Managing the Interrelationships Between Manufacturing System Elements for Productivity Improvement in the Factory

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MANAGING THE INTERRELATIONSHIPS BETWEEN MANUFACTURING SYSTEM ELEMENTS FOR PRODUCTIVITY IMPROVEMENT IN THE FACTORY

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Department of Operations Management
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Managing the interrelationships between manufacturing system elements for productivity improvement in the factory

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Foreword

Returning to academics 15 years after finishing my master’s degree for this PhD project was like entering a new world—exciting and challenging. It has been exhilarating to have had the opportunity to dive into the topic of this study, which is of deep interest to me, but one that my daily routine previously offered scant time. Notably, it was challenging to learn and master a new writing style while focusing on the scope and scale of each word in such a complex narrative. This differs greatly from my business background, which is filled with tables, figures and data presentations that offer little time for exposition. Moreover, mastering the research design skills at the PhD level has been daunting, as the motivation is largely to avoid tripping ‘landmines’ of fallacy and previously claimed topics as I built a compelling and field-impacting thesis—research that creates beneficial changes. I have sought to provide these things humbly and tirelessly while also becoming familiar with an entirely new academic environment with unknown systems in a new country. Hence, I wish that I had paid more attention to the ‘Olsenbanden’ TV series prior to this adventure.

My purpose in this PhD project was to systematically investigate and gain a deep understanding of how factory managers can influence productivity in a variety of settings to orchestrate and fuel an ‘organic’ process for which the manager’s skill set is the ‘DNA’. The nature of this problem is complex and somewhat enigmatic, and a generalisable rubric of any kind has been less than forthcoming until now. Thus, I am very grateful for the guidance and support of Professor Rüdiger Mottl, my diploma supervisor and sparring partner, who encouraged me to take this journey and tackle this problem—a true pioneer and mentor.

At Copenhagen Business School, I was extremely lucky that Kim Sundtoft Hald and Allan Hansen agreed to supervise my work, as their complementary capabilities, shared wisdom and welcoming demeanour helped me entwine the DNA of my scholarship. They have always had open ears, open minds and open calendars whenever I need their guidance. Although my time at the Department of Operations Management (OM) seemed fleeting, I always felt welcomed by the inviting and friendly atmosphere provided by the department team, including the other students, professors, coordinators, assistants and especially Yana, the department secretary.

My pursuit of this PhD project was made possible by the great support of my case firm, whose management strongly supported a mutually beneficial outcome. I also want to thank the many co-workers who agreed to participate in the interviews for my data collection while also picking up my slack. They have contributed greatly to the findings, and I truly believe that we will all benefit.

Very sincerely, I know that I would not have been able to embark upon this journey without the loving support of my wife, Manja, who unfortunately had to periodically take a backseat to my research, for which I will always gratefully repay with every spare minute. Many thanks are also owed to my parents, family and friends who supported me and Manja along this epic journey with their thoughts and prayers. This means the world to me as a Christian, and I want to thank God for His accompaniment and enduring power during this PhD production.

In my field and on my job, we follow classic and enduring OM scholarship, and these lessons will always be important to global production networks and sustainability. However, upon that eminent backdrop, I pray that the results of my efforts will contribute positively in two ways.
First, I want to encourage present and future OM researchers to focus more keenly on versatile productivity management in the face of the many forthcoming changes driven by remarkable new intermixed human resources and technology advancements. Second, I want to extend my research design as a new model for academic–practitioner exchange that not only acknowledges but also captures and incorporates the benefits of fertile OM knowledge sharing between academics and professionals.

Michael Güldenpfennig
(Eisenach, November 2023)
Abstract

For manufacturers, productivity improvements are essential. Understanding how to improve productivity is fundamental for gaining a strong competitive position with sustainable growth and ensuring the survival of the business. Productivity is key, and it is essential that we understand how managers influence improvements as they intertwine numerous talents and processes to build the ‘DNA’ of a factory. Productivity science has been a key aspect of operations management research since the 1980s, and productivity differs across factories. Many pragmatic and empirical reasons have been highlighted and managers are familiar with them, but the managers know less about how they work together and literature barely touches on the impact of organic management as it relates to the identification and mitigation of barriers that appear at multiple stages in improving productivity. A systems perspective on improving productivity in the factory is widely neglected in operations management.

Organisational studies and systems theory can help in understanding how success can arise from less-understood management practices and methods, but fragmented knowledge has led to confusion and disagreement over the various manufacturing system elements and their interrelationships in productivity improvement. Thus, manifold manufacturing system elements, including technical resources like machines, human resources with their social needs, and management control systems or environmental elements like labour market regulations, must be considered in managers’ orchestration of productivity improvement. The many attributes of manufacturing organisations and their elements are quite broad in scope, and their interrelationships are complex. Highlighting them in a way that deconflicts and facilitates intricate activities would benefit continuous productivity improvement. To achieve this, we must answer the question, ‘How do managers manage manufacturing system elements and their interrelationships to improve productivity?’

Several aspects of systems theory relate to this question, and three of the articles in this dissertation address these. The first article, ‘Managing productivity improvement in a complex manufacturing world: What we know from 40 years of OM literature’, illuminates and organises various productivity improvement options and identifies the resulting complexities faced by managers. It is a systematic literature review that applies contingency systems view to identify factories’ system elements and investigate their effects and the interrelationships involved. The second article, ‘Productivity improvement and multiple management controls: Evidence from a manufacturing firm’, has a single case design that follows an abductive approach. The actions of managers and their management mechanisms were investigated by applying the lens of multiple management control systems. In the third article, ‘Exploring the control problems and the interplay of management control systems for productivity outcome on the assembly line’, the management control systems theory was used to examine the control problems managers apply to manage their teams on shop floors for productivity outcomes. The author’s full-time presence at the case firm allowed for deep insights that would otherwise have been inaccessible.

This article-based dissertation investigates how managers in factories, the unit of analysis, engage in the orchestration of the many interrelationships among manufacturing elements as they pursue productivity improvements, which is the phenomenon researched. This dissertation provides a novel systems view of productivity management at factories and therewith an
opportunity to gain deeper insights into the barriers hindering productivity improvement. It conveys a new understanding that productivity management must be understood as a multi-dimensional responsibility of managers in the manufacturing system involving highly individual decision-making opportunities, resulting in differentiated actions and tasks. Five different overall types of system elements are identified and three different dimensions of interrelationships between them are investigated, providing the basis for specific managerial tasks, which are described for each dimension. Further, this dissertation describes the heterogeneity of complexity in relations to productivity improvement in the factory. On the one hand, the findings suggest that complexity is high through the manifold options to improve productivity and interrelationships between resources to control. On the other hand, the complexity can be diverse, for instance as shop floor managers face few control problems but each of them requiring high social interaction with the team. It highlights a different understanding of middle managers’ roles as determined by day-by-day management as they continuously drive improvement activities. For practitioners, the findings provide a catalogue of 83 elements structured into nine themes as practical options managers can draw on to improve the productivity outcomes of their factory floors. Above this, it provides specific guidance how to handle these many options to improve and many examples of tasks how to overcome and mitigate conflicts between resource elements for productivity improvement.
Dansk resume

Produktivitetsforbedringer er afgørende for produktionsvirkomheder. Forståelse for, hvordan produktiviteten konkret kan forbedres, er fundamental for at opnå en stærk konkurrenceposition med bæredygtig vækst og for at sikre virksomhedens overlevelse. Produktivitet er nøglen, og det er vigtigt at forstå, hvordan ledere påvirker forbedringer, da de sammenfletter mange talenter og processer for at opbygge en fabriks "DNA". Produktivitetsvidenskab har været et centralt aspekt af forskningen i operations management (driftsledelse) siden 1980'erne, og produktiviteten er forskellig fra fabrik til fabrik. Mange pragmatiske og empiriske årsager til forskelle i produktivitet på tværs af fabrikker er blevet fremhævet, og lederne kender allerede mange af dem, men lederne ved mindre om, hvordan disse årsager og produktionsystemets mange elementer hænger sammen og påvirker hinanden. Litteraturen er ligeledes mangelfuld når det kommer til organisk ledelse af produktivitetsforbedringer, da den vedrører identifikation og afhjælpning af barrierer, der optreder på flere stader i forbindelse med forbedring af produktiviteten. Et systemperspektiv på forbedring af produktiviteten i fabrikken er i høj grad forsømt i operations management.

Organisationsstudier og systemteori kan hjælpe med at forstå, hvordan succes kan opstå på baggrund af mindre forståede ledelsespraksisser og -metoder, men den fragmenterede viden har fort til forvirring og uenighed om de forskellige elementer i produktionssystemet og deres indbyrdes relationer i forbindelse med produktivitetsforbedring. Der skal således tages hensyn til mange forskellige elementer i produktionssystemet, herunder tekniske ressourcer som maskiner, menneskelige ressourcer med deres sociale behov og ledelseskontrolsystemer eller omverdenselementer som f.eks. arbejdsmarkedskrav, når ledere skal tilrettelægge produktivitetsforbedringer. De mange egenskaber ved produktionsorganisationer og deres elementer er ret omfattende, og deres indbyrdes relationer er komplekse. Hvis de ledes og organiseres på en måde, der gør det muligt at fjerne konflikter og lette komplicerede aktiviteter, vil det være til gavn for den løbende produktivitetsforbedring. For at opnå indsiget i mulighederne for at opnå dette må vi besvare spørgsmålet: "Hvordan orkestrerer ledere elementerne i produktionsystemet og deres indbyrdes relationer med henblik på at forbedre produktiviteten?"

fuldtidstilstedeværelse i case-virksomheden gav mulighed for dybtgående indsigt, som ellers ville have været utilgængelig.

