reflected on relates to the research on managing contradictory goals in organizations (Calabretta et al., 2017, Poole and Van.de.Ven, 1989). Overall, the literature on paradox and ambidexterity suggest two main ways to deal with tensions and paradoxes: "integration" and "separation" (Andriopoulos and Lewis, 2009, Smith and Tushman, 2005). Dominantly the research suggests a structural separation at the organizational level by having two business units in which one would focus, for example, on exploration and the other on exploitation activities (Tushman and Oreilly, 1996). In addition, others suggest a contextual approaches (Gibson and Birkinshaw, 2004) through creating an environment for individual to manage tensions and be able to "wear two hats" (Ambos et al., 2008, P. 1433). Overall, the findings align with the proposition of pursuing a structural separation as a solution to the efficiency and innovation tension (Benner and Tushman, 2003, 2015), as is the case with the use of the operational configuration (at Innovative-PharmaCo); however, structural separation is not necessarily the only solution (Gibson and Birkinshaw, 2004) but, rather, productivity and efficiency enhancing activities can be integrated to the innovation areas through adapting them to the local needs as is the case at FastCarCo and Excellent-AeroCo. With respect to the previously mentioned, the findings of this research align with a paradoxical way of thinking (Schad and Bansal, 2018, Schad et al., 2016, Smith and Lewis, 2011), that suggests that various poles can co-exist in a complementary and integrated manner.

Additionally, considering the management of the interplay between PI and product innovation-related activities across functional units, the findings highlight the role of functional and senior managers in shaping the organizational approach for managing contradictory goals (i.e., PI and innovation). For instance, findings show that functional managers can adapt PI to the area that it is used in (FastCarCo and Excellent-AeroCo); or, alternatively, not using PI in association with the product innovation-related activities (Innovative-PharmaCo and CheapCarCo). This depends upon the viewed applicability of PI to their working areas and the viewed potential impact of PI to innovation. For instance, despite the design manager in CheapCarCo being a certified black belt, he discourages the use of PI in the design functional areas since he views PI as a rigid process that is "conflicting" with innovation, and thus inapplicable to the design function. However, the opposite can be applied to other cases. For example, the head of research at FastCarCo views PI approaches as applicable and as "complementary" to the innovation activities;

hence, PI tools get adapted to the research area through, for example, using DMAIC[17] in a less structured way (see tables 33, A-D). This line of argument suggests that managers across functions can possibly shape the overall approach for managing contradictory goals at the organizational level - through separation/integration - based on their perception of the interplay and whether they decide to use PI (and other associated concepts and practices) or not in their functional units and at different stages of the NPD. Altogether, this depicts a horizontal approach for managing contradictory goals (in this case PI and innovation) across functions. Therefore, this builds on the proposed multi-levels and vertical approach for managing contradictory goals and pursuing ambidexterity (Papachroni et al., 2016, Andriopoulos and Lewis, 2009). For instance, Andriopoulos and Lewis (2009) identify a multi-level approach for managing nested innovation tensions in organizations through integration and differentiation. Papachroni et al. (2016) further elaborate that managers' perceptions of the interplay between efficiency and innovation shape their approach for managing this tension at both the corporate and middle manager level. According to them, middle managers deal with the tension between efficiency and innovation through reconceptualising innovation as continuous improvement. Thus, highlighting the role of functional managers' perception and actions as one of the factors that plays a role in managing the interplay between PI and innovation, suggests that a horizontal approach (Kassotaki et al., 2018) for ambidexterity across function and at the NPD level can be an important avenue to be explored further by future research on ambidexterity.

Overall, the findings on PI and innovation interplay fit with the recent call for a more complex and configurational perspective for pursuing ambidexterity and dealing with paradoxes (Raisch et al., 2018, Zimmermann et al., 2018, Schad and Bansal, 2018). Also, findings align with researchers that suggest a dynamic process for managing conflicting and contradictory goals in organizations (Andriopoulos and Lewis, 2009, Jarzabkowski et al., 2013, Papachroni et al., 2016, Duncan, 1976).

[17] DMAIC is a structured problem-solving tool commonly used when implementing six sigma

7.5 Chapter summary

This chapter discussed the research findings' contributions in light of the previous research in PI and its impact on innovation and ambidexterity and paradox literature. The research findings extend the literature of PI in two main ways: First, by shifting the conceptualization of PI from discrete approaches to PI as a bundle of approaches and identifying different factors that shape the bundle of approaches. Examining PI as a bundle facilitates understanding the impact of PI on product innovation. Second, by expanding the characteristics of PI deployment in organizations. This is achieved by identifying additional dimensions for the use of PI in organizations; this involves PI formality, PI scope and PI usage, in addition to PI aspects (practices). These dimensions stress the importance of the contextual and managerial factors when deploying PI.

The second stream of research that the findings of this thesis contribute to is that of discussing the impact of PI on innovation. Four configurations for managing the interplay between PI and product innovation were identified. Each configuration has its own characteristics and associated mechanisms. These are "strategic and holistic", "facilitating and empowering", "operational", and "project based "configurations. These emerged configurations suggest that the interplay between PI and product innovation is configurational. Moreover, the findings of this research move beyond the intensity of the relationship between PI and product innovation and identify different factors at the NPD level that interact to shape the interplay between PI and product innovation-related activities and its potential effect. These include when PI is used in the NPD (NPD stage), how PI is used (adapted to the area or not used), viewed PI applicability and viewed interplay between PI and innovation by senior/functional managers (complementary, conflicting). Thus, the contributions to this literature are three-fold. First, providing a language for elaborating the interplay between PI and product innovation in organizations. Second, identifying four configurations for managing the interplay and its possible effect. Third, moving beyond the direction of the relationship between PI and product innovation and identifying different factors for shaping the interplay between their associated processes, practices and activities.

Finally, drawing on the research findings on exploring the interplay between PI and product innovation-related activities, the research provides some insights into the wider literature on managing contradictory goals in organizations (including the literature on ambidexterity and paradox) that can be explored deeply by further research. These insights include: First, the research proposes a configurational view to the relationship between different contradictory goals. Second, the findings qualify the research concerning managing contradictory goals and pursuing ambidexterity in the organization. This is by building on the multi-level vertical ambidexterity and suggesting that a horizontal approach for managing contradictory goals across functional units (and at the level of the NPD), is a potential path toward ambidexterity.

The next chapter will conclude the thesis and discuss avenues for future research and research implications for practice.

CHAPTER 8: CONCLUSION

8.1 Overview

The primary aim of this thesis has been to explore the interplay between PI approaches and product innovation. Drawing on the findings of four multiple case studies in multinational product-based organizations, four configurations for managing the interplay between PI and product innovation emerged. These are: “strategic and holistic”, “facilitating and empowering”, “operational”, and “project-based”. In doing so, this research contributes to both management theory and practice. This chapter summarizes these contributions, practical implications, and suggests directions for future research.

8.2 Summing up the contributions of the thesis

This research is grounded in the literature on contradictory goals management (Abernathy, 1978, Adler et al., 2009, Andriopoulos and Lewis, 2009, Benner and Tushman, 2003, Raisch and Birkinshaw, 2008, Smith and Lewis, 2011, Schad et al., 2016), such as ‘exploitation and exploration’ (Andriopoulos and Lewis, 2009), ‘efficiency and innovation’ (Papachroni et al., 2015), ‘alignment and adaptability’ (Gibson and Birkinshaw, 2004), ‘incremental and radical innovation’ (Cardinal, 2001, Dewar and Dutton, 1986), ‘standardization and creativity’ (Gilson et al., 2005) and ‘efficiency and flexibility’ (Adler et al., 1999). This literature usually views PI and innovation and their associated practices, activities and tools as mutually exclusive or separate from each other (Birkinshaw and Gupta, 2013, Gupta et al., 2006, Lavie et al., 2010). Arguably, this stream of research has looked at the interplay between various concepts at too a high level for example bundling various concepts and portraying in dichotomic ways. For example, productivity, formalization, improvement, standardization, stability, exploitation and efficiency have been seen as opposed to innovation, adaptability, change, exploration and creativity (Benner and Tushman, 2003, Schad et al., 2016). While this merging of various related practices and activities may facilitate generalizability, this perspective may be inaccurate as it overlooks the complexity of the empirical phenomena (Adler and Borys, 1996, Farjoun, 2010).

This thesis has therefore further investigated the relationship between PI and innovation, challenging apparent dichotomies, eventually re-conceptualizing the interplay between PI and product innovation-related activities, and providing insight into how this interplay could be managed. Specifically, this research empirically demonstrates that PI and innovation related concepts, practices and activities are not necessarily in opposition (Abernathy, 1978, Adler et al., 2009, Benner and Tushman, 2015). Indeed, PI can be an enabler, a barrier or an irrelevant factor when considering an organization's capacity to innovate, as its effects depend on how PI and innovation interact, and whether related activities are integrated or separate from each other. Thus, this thesis offers a configurational explanation for the divergent arguments that exist in the literature regarding the relationship between PI and innovation (Benner and Tushman, 2003, 2002, Choo et al., 2007a, Kim et al., 2012, Schroeder et al., 2008). In so doing, it presents findings that incorporate the learning and the control perspectives on the impact of PI on product innovation that were mentioned in the literature, but also moves beyond that by identifying various configurations for managing the interplay between PI and product innovation and its effect. In other words, how PI related activities and innovation related activities (e.g. processes) interact with each other shapes the outcome in term of product innovation. (See sections 6.3 and 7.3.1).

Additionally, this research shows that multiple factors matter, including *when* PI is used in NPD, *how* is it used, and how senior and middle managers regard its links with innovation. For example, the positive or negative impact of various PI approaches on product innovation appear to depend on whether they are used in the early stages of the product development process (discovery, development), whether PI is adapted to the context, and whether senior and middle managers view PI as either complementary or conflicting with innovation. (See sections 6.2.4 and 7.3.3)

In relation to the PI literature, this research qualifies the conceptualization and deployment of PI. Rather than defining PI as discrete approaches (Bortolotti et al., 2015, Swink and Jacobs, 2012, Kim et al., 2012), this study highlights that PI is a bundle of various PI approaches that are combined over time through a number of organizational events (e.g., change in leadership). (See sections 6.2.1 and 7.2.1). Moreover, this study suggests that PI deployment does not consist only of tools and practices; on the contrary, it is multi-dimensional and includes PI formality, scope, and usage. These dimensions provide a framework for the deployment of PI at a higher level of abstraction. (See sections 6.2.3.2 and 7.2.2).