Denne artikelbaserede afhandling undersøger, hvordan ledere på fabrikker engagerer sig i orkestreringen af de mange indbyrdes sammenhænge mellem produktionssystemets elementer, når de stræber efter produktivitetsforbedringer. Den giver et nyt systemisk perspektiv på produktivitetsstyring i fabrikker og dermed mulighed for at få dybere indsigt i de barrierer, der hindrer produktivitetsforbedringer. Den giver en ny forståelse af, at produktivitetsstyring skal forstås som et flerdimensionalt ansvar for ledere i produktionssystemet, der indebærer meget individuelle beslutningsmuligheder, hvilket resulterer i differentierede handlinger og opgaver. Der identificeres fem forskellige overordnede typer af systemelementer, og der undersøges tre forskellige dimensioner af indbyrdes relationer mellem dem, som danner grundlag for specifikke ledelsesopgaver, der beskrives for hver dimension. Yderligere beskriver denne afhandling heterogeniteten af kompleksitet i forhold til produktivitetsforbedring i fabrikken. På den ene side tyder resultaterne på, at kompleksiteten er høj på grund af de mange muligheder for at forbedre produktiviteten og de indbyrdes relationer mellem ressourcer, der skal kontrolleres. På den anden side kan kompleksiteten være mangfoldig, for eksempel står værkføren over for få kontrolproblemer, men hver af dem kræver høj social interaktion med teamet. Afhandlingen fremhæver også en anden og ny forståelse af mellemledernes roller som bestemt af daglig ledelse og fokus på løbende forbedringsaktiviteterne. For praktikere giver resultaterne et katalog med 83 elementer struktureret i ni temaer som praktiske muligheder, som lederne kan trække på for at forbedre produktivitetsresultaterne på deres fabriksgulve. Derudover indeholder rapporten specifik vejledning i, hvordan man håndterer disse mange muligheder for at forbedre produktivitet og mange eksempler på opgaver, der kan overvinde og mindske konflikter mellem ressourceelementer med henblik på produktivitetsforbedring.
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### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>CT</td>
<td>Contingency theory</td>
</tr>
<tr>
<td>DNA</td>
<td>Deoxyribonucleic acid (used as a metaphor)</td>
</tr>
<tr>
<td>HRM</td>
<td>Human resource management</td>
</tr>
<tr>
<td>IT</td>
<td>Information technology</td>
</tr>
<tr>
<td>JIT</td>
<td>Just-in-time</td>
</tr>
<tr>
<td>MC</td>
<td>Management control</td>
</tr>
<tr>
<td>MCS</td>
<td>Management control system</td>
</tr>
<tr>
<td>MTM</td>
<td>Methods-Time Measurement</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
</tr>
<tr>
<td>OEE</td>
<td>Overall equipment effectiveness</td>
</tr>
<tr>
<td>OM</td>
<td>Operations management</td>
</tr>
<tr>
<td>PI</td>
<td>Productivity improvement</td>
</tr>
<tr>
<td>PIS</td>
<td>Productivity improvement system</td>
</tr>
<tr>
<td>PMS</td>
<td>Productivity management system</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and design</td>
</tr>
<tr>
<td>REFA</td>
<td>German Association for Work Design, Business Organization and Business Development</td>
</tr>
<tr>
<td>SFM</td>
<td>Shop floor management</td>
</tr>
<tr>
<td>SLR</td>
<td>Systematic literature review</td>
</tr>
<tr>
<td>TFP</td>
<td>Total factor productivity</td>
</tr>
<tr>
<td>TPS</td>
<td>Toyota Production System</td>
</tr>
<tr>
<td>TPM</td>
<td>Total productive maintenance</td>
</tr>
<tr>
<td>TQM</td>
<td>Total quality management</td>
</tr>
<tr>
<td>TQM/A</td>
<td>Total quality management and assurance</td>
</tr>
<tr>
<td>VSM</td>
<td>Value stream mapping</td>
</tr>
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Chapter 1: Introduction

This chapter explains the research problem and purpose of the present dissertation and clarifies its position and role in academic fields. In Section 1.1, the motivation and academic background are explained. In Section 1.2, the research question and framework are presented, and in Section 1.3, an outline of the dissertation is given.

1.1 Motivation and background

For manufacturing companies, productivity improvement is understood as being fundamental to attaining a strong competitive position, maintaining sustainable growth and ensuring firms’ survival (Bernolak, 1997; Lowe & Fernandes, 1994; Tangen, 2005). Failing to meet productivity targets can result in factory closures, work relocations and/or lost customers, regardless of the company’s predominance in low-wage countries (Mirzaei et al., 2021; Spring et al., 2017). The importance of productivity improvement has increased with global competition and the consolidation of industrial sectors (Naoum, 2016; Wacker et al., 2006; Walker et al., 2015). The resulting dependence on a few large customers in major sectors (e.g., automobile manufacturing) has led to a large amount of competition and heavily restricted profit margins, which continues to drive the need for even more efficient resource utilisation and streamlined operations (Lazard & Co. GmbH & Roland Berger GmbH, 2020). Manufacturing organisations such as factories are complex entities whose relationships must be precisely coordinated and controlled to meet production goals (Miller & Friesen, 1984).

From the literature on OM and adjacent domains, such as management accounting and economics, we know that there are multiple reasons for productivity growth and decline (Dutton & Thomas, 1982; Lowe & Fernandes, 1994; Naude & Nagler, 2018). Contemporarily, economists (e.g., Forrest & Liu, 2022; Lowe & Fernandes, 1994; Naude & Nagler, 2018) and early OM researchers (e.g., Hayes & Clark, 1986) have aimed to explicitly identify the reasons for productivity differences among factories. Notably, changing governmental policies and new laws were found to be contributory (Dutton & Thomas, 1982), as were weak national innovation mechanisms (Naude & Nagler, 2018). Inflation and governmental regulations (Dutton & Thomas, 1982), inadequate market controls that do not allow low productivity companies to fail (Naude & Nagler, 2018) and industrial technological changes (Lowe & Fernandes, 1994) have also been noted. However, despite much research on productivity, economists have observed a decline in the Organisation for Economic Co-operation and Development (OECD) state labour productivity growth and total factor productivity (TFP) since 1990 in the manufacturing sector, especially after the financial crisis of 2008/2009 (Ademmer et al., 2017). Annual productivity improvement has slowed over the past 30 years, which begs an explanation for why it has become more difficult to improve productivity in manufacturing.

Among other reasons, productivity management has been discussed as affecting manufacturing productivity, and for more than four decades, productivity improvement has been the subject of operations management (OM) research (Jin et al., 2016) and is essential to the discipline (Schmenner, 2015). In OM, productivity improvement without the concepts of Lean manufacturing and Toyota Production System (TPS) (Liker, 2004; Taiichi Ohno, 1988; Shah & Ward, 2003; Womack et al., 1990) is unthinkable in today’s manufacturing (Antony et al., 2021),
and there is a strong connectiveness between productivity and Lean because they both aim to optimise processes, eliminate waste and create value. From this perspective, OM research has addressed many inefficiencies by applying Lean manufacturing concepts, alongside their multifarious operational toolkits (Abolhassani et al., 2019; Bernolak, 1997; Gunasekaran et al., 2000; Mohanty, 1992) or Six Sigma (Kirkham et al., 2014; Manville et al., 2012). In addition to Lean manufacturing, multiple other concepts influencing productivity have been identified and analysed in OM. One example is today’s emerging digitalisation via the expansion of Industry 4.0 that has provided new opportunities for productivity improvement (Alavian et al., 2020; Hannola et al., 2018). Another example is the research that examines managers’ applied leadership styles, skills and communications (Inman & Blumenfeld, 2010; McCreery et al., 2004; Oudhuis, 2004; Pagell & LePine, 2002). Furthermore, we have more knowledge about the complex sets of elements in the external environment that influence productivity improvement but are outside of managers’ control (Mohanty, 1992; Song et al., 2018; Spring et al., 2017). Research on the management of factory resources (Bello-Pintado et al., 2019; Demeter et al., 2011; Kao et al., 1995) and productivity measurements (Alavian et al., 2020; Park & Li, 2019; Sáenz-Royo & Salas-Fumás, 2014) complement our knowledge on productivity management in OM.

However, there is little research referring to what managers explicitly and detailly do to mediate productivity stagnation (Giardili et al., 2023; Hayes & Clark, 1986; Holmström, 1995; Skinner, 1986). Studies have explored this but have failed to go deeply into the details of tasks and decision-making of day-by-day managerial work. Studies have shown several potential ways in which managers can influence productivity within their control. However, many of these studies reported on a single optimisation project implementing technical improvements, such as line balancing or the rearrangement of machine layout (e.g., Park & Li, 2019). Alternatively, they focused on the technical dimension of a single production process, such as an assembly line (e.g., (Karim et al., 2016), neglecting the complexity of the manufacturing system, which might have more inherent interrelationships that must be considered for productivity improvement reasons (Hasle et al., 2012; Negrão et al., 2017). In some productivity studies, the managerial tasks involved are named in relation to productivity improvement, but the mechanisms underlying why managers decide on certain tasks or the impacts of their execution are not explained (Bernolak, 1997; Gunasekaran et al., 1994; Schmenner, 1991; Schmenner & Cook, 1985; Skinner, 1986; Sting & Loch, 2016). Hence, despite the long and well-documented history of OM, we only have a limited understanding of how factory managers (not merely processes) influence the productivity outcomes of their factories. As researchers have focused mainly on technical production processes only and not on the entire manufacturing system, the managerial activities and tasks that lead to the identification and mitigation of barriers to productivity improvement are not fully understood.