The research findings also, provide insights for the ambidexterity and paradox literature that can be extended by future research. These include: first, findings offer a different perspective to the productivity dilemma and the tension between efficiency and innovation by suggesting that productivity and efficiency enhancing activities are not necessarily determinants for radical innovation, but instead, the interplay is configurational. While in some cases PI approaches can co-exist with innovation activities and, even further, they may facilitate the development of radically innovative products, in other cases, PI can act as a barrier for radical type of innovation. Second, this research proposes that managing contradictory goals can be done not only at the organizational level or vertically across hierarchal levels, but that it can be pursued horizontally across functional units. Based on the senior and middle managers views of the potential influence of the association between PI and product innovation related activities (conflicting or complementary), PI could be used or not in different functions. (See sections 6.3 and 7.4).

Overall, this research provides fruitful insights from an operations management perspective into the literature on managing tensions and contradictory goals, by opening the black-box of the interplay between PI and product innovation related activities and suggests that there is much more variety beyond the dilemma perspective over the impact of PI on product innovation. Table 35 provides a summary of the main research contributions.

Table 35: Summary of the main research contributions

Target literature	Previous research argument	Research contribution
PI	• PI approaches, such as lean, Six Sigma, TQM and TOC, are considered separately as discrete approaches (Shah and Ward, 2003, 2007, Schroeder et al., 2008, Flynn et al., 1994)	**PI as a bundle of approaches:** • This research re-conceptualizes PI as a set of approaches. This "bundle" evolves through the introduction and use of various PI approaches over time. Different organizational events shape the characteristics and the creation of the improvement bundle, such as the history of PI usage in the organization, leadership the area in which PI is used in, the mixed of talents, industry.
	• PI approaches consist of a set of practices / elements including both tools and behavioural practices (Bortolotti et al., 2015, Choo et al., 2007a, Zeng et al., 2015, Naor et al., 2008)	**Expanding the characteristics of PI:** • The findings of this research expand PI deployment characteristics to include different dimensions: scope, formality, and adaptation in addition to PI tools. These dimensions shift the conceptualization of PI from PI as a set of practices -by only considering "what" tools to implement- to regarding PI as a contextual concept by considering "how", and "where" PI (approaches, tools, practices) are used in the organization.
The link between PI and innovation	• There are two contradictory arguments in the literature regarding the impact of different PI approaches on product innovation. One argument view PI approaches as efficiency-oriented and rigid practices that hinder innovation in particular radical innovation. The other argument views PI approaches as beneficial practices that create an environment of trust, collaboration and learning that facilitate innovation. Also, empirical research showed mixed results (Benner and Tushman, 2002, 2003, Kim et al., 2012, Choo et al., 2007a, Schroeder et al., 2008). • Previous research on the impact of PI on innovation focus on the intensity and the direction (positive /negative) of the relationship and missed "how" PI & innovation interact with each other (Kim et al., 2012). • Previous research focuses on identifying the appropriate tools/ practices (*what*) that can enable/hinder product innovation (Benner and Tushman, 2002, 2003, Kim et al., 2012, Choo et al., 2007).	**Configurational view for the interplay between PI and product innovation** •The findings of this research suggest that PI and innovation relationship is configurational. This suggests that the interplay gets shaped by different factors in the organization. In particular, four configurations have emerged from the data, these are: Strategic and holistic, Facilitating and empowering, Operational and Project-based. •Also, the interplay between PI and innovation and the potential outcome in term of product innovation depends on the used configuration. In some cases, PI and innovation might be segregated from each other and thus PI is irrelevant to innovation, in other cases, they can be formally and loosely integrated.
		Unpacking the interplay between PI and innovation in organizations: •This research moves beyond identifying whether the relationship between PI and innovation is positive or negative, instead, it argues that the relationship depends on "how" PI is used, "when" PI is used in the NPD and the middle/ senior managers views of PI applicability in the innovation areas.
		Identifying two main dimensions that shape the interplay between PI and innovation • Expanding previous research findings by identifying two dimensions for managing the interplay between PI and innovation: the *scope of PI usage* and the *formality of PI*. Thus, this research provides a language for articulating the interplay between PI and innovation. • The intersection between these dimensions highlight the importance of the deployment of PI (scope and formality) in shaping the product innovation. • Highlights the importance of *where* and *how* PI is used in the organization, and the intersection between the two, in shaping the potential product innovation (incremental / radical).

8.3 Limitations

This study is not without limitations: first, findings are drawn from multiple case studies and are therefore limited in their generalizability. However, the main purpose of this research was not to generalize across other settings, but rather to explore how organizations deploy PI and manage the interplay between PI and product innovation-related activities and its impact. Thus, the findings of this research may be applicable in other similar contexts (product-based organizations). For instance, this research stressed the importance of PI deployment dimensions (including the scope, formality, and usage of PI) and these dimensions can be considered in different context were PI and innovation goals considered as essential part of the business. Further research could explore the pervasiveness of the research findings.

Second, since organizations were sampled to achieve maximum variation in terms of PI usage and product innovativeness, organizations from various industries were selected. This limits the possibility of drawing causal relationships between the identified factors that shape the interplay between PI and product innovation. As Doty and Glick (1994) noted, one of the limitations of typology research is "inadequately developed because the causal processes operating within each type of organization are not fully specified" (P. 230). Thus, future research is encouraged to test the relationship between these factors and explore causality where possible. For instance, it will be interesting to explore whether PI formality (expected, voluntary) lead to a certain type of innovation (radical or incremental and what is the role of the managerial and structural factors in shaping this impact.

Third, the case organizations' positioning in the sampling matrix (high/low PI usage and high/low product innovativeness) may have been affected by the researcher's interpretation of the organizations' characteristics. However, this subjective element was addressed in three main ways. First, different sources of evidence were consulted (Voss et al., 2002), including company documents, interviews, and industry documents. Second, the researcher drew conclusions on the basis of the perspectives of multiple informants from various functional specialism. Third, previous research was used to support the researcher's evaluation of the extent of PI usage and product innovativeness in the case organizations.

Fourth, due to data access limitation in some of the case organizations, the number of interviews varies between the cases. However, this issue was addressed by, first, using multiple data sources including companies' online documents and internal documents were possible. Second, meeting people from multiple units/ functional specialism to get a divergent perspective on the topic of interest.

8.4 Future research

This research suggests that the interplay between PI and product innovation exists in various Configurations and is shaped by different factors. This thesis opens fruitful avenues for future research. First, this study encourages scholars to consider not only the impact of PI approaches on innovation, instead, but scholars should also take a step back to identify the used configuration first and then test the effect of PI on innovation in the targeted organizations. Therefore, rather asking directly "what is the impact of PI on innovation?" the question should be first: "how and where PI and innovation are getting deployed in the organization?" and "which configuration is used in the organization?" Then accordingly, whether the PI has a positive or negative impact on innovation can be measured within different clusters according to the configuration. Otherwise, not considering the used configuration might result in drawing inaccurate conclusions that miss the variety of the phenomenon.

Second, seeking to learn from organizations that use PI approaches for a long period of time, have sufficient level of PI usage maturity and product-based, this research was conducted in very large organizations in the manufacturing sector. However, whether or not the identified configurations can be applied to other contexts raises important questions. Future studies are encouraged to examine the interplay between PI and product innovation related activities and its impact in another context such as the service sector. Existing research in operations management reported increasing interest in the adoption of lean in services (e.g. healthcare) (Burgess and Radnor, 2013). It will be interesting to explore how service organizations manage the interplay between PI and service innovation and whether the identified configurations in the manufacturing sector can be applicable to the service context.

Third, this research examined the interplay between PI and product innovation at the organizational level through interviewing managers in different functional specialisms. Findings show that senior and middle managers' views of PI applicability in the innovation processes contribute to shaping the interplay management. Further research could expand on that and explore the role of subordinates and employees in non-managerial position in shaping and managing the interplay between PI and product innovation. Recent research in ambidexterity highlighted the importance of the bottom-up approach in pursuing ambidexterity (Zimmermann et al., 2015). Zimmermann et al. (2018) noted that frontline managers play a central and proactive role in managing and pursuing contradictory goals in organizations.

Fourth, this research focuses on organizations in industries that have a relatively long-life cycle to produce new products (7-15 years), future research could explore the applicability of the identified configurations in other industries that characterized by shorter NPD process length such as consumer electronics, high velocity or start-up industries. I might speculate that a consumer electronics company, that characterized by a shorter life cycle and highly innovative products, might use a facilitating and empowering configuration; as integrating PI across the innovation process might be needed to speed up the innovation process at the same time allowing a room for generating and implementing new ideas. In high velocity industries -such as biotechnology, information and computer technology and microcomputers-(Wirtz et al., 2007, Bourgeois and Eisenhardt, 1988), which characterized by continuous change in technology, demand and competition (Wirtz et al., 2007) and seek efficiency, speed and rigor in processes (Eisenhardt, 1989b), a strategic and holistic configuration might be applicable. A project-based configuration might fit in start-up and small organizations. Thus, in order to develop a better understanding of the interplay of PI and product innovation and the prevalence of the identified configurations, future research could examine the interplay in different industries.

Fifth, the findings of this thesis highlighted that the use of PI in organizations is dynamic. Not only through adapting PI to the area that it is used in, but also the overall approach for PI and product innovation interplay management can change over time as it is the case in Innovative-PharmaCo As Pharma's approach for managing the interplay between PI and innovation changed from integration of PI in the innovation processes between 2003-2008 to separation (2008 onward). Time and managers' learning about tensions is crucial in shaping the organizational approaches for managing contradictory goals (Raisch et al., 2018). Future research can build on this and conduct a longitudinal study to examine how the organizational approach for managing the interplay between PI and product innovation related-activities evolves over time. And if different configurations can be used at a different point in time.

Sixth, this research found that PI approaches are used as a bundle of approaches in the case organizations. Thus, future research should be careful when studying PI implementation and benefits in product-based organizations as examining the impact of PI as discrete approaches can be misleading. Organizations have been used PI for a long period of time and their concepts and practices have blurred together. Therefore, considering the impact of PI as discrete approaches rather than PI as a set of approaches can be misleading (Ittner and Larcker, 1997). As extracting the effect of one approach may be inaccurate as the implementation of PI in organizations may include characteristics of various PI approaches instead of a single approach. Accordingly, the researcher urges scholars to consider PI usage maturity in the organization (Swink and Jacobs, 2012) and to define PI as a bundle of approaches rather than discrete approaches when examining the effect of PI. Additionally, it will be interesting to examine how different PI approaches interact within the bundle and what kind of outcome this can lead to.