Systems theory and organisational science suggest that deficiencies and barriers in organisations stem from missing and unexplained links between system elements (e.g., Khandwalla, 1973, 1977; Mintzberg & Quinn, 1996; Siggelkow, 2011; Thompson, 1967). Because the context of this investigation is the factory as an organisational system, the present dissertation applies the understanding that specific settings (e.g., factories) are characterised by organisational elements and interrelationships. Indeed, the nature of organisational elements, such
as factory resources, management control systems (MCSs) or even the social aspects of operators, is overly broad; their interrelationships are numerous because elements relate by following a common objective. Interrelationships between manufacturing system elements can result in truly complex synergies and trade-offs of efficacy (Friis et al., 2015). Hence, an interrelationship between manufacturing system elements can lead to negative, conflicting and substitutional outcomes because targets are not aligned between two different resources (Friis et al., 2015; Grabner & Moers, 2013; Malmi & Brown, 2008; Van der Kolk et al., 2020). Seeing the factory from a systems perspective in relation to productivity improvements remains widely neglected in OM but offers an opportunity to gain knowledge on the mediation tasks of managers.

However, in the OM literature, the details (activities and tasks) are widely missing regarding how managers identify and mitigate the barriers arising in improving productivity. Such a perspective would involve the character of the manufacturing system elements, for instance machine groups, assembly lines but also operator needs, in productivity improvement; their interrelationships; and the consequential managerial tasks for mitigating the barriers that arise. Highlighting these elements and understanding their nature in manufacturing organisations is essential for gaining an understanding of their impact on productivity.

1.2 Research question and initial research framework

The present dissertation addresses a gap in the research: the activities and tasks of managers for improving productivity are not fully understood because of the systems view being widely neglected in productivity improvement research. There are many methods to improve productivity, and managers are familiar with them, but they know less about how these systems work together and, thus, might lower the effect of each of the individual activities or methods applied. In OM, we must contemplate how managers are also designers who ideate and frame the character of manufacturing system elements (i.e., humans, machines and processes) and articulate the nodes and edges of their interrelationships. Thus, we could enhance our understanding of their roles as organisers by placing their daily decision-making activities in an authentic, productivity-enhancing behaviour design light. From this perspective, the present dissertation follows the call of McCreery et al. (2004) for empirical work exploring complex interrelationships and providing guidance to managers when ‘configurating, training and deploying their workforce’ (p. 409). Because the system view is promising in helping us identify the relevant manufacturing system elements and their interrelationships and is widely neglected in OM when it comes to productivity improvement, the following questions will guide the research:

RQ: How do managers manage manufacturing system elements and their interrelationships to improve productivity?

The research design of the current dissertation comprises three related scholarly components, as illustrated in Figure 1.1. Thus, the unit of analysis of the present PhD dissertation is the factory, and the phenomenon researched is productivity improvement in the factory.
The first part of the research framework includes ‘setting for managing productivity improvement’, which includes manufacturing system elements and external forces. The setting relates to manufacturing system elements and their interrelationships. Second, the ‘productivity improvement in the factory’ is the objective, that is, the phenomenon. The connections between the two are mediation by the managers. Hence, what managers do to manage these interrelationships and enhance productivity is within the scope of this dissertation. The direct relationship between the setting (the factory) and productivity improvement is not a focus.

1.3 Outline
Following this introduction, in Chapter 2, the status quo of the academic field on productivity management is analysed and the systems perspective and related theoretical concepts of contingency theory (CT) and MCS theory are discussed as lenses to focus the means of answering the research question. In Chapter 3, the position of the articles in the dissertation and their philosophical assumptions are elaborated. In Chapters 4–6, the three articles comprising this PhD project are presented in their most recent states, and in Chapter 7, the overall findings are discussed as an answer to the research question and conclusions are drawn as well as contributions are presented. Furthermore, the limitations and outlooks for additional research are discussed.
Chapter 2: Theoretical background

This chapter discusses the theoretical background of managing productivity improvement in factories and provides an overview about the theoretical lenses applied. This research area has been well-covered for decades in terms of OM and adjacent domains (Jin et al., 2016). However, productivity management theory is fragmented, and this chapter highlights the relevant gap that should be answered by the research question and the analytical framework that will be applied (see Figure 1.1).

In Section 2.1, productivity is defined for this dissertation, and Section 2.2 describes the manufacturing settings in which factory managers are tasked to improve productivity. In Section 2.3, the streams of literature that focus on productivity differences are discussed, noting that productivity management is one of the many varieties. In Section 2.4, the characteristics of organisational elements and their interrelationships are discussed since they are fundamental to this research. Section 2.5 elucidates how productivity management is established in literature. In Section 2.6, the missing knowledge of the contributing research streams that is needed to answer the research question is summarised. Section 2.7 illuminates the characteristics of systems and highlights different systems views. Section 2.8 explains how a factory can be regarded as a set of organisational systems and Section 2.9 introduces the two system views applied in this dissertation.

2.1 What is productivity?

Although researchers and practitioners generally agree that productivity is the ratio of desired output in relation to the resources input to the process (Brown & Mitchell, 1988; Demeter et al., 2011; Tangen, 2005), productivity takes many forms that need to be distinguished. The concept of productivity is ancient, being described as ‘making the best use of time, because the days are evil’ (The Bible, ESV, Ephesians 5:16) and is for instance reflected in the productivity recordings of Athenian vase-painters between 500 and 400 BC (Sapirstein, 2019). The meaning of productivity in OM parlance has changed over time (Tangen, 2005). The French philosopher Littré stated in 1883 that ‘Productivity = faculty to produce’ (Tangen, 2005, p. 36). A more extensive description originates from (Bernolak, 1997), who emphasised the resource side of productivity and presents the understanding of productivity of this dissertation:

‘Productivity means how much and how good we produce from the resources used. If we produce more or better goods from the same resources, we increase productivity. Or, if we produce the same goods from less resources, we also increase productivity. The same applies to services. If we provide more services or better-quality services from the same resources, our productivity has increased. Or, if we provide the same services and just as well, from less resources, we also improve productivity. By ‘resources’, we mean all human and physical resources (i.e. the people who produce the goods or provide the services, and the assets with which the people can produce the goods or provide the services). The resources that people use include the land and buildings, fixed and moving machines and equipment, tools, raw materials, inventories and other current assets’ (p. 204).
Although the basic theme of these definitions is the same, Ghobadian and Husband (1990) analysed three major categories of productivity definitions, summarising them as technological (e.g. based on the relationship between ratios of outputs to inputs), engineering (e.g. relationships between actual and potential process outputs), and economics (e.g. efficiency of resource allocation; p. 1435).

Productivity measurement values have no meaning unless they can be compared with other measures, either longitudinally or cross-sectionally (Kao et al., 1995; Schmenner, 1991; Tangen, 2005). The OM literature covers several varieties of productivity management measures that are distinguished by the types of input resources being used (Baines, 1997; Demeter et al., 2011; Dorner, 2014), including labour (e.g. Demeter et al., 2011; Orzes et al., 2017; Shah & Ward, 2003), capital investments (e.g. Aggarwal, 1980; Demeter et al., 2011; Misterek et al., 1992) and material (e.g. Kamble et al., 2020; Sartal et al., 2020). In OM, labour productivity, which is the dominant measure, tracks the output quantity of products in relation to the number of labourers (Noble, 1997; Skinner, 1986).

When considering the total resources utilised in a production, TFP is applied in OM studies (Jin et al., 2016) and is calculated as the value added divided by the total capital plus employment costs (Li & Hamblin, 2003). Neoclassical economic growth theory considers TFP as the rate of technological progress (Song et al., 2018). Notably, the term ‘manufacturing productivity’ is defined in OM as the manufacturing value added per capita, and ‘size’ indicates the population of the respective country (Lowe & Fernandes, 1994).

These concepts assume that productivity reflects the results of a process (i.e. a dependent variable). However, there are multiple examples of productivity being used as an input variable, such as company performance (Demeter et al., 2011). In this dissertation, productivity is analysed as an outcome.

### 2.2 Manufacturing setting

Besides the variety of interrelationships between organisational elements that is central to this investigation, the setting, where the organisational problem appears and hopefully can be resolved, must be described.

This dissertation defines the manufacturing setting as the place where the activities of management unfold. Various syntheses of relevant business and OM literature have led to the much-needed understanding of manufacturing scope as it pertains to the activities taking place in manufacturing settings. Notably, many aspects of manufacturing methods can affect the settings, as shown in Figure 2.1. These aspects include economic sector (Forrest & Liu, 2022; Halkos et al., 2021; Marconi et al., 2016), technology (Fettermann et al., 2018; Kao et al., 1995; Son, 1994; Tortorella et al., 2020) and function/department (Franks et al., 1987; Leoni, 2013; Skinner, 1974). Not all extant studies’ focus areas can be delimited to just one of these three areas, such as offshoring studies (e.g. Abolhassani et al., 2019). For this dissertation, all three areas are considered for the analysis.
Chapter 2 – Theory

Figure 2.1: Three key aspects of manufacturing that influence ‘setting’

The following three subsections expound upon these three aspects to provide the three analytical perspectives of this dissertation, so that the findings may be coherently organised with action potential.

2.2.1 Economical sector aspect of manufacturing settings
The literature classifies the manufacturing sector as ‘secondary’ (Forrest & Liu, 2022; Kellerman, 1985; Selstad, 1990). However, in economics, scholars tend to agree that this sector has a strong impact on economic growth (Forrest & Liu, 2022; Halkos et al., 2021; Marconi et al., 2016). In 2020, the manufacturing share of world economies was about 13%. This reflects the value added by manufacturing to gross domestic products (TheGlobalEconomy.com, 2021). For OECD countries, this value was slightly higher at ~14% (TheGlobalEconomy.com on 15th Oct 2022). Notably, Ireland had the greatest portion of manufacturing/GDP in Europe at ~37% (TheGlobalEconomy.com, 2021). Concerning labour markets, manufacturing sector employment in the EU28 countries was ~15% in 2017 (Storrie, 2019).