Finally, the research findings stress the importance of the structural and managerial mechanisms - such as performance measurement and objectives, training, and entrepreneurial orientation- in supporting the deployment of PI approaches and the development of product innovation. Future research could build on this and explore whether the use of these mechanisms could drive certain types of innovation- radical or incremental-. Furthermore, future research could focus on one of these mechanisms- e.g. performance measurements (PM) - and deeply examined how PM support the deployment of PI? And how its use shapes the interplay between PI and innovation? Existing research in PM suggests that PM can be used to drive learning and controlling goals in organizations (Pešalj et al., 2018, Simons, 1995). Thus, it will be interesting to see how various uses of PM shape /or not the interplay between PI and product innovation? And whether it drives one over the other.

8.5 Practical implications

This research provides various implications for practice. First, organizations face pressure to manage different goals including being efficient and at the same time being innovative. This research offers four configurations for managing the association between PI and product innovation-related activities. Each one can be used in different contexts and based on company's performance priorities. For example, if managers are interested in broadening the use of operational excellence and improvement programs, a "strategic and holistic" or "facilitating and empowering" configurations can be considered as appropriate options. On the other hand, a "project-based" configuration could be used in an organization that is still in the beginning of its journey toward excellence and innovation enhancement.

Second, managers often face a challenge in distinguishing between slack and waste, in deciding whether an idea is a good idea or not, in differentiating unproductive and creative time. While the informants in the case organizations expressed similar concerns, especially when using PI in creative areas, findings identify some practices that can be helpful for managers. For example, translating the meaning for waste to the product development, engineering and design environments instead of applying the concept of lean in that same way across functions. Another practice is through developing a deep understanding of employees' skills and preferences. Therefore, managers could distinguish the productive and unproductive time by familiarizing themselves with their team members' skills and preferences and whether employees prefer a process-oriented type of work or more creative one.

Third, this research identified various organizational mechanisms that are used by the case organizations to manage the interplay between PI and innovation. Managers need to consider different factors when managing the interplay, these include the use of PI, PI scope, PI formality and other organizational factors including performance measurements and objectives, training, structure, employees' empowerment and autonomy. For instance, managers could maintain employees' commitment toward PI and innovation initiatives through aligning these initiatives with the performance measurements and objectives system.

Fourth, the findings stress the importance of "how" and "where" PI is used, in the organization, on shaping the interplay between PI and incremental and radical product innovation. Managers need to be mindful regarding the use of PI and the area it is implemented in. Fast-CarCo and Excellent-AeroCo use PI for a larger degree, in both organizations PI approaches get adapted to the area that it is implemented in. For instance, lean is mixed with agile in the product development environment in Excellent-AeroCo to maintain rigor and flexibility that are needed in this environment. Similarly, in Fast-CarCo, flexible and loosely managed processes are used in the R&D area compared to other areas in the business.

Finally, managers might need to devote more attention to PI deployment. For instance, PI usage in non-manufacturing areas needs to be adapted to the areas that PI is implemented in. For example, the findings suggest that it is possible to use PI in R&D but managers need to take different factors into considerations, these include: PI formality, the flexibility of the used PI approach in addition to the managerial mechanisms that can be used to support the deployment of PI in R&D.

REFERENCES

Abernathy, W. J. 1978. *The Productivity Dilemma.*, Baltimore: Johns Hopkins University Press.

Abernathy, W. J. & Clark, K. B. 1985. Innovation - Mapping The Winds Of Creative Destruction. *Research Policy,* 14**,** 3-22.

Abrunhosa, A. & Sa, P. M. E. 2008. Are Tqm Principles Supporting Innovation In The Portuguese Footwear Industry? *Technovation,* 28**,** 208-221.

Adler, P. S., Benner, M., Brunner, D. J., Macduffie, J. P., Osono, E., Staats, B. R., Takeuchi, H., Tushman, M. L. & Winter, S. G. 2009. Perspectives On The Productivity Dilemma. *Journal Of Operations Management,* 27**,** 99-113.

Adler, P. S. & Borys, B. 1996. Two Types Of Bureaucracy: Enabling And Coercive. *Administrative Science Quarterly,* 41**,** 61-89.

Adler, P. S., Goldoftas, B. & Levine, D. I. 1999. Flexibility Versus Efficiency? A Case Study Of Model Changeovers In The Toyota Production System. *Organization Science,* 10**,** 43-68.

Amabile, T. 1998. How To Kill Creativity. *Harvard Business Review,* September-October.

Amabile, T., Conti, R., Coon, H., Lazenby, J. & Herron, M. 1996. Assessing The Work Environment For Creativity. *Academy Of Management Journal,* 39**,** 1154–1184.

Ambos, T. C., Mäkelä, K., Birkinshaw, J. & D'este, P. 2008. When Does University Research Get Commercialized? Creating Ambidexterity In Research Institutions. *Journal Of Management Studies,* 45**,** 1424-1447.

Anand, G., Ward, P. T., Tatikonda, M. V. & Schilling, D. A. 2009. Dynamic Capabilities Through Continuous Improvement Infrastructure. *Journal Of Operations Management,* 27**,** 444-461.

Andersson, R., Eriksson, H. & Torstensson, H. 2006. Similarities And Differences Between Tqm, Six Sigma And Lean. *The Tqm Magazine,* 18**,** 282-296.

Andries, P. & Czarnitzki, D. 2014. Small Firm Innovation Performance And Employee Involvement. *Small Business Economics,* 43**,** 21-38.

Andriopoulos, C., Gotsi, M., Lewis, M. & Ingram, A. 2018. Turning The Sword: How Npd Teams Cope With Front-End Tensions. *Journal Of Product Innovation Management,* 35**,** 427–445.

Andriopoulos, C. & Lewis, M. W. 2009. Exploitation-Exploration Tensions And Organizational Ambidexterity: Managing Paradoxes Of Innovation. *Organization Science,* 20**,** 696-717.

Antony, J., Setijono, D. & Dahlgaard, J. J. 2016 Lean Six Sigma And Innovation – An Exploratory Study Among Uk Organisations. *Total Quality Management & Business Excellence,* 27**,** 124-140

Asif, M. & De Vries, H. J. 2015. Creating Ambidexterity Through Quality Management. *Total Quality Management & Business Excellence,* 26**,** 1226-1241.

Atuahene-Gima, K. 2005. Resolving The Capability-Rigidity Paradox In New Product Innovation. *Journal Of Marketing,* 69**,** 61-83.

Bateman, N. & David, A. 2002. Process Improvement Programmes: A Model For Assessing Sustainability. *International Journal Of Operations & Production Management,* 22**,** 515-526.

Benner, M. & Tushman, M. 2002. Process Management And Technological Innovation: A Longitudinal Study Of The Photography And Paint Industries. *Administration Science Quarterly,* 47**,** 676-706.

Benner, M. J. 2002. Process Management And Technological Innovation: A Longitudinal Study Of The Photography And Paint Industries. *Administrative Science Quarterly,* 47**,** 676-706.

Benner, M. J. 2009. Dynamic Or Static Capabilities? Process Management Practices And Response To Technological Change. *Journal Of Product Innovation Management,* 26**,** 473-486.

Benner, M. J. & Tushman, M. L. 2003. Exploitation, Exploration, And Process Management: The Productivity Dilemma Revisited. *Academy Of Management Review,* 28**,** 238-256.

Benner, M. J. & Tushman, M. L. 2015. Reflections On The 2013 Decade Award-"Exploitation, Exploration, And Process Management: The Productivity Dilemma Revisited" Ten Years Later. *Academy Of Management Review,* 40**,** 497-514.

Bergen, A. 2007. Towards A Critical Realist Comparative Methodology: Context-Sensitive Theoretical Comparison. *Journal Of Critical Realism,* 6**,** 5-27.

Bessant, J., Caffyn, S. & Gallagher, M. 2001. An Evolutionary Model Of Continuous Improvement Behaviour. *Technovation,* 21**,** 67-77.

Bessant, J., Öberg, C. & Trifilova, A. 2014. Framing Problems In Radical Innovation. *Industrial Marketing Management,* 43**,** 1284–1292.

Beverland, M., Micheli, P. & Farrelly, F. 2016. Resourceful Sensemaking : Overcoming Barriers Between Marketing And Design In Npd. *Journal Of Product Innovation Management,* 33**,** 628-648.

Beverland, M. B., Wilner, S. J. S. & Micheli, P. 2015. Reconciling The Tension Between Consistency And Relevance: Design Thinking As A Mechanism For Brand Ambidexterity. *Journal Of The Academy Of Marketing Science,* 43**,** 589-609.

Bhasin, S. 2013. Impact Of Corporate Culture On The Adoption Of The Lean Principles. *International Journal Of Lean Six Sigma,* 4 118-140.

Bhuiyan, N. & Baghel, A. 2005. An Overview Of Continuous Improvement: From The Past To The Present *Management Decision,* 43**,** 761-771.

Birkinshaw, J., Bessant, J. & Delbridge, R. 2007. Finding, Forming, And Performing: Creating Networks For Discontinuous Innovation. *California Management Review,* 49**,** 67-+.

Birkinshaw, J. & Gupta, K. 2013. Clarifying The Distinctive Contribution Of Ambidexterity To The Field Of Organization Studies. *Academy Of Management Perspectives,* 27**,** 287-298.

Birkinshaw, J., Zimmermann, A. & Raisch, S. 2016. How Do Firms Adapt To Discontinuous Change? Bridging The Dynamic Capabilities And Ambidexterity Perspectives. *California Management Review,* 58.

Bortolotti, T., Boscari, S. & Danese, P. 2015. Successful Lean Implementation: Organizational Culture And Soft Lean Practices. *International Journal Of Production Economics,* 160**,** 182-201.

Bourgeois, L. J. & Eisenhardt, K. 1988. Strategic Decision Processes In High Velocity Environments: Four Cases In The Microcomputer Industry. *Management Science,* 34**,** 816-835.

Bourke, J. & Roper, S. 2015. Innovation, Quality Management And Learning: A Dynamic Analysis. *Erc Research Paper*No.30.

Bourke, J. & Roper, S. 2017. Innovation, Quality Management And Learning: Short-Term And Longer-Termeffects. *Research Policy,* 46**,** 1505–1518.

Braunscheidel, M. J., Hamister, J. W., Suresh, N. C. & Star, H. 2011. An Institutional Theory Perspective On Six Sigma Adoption. *International Journal Of Operations & Production Management,* 31**,** 423-451.