Global manufacturing in the past few decades has been characterised by the continued trajectory toward higher product customisation and individualisation, which include faster response times to customer needs and an increasing geographical spread of manufacturing networks and supply chains (i.e. ‘transnational manufacturing’; Ferdows, 1997). In the context of transnational manufacturing, multiple research streams have addressed the impact of economic trends, such as offshoring (Autor et al., 2017; Jensen & Pedersen, 2012) and global import and export tariff regulations (Storrie, 2019).

Current manufacturing trends continually alter working environments in developed and developing countries, and the result is a tendency toward more sophisticated jobs and higher education levels, which is challenging and often a limiter. In the US, this scenario applied to 35
advanced manufacturing industries (e.g. agriculture chemicals, motor vehicles and semiconductors), which, on the one hand, accounted for higher increasing earnings than the rest of their economy (Hessman, 2015). This observation reflects the growth of a highly skilled workforce in science, technology, engineering and math fields (Hessman, 2015). Some national economies have changed drastically, as with China (i.e. the ‘factory of the world’) in the manufacturing industry.

### 2.2.2 Technological aspect of manufacturing settings

Throughout history, the development of manufacturing has been strongly driven by technical innovations. The period of industrialisation in the 18th and 19th centuries produced ground-breaking innovations in manufacturing. For example, the Watts steam engine allowed, for the first time, the free selection of manufacturing locations, freeing up precious major waterways for other industries (Miller & Glithero, 2016). For textile production, it enabled power-driven spinning and looming machines for mass production, resulting in dramatically increased productivity and improved quality. In 1776, Sir Richard Arkwright’s cotton factory with the Shudehill mill (Figure 2.2) in Manchester, UK, was the first to bring machinery, labour, materials and power to a single location, birthing a brand-new type of manufacturing organisation (Schmenner, 2015). Much later in 1914, the first moving assembly line was installed by Henry Ford, dividing work tasks into smaller, specialised steps, further increasing productivity and, for the first time in a major capacity, people with machines.

![Illustration of the Shudehill mill](From Miller & Glithero (2016), taken from the catalogue of the Baxendale & Co. ironmongery complex of 1910)
Presently, a techno-industrial transformation is taking place in the UK, Germany, France, China, Japan and the US for transforming increasingly automated manufacturing to a future state of intelligent manufacturing (Forrest & Liu, 2022). Often, governmental programmes initiate and support these types of industrial transformations. In OM parlance, the current phase is Industry 4.0 (Fettermann et al., 2018; Forrest & Liu, 2022; Tortorella et al., 2020), whose technologies are manifold. Unfortunately, practitioners and scholars remain unclear about which contemporary concepts are being enwrapped in Industry 4.0. The review of Zheng et al. (2021) provides an overview of Industry 4.0-enabling technologies in the manufacturing context (see Table 2.1).

Table 2.1: Industry 4.0-enabling technologies in the manufacturing context (Zheng et al., 2021)

<table>
<thead>
<tr>
<th>Cyber-physical systems</th>
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<tbody>
<tr>
<td>Internet of things</td>
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<tr>
<td>Big data and analytics</td>
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<td>Cloud technology</td>
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<td>Artificial intelligence</td>
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<td>Blockchain</td>
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<td>Simulation and modelling</td>
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<tr>
<td>Visualisation technology (augmented and virtual reality)</td>
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<tr>
<td>Automation and industrial robots</td>
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<td>Additive manufacturing</td>
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2.2.3 Functional/departmental aspect of manufacturing settings

Whereas the previous two functional settings provided macro views of manufacturing, this section refers to the micro view. Company sites can be organised in several ways, such as functionally or by department, so that jobs can be grouped into appropriate teams (Scott & Davis, 2016). Apart from human resource management (HRM), supply-chain management, finance, controlling, sales, quality, engineering and research and design (R&D), the manufacturing or production department is nearly always the largest function or department (Karlsson, 2009). In many cases, these departments are divided into sections according to product lines, technologies, customers or combinations thereof. Many times, they are hierarchically structured. Hence, machine operators and production line employees report to one or more supervisors who report to operations managers and/or directors. There are also several supporting functions, including maintenance, engineering, quality and others. Other corporate manufacturing functions focus on strategy and production network management (Wheelwright, 1984), developing standards and core competencies for technology applications and practises.
2.3 Explicit search for reasons why some factories are more productive than others

The body of literature explicitly searching for reasons why productivity levels differ among manufacturing organisations seems to have the potential to contribute to the research question. This research is covered by at least two fields: OM (Hayes & Clark, 1985; Skinner, 1974) and economics. Although economists tend to apply a macro view to this issue when applied to firms and industries, OM scholars take a micro view (i.e. inside a firm; Hayes & Clark, 1985).

Thus, Hayes & Clark (1986) studied 12 factories from three major corporations and sought to find out ‘why some factories are more productive than others’ (Title of their study) and emphasised the importance of how actions are operationalised to improve productivity. From their perspective, the way productivity measurement is applied is relevant to its improvement when measuring what is really going on. For example, processed materials can either be precisely counted or estimated by their standard costs. Furthermore, the way productivity improvements are made matters, and management has a significant impact on the results. Accordingly, just throwing money into investments does not trigger solutions because major changes in routines and processes can lead to inefficiencies. Thus, investments required the right timing and management, long-term productivity improvement and understanding of processes (Hayes & Clark, 1985). Long-term productivity improvements come from honest productivity measurement efforts and a deep understanding of manufacturing processes that preclude improvement actions. Hence, understanding an organisation allows change-making to be more effective. Holmström (1995) called this ability ‘operations development effort’.

Productivity improvement does not mean simply cutting costs (Skinner, 1986). Doing so blindly leads to the productivity paradox, in which companies suffer stagnating productivity growth afterward. Instead, firms with manufacturing-orientated competitive strategies require structured changes that address location, size and location decisions, as these things often account for a higher proportion of productivity improvement than conventional productivity actions (Skinner, 1986). The potential of productivity improvements depends on equipment and technology upgrades. Here, Skinner (1986) agreed with Hayes and Clark (1985) that the installation of new and emerging technologies must be evaluated and carefully planned so that they do not cause productivity losses. Skinner promoted the lean concepts that originated from the TPS, which include quality, reliable delivery, short lead times, good customer service, rapid product delivery, flexible capacity and efficient capital employment. According to Skinner (1986), these are the primary operational sources of competitive advantage. Furthermore, productivity improvements dictated by the workforce can lead to divergent values and goals, which can curtail innovation and degrade company culture (Skinner, 1986). Skinner (1986) pointed to a new understanding of productivity based not only on simple cost reductions, but also on a detailed management understanding of manufacturing settings, whose detailed elements must be orchestrated to develop competitive advantages and ‘unleash the powerful team of people supported by the right technology’ (p. 45).

Even though primarily classic OM scholars in the 80s explicitly ask for productivity differences, there are few examples in recent research that make productivity as a major topic such as Karim et al. (2016) that report about the application of the work method ‘Maynard
Operation Sequence Technique (MOST)’ to eliminate bottle necks and reduce cycle time at the assembly line of a carmaker.

Researchers in other domains have contributed analyses on productivity differentiation at macro levels, for example by looking for explanations outside the scope of operations managers. One reason refers to differences in the growth of output because productivity gains tend to accelerate with production increase and growth of manufacturing sector is fundamental for economic development and productivity increase (Marconi et al., 2016). Notably, exports can amplify an increase in output growth, which further increases manufacturing productivity through experience. This, in turn, generates new comparative advantages (Marconi et al., 2016). Another reason for differences in productivity comes with the power of innovation expended by a firm or industry (Forrest & Liu, 2022; Naude & Nagler, 2018). Noting that innovation is the ability of entrepreneurs to turn ideas into businesses or products, the reasons for weak innovation and resulting productivity decline often stem from weaknesses in the national system in place to support them, and this weakness can be measured using the declining number and quality of patents (Naude & Nagler, 2018).

Apart from external reasons, economists have acknowledged many internal causes for productivity changes, including poor management quality and practises (Broszeit et al., 2019; Naude & Nagler, 2018). Moreover, the levels of learning at organisations that would otherwise ensure the stability of routines and processes can be a cause if they are low (Dutton & Thomas, 1982). There are many other possible explanations, such as inflation, excessive/insufficient governmental regulations (Dutton & Thomas, 1982), inadequate competition, not allowing poor performers to fail (Naude & Nagler, 2018) and unanticipated changes in technology (Lowe & Fernandes, 1994).

In summary, widely classic OM and economic scholarship have both sought to understand the causes of productivity differences in manufacturing organisations. Although their pursuits differ in focus, they provide valuable perspectives that can be triangulated. Classic OM scholars focus on manufacturing strategies, the ability of single firms to compete within an industry and the efficiency measures needed to improve productivity (e.g. investments and structural changes). Although OM scholars study the technologies that drive productivity, economists look at the power of innovation in general. Both perspectives are interrelated, and both consider managers and teams highly relevant to productivity outcomes (Broszeit et al., 2019; Naude & Nagler, 2018; Skinner, 1986). The details of their methods and measures are different; hence, understanding their interrelationships is key to moving forward with practical alternatives.

2.4 The management of productivity in manufacturing
Productivity has been viewed in OM as a result of manufacturing strategy (Skinner, 1986) and an important prerequisite to operationalising basic competitive priorities (i.e. cost, delivery, flexibility and quality; Christiansen et al., 2003; Grubbström & Olhager, 1997; Kathuria, 2000, Noble, 1997). By defining manufacturing strategy execution as a managerial task, managers influence manufacturing capabilities that influence productivity (Noble, 1997). The utilisation and exposure of all tangible and intangible resources in a factory are under the direct control of management and can be manipulated to achieve desired changes (Dangayach & Deshmukh, 2001;
Luthans & Stewart, 1977). Therefore, the job of management in terms of managing productivity improvement is to recognise when applied approaches do not work and to change system structures and infrastructures to apply manufacturing strategy as a ‘competitive weapon’ (Skinner, 1986, p. 45).

Typically, one would expect productivity management systems (PMS), also named productivity improvement systems (PIS), being the target of productivity management studies in manufacturing and the concept of such a system would explain how productivity is managed by considering elements and interrelationships. However, in the body of OM, the systems mentioned by the term ‘PMS’ or ‘PIS’ in relation to manufacturing in the literature of OM (Arnold & Liu, 1988; Franks et al., 1987; Grotepaß et al., 2014; Ong, 1997; Shimizu, 2009) have a one-sided and heterogenies understanding either representing an information technology (IT)-support system, engineering driven work studies or a control loops system, lacking a detailed description and generalisability.

Managing productivity improvement in manufacturing has continuously been part of OM research (Jin et al., 2016; Schmenner, 2015). Since the 1980s, managing productivity improvement has been among the top priorities (Karlsson, 2009); not always explicitly under the term ‘productivity’ or looking for reasons of differing productivity but with the purpose to improve productivity outcome, often targeted by concepts of Lean manufacturing and TPS.

In addition to the concepts of Lean manufacturing and TPS, such as overall equipment effectiveness (OEE), other streams of research, sometimes connected to Lean but not necessarily, are relevant for productivity management in manufacturing. Thus, the research on team leadership in manufacturing and general management’s research on the roles of managers are relevant for examining productivity management. Hence, these streams are discussed in this section.

2.4.1 The Lean manufacturing concept

Lean manufacturing, also known as Lean production or simply Lean, is a systematic approach to manufacturing and production focusing on minimising waste while maximising value for the customer. The origins of Lean manufacturing can be traced back to post-World War II Japan, which has been back then a country with limited raw materials, skilled workers and capital (Holloway & Hall, 1997).

The development of Lean principles and practices is associated with Sakichi Toyoda (1867–1930), who is often referred to as the father of the Japanese industrial revolution. Kiichiro Toyoda (1894–1952), the son of Sakichi Toyoda, established the Toyota Motor Corporation (Holloway & Hall, 1997). Taiichi Ohno (1912–1990), an engineer executive at Toyota, is often regarded as the father of the TPS. He is credited with developing many of the key concepts of Lean manufacturing, including just-in-time (JIT) production and the elimination of waste (Liker, 2004). Another influential figure in the development of Lean manufacturing, Shigeo Shingo, worked closely with Toyota and contributed to the concept of ‘poka-yoke’, which focuses on mistake-proofing processes to prevent errors from occurring. James P. Womack, along with his colleagues Daniel T. Jones and Daniel Roos, conducted research in the 1980s and 1990s that laid the foundation for the concept of Lean thinking and the principles of Lean management. Their groundbreaking research culminated in the publication of the influential book The Machine that
Changed the World (Womack et al., 1990), which introduced the world to the ideas of Lean production and management (Danese et al., 2018). Through their research, Womack et al. identified a set of principles that defined Lean production, coining the term ‘Lean thinking’ to describe the mindset and philosophy, which is considered by some as an organisational culture (e.g., Amaro et al., 2021).

In the context of productivity improvement, many studies have examined the implementation and results of Lean manufacturing tools in OM, such as 5S (e.g., Abu et al., 2019; Bernolak, 1997; Mohanty, 1992), value stream mapping (VSM, e.g., Abisourour et al., 2020, Seth & Gupta, 2005), total productive maintenance (TPM, e.g., Gunasekaran et al., 1994; Shah & Ward, 2003), total quality management (TQM, e.g., Dostaler, 2001; Fisher, 2007); HRM (Shah & Ward, 2003; Youndt et al., 1996), JIT (Fisher, 2007; García et al., 2014; Schonberger, 1982), and assembly line balancing (e.g., Saurin & Ferreira, 2009). In the OM literature, 18 Lean practices have been identified (Negrão et al., 2017), and the implementation of Lean practice bundles has been examined and its complementarity effects were discovered, as well as the integration level of Lean decisions about its effect on productivity (Antony et al., 2021).

2.4.2 The character of connectivity between Lean and productivity

In OM, various studies include the connectivity of productivity and Lean. Productivity and Lean concepts are closely interrelated because both are focused on improving efficiency, reducing waste and maximising value within an organisation. Productivity research without Lean is unthinkable in today’s manufacturing (Antony et al., 2021). The connectivity between productivity and Lean philosophy has multiple dimensions, as follows.

(1) Waste reduction and sustainability: One of the core principles of Lean thinking is the elimination of waste in processes. Waste can include overproduction, waiting time, transportation, excess inventory, motion, defects and underutilised talent. By identifying and eliminating these wastes, organisations can streamline processes and improve overall productivity. Increased productivity can also lead to resource savings and reduced environmental impacts. Daugherty et al. (1994) conveyed a complementary understanding and emphasis that industry should concentrate all different kinds of waste, not only a particular type of waste in a particular part of an organisation.

(2) Efficiency improvement: Lean concepts emphasise optimising processes to achieve higher efficiency. This aligns with the goal of productivity improvement because both seek to achieve more output with the same or fewer resources (Bernolak, 1997). Lean concepts, such as standardised work, continuous improvement and VSM, all contribute to increased productivity. Efficiency improvement includes all areas of the factory. Seth and Gupta (2007) also pointed to a rather neglected, reverse interrelationship that improved productivity leads to a Leaner operation that again helps identify further waste and quality problems (Seth & Gupta, 2007).

(3) Value maximisation and optimal resource utilisation: Both productivity and Lean concepts aim to maximise value creation and stress the importance of using resources wisely. Lean focuses on delivering value to customers while minimising waste, guiding organisations to allocate resources where they provide the most value. Thus, Lean conveys an understanding of added value and eliminating non-added value, which aligns with the productivity concept of
reducing input resources (Jastia & Kodali, 2015). There is the Japanese term ‘Gentan-I’ (usage per unit), a productivity ratio applied in Toyota for the usage per or man-hour per vehicle and the amount of material to complete a car (Minh, 2023).

(4) Continuous improvement: Lean principles are rooted in the idea of continuous improvement, also known as Kaizen. Similarly, productivity improvement is an ongoing effort to enhance processes, systems and workflows (Gutierrez et al., 2022). Both concepts encourage organisations to consistently seek better ways of doing things. Minh (2023) stated that TPS activities should have a learning and a productivity goal: thus, Lean concepts can connect learning and productivity.

(5) Standardisation and consistency: Lean practices often involve standardising processes to ensure consistent quality and reduce variability. This standardisation contributes to improved productivity by reducing errors and rework. Thus, productivity research in OM has examined way to manage bottlenecks in the process by applying standards such as the German Association for Work Design, Business Organization and Business Development (REFA) or Methods-Time Measurement (MTM) (Aripin et al., 2023). Furthermore, the standards of the Lean six sigma approach help identify losses, for instance to increase material productivity by avoiding defects and rework (e.g., Anand et al., 2007; Ciano et al., 2019; Walter et al., 2021).

(6) Employee engagement: Lean and productivity improvement recognise the importance of involving employees in the process. Engaged employees are more likely to identify areas for improvement, suggest innovative solutions and actively participate in making processes more efficient. Further, scholars also point to a risk creating perceptions against Lean by prioritising the efficiency (productivity) over worker care (Gambatese et al., 2017). Bellisario and Pavlov (2018) further pointed out that productivity management practices are the most prominent when located closest to front-line actions, that is, the area where there is high engagement between shopfloor managers and operators.

(7) Flow: Flow is at the heart of the Lean system (Liker, 2004), and one-piece flow aims to work without creating large batches to eliminate waiting and warehousing problems (Santos et al., 2006). The goal of TPS is to create a smooth operation (Liker, 2004), and managers must control the loss, including line stops, machine loss, quality loss, human loss, nonproduction loss and model change loss (Ahmad et al., 2018; Liker, 2004; Ohno, 1988; Womack et al., 1990) In productivity management, connecting to the one-piece-flow concept, the ‘theory of swift, even flow’ (Schmenner & Swink, 1998) has become prominent in OM; it states that, by improving the flow of goods, productivity will increase.

In summary, productivity and Lean concepts share a strong relationship because they both aim to optimise processes, eliminate waste and create value. Implementing Lean principles can lead to improved productivity; focusing on productivity enhancement often involves adopting Lean practices to streamline operations. Most scholars agree on a positive interrelationship of Lean concepts and productivity, and that Lean has a positive effect on productivity (e.g., Arlbjørn & Freytag, 2013; Ciano et al., 2019; Dora et al., 2013; Gutierrez et al., 2022; Jastia & Kodali, 2015; Knapić et al., 2023; Negrão et al., 2017; Staats & Upton, 2011).
2.4.3 The overall equipment effectiveness (OEE) as a productivity measure and concept

The OEE and productivity are closely interrelated concepts in manufacturing and production industries (Dresch et al., 2019; Gupta & Vardhan, 2016). The OEE is a key performance indicator (KPI) that provides valuable insights into the efficiency and effectiveness of manufacturing processes and equipment. Productivity, on the other hand, is a broader measure of how efficiently resources are used to produce goods or services (e.g., Bernolak, 1997). Along with the introduction of Lean and TPS philosophy, the OEE has been a groundbreaking concept in manufacturing companies.