Brettel, M., Heinemann, F., Engelen, A. & Neubauer, S. 2011. Cross-Functional Integration Of R&D, Marketing, And Manufacturing In Radical And Incremental Product Innovations And Its Effects On Project Effectiveness And Efficiency. *Journal Of Product Innovation Management,* 28**,** 251-269.

Browning, T. R. & Sanders, N. R. 2012. Can Innovation Be Lean? *California Management Review,* 54**,** 5-19.

Brunner, D., Staats, B., Tushman, M. & Upton, D. 2010. Wellsprings Of Creation: How Perturbation Sustains Exploration In Mature Organizations. . *Harvard Business School Working Paper,* 09-011.

Burgess, N. & Radnor, Z. 2013. Evaluating Lean In Healthcare. *International Journal Of Health Care Quality Assurance,* 26**,** 220-235.

Burgess, N., Strauss, K., Currie, G. & Wood, G. 2015. Organizational Ambidexterity And The Hybrid Middle Manager : The Case Of Patient Safety In Uk Hospitals *Human Resource Management,* 54**,** S87-S109.

Calabretta, G., Gemser, G. & Wijnberg, N. 2017. The Interplay Between Intuition And Rationality In Strategic Decision Making: A Paradox Perspective. *Organization Studies,* 38**,** 365-401.

Canato, A., Ravasi, D. & Phillips, N. 2013. Coerced Practice Implementation In Cases Of Low Cultural Fit: Cultural Change And Practice Adaptation During The Implementation Of Six Sigma At 3m. *Academy Of Management Journal,* 56.

Cardinal, L., Sitkin, S., Long, C. & Miller, C. 2019. The Genesis Of Control Configurations During Organizational Founding. *Organization Design Advances In Strategic Management40.* Emerald Publishing Limited

Cardinal, L. B. 2001. Technological Innovation In The Pharmaceutical Industry: The Use Of Organizational Control In Managing Research And Development. *Organization Science,* 12**,** 19-36.

Chandy, R. K. & Tellis, G. J. 1998. Organizing For Radical Product Innovation: The Overlooked Role Of Willingness To Cannibalize. *Journal Of Marketing Research,* 35**,** 474-487.

Chandy, R. K. & Tellis, G. J. 2000. The Incumbent's Curse? Incumbency, Size, And Radical Product Innovation. *Journal Of Marketing,* 64**,** 1-17.

Chay, T., Xu, Y., Tiwari, A. & Chay, F. 2015. Towards Lean Transformation: The Analysis Of Lean Implementation Frameworks. *Journal Of Manufacturing Technology Management,* 26**,** 1031-1052.

Choo, A. S., Linderman, K. W. & Schroeder, R. G. 2007a. Method And Context Perspectives On Learning And Knowledge Creation In Quality Management. *Journal Of Operations Management,* 25**,** 918-931.

Choo, A. S., Linderman, K. W. & Schroeder, R. G. 2007b. Method And Psychological Effects On Learning Behaviors And Knowledge Creation In Quality Improvement Projects. *Management Science,* 53**,** 437-450.

Christensen, C. 1998. *The Innovator's Dilemma: When New Technologies Cause Great Firms To Fail,* Boston, Harvard Business School Press.

Cooper, R. G. 2008. Perspective: The Stage-Gate® Idea-To-Launch Process—Update, What's New, And Nexgen Systems*. *Journal Of Product Innovation Management,* 25**,** 213-232.

Crossan, M. M. & Apaydin, M. 2010. A Multi-Dimensional Framework Of Organizational Innovation: A Systematic Review Of The Literature. *Journal Of Management Studies,* 47**,** 1154-1191.

Crute, V., Ward, Y., Brown, S. & Brown, A. 2003. Implementing Lean In Aerospace—Challenging The Assumptions And Understanding The Challenges. *Technovation,* 23**,** 917–928.

Dalgleish, S. 2003. Six Sigma? No Thanks. *Quality* 42**,** 22.

Dalton, M. A. 2009. What's Constraining Your Innovation? *Research-Technology Management,* 52**,** 52-64.

Danese, P., Manfè, V. & Romano, P. 2018. A Systematic Literature Review On Recent Lean Research: State-Of-The-Art And Future Directions. *International Journal Of Management Reviews,* 20.

Danneels, E. 2003. Tight-Loose Coupling With Customers: The Enactment Of Customer Orientation. *Strategic Management Journal,* 24**,** 559-576.

Danneels, E. & Kleinschmidt, E. J. 2001. Product Innovativeness From The Firm's Perspective: Its Dimensions And Their Relation With Project Selection And Performance. *Journal Of Product Innovation Management,* 18**,** 357-373.

De Treville, S. & Antonakis, J. 2006. Could Lean Production Job Design Be Intrinsically Motivating? Contextual, Configurational, And Levels-Of-Analysis Issues. *Journal Of Operations Management,* 24**,** 99-123.

Denzin, N. & Lincoln, Y. 2011. *Qualitative Research,* California, United State, Sage Publications, Inc.

Dewar, R. D. & Dutton, J. E. 1986. The Adoption Of Radical And Incremental Innovations - An Empirical-Analysis. *Management Science,* 32**,** 1422-1433.

Doolen, T. L. & Hacker, M. E. 2005. A Review Of Lean Assessment In Organizations: An Exploratory Study Of Lean Practices By Electronics Manufacturers. *Journal Of Manufacturing Systems,* 24**,** 55-67.

Doty, H. & Glick, W. 1994. Typologies As A Unique Form Of Theory Building: Toward Improved Understanding And Modeling. *Academy Of Management Review,* 19**,** 230-251.

Drohomeretski, E., Gouvea Da Costa, S. E., De Lima, E. P. & Da Rosa Garbuio, P. A. 2014. Lean, Six Sigma And Lean Six Sigma: An Analysis Based On Operations Strategy. *International Journal Of Production Research,* 52**,** 804-824.

Duncan, R. B. 1976. The Ambidextrous Organization: Designing Dual Structures For Innovation. . *In:* R. H. Kilmann, Pondy, L. R. & Slevin, D. (Eds.) *The Management Of Organization.* New York: North-Holland.

Eisenhardt, K. & Westcott, B. 1988. Paradoxical Demands And The Creation Of Excellence: The Case Of Just-In-Time Manufacturing. *In:* Quinn, R. & Cameron, K. (Eds.) *Paradox And Transformation: Toward A Theory Of Change Inorganization And Management.* Cambridge, : Ma: Ballinger.

Eisenhardt, K. M. 1989a. Building Theories From Case-Study Research. *Academy Of Management Review,* 14**,** 532-550.

Eisenhardt, K. M. 1989b. Making Fast Strategic Decisions In High-Velocity Environments. *Academy Of Management Journal,* 32**,** 543-576.

Eisenhardt, K. M., Furr, N. R. & Bingham, C. B. 2010. Microfoundations Of Performance: Balancing Efficiency And Flexibility In Dynamic Environments. *Organization Science,* 21**,** 1263-1273.

Farjoun, M. 2010. Beyond Dualism: Stability And Change As A Duality. *Academy Of Management Review,* 35**,** 202–225.

Flynn, B., Sakakibara, S. & Schroeder, R. 1995. Relationship Between Jit And Tqm: Practices And Performance. *Academy Of Management Journal,* 38**,** 1325-1360.

Flynn, B., Schroeder, R. & Sakakibara, S. 1994. A Framework For Quality Management Research And An Associated Measurement Instrument. . *Journal Of Operations Management* 11**,** 339-366.

Ford-Media-Center. 2013. *Game Changer: 100th Anniversary Of The Moving Assembly Line* [Online]. [Accessed February 22 2019].

Forés, B. & Camisón, C. 2016. Does Incremental And Radical Innovation Performance Depend On Different Types Of Knowledge Accumulation Capabilities And Organizational Size? *Journal Of Business Research,* 69**,** 831–848.

Fuentes-Fuentes, M. M., Albacete-Saez, C. A. & Llorens-Montes, F. J. 2004. The Impact Of Environmental Characteristics On Tqm Principles And Organizational Performance. *Omega-International Journal Of Management Science,* 32**,** 425-442.

Fullerton, R., Kennedy, F. & Widener, S. 2013. Management Accounting And Control Practices In A Lean Manufacturing Environment. *Accounting, Organizations And Society,* 38**,** 50-71.

Fullerton, R. R., Kennedy, F. A. & Widener, S. K. 2014. Lean Manufacturing And Firm Performance: The Incremental Contribution Of Lean Management Accounting Practices. *Journal Of Operations Management,* 32**,** 414-428.

Garcia, R. & Calantone, R. 2002. A Critical Look At Technological Innovation Typology And Innovativeness Terminology: A Literature Review. *Journal Of Product Innovation Management,* 19**,** 110-132.

Garvin, D. 1998. The Processes Of Organization And Management. *Sloan Management Review,* Summer.

Gendron, M. 2013. *Business Intelligence Applied: Implementing An Effective Information And Communications Technology Infrastructure*, John Wiley & Sons, Inc.

Ghoshal, S. & Bartlett, C. A. 1997. *The Individualized Corporation,* New York, Harper Collins.

Gibson, C. B. & Birkinshaw, J. 2004. The Antecedents, Consequences, And Mediating Role Of Organizational Ambidexterity. *Academy Of Management Journal,* 47**,** 209-226.

Gil-Marques, M. & Moreno-Luzon, M. D. 2013. Driving Human Resources Towards Quality And Innovation In A Highly Competitive Environment. *International Journal Of Manpower,* 34**,** 839-860.

Gilson, L., Mathieu, J., Shalley, C. & Ruddy, T. 2005. Creativity And Standardization: Complementary Or Conflicting Drivers Of Team Effectiveness? . *Academy Of Management Journal,* 48**,** 521-531.

Gioia, D. A., Corley, K. G. & Hamilton, A. L. 2013. Seeking Qualitative Rigor In Inductive Research: Notes On The Gioia Methodology. *Organizational Research Methods,* 16**,** 15-31.

Grover, V., Purvis, R. L. & Segars, A. H. 2007. Exploring Ambidextrous Innovation Tendencies In The Adoption Of Telecommunications Technologies. *Ieee Transactions On Engineering Management,* 54**,** 268-285.

Gupta, A. K., Smith, K. G. & Shalley, C. E. 2006. The Interplay Between Exploration And Exploitation. *Academy Of Management Journal,* 49**,** 693-706.