The OEE is a quantitative tool related to the three principles of TPM: (1) maximising equipment effectiveness, (2) autonomous maintenance by operators and (3) small group activities (Nakajima, 1988). The OEE is expressed as a percentage, with a perfect score of 100% indicating that a machine or process is operating at its highest level of efficiency and effectiveness, with no downtime, no performance issues and perfect quality. Nakajima (1988) suggested that, in reality, 85% OEE is an ideal value, which is still considered a world-class value (Gupta & Vardhan, 2019; Tsarouhas, 2013). To calculate the OEE, the following overall formula is used (Nakajima, 1988):

\[
\text{OEE} = \text{Availability} \times \text{Performance} \times \text{Quality}
\]

‘Availability’ measures the percentage of time that a machine or process is available for production, here considering downtime because of equipment breakdowns, changeovers and planned maintenance, for instance, for change over (Muchiri & Pintelon, 2008). ‘Performance’ measures how efficiently a machine or process is running when it is available and includes factors such as minor stoppages, slowdowns and the speed an operator and equipment is performing at the machines and assembly line stations. The ‘quality’ component measures the percentage of products or parts that meet the required quality standards and accounts for defects, rework and scrap produced during the manufacturing process. Although most authors agree on the definitions of the OEE, concerning its three components, authors have favoured different calculations (Jonsson & Lesshammar, 1999).

Although, at first sight, the OEE looks like a pure measure, the literature and practitioners have viewed it as a concept to improve performance and productivity. In this way, the OEE can be used to do benchmarks within the company, comparing first initial value with future value and comparing the values of different assembly lines and machines across the factory (Jonsson & Lesshammar, 1999). By analysing OEE data, companies can make informed decisions about maintenance schedules, process optimisation and quality control, ultimately leading to increased productivity and profitability. There are multiple levers for improving the OEE and ensuring that production resources are used more efficiently. Thus, the OEE helps identify and eliminate bottlenecks of the process (e.g., Gupta & Vardhan, 2016; Muthiah & Huang, 2007), provides a basis for maximising the utilisation of manufacturing equipment (e.g., Ron & Rooda, 2006), helps identify losses though defects and rework (e.g., Ahmad et al., 2018; Ylipää et al., 2017) or even uncovers hidden capacities (Hung & Chen, 2022). Hence, by optimising the OEE, companies can make better decisions about resource allocation, including labour, materials and machine time, hence boosting overall productivity because it ensures that resources are used effectively.
In OM, many applications of the OEE are examined for different industries, more widely so in case studies for the car parts industry (Dal et al., 2000), chemical and packaging industry (Muchiri & Pintelon, 2008), electronics (Cheat et al., 2020; Muthiah & Huang, 2007), food and beverage production (Tsarouhas, 2013, 2019, 2020), glass manufacturing (Muthiah & Huang, 2007), pharmaceutical industry (De Carlo, 2014) and textile industry (Ahmad et al., 2018). Surveys on the OEE are sparse in OM research, besides few examples (e.g., Ylipää et al., 2017).

In OM, the exact calculations and calculation scheme that depend on the context have held a strong focus, for instance, for capital-intensive industries (e.g., Jeong & Phillips, 2021), the introduction of OEE extensions such as material indicators (Braglia et al., 2019) for cumulating the OEE on the factory level (Muthiah & Huang, 2007) and multistage calculation at the equipment, operations and business levels (Muchiri & Pintelon, 2008). Recent studies have increasingly started to discover the interrelationship between the human factor and OEE (Luozzo et al., 2023).

2.4.4 Team leadership and productivity
The OM literature is also concerned about how managers in leadership roles direct productivity improvement. Team leadership in manufacturing environments is strongly influenced by the technical aspects of the production systems, and line managers form the contact layer between leadership and technical operations (Pagell & LePine, 2002). Productivity leadership begins with the education of managers and supervisors to strengthen their ability to apply productivity-enhancing practices (Gunasekaran et al., 1994, 2000; Madiedo & Salvador, 2020; Schmenner, 1991). The literature reflects that the management promotion of company beliefs (e.g. ‘zero defects’; Fisher, 2007; Mohanty, 1992) and managers’ presence and support (Bernolak, 1997) are highly relevant to productivity improvement. Additionally, leadership and communication skills have been studied in relation to productivity improvement, noting that consistent feedback, motivation and appreciation measures are highly useful (Demeter et al., 2011; Schmenner & Cook, 1985; Sting & Loch, 2016). Kathuria et al. (2010) drew on behavioural science theories to evaluate manufacturing group performance in OM by applying Yukl’s (1989) taxonomy of 14 generic leadership practises. For OM team leadership, the literature has enhanced and supported many of these practises, such as delegating novel problems to team members (Pagell & LePine, 2002), inspiring members to rotate positions (Oudhuis, 2004), supporting line workers with their tasks (Inman & Blumenfeld, 2010) and team-building (McCreery et al., 2004). Moreover, leadership styles matter. Tortorella et al. (2018) separated task- and relationship-oriented leadership styles and showed that not one leadership style per se is preferable; on the other hand, leaders should apply different behaviours based on the context. Notably, Laohavichien et al. (2011) applied the transactional–transformational leadership model, in which the transactional aspects relate to the greater needs of team members and offer initiating behaviours to motivate them to perform at higher levels. The transformational aspects relate to increasing team members’ awareness of the importance of achieving objectives and encouraging them to overcome their self-interests for the benefit of the collective (Laohavichien et al., 2011).
2.4.5 The role of managers influencing company results

The ways managers influence company outcomes have been studied for centuries (Bloom et al., 2013). Early OM scholars, such as Skinner (1969), emphasised the importance of manufacturing policy and the role of managers to act as the ‘missing link’ between strategy and operations. Advocates of CT (Burns & Stalker, 1961) follow this line of reasoning and have noted that managerial actions must consider many external elements to ensure success. According to behavioural sciences, the key to managerial success involves behaviours. In short, context, strategy and managerial actions and behaviours are highly relevant to operational outcomes.

In factories, there are many possible managerial positions at various levels, and the literature does not always offer clear delineations. However, the consensus is that there are senior managers (Jääskeläinen & Luukkanen, 2017; Mantere, 2008; Soltani & Wilkinson, 2010), middle managers, and employees/operators. Huy (2011) defined middle management as any manager two levels below the chief executive and one level above operators. Mantere (2008) provided a broader perspective and included professionals lacking direct subordinates who manage functional areas. The operations manager, who is responsible for transformational shop floor operations, is often considered middle management (Bloom et al., 2013), a frontline manager (Rouleau, 2005; Sting & Loch, 2016) or a line leader (Manville et al., 2012; Østbø et al., 2016; Oudhuis, 2004).

From the general management literature (e.g. Fayol, 1949; Mintzberg; 1973), we now understand many of the different elements engaged by managers and their multifaceted roles. Fayol (1949) described five elements (i.e. planning, organising, command, co-ordination and control), and Mintzberg (1973, p. 59) classified managerial work into 10 roles aligned to three groups:

- Interpersonal roles (i.e. figurehead, leader and liaison)
- Informational roles (i.e. monitor, disseminator and spokesperson)
- Decisional roles (i.e. entrepreneur, disturbance handler, resource allocator and negotiator)

Managers are also viewed as implementers of firm strategy (Mantere, 2008). According to Floyd and Wooldridge (1997), middle managers connect strategic and operational levels of a company via mediation, negotiation and interpretation (Balogun & Johnson, 2004). Researchers tend to agree that negotiations between senior and middle management are beneficial to organisations as they increase strategic consensus, forge agreements and decrease bias (Mantere, 2008). Hence, middle managers share crucial functional roles in the translation and implementation of senior managements’ aims (Mantere, 2008).

Other terms used for middle managers include ‘change agent’ and ‘communicator’, and as organisations continue to grow in complexity and geographical separation, these roles grow ever-more important in terms of developing new operational details and organisational structures (Balogun & Johnson, 2004). Moreover, the cognitive dissonance generated by organisational changes must be resolved by these managers (McKinley & Scherer, 2000), including working-out the details of their own new roles and responsibilities (Balogun & Johnson, 2004). Successful change implementation requires clear communications to address employee fears and needs, and it is the manager’s role to get people ‘on board’ (Huy, 2011). Sometimes, they assume the role of ‘therapist’ when they ‘address their employees’ emotional wellbeing’ because ‘uncertainty about change can deflate morale and… once people are depressed, they stop learning, adopting or
helping to move the group forward’ (Huy, 2011, p. 77). The communications role of middle managers is not simply top-down, it is also bottom-up when relaying information to senior management (Mantere, 2008). Hence, middle managers’ reputations are influenced bidirectionally.

Middle-management roles comprise their own OM body of work (e.g. Balogun & Johnson, 2007; Mantere, 2008; Wooldridge & Floyd, 2017); however, their responsibilities in terms of performing their daily tasks to reach routine work targets while implementing the improvements needed to reach them tend to be neglected in the literature. This does not imply that knowledge is lacking; however, the collection, organisation and discussion of the details are. There are a few exceptions, and singular contributions have been documented in terms of managers’ roles of facilitator and translator (Spring & Unterhitzenberger, 2022). A study of small- and medium-sized enterprises (SMEs) explained how management ideas and operational practises were exchanged among firms and how middle managers coded and translated them for their own firms and their partners. Another example (Bloom et al., 2013) identified 38 middle management practises applied in 20 Indian textile factories before and after consulting firm treatment, noting an average rise in productivity of 17% during the first year. Notable sustaining effects have also been reported. The point is that applying managerial best practises makes a difference.

The scope of this dissertation’s analysis includes the activities of managers in hierarchical positions between senior management and production employees. For the purposes of this study, senior managers are not positioned at the factory site but are responsible for overall operations at multiple locations, business units and regions.

2.5 Organisational elements and their interrelationships

Interrelationships between organisational elements are central to the investigation of this dissertation. Therefore, it is fundamental to understand what organisational elements account for and the variety of organisational relationships between them, which is elaborated on in this section. However, first, it must be explained why it is important to focus on interrelationships for an organisational problem.