Gutierrez Gutierrez, L. J., Bustinza, O. F. & Barrales Molina, V. 2012. Six Sigma, Absorptive Capacity And Organisational Learning Orientation. *International Journal Of Production Research,* 50**,** 661-675.

Gutierrez, L., Llorens-Montes, F. & Bustinza, O. 2009. Six Sigma: From A Goal-Theoretic Perspective To Shared-Vision Development. *International Journal Of Operations & Production Management,* 29**,** 151-169.

Hackman, J. R. & Wageman, R. 1995. Total Quality Management - Empirical, Conceptual, And Practical Issues. *Administrative Science Quarterly,* 40**,** 309-342.

Hammer, M. & Champy, J. 2001. *Reengineering The Corporation : A Manifesto For Business Revolution,* London, Nicholas Brealey.

He, Z. L. & Wong, P. K. 2004. Exploration Vs. Exploitation: An Empirical Test Of The Ambidexterity Hypothesis. *Organization Science,* 15**,** 481-494.

Helander, M., Bergqvist, R., Stetler, K. L. & Magnusson, M. 2015. Applying Lean In Product Development - Enabler Or Inhibitor Of Creativity? *International Journal Of Technology Management,* 68**,** 49-69.

Herrmann, A., Gassmann, O. & Eisert, U. 2007. An Empirical Study Of The Antecedents For Radical Product Innovations And Capabilities For Transformation. *Journal Of Engineering And Technology Management,* 24 (1-2), 92–120**,** 92-120.

Hidalgo, A. & Albors, J. 2008. Innovation Management Techniques And Tools: A Review From Theory And Practice. *R & D Management,* 38**,** 113-127.

Hill, A. 2018. Managers Can Draw A Line Between Slack And Slacking: More Thinking Time For Staff Often Results In Better Ideas. . *Finantial Times*.

Hindo, B. 2007. *At 3m, A Struggle Between Efficiency And Creativity How Ceo George Buckley Is Managing The Yin And Yang Of Discipline And Imagination* [Online]. Inside Innovation - In Depth. [Accessed February 19th 2019].

Hines, P., Holweg, M. & Rich, N. 2004. Learning To Evolve - A Review Of Contemporary Lean Thinking. *International Journal Of Operations & Production Management,* 24**,** 994-1011.

Hoang, D. T., Igel, B. & Laosirihongthong, T. 2006. The Impact Of Total Quality Management On Innovation: Findings From A Developing Country. *International Journal Of Quality & Reliability Management,* 23**,** 1092-1117.

Holweg, M., Staats, B. & Upton, D. 2018. Making Process Improvements Stick. *Harvard Business Review,* 96**,** Pp. 16-18.

Hopp, W. & Spearman, M. 2004. To Pull Or Not To Pull: What Is The Question? *Manufacturing & Service Operations Management* 6**,** 133.

Hung, R. Y.-Y., Lien, B. Y.-H., Fang, S.-C. & Mclean, G. N. 2010. Knowledge As A Facilitator For Enhancing Innovation Performance Through Total Quality Management. *Total Quality Management & Business Excellence,* 21**,** 425-438.

Hung, R. Y. Y., Lien, B. Y.-H., Yang, B., Wu, C.-M. & Kuo, Y.-M. 2011. Impact Of Tqm And Organizational Learning On Innovation Performance In The High-Tech Industry. *International Business Review,* 20**,** 213-225.

Inman, R. A., Sale, M. & Green, K. 2009. Analysis Of The Relationships Among Toc Use, Toc Outcomes, And Organizational Performance. *International Journal Of Operations & Production Management,* 29**,** 341 - 356.

Ittner, C. & Larcker, D. 1997. The Performance Effects Of Process Management Techniques. *Management Science,* 43**,** 522-534.

Jacobs, B. W., Swink, M. & Linderman, K. 2015. Performance Effects Of Early And Late Six Sigma Adoptions. *Journal Of Operations Management,* 36**,** 244-257.

Jansen, J. J. P., Tempelaar, M. P., Van Den Bosch, F. A. J. & Volberda, H. W. 2009. Structural Differentiation And Ambidexterity: The Mediating Role Of Integration Mechanisms. *Organization Science,* 20**,** 797-811.

Jansen, J. J. P., Van Den Bosch, F. A. J. & Volberda, H. W. 2006. Exploratory Innovation, Exploitative Innovation, And Performance: Effects Of Organizational Antecedents And Environmental Moderators. *Management Science,* 52**,** 1661-1674.

Jarzabkowski, P., Lê, J. K. & Ven, A. H. V. D. 2013. Responding To Competing Strategic Demands: How Organizing, Belonging, And Performing Paradoxes Coevolve. *Strategic Organization,* 11**,** 245–280.

Jayaram, J., Ahire, S. L. & Dreyfus, P. 2010. Contingency Relationships Of Firm Size, Tqm Duration, Unionization, And Industry Context On Tqm Implementation-A Focus On Total Effects. *Journal Of Operations Management,* 28**,** 345-356.

Johnson, P. & Dubcrley, J. 2000. *Understanding Management Research,* London, Sage.

Jones, D. & Womack, J. 2017. The Evolution Of Lean Thinking And Practice. *In:* T Netland & Powell, D. (Eds.) *The Routledge Companion To Lean Management.* Routledge,.

Jones, D. T. 2014. *What Lean Really Is* [Online]. The Lean Enterprise Academy Available: Http://Www.Leanuk.Org/Article-Pages/Articles/2014/September/11/What-Lean-Really-Is.Aspx [Accessed February 19th 2019].

Karlsson, C. & Ahlstrom, P. 1996a. Assessing Changes Towards Lean Production. *International Journal Of Operations & Production Management,* 16**,** 24-&.

Karlsson, C. & Ahlstrom, P. 1996b. The Difficult Path To Lean Product Development. *Journal Of Product Innovation Management,* 13**,** 283-295.

Kassotaki, O., Paroutis, S. & Morrell, K. 2018. Ambidexterity Penetration Across Multiple Organizational Levels In An Aerospace And Defense Organization. *Long Range Planning,* In Press.

Kaynak, H. 2003. The Relationship Between Total Quality Management Practices And Their Effects On Firm Performance. *Journal Of Operations Management,* 21**,** 405-435.

Kim, D.-Y., Kumar, V. & Kumar, U. 2012. Relationship Between Quality Management Practices And Innovation. *Journal Of Operations Management,* 30**,** 295-315.

Knight, E. & Paroutis, S. 2017. Becoming Salient: The Tmt Leader's Role In Shaping The Interpretive Context Of Paradoxical Tensions. *Organization Studies,* 38**,** 403-432.

Koukoulaki, T. 2014. The Impact Of Lean Production On Musculoskeletal And Psychosocial Risks: An Examination Of Sociotechnical Trends Over 20 Years. *Applied Ergonomics,* 45**,** 198–212.

Lam, M., O'donnell, M. & Robertson, D. 2015. Achieving Employee Commitment For Continuous Improvement Initiatives. *International Journal Of Operations & Production Management,* 35**,** 201-215.

Lavie, D., Stettner, U. & Tushman, M. 2010. Exploration And Exploitation Within And Across Organizations. *Academy Of Management Annals,* 4**,** 109-155.

Leavengood, S., Anderson, T. R. & Daim, T. U. 2014. Exploring Linkage Of Quality Management To Innovation. *Total Quality Management & Business Excellence,* 25**,** 1126-1140.

Levinthal, D. A. & March, J. G. 1993. The Myopia Of Learning. *Strategic Management Journal,* 14**,** 95-112.

Li, S. H., Rao, S. S., Ragu-Nathan, T. S. & Ragu-Nathan, B. 2005. Development And Validation Of A Measurement Instrument For Studying Supply Chain Management Practices. *Journal Of Operations Management,* 23**,** 618-641.

Lin, L.-H. 2009. Effects Of National Culture On Process Management And Technological Innovation. *Total Quality Management & Business Excellence,* 20**,** 1287-1301.

Lopez-Mielgo, N., Montes-Peon, J. M. & Vazquez-Ordas, C. J. 2009. Are Quality And Innovation Management Conflicting Activities? *Technovation,* 29**,** 537-545.

Mabin, V. & Balderstone, S. 2003. The Performance Of The Theory Of Constraints Methodology: Analysis And Discussion Of Successful Toc Applications. *International Journal Of Operations & Production Management,* 23**,** 568-595.

Malmbrandt, M. & Åhlström, P. 2013. An Instrument For Assessing Lean Service Adoption. *International Journal Of Operations & Production Management,* 33**,** 1131-1165.

March, J. 2006. Rationality, Foolishness, And Adaptive Intelligence. . *Strategic Management Journal,* 27**,** 201-214.

March, J. G. 1991. Exploration And Exploitation In Organizational Learning. *Organization Science,* 2**,** 71-87.

Marodin, G., Frank, A. G., Tortorella, G. L. & Netland, T. 2018. Lean Product Development And Lean Manufacturing: Testing Moderation Effects. *International Journal Of Production Economics,* 203**,** 301–310.

Martinez-Costa, M. & Martinez-Lorente, A. R. 2008. Does Quality Management Foster Or Hinder Innovation? An Empirical Study Of Spanish Companies. *Total Quality Management & Business Excellence,* 19**,** 209-221.

Martinez-Jurado, P. J., Moyano-Fuentes, J. & Gomez, P. J. 2013. Hr Management During Lean Production Adoption. *Management Decision,* 51**,** 742-760.

Mehri, D. 2006. The Darker Side Of Lean: An Insider's Perspective On The Realities Of The Toyota Production System. *Academy Of Management Perspectives,* 20**,** 21-42.

Meyer, A., Tsui, A. & Hinings, C. 1993. Configurational Approaches To Organizational Analysis. *Academy Of Management Journal,* 36**,** 1175-1195.

Micheli, P. & Pavlov, A. 2017. What Is Performance Measurement For? Multiple Uses Of Performance Information Within Organizations. *Public Administration***,** 1-17.

Miller, D. 2017. Challenging Trends In Configuration Research: Where Are The Configurations? . *Strategic Organization,* 00**,** 1-17.

Modig, N. & Ahlstrom, P. 2012. *This Is Lean: Resolving The Efficiency Paradox,* Stockholm, Rheolgica Publishing

Moreno-Luzon, M. D., Gil-Marques, M. & Arteaga, F. 2014. Driving Organisational Ambidexterity Through Process Management. The Key Role Of Cultural Change. *Total Quality Management & Business Excellence,* 25**,** 1026-1038.