2.5.1 Why focus on interrelationships?

Focusing explicitly on adequately understanding the principles of relationship management among organisational elements is crucial to organisational success (Siggelkow, 2011) because the configurations of the central forces and multivariate relationships provide insights that can be used to guide managerial actions (Miller & Friesen, 1984).

As organisations expand globally with multiple subsidiaries and outsourced processes, the number and scale of elemental interrelationships increase, and a change in one can lead to cascading changes to the entire system (Miller & Friesen, 1984). Organisational elements, components, departments and functions are highly interrelated, and conflicts necessarily arise in values and operating procedures (Khandwalla, 1977). Thus, processes move interdependently, and many of the changing elements cannot be predicted or controlled while studying the others (Miller & Friesen, 1984). Thus, visualising and accounting for these interrelationships provide important elements and their attributes which can be different across different types of
organisations (Miller & Friesen, 1984). Thus, oversimplifying the problem is dangerous because understanding the interrelationships among organisational elements is important for keeping coordinative costs low (Khandwalla, 1977). When changing an organisational strategy, many elements are affected, which can lead to high costs related to their interdependence. Thus, short- and long-term costs must be assessed, and sometimes the status quo is optimal (Miller & Friesen, 1984).

Following Thompson (1967), organisations strive for a purpose of defeating uncertainty that is a fundamental problem for complex organisations and can be understood as the ‘antithesis of purpose’ (p. 159). Uncertainty stems from contingency influencing the outcome of organisational actions, that again is determined by the actions of environmental elements and the internal interrelationships of the components (Thompson, 1967). Hence, the study of interrelationships between external and internal organisational elements is fundamental to reducing and managing uncertainty in organisations.

2.5.2 Organisational elements
The nature of organisational elements is broad. Hayes and Wheelwright (1984) examined the organisational elements comprising a supply chain and consisting of suppliers, facilities, distribution and customers. Weick (1976) distinguished between elements such as technology, task, subtask, role, territory and person and authority-related elements, such as positions, offices, responsibilities, opportunities, rewards and sanctions. In contrast, Siggelkow (2011) conveyed the systems view by classifying incentive systems, hierarchical structures and communications with manager. Galbraith (1973) identified elements that express attributes like task uncertainty, diversity of parts, division of labour such as labour skills and machines. In OM, we can find two major types of organisational elements that are involved in relation to productivity improvement, which are external elements that effect manufacturing system and resources of the manufacturing organisation.

The OM literature shows that productivity improvement cannot be performed in isolation from external elements (Kathuria, 2000; Shah & Ward, 2003). External elements stand for forces that are outside the range of organisational control (Luthans & Stewart, 1977; Sousa & Voss, 2008). The utility of external elements in OM is strongly influenced by CT, which assumes that improved performance and productivity reflect a strong organisational culture that reacts well to external forces (Burns & Stalker, 1961). In CT, the elements in focus that interact are often named variables (e.g., Sousa & Voss, 2008) and when referring to CT in this dissertation, especially in Article 1, this term is applied. However, extant research supplies many clues about them and their interrelationships. For example, Shah and Ward (2003) analysed labour productivity dependencies in several countries and found that the location of the firm strongly affects labour productivity, even more so than the nature of the industry. Hence, there are clear contextual limitations to globalisation related to political geography (Mapes, 2000; Saldanha et al., 2013) because economies, laws, regulations and policies differ from country to country (Song et al., 2018; Spring et al., 2017). Nevertheless, productivity in manufacturing depends largely on world markets, technology transfers (Mohanty, 1992) and resource availability (e.g. labour, energy and capital; Bhattacharya & Narayan, 2015; Mohanty, 1992). Some external elements are internal
while remaining outside the control of management (e.g. worker health; Farid & Neumann, 2019). Resource availability is one of several resource-related external elements.

The OM literature has shown that resource exposure is strongly correlated with productivity improvement (Jin et al., 2016). On the one hand, productivity requires the least possible resource consumption during manufacturing, but on the other, resources must be mobilised for productivity improvements, even for lean projects (Bernolak, 1997) or high-technology operations (Schmenner, 1991). Productivity in this case is a property of the production function that emerged in the 20th century, which describes how resources are transformed into products (Grubbström & Olhager, 1997). It is easy to understand how research coordination and production harmonisation can quickly become extremely complex and expensive (Thanki & Thakkar, 2014). In OM, labour (Demeter et al., 2011; García et al., 2014), materials (Kao et al., 1995; Lee et al., 2018), equipment (Bernolak, 1997; Fisher, 2007), technology (Gunasekaran et al., 1994; Saldanha et al., 2013) and knowledge (Bello-Pintado et al., 2019; Mohanty, 1992) have been covered in terms of their relationships to productivity improvement. More precisely, the existence of specific IT-based data exchanges with customers and suppliers (Saldanha et al., 2013; Schmenner & Cook, 1985) and assembly line automation level (Demeter et al., 2011; Kao et al., 1995; Son, 1994) have been associated with productivity. Thus, the mechanisms behind operational improvements are manifold; however, their interrelationships lack elaboration in the literature.

Organisational science conveys the insight, that the understanding of organisational elements is crucial to guide managerial actions (Miller & Friesen, 1984). Codifying the tasks required to manage productivity requires an understanding of the organisational elements of manufacturing systems and their interrelationships. This also requires an understanding of the available options. The nature of organisational elements is broad and the body of OM literature identifies important clusters of elements involved in productivity improvement which are elements of the external environment (Kathuria, 2000; Shah & Ward, 2003) and the resources of the factory (Garcia et al., 2014; Lee et al., 2018; Saldanha et al., 2013) facilitating improvement actions. Even though multiple elements of these clusters are analysed in OM, an exhaustive catalogue of numerous OM elements relevant to productivity improvement, their characteristics and effects on productivity does not exist.

2.5.3 Dimensions of interrelationships
Studies of organisational studies have analysed multi dimensions of interrelationships, noting that the organisational structure should represent interrelationships of the organisation, its environment and technology (Thompson, 1967). Accordingly, management must consider the networks of elements in which their own domains and task environments are reflected. Organisational studies have distinguished the organisational interrelationships of organisational elements both inside and outside the organisation, noting that these types ‘may be uncooperative’ (Thompson, 1967, p. 160). From this perspective, CT clearly dominates the understanding of external environmental elements. However, it also applies to the internal relationships that are driven by reactions to external forces (Burns & Stalker, 1961; Mintzberg & Quinn, 1996; Thompson, 1967).
Table 2.2: Dimensions of interrelationships in organisations

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Interrelationship</th>
<th>Explanation</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>External</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple</td>
<td>Interrelationships between organisational elements and environment</td>
<td>Contingency variables and elements</td>
<td>Burns &amp; Stalker (1961); Mintzberg &amp; Quinn (1996); Thompson (1967)</td>
</tr>
<tr>
<td></td>
<td>Interrelationships among contingency variables</td>
<td>In addition to the interrelationships among internal and external elements, interrelationships exist between contingency variables</td>
<td>Mintzberg &amp; Quinn (1996)</td>
</tr>
<tr>
<td>Internal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision</td>
<td>Interdependencies of decisions</td>
<td>For instances, a good decision for a department is not necessarily the best decision for global co-operation (p. 13)</td>
<td>Galbraith (1973)</td>
</tr>
<tr>
<td>Economic</td>
<td>Scale interdependencies</td>
<td>Economies of scale for reaching a certain size for function</td>
<td>Mintzberg &amp; Quinn (1996)</td>
</tr>
<tr>
<td>Goal</td>
<td>Interdependencies between needs and goals</td>
<td>Conflict over goals: a greater perception of interdependencies used to solve job-related problems because each party ‘will try to get others to fit in with its goals and plans’ (p. 361)</td>
<td>Khandwalla (1977)</td>
</tr>
<tr>
<td>Hierarchy</td>
<td>Interdependencies within a vertical hierarchy</td>
<td>Interrelationships between employees and superiors</td>
<td>Rivkin &amp; Siggelkow (2003)</td>
</tr>
<tr>
<td>Social</td>
<td>Social interdependencies</td>
<td>Facilitating mutual support in dangerous environments (e.g. coal mines; Trist &amp; Bamforth, 1951)</td>
<td>Mintzberg &amp; Quinn (1996); Trist &amp; Bamforth (1951)</td>
</tr>
<tr>
<td>System</td>
<td>Interdependencies between multiple organisational systems</td>
<td>Performance control and action planning systems</td>
<td>Mintzberg &amp; Quinn (1996)</td>
</tr>
<tr>
<td>Task/Process/Workflow</td>
<td>Pooled interdependencies</td>
<td>Each element affects the entire organisation (e.g. component failures)</td>
<td>Thompson (1967)</td>
</tr>
<tr>
<td></td>
<td>Sequential/Workflow interdependencies</td>
<td>An order in the process (e.g. an organisational branch that produces a part for another branch or functions as engineering, production or maintenance to interrelate production runs</td>
<td>Thompson (1967); Galbraith (1973); Mintzberg &amp; Quinn (1996)</td>
</tr>
<tr>
<td></td>
<td>Reciprocal interdependencies</td>
<td>Output of one process step is the input to the following step (most complex).</td>
<td>Thompson (1967)</td>
</tr>
<tr>
<td></td>
<td>Process interdependencies</td>
<td>Specialist process knowledge applied across hierarchies, functions and business units</td>
<td>Mintzberg &amp; Quinn (1996)</td>
</tr>
</tbody>
</table>
Internal interrelationships are typically finer-grained than external ones and comprise more categories, as presented in Table 2.2 alongside commentary on their interrelationships (Mintzberg & Quinn, 1996; Thompson, 1967). Many of these relationships exist because of economic and social considerations (Mintzberg & Quinn, 1996) or extant multiple organisational systems (Mintzberg & Quinn, 1996). Hence, they are commonly found within vertical organisational hierarchies (Rivkin & Siggelkow, 2003). Table 2.2 presents an overview of the dimensions of interrelationships.