Moreno Luzon, M. D. & Valls Pasola, J. 2011. Ambidexterity And Total Quality Management: Towards A Research Agenda. *Management Decision,* 49**,** 927-947.

Nair, A., Malhotra, M. K. & Ahire, S. L. 2011. Toward A Theory Of Managing Context In Six Sigma Process-Improvement Projects: An Action Research Investigation. *Journal Of Operations Management,* 29**,** 529-548.

Naor, M., Bernardes, E. S., Druehl, C. T. & Shiftan, Y. 2015. Overcoming Barriers To Adoption Of Environmentally-Friendly Innovations Through Design And Strategy: Learning From The Failure Of An Electric Vehicle Infrastructure Firm. *International Journal Of Operations & Production Management,* 35**,** 26-59.

Naor, M., Goldstein, S. M., Linderman, K. W. & Schroeder, R. G. 2008. The Role Of Culture As Driver Of Quality Management And Performance: Infrastructure Versus Core Quality Practices. *Decision Sciences,* 39**,** 671-702.

Nave, D. 2002. How To Compare Six Sigma, Lean And The Theory Of Constraints - A. Framework For Choosing What's Best For Your Organization. *Quality Progress,* 35**,** 73-78.

Naveh, E. & Erez, M. 2004. Innovation And Attention To Detail In The Quality Improvement Paradigm. *Management Science,* 50**,** 1576-1586.

Netland, T. 2013. Exploring The Phenomenon Of Company-Specific Production Systems: One-Best-Way Or Own-Best-Way? *International Journal Of Production Research,* 51**,** 1084-1097.

Netland, T. & Ferdows, K. 2016. The S-Curve Effect Of Lean Implementation. *Production And Operations Management* 25**,** 1106-1120.

Netland, T. & Powell, D. 2017. *The Routledge Companion To Lean Management,* Abingdon, Oxon, Routledge.

Netland, T., Schloetzer, J. & Ferdows, K. 2015. Implementing Corporate Lean Programs: The Effect Of Management Control Practices. *Journal Of Operations Management,* 36**,** 90-102.

Nightingale, D. & Mize, J. 2002. Development Of A Lean Enterprise Transformation Maturity Model. *Information Knowledge Systems Management,* 3**,** 15-30.

Nohria, N. & Gulati, R. 1996. Is Slack Good Or Bad For Innovation? *Academy Of Management Journal,* 39**,** 1245-1264.

O'reilly, C. A. & Tushman, M. L. 2004. The Ambidextrous Organisation. *Harvard Business Review,* 82**,** 74-+.

Oecd/Eurostat 2018. Oslo Manual2018: Guidelines For Collecting, Reporting And Using Data On Innovation. *The Measurement Of Scientific, Technological And Innovation Activities.* Paris / Eurostat, Luxembourg: Oecd Publishing.

Olson, E. M., Walker, O. C. & Ruekert, R. W. 1995. Organizing For Effective New Product Development - The Moderating Role Of Product Innovativeness. *Journal Of Marketing,* 59**,** 48-62.

Pakdil, F. & Leonard, K. M. 2014. Criteria For A Lean Organisation: Development Of A Lean Assessment Tool. *International Journal Of Production Research,* 52**,** 4587-4607.

Pakdil, F. & Leonard, K. M. 2015. The Effect Of Organizational Culture On Implementing And Sustaining Lean Processes. *Journal Of Manufacturing Technology Management,* 26**,** 725-743.

Pande, P. S., Neuman, R. P. & Cavanagh, R. R. 2000. *The Six Sigma Way: How Ge,Motorola And Other Top Companies Are Honing Their Performance.*, Mcgraw-Hill, New York.

Papachroni, A., Heracleous, L. & Paroutis, S. 2015. Organizational Ambidexterity Through The Lens Of Paradox Theory: Building A Novel Research Agenda. *The Journal Of Applied Behavioral Science,* 51**,** 71-93.

Papachroni, A., Heracleous, L. & Paroutis, S. 2016. In Pursuit Of Ambidexterity: Managerial Reactions To Innovation-Efficiency Tensions. *Human Relations,* 69**,** 1791-1822.

Parast, M. M. 2011. The Effect Of Six Sigma Projects On Innovation And Firm Performance. *International Journal Of Project Management,* 29**,** 45-55.

Pekovic, S. & Galia, F. 2009. From Quality To Innovation: Evidence From Two French Employer Surveys. *Technovation,* 29**,** 829-842.

Perdomo-Ortiz, J., Gonzalez-Benito, J. & Galende, J. 2006. Total Quality Management As A Forerunner Of Business Innovation Capability. *Technovation,* 26**,** 1170-1185.

Pešalj, B., Pavlov, A. & Micheli, P. 2018. The Use Of Management Control And Performance Measurement Systems In Smes: A Levers Of Control Perspective. *International Journal Of Operations & Production Management,* 38**,** 2169-2191.

Poole, M. & Van.De.Ven, A. 1989. Using Paradox To Build Management And Organization Theories. *Academy Of Management Review,* 14**,** 562–578.

Prajogo, D. I. & Hong, S. W. 2008. The Effect Of Tqm On Performance In R&D Environments: A Perspective From South Korean Firms. *Technovation,* 28**,** 855-863.

Prajogo, D. I. & Sohal, A. S. 2001. Tqm And Innovation: A Literature Review And Research Framework. *Technovation,* 21**,** 539-558.

Prajogo, D. I. & Sohal, A. S. 2004. The Sustainability And Evolution Of Quality Improvement Programmes - An Australian Case Study. *Total Quality Management & Business Excellence,* 15**,** 205-220.

Prajogo, D. I. & Sohal, A. S. 2006. The Relationship Between Organization Strategy, Total Quality Management (Tqm), And Organization Performance - The Mediating Role Of Tqm. *European Journal Of Operational Research,* 168**,** 35-50.

Rahman, S. 1998. Theory Of Constraints - A Review Of The Philosophy And Its Applications. *International Journal Of Operations & Production Management,* 18**,** 336-+.

Raisch, S. & Birkinshaw, J. 2008. Organizational Ambidexterity: Antecedents, Outcomes, And Moderators. *Journal Of Management,* 34**,** 375-409.

Raisch, S., Birkinshaw, J., Probst, G. & Tushman, M. 2009. Organizational Ambidexterity: Balancing Exploitation And Exploration For Sustained Performance. *Organization Science,* 20**,** 685-695.

Raisch, S., Hargrave, T. & Ven, A. V. D. 2018. The Learning Spiral: A Process Perspective On Paradox. *Journal Of Management Studies,* 55.

Raisch, S. & Zimmermann, A. 2017. Pathways To Ambidexterity: A Process Perspective On The Exploration–Exploitation Paradox. *In:* Smith, W., Lewis, M., Jarzabkowski, P. & Langley, A. (Eds.) *The Oxford Handbook Of Organizational Paradox.* Oxford Handbooks Online.

Ramoglou, S. & Tsang, E. 2016. A Realist Perspective Of Entrepreneurship: Opportunities As Propensities. *Academy Of Management Review,* 41.

Robbins, S., Coulter, M., Sidani, Y. & Jamali, D. 2011. *Management*, Pearson.

Rossi, M., Morgan, J. & Shook, J. 2017. Lean Product And Process Development. *In:* Netland, T. & Powell, D. (Eds.) *The Routledge Companion To Lean Management.* Routledge.

Sadikoglu, E. & Zehir, C. 2010. Investigating The Effects Of Innovation And Employee Performance On The Relationship Between Total Quality Management Practices And Firm Performance: An Empirical Study Of Turkish Firms. *International Journal Of Production Economics,* 127**,** 13-26.

Salomo, S., Weise, J. & Gemuenden, H. G. 2007. Npd Planning Activities And Innovation Performance: The Mediating Role Of Process Management And The Moderating Effect Of Product Innovativeness. *Journal Of Product Innovation Management,* 24**,** 285-302.

Samuel, D., Found, P. & Williams, S. 2015. How Did The Publication Of The Book The Machine That Changed The World Change Management Thinking? Exploring 25 Years Of Lean Literature. *International Journal Of Operations & Production Management,* 35**,** 1386-1407.

Sanchez, A. M. & Perez, M. P. 2001. Lean Indicators And Manufacturing Strategies. *International Journal Of Operations & Production Management,* 21**,** 1433-1451.

Santos-Vijande, M. L. & Alvarez-Gonzalez, L. I. 2007. Innovativeness And Organizational Innovation In Total Quality Oriented Firms: The Moderating Role Of Market Turbulence. *Technovation,* 27**,** 514-532.

Schad, J. & Bansal, P. 2018. Seeing The Forest And The Trees: How A Systems Perspective Informs Paradox Research. *Journal Of Management Studies,* 55**,** 1490-1506.

Schad, J., Lewis, M., Raisch, S. & Smith, W. K. 2016. Paradox Research In Management Science: Looking Back To Move Forward. *The Academy Of Management Annals,* 10**,** 5-64.

Schroeder, R. G., Linderman, K., Liedtke, C. & Choo, A. S. 2008. Six Sigma: Definition And Underlying Theory. *Journal Of Operations Management,* 26**,** 536-554.

Schulze, A., Schmitt, P., Heinzen, M., Mayrl, P., Heller, D. & Boutellier, R. 2013. Exploring The 4i Framework Of Organisational Learning In Product Development: Value Stream Mapping As A Facilitator. *International Journal Of Computer Integrated Manufacturing,* 26**,** 1136-1150.

Sethi, R. & Sethi, A. 2009. Can Quality-Oriented Firms Develop Innovative New Products? *Journal Of Product Innovation Management,* 26**,** 206-221.

Shafer, S. M. & Moeller, S. B. 2012. The Effects Of Six Sigma On Corporate Performance: An Empirical Investigation. *Journal Of Operations Management,* 30**,** 521-532.

Shah, R. & Ward, P. T. 2003. Lean Manufacturing: Context, Practice Bundles, And Performance. *Journal Of Operations Management,* 21**,** 129-149.

Shah, R. & Ward, P. T. 2007. Defining And Developing Measures Of Lean Production. *Journal Of Operations Management,* 25**,** 785-805.

Shingo Prize. Http://Www.Shingoprize.Org/Model

Silva, G. M., Gomes, P. J., Lages, L. F. & Pereira, Z. L. 2014. The Role Of Tqm In Strategic Product Innovation: An Empirical Assessment. *International Journal Of Operations & Production Management,* 34**,** 1307-1337.

Simons, R. 1995. *Levers Of Control : How Managers Use Innovative Control Systems To Drive Strategic Renewal*, Harvard Business School Press.

Sitkin, S. B., Sutcliffe, K. M. & Schroeder, R. G. 1994. Distinguishing Control Form Learning In Total Quality Management - A Contingency Perspective. *Academy Of Management Review,* 19**,** 537-564.

Sivadas, E. & Dwyer, F. R. 2000. An Examination Of Organizational Factors Influencing New Product Success In Internal And Alliance-Based Processes. *Journal Of Marketing,* 64**,** 31-49.

Slack, N. 2017. *The Operations Advantage: A Practical Guide To Making Operations Work*, Kogan Page.

Slack, N., Brandon-Jones, A. & Johnston, R. 2013. *Operations Management*, Edinburgh Gate, Pearson Education Limited.

Slack, N., Chambers, S. & Editio, R. J. T. 2010. *Operations Management*, Financial Times: Prentice Hall.

Slater, S. & Narver, J. 1995. Market Orientation And Learning Organization. *Journal Of Marketing,* 59**,** 63-74.

Slater, S. F., Mohr, J. J. & Sengupta, S. 2014. Radical Product Innovation Capability: Literature Review, Synthesis, And Illustrative Research Propositions. *Journal Of Product Innovation Management,* 31**,** 552-566.

Slater, S. F. & Narver, J. C. 1998. Customer-Led And Market-Oriented: Let's Not Confuse The Two. *Strategic Management Journal,* 19**,** 1001-1006.

Smith, W. & Tushman, M. 2005. Managing Strategic Contradictions: A Top Management Model For Managing Innovation Streams. *Organization Science,* 16**,** 522-536.

Smith, W. K. & Lewis, M. W. 2011. Toward A Theory Of Paradox: A Dynamic Equilibrium Model Of Organizing. *Academy Of Management Review,* 36**,** 381-403.

Souder, W. & Jenssen, S. 1999. Management Practices Influencing New Product Success And Failure In The United States And Scandinavia: A Cross-Cultural Comparative Study. *Journal Of Product Innovation Management* 16**,** 183-203.

Sousa, R. & Voss, C. 2008. Contingency Research In Operations Management Practices. *Journal Of Operations Management,* 26**,** 697-713.

Sousa, R. & Voss, C. A. 2002. Quality Management Re-Visited: A Reflective Review And Agenda For Future Research. *Journal Of Operations Management,* 20**,** 91-109.

Staats, B. & Upton, D. 2011. Lean Knowledge Work. *Harvard Business Review*.

Staats, B. R., Brunner, D. J. & Upton, D. M. 2011. Lean Principles, Learning, And Knowledge Work: Evidence From A Software Services Provider. *Journal Of Operations Management,* 29**,** 376-390.

Sun, H. & Zhao, Y. 2010. The Empirical Relationship Between Quality Management And The Speed Of New Product Development. *Total Quality Management & Business Excellence,* 21**,** 351-361.

Sun, Y. & Du, D. 2010. Determinants Of Industrial Innovation In China: Evidence From Its Recent Economic Census. *Technovation,* 30**,** 540-550.

Swink, M. 2000. Technological Innovativeness As A Moderator Of New Product Design Integration And Top Management Support. *Journal Of Product Innovation Management,* 17**,** 208-220.

Swink, M. & Jacobs, B. W. 2012. Six Sigma Adoption: Operating Performance Impacts And Contextual Drivers Of Success. *Journal Of Operations Management,* 30**,** 437-453.

Taylor, F. W. 1911. *The Principles Of Scientific Management*, Dover Publications.

Troilo, G., De Luca, L. M. & Atuahene-Gima, K. 2014. More Innovation With Less? A Strategic Contingency View Of Slack Resources, Information Search, And Radical Innovation. *Journal Of Product Innovation Management,* 31**,** 259-277.

Trott, P. 2012. *Innovation Management And New Product Development* Paul Trott.

Tuli, P. & Shankar, R. 2015. Collaborative And Lean New Product Development Approach: A Case Study In The Automotive Product Design. *International Journal Of Production Research*, 53**,** 2457-2471.

Tushman, M. L. & Oreilly, C. A. 1996. Ambidextrous Organizations: Managing Evolutionary And Revolutionary Change. *California Management Review,* 38**,** 8-&.

Volberda, H., Van.Den.Bosch, F. & Mihalache, O. 2014. Advancing Management Innovation: Synthesizing Processes, Levels Of Analysis, And Change Agents. *Organization Studies,* 35**,** 1245–1264.

Voss, C. 2009. Case Research In Operations Management. *In:* Karlsson, C. (Ed.) *Researching Operations Management.* Routledge Publications.

Voss, C., Tsikriktsis, N. & Frohlich, M. 2002. Case Research In Operations Management. *International Journal Of Operations & Production Management,* 22**,** 195-219.

Voss, C. A. 1995. Operations Management- From Taylor To Toyota- And Beyond. *British Journal Of Management,* 6**,** S17-S29.

Voss, C. A. 2005. Paradigms Of Manufacturing Strategy Re-Visited. *International Journal Of Operations & Production Management,* 25**,** 1223-1227.

Ward, A. 2007. *Lean Product And Process Development,* Cambridge, Ma, Lean Enterprise Institute.

Welch, C., Piekkari, R., Plakoyiannaki, E. & Paavilainen-Mantymaki, E. 2011. Theorising From Case Studies: Towards A Pluralist Future For International Business Research. *Journal Of International Business Studies*, 42**,** 740–762.

Westphal, J. D., Gulati, R. & Shortell, S. M. 1997. Customization Or Conformity? An Institutional And Network Perspective On The Content And Consequences Of Tqm Adoption. *Administrative Science Quarterly,* 42**,** 366-394.

Wiengarten, F., Fynes, B., Cheng, E. T. C. & Chavez, R. 2013. Taking An Innovative Approach To Quality Practices: Exploring The Importance Of A Company's Innovativeness On The Success Of Tqm Practices. *International Journal Of Production Research,* 51**,** 3055-3074.

Wirtz, B., Mathieu, A. & Schilke, O. 2007. Strategy In High-Velocity Environments. *Long Range Planning,* 40**,** 295-313.

Womack, J. & Jones, D. 1994. From Lean Production To The Lean Enterprise. *Harvard Business Review*.

Womack, J. & Jones, D. 1996. *Lean Thinking: Banish Waste And Create Wealth In Your Corporation,* New York, Free Press A Division Of Simon And Schuster Inc. .

Womack, J., Jones, D. & Roos, D. 1990. *The Machine That Changed The World,* New York, Free Press A Division Of Simon And Schuster Inc. .

Yeung, A. C. L., Cheng, T. C. E. & Lai, K. H. 2006. An Operational And Institutional Perspective On Total Quality Management. *Production And Operations Management,* 15**,** 156-170.

Yin, R. K. 2009. *Case Study Research: Design And Methods,* United States, Sage Publications, Incorporated.

Zbaracki, M. J. 1998. The Rhetoric And Reality Of Total Quality Management. *Administrative Science Quarterly,* 43**,** 602-636.

Zeng, J., Chi Anh, P. & Matsui, Y. 2015. The Impact Of Hard And Soft Quality Management On Quality And Innovation Performance: An Empirical Study. *International Journal Of Production Economics,* 162**,** 216-226.

Zilber, T. B. 2006. The Work Of The Symbolic In Institutional Processes: Translations Of Rational Myths In Israeli High Tech. *Academy Ofmanagement Journal,* 49**,** 281–303.

Zimmermann, A., Raisch, S. & Birkinshaw, J. 2015. How Is Ambidexterity Initiated? The Emergent Charter Definition Process. *Organization Science,* 26**,** 1119-1139.

Zimmermann, A., Raisch, S. & Cardinal, L. 2018. Managing Persistent Tensions On The Frontline: A Configurational Perspective On Ambidexterity. *Journal Of Management Studies,* 55**,** 739-769.

Zu, X., Fredendall, L. D. & Douglas, T. J. 2008. The Evolving Theory Of Quality Management: The Role Of Six Sigma. *Journal Of Operations Management,* 26**,** 630-650.

APPENDICES

Appendix A: Research invitation letters

Appendix A1: Participants invitation letter (general letter)

Subject line: Opportunity: Innovation, excellence and process improvement research / WBS

Dear [Name of the recipient],

I am doctoral researcher at Warwick Business School (WBS) - Warwick University. I am currently undertaking a research project on *the impact of process improvement approaches on innovation.* The purpose of the study is to investigate how process improvement approaches - such as lean, six sigma, total quality management and theory of constraints - affect companies' capacity to radically and incrementally innovate their products.

This study is intended to give managers relevant insights into how operational excellence can be achieved, what factors affect the successful implementation of process improvement approaches, and how these approaches can enable radical and incremental product innovation.

I am writing to you to ask for permission to conduct this study in your company, as it has been selected as an appropriate site for this research.

The research will involve interviews for 30-50 minutes and documents analysis; however, companies' and participants' names will be treated confidentially and will not be disclosed. The results will be fed back to you, and I would be happy to discuss the good practices we will have identified also in other companies.

If you would like to participate in this research, and feel that this study is relevant to your company, please let me know.

Thank you very much for your time,

Yours Sincerely,

Rima Al Hasan

Doctoral Researcher
Operations Management Group
Warwick Business School
University of Warwick | CV4 7AL
Phd14ra@mail.wbs.ac.uk
Mobile: +447778366004
Skype: Rima.alhasan1

Appendix A2: General Research brief

Research Brief

Research Title: THE INTERPLAY BETWEEN PROCESS IMPROVEMENT APPROACHES AND PRODUCT INNOVATION

Supervisors: Prof. Pietro Micheli and Prof. Sotirios Paroutis

Research purpose: This research project is part of a Doctoral thesis, about the impact of process improvement approaches on innovation. The purpose of the study is to investigate how process improvement approaches - such as lean, six sigma, total quality management and theory of constraints - affect companies' capacity to radically and incrementally innovate their products. In particular, to get an understanding of how organisations manage processes to generate innovative products.

Research Methodology: The research will involve interviews and documents analysis. The project aims to interview people at different levels of seniority (mainly senior to middle management) and in different roles/functions (e.g., R&D, product development, operations, marketing, and engineering). Interviews will take about 1 hour each.

Also, this research looking to review documents on innovation processes (e.g., Stage Gate), main operations and/or quality awards. In the research everything will be anonymised. Companies' and participants' names, and companies' information will be treated confidentially and will not be disclosed.

The benefits of the research: This study is intended to give managers relevant insights into how operational excellence can be achieved, how to introduce processes and systems that ensure consistency and efficiency in operations, and being able to leave room for creativity and innovation, what factors affect the successful implementation of process improvement approaches, how these approaches can enable radical and incremental product innovation, and how to improve efficiency, productivity and quality, while being capable of getting innovative products and services.

At the end of the research, [*Name of the company*] will become a key beneficiary of the study's findings and will get a feedback for their own approach and in term of best practices that will be identified in the research.

Research timeline: Doctoral thesis is expected to be completed in June 2018. The data collection and the interviews are expected to complete in June 2017.

Contact details: Rima Al Hasan, Doctoral Researcher, Operations management group (OM), Phd14ra@mail.wbs.ac.uk, Mobile: +447778366004, Skype: Rima.alhasan1, Warwick business School | University of Warwick | CV4 7AL, United Kingdom

Appendix B: list of interview questions

1. Could you please tell me about your current role?
2. What process improvement approaches do you use in your company?
Probes: Have you implemented lean, six sigma etc.?
3. Why do you use them?
4. Who is responsible for improvement in your company?
5. Do you use these approaches everywhere in the company or only in certain departments or units?
6. How do you use them (lean, six sigma…)?
7. To what extent are employees involved in process improvement?
8. What are the main challenges your company faces in implementing these approaches (lean, six sigma, etc.)?
9. What are the main problems caused by the use of Process improvement approaches, if any?
10. Could you take me through your new product development process?
Probe: Do you have a formalized NPD process?
11. Could you give me examples of product innovations in your company (incremental vs radical)? *Probes: Are your innovations more radical or incremental?*
12. What is the impact of process improvement approaches on innovation and new product development? (Positives and negatives)
Probes: Do you think process improvement have an impact on research and development, design or engineering?
13. Does having a standardized process / operation affect your company's ability to innovate? *Probes: How?*

Additional interview questions (developed during the data collection process):

1. What happen to the ideas that you did not use? (In the stage process)
   Probes: Do you consider them as wastes? or not?
2. How do you define wastes in engineering / design/ R&D/ innovation departments?
3. How is the new product development process for radical innovation differing from the one for the incremental innovation?
4. Do all departments/ areas use process improvement in the same degree or they vary? How?
5. Did you face any challenges in using process improvement in engineering/ design/ R&D?

Appendix C: Data and coding structure

Table 36: Data and coding structure

Aggregate dimension	Second order coding	First order coding
PI characteristics (Configuration characteristics)	**PI formality**	*Expected*
		Voluntary (individual choice)
	PI scope and integration	*Pervasive and integrated*
		Isolated and separated
Mechanisms (a): managerial related	**Balanced performance objectives**	*Performance objectives: operations excellence/ PI*
		Performance objectives for innovation / future-oriented
	Balanced training	*Training for PI*
		Training for innovation
	Entrepreneurship -orientation	*Employees' autonomy and flexibility to initiate new projects*
		Internal innovation competitions
Mechanisms (b): Structure related	**Balanced specialized teams**	*Teams to facilitate PI*
		Teams to facilitate innovation
	Structural integration	*Process-oriented structure*
		Operations excellence representatives
PI usage mechanisms	**Adapting PI usage**	*Translating PI /process to the area: Varying PI usage across areas*
		Meaning of wastes: distinguishing waste and slack
		Using the appropriate tools/ practices
	Not using PI	*PI is not used in innovative areas*
Perceived interplay	**Managers' perception of the association between PI and the product innovation related activities and its potential impact on the product.**	*PI as enabler (complementary)*
		PI as indirect facilitator (Complementary)
		PI as irrelevant
		Barrier (Conflicting)
Potential Outcome	**Product innovation**	*Incremental innovation focus*
		Radical and incremental innovation focus

Appendix D: illustrative quotes table for the interplay at the NPD level

Table 37: Illustrative quotes: the interplay between PI and innovation at different stages of the NPD

Viewed interplay-NPD stage and its perceived impact)	Conflicting	**<u>Discovery-Conflicting</u>** • "*If you're still trying to understand how to resolve or how to deal with a business opportunity, Design for Six Sigma doesn't particularly help you there"* (Chief Programme engineer, Cheap-CarCo) • The technology lead in Excellent-AeroCo explained the reasons behind the lack of applicability of PI in research area at the early stage of product development: "*Because you're dealing with new technology, new products, new ideas, they are less constrained by process. In many cases, they don't exist or are new to the business, and it's not until they get taken into the mainstream that more rigorous processes get applied to them. By which time, they're out of R&D, so we're not affected by that, again"* (Technology lead-innovation team, Excellent-AeroCo) • "*Earlier in discovery, they [PI such as six sigma] become less relevant and actually, they just become a hindrance because it's all about the creative spark and the creative spark doesn't gel very well with structured template and process".* (Fund Director, Immunology Innovation Fund, Innovative-PharmaCo) • "*I have to be very flexible and very open because I'm dealing with different people, different types of technology, potentially different market places. So, to try and impose a process, a structured process is not a great idea"* (head of digital, Cheap-CarCo). • *"And I do think we have to be… acknowledge that humans are slightly fragile people and that the earlier in the process you are in a more creative process, an idea generation process, the more rigid process you apply to it, the more rigid structure you apply around it, there are real chances that you've actually inhibited the proper creation process".* (Head of Propulsion and innovation, Cheap-CarCo) • *"Whilst thinking about process is always important, forcing people into a very rigid set of high walls and feeling they're going down a tunnel I think typically makes people say, I'm not actually being creative".* (Head of Propulsion and innovation, Cheap-CarCo). **<u>Development-conflicting</u>** • "*I think you've got to choose the right processes. If you try and force operational Six Sigma into a development organisation, there will be problems, because you may be able to improve… say you've got processes for recruitment or for budgeting, their*

		current processes that run…but in terms of the development of technology projects, if you apply an operational Six Sigma approach to that, you will stifle the innovation and development of new ideas" (Chief Programme engineer, Cheap-CarCo) • *"I think standard process is good for one thing, obviously, because you're producing quality products, but I think it can hinder innovation, in my view. I think if you are almost boxing people to think in a certain way and to produce in a certain way, you might hinder innovation, you might hinder the culture of producing innovative ways of thinking, if that's probably a better way to answer it"* (product introduction lead, Innovative-PharmaCo).
	Complementary	**<u>Discovery-Complementary</u>** • "*Lean, through use of things like Visual Factories, where you are trying to get stakeholder engagement and buy-in, the Visual Factory, if you just put information about the technology that you're developing in a room and you put information about all the tests that you've ever carried out, and you're honest and you declare all the failures you've ever had, but then you illustrate what the solution was to each of those failures that you had."* (head of research, Fast-CarCo) • "*It's more of a case of… So, we have an innovation website and we may get hundreds of ideas coming in every day. Where Lean plays a part is spotting the good ideas and moving them efficiently to product. Where waste comes out is spotting the wrong one or spotting the right one and implementing it purely. That's kind of more of an angle"* (Head of engineering strategy and Enterprise Architecture, Excellent-AeroCo). • Talking about the potential advantage of using PI at early stages: *"Then why wouldn't you want to try and efficiently answer the question of the hypothesis in your mind as an innovator, as opposed to just randomly testing it and then maybe actually finding later down the line that it's not a statistically significant result, or you misled yourself with some kind of belief that, yes… I don't think it should stifle creativity at all"* (head of Lean transformation team, Excellent-AeroCo). **<u>Development-Complementary</u>** • "*if you would argue that the real learning begins when soon you start building and testing engines and proven that out, as faster you can get to that point the better so if you can lean out your design activities and your build activity to be really effective you can get product developed much quicker"* (Head of Continuous improvement in engineering, Excellent-AeroCo) • "*I would like to talk about it within engineering… we can make the processes as easy and as simple and you can take out as much waste you can from that… you can take away the time that spend on rework or waiting time all the wasteful time and focused that on the interesting innovation so you can spend more time designing… more time thinking about what could new concepts be and what new radical ideas… and have less time on the stuff that is annoying and wasteful so you don't actually do as many rework loop, so you don't have to spend time on non-value activities and you can really focus on training and the*

		expertise of engineers on engineering. So, I think that's quite well linked." (Head of continuous improvement in engineering, Excellent-AeroCo) • "*If you put Lean into the research and development process, you're just making your process faster or more efficient, doing it with less resources. Effects less the product"* (Process excellence & improvement senior manager in marketing and sales, Fast-CarCo). • "*If we can get Lean behaviours embedded so that people are thinking about the Lean principles, I think that's tremendously powerful. I think if we just assume, we can lift Lean tools from the manufacturing environment and deploy them in product creation, we are wasting our time. Because it's a different environment. The tools need adaption, but the behaviours, I think, are very good"* (Technical specialist vehicle dynamics systems, Fast-CarCo) • *"process improvement will make the process better so that you get better outcomes in terms of defect-free, less cost, more aligned to customers"* (Head of business excellence, Fast-CarCo) • "*There's no harm in having standards, because it just makes sure that nothing's missed. So even if you're doing a radical innovation, it might say, check this, check that, check the other, have you spoken to so-and-so, have you explored in this area? And it might just be making sure that you've not missed anything"* (Head of the production system, Excellent-AeroCo). • *"If they [engineers] have the mindset of Lean or Six Sigma, when they're designing that vehicle and they have that in mind, they will design for efficiency. They will also design with creativity but taking into account efficiency and quality in mind" (*lead engineer, Fast-CarCo) **<u>Deployment-Complementary</u>** • *"I think having a standardised process is fine, because I think part of innovation is your ability to improve processes and I think… e.g., an extreme case would be let's take away all the processes and just have chaos or whatever people want to do. That doesn't mean you're going to innovative, it doesn't mean you're going to be good at continuous improving."* (Manufacturing unit manager, Innovative-PharmaCo) • The chief programme engineer in Cheap-CarCo describing how six sigma and lean fit in the operational environment: *"So in the operational context… the purpose of many operational processes, particularly problem resolution processes, is to define things very clearly, to define processes very clearly, to avoid noise factors and error states and minimise the risk of things not happening".* • "*So, typically we would start…standardising once we start producing products for patients, you know…You start becoming more tight in terms of your control strategy, in terms of your specifications. So it might be slightly wide when you start off, but it becomes a bit more, you know, tighter, I want to say, once you get to patients, because obviously your main focus is to make sure that the patient is safe*" (New product introduction lead, Innovative-PharmaCo)