2.5.4 Mechanisms of managing interrelationships between organisational elements

Element relationship management is fundamental to ensuring competitive advantage. The literature identifies several mechanisms that can be used to design effective organisational relationships while coordination various configurations. One mechanism groups organisational tasks with multiple interrelationships into workflows (grouping tasks), work processes of scale and social relationships (Mintzberg & Quinn, 1996), and task interrelationships (Thompson, 1967). Following this perspective, Siggelkow (2011) emphasises the importance of not splitting those system apart having elements with many interrelationships, because interaction effects would be neglected resulting coordination and communication costs. The grouping of tasks in this way follows hierarchical, chain-of-command motifs (Thompson, 1967), which are often effective when designing an element, coordinating its connections or restructuring its hierarchies (Khandwalla, 1977).

A second mechanism used to manage the interrelationships of organisational elements requires coordination by standardisation (March & Simons, 1958; Thompson, 1967). Thus, to standardise the routines, rules, policies, procedures (Khandwalla, 1977) and specifications in product design (Galbraith, 1973), a type of coordination applied to align elements within an organisation in light of stable situations (Thompson, 1967).

A third mechanism involves coordination by plans, goals and targets (Galbraith, 1973; Khandwalla, 1977; Thompson, 1967). Coordination by planning focuses on scheduling, especially during dynamic situations; hence, doing so does not require as much stability as standardisation and may apply to influencing or reacting to external environment (Thompson, 1967). To cover primary interrelationships, organisations set goals and targets supported by processes (Galbraith, 1973). In this perspective, the interrelationships bear potential for conflicts concerning the goals, because every part wants that the others fits in their goals (Khandwalla, 1977).

A fourth mechanism used to coordinate organisational interrelationships involves coordination by mutual adjustments (Thompson, 1967). According to March and Simons (1958), this is called ‘feedback’. By any term, it is characterised by the transmission of added information during actions, and it tends to increase when situations become unreliable or unpredictable (March & Simons, 1958; Thompson, 1967).

A fifth mechanism is the promotion of lateral relations, which is characterised by implemented communication channels across lines of authority for instance between departments. These channels need to be established because informal organisation did not seize this coordination of interrelationships spontaneously (Galbraith, 1973). Khandwalla (1977) extended
lateral relations to committees and group decision-making and added incentives as a ‘coordination mechanism.

General management literature respectively organisational studies have provided a sound understanding of roles and mechanisms for influencing company results. Managers engage in these roles (Fayol, 1949; Mintzberg, 1973) and apply multiple mechanisms (Galbraith, 1973; Khandwalla, 1977; March & Simons, 1958; Siggelkow, 2011; Thompson, 1967) to manage interrelationships between organisational elements. For the specific objective of managing productivity improvement, roles and mechanisms have not been investigated. We can only speculate that some of these roles and mechanisms discovered apply also to productivity improvement.

2.6 Systems view
To understand how operations managers manage teams and resources, overcome frictions, tensions and barriers and motivate humans in obtaining productivity improvements, the knowledge fragments from the literature must be pieced together using a systems approach. Thereby the author follows Checkland (1981) who stated, ‘The aim of systems thinking is to tackle problems of irreducible complexity by thinking in wholes’ (p. 71).

Systems theorists have provided several system constructions. The aspect of unity and holism (Checkland, 1981; Churchman, 1979; Ropohl, 1999)is the perspective taken by this study. As such, Ropohl (1999) identified several important epistemological polarities in systems theory, such as unity vs. diversity, holism vs. atomism and model vs. reality. With unity vs. diversity, the theory identifies unity as ‘a uniform language for describing and explaining diverse phenomena’ (p. 189) and does not take away diversity but creates a new level of unity apart from specialisation (Ropohl, 1999). Ackoff (1994) clarified that a system is a whole that cannot be divided into parts and its performance is not the sum of actions of its parts but must be understood as a function of the interaction of its parts. Consequently, as applied to organisations and enterprises, Ackoff showed how optimising one part at the expense of others can lead to failure. Generally, managers should instead focus on optimising parts’ interactions.

Churchman (1979) defined five key system characteristics: (C1) objectives, (C2) environment, (C3) resources, (C4) components and (C5) management. C5 is vital to answering the research question, and C1–C4 are supportive characteristics. C1 reflects the goal of productivity improvement, C2 captures the external elements to the factory, C3 includes the materials leveraged for operations and managerial actions and C4 indicates the elements having the interrelationships that we seek to understand.

The growth and complexity of systems theory applications naturally correspond to IT advancements (Miller & Page, 2009). This has led to adaptive systems theory, which models interrelationships between a large number of unique agents in a network using signals between agents (Holland, 2012). Thus, complexity arises from fast, intermediate interactions, and agents will have a different combination of condition and action at a certain time that leads to complexity that defines a complex adaptive system (Holland, 2012).
In summary, the systems view provides a suitable lens through which we can reduce the complexity of OM elements and their interrelationships. Thus, systems theory provides the definitions needed to ground the analytical approach.

2.7 Factory as an organisational system

To investigate how managers manage the interrelationships related to productivity improvement, the factory must be viewed as an organisational system. Organisational science supplies useful models for this purpose (Miller & Rice, 1967); thus, selected models from systems theory are applied to the research question. The organisational science literature provides two beneficial systems-thinking models. Influenced by the transition from wartime operations to civil industry in the 1950s and 1960s, orthodox organisational theory and Simonian management science gave us ‘hard systems thinking’, which assumes that the world is a set of systems that can be purposefully (re)engineered to achieve objectives (Checkland, 1985, 1995). Hard systems are striving for goals and its system control is widely limited to cybernetics (Checkland, 1995). However, real-world problems tend to be too complex for this assumption; they are too ‘ill-defined, messy or wicked’ to fit in a well-defined systems model (p. 4). Consequently, soft systems thinking grew upon the notion of ‘appreciation’ (Checkland, 1995). Hence, soft systems methodologies view the world as problematic, but it assumes that the ‘process of inquiry’ into the problematic situation can be considered as a system (Checkland, 1985, 1995). Nevertheless, the soft systems view is complementary to the hard systems view (Checkland, 1995), such that they are often used together.

Following soft systems, systems theory distinguishes three types: mechanical, organismic and social (Ackoff, 1994). Although mechanical systems lack purpose on their own and are either open or closed depending on their function, organismic systems are necessarily open and subject to external influences; moreover, they have at least one innate purpose. Social systems are also open and purposeful, but they are nearly always part of a larger system. Although humans are organismic, most systems theorists believe that systems of people should be conceptualised as ‘social’ (Ackoff, 1994). Scott (1992) further delineated corresponding rational (i.e. management tool) and natural (i.e. growing and developing) types, which helped move OM literature forward.

This dissertation considers the factory as a structured, organisational and open system. For this configuration, CT is useful (Scott & Davis, 2016). Although Woodward (1965) provided a similar model for classifying open systems for structural analysis, our stated analytical approach is more qualitative and descriptive (Scott, 1992).

CT provide a good lens through which the organisational parts of the overall system can be focused. However, to fully ascertain the answer to the research question, MCS theory is also needed to provide a second dimension for triangulation (Churchman, 1979). Although MCS theory is considered an important explanatory tool for organisational systems, it has rarely been integrated to study the elemental interrelationships of organisational models (Scott, 1992). Otley et al. (1995) stated that the theory had ‘wrongly’ been limited to management accounting; hence, they showed how the organisational literature supports the same theoretical roots in closed and open systems and across rational and natural models, as illustrated in Figure 2.3 at the end of Section 2.8.2.
2.8 Systems theory applied as a lens to focus the research question

To paint a detailed picture of how managers manage the interrelationships that are relevant to productivity improvement in factories, two system views are converged to provide a 2D lens to help us answer the central research question of the dissertation. The contingency view is a rational open system approach, whereas the MCS theory ties multiple system approaches together (ref). Both CT and MCS theory use the concept of ‘fit’ they apply it to different aspects of organizational management. While Contingency theory focuses on the fit between the organization and its external environment, MCSs theory focuses on the fit between an organization’s strategy and its internal control mechanisms, emphasizing the coherence and alignment of internal components (Grabner & Moers, 2013).

It will be argued that CT and MCS theory are both system theories, justified alongside the five C1–C5 characteristics of a system from Churchman (1979, p. 11). See the summary in Table 2.3.

Table 2.3: Characteristics of systems applied as lenses

<table>
<thead>
<tr>
<th>Characteristics (Churchman, 1979)</th>
<th>Contingency theory</th>
<th>Management control systems theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>(C1) System objective</td>
<td>Internal and external fitness for system performance</td>
<td>Achievement of organisational objectives</td>
</tr>
<tr>
<td>(C2) Environment</td>
<td>Contextual variables and Environmental forces</td>
<td>Other management control systems</td>
</tr>
<tr>
<td>(C3) Resources</td>
<td>Resource variables</td>
<td>Employees and their skills</td>
</tr>
<tr>
<td>(C4) Components</td>
<td>Organisational structures</td>
<td>Management tools, devises, systems or processes</td>
</tr>
<tr>
<td>(C5) Management</td>
<td>Organisational and managerial actions</td>
<td>Employee behaviours are directed toward goal achievement</td>
</tr>
</tbody>
</table>

2.8.1 Contingency theory

CT is a rational open systems theory that became popular in the 1960s (Scott & Davis, 2016). Since seminal CT works and increasingly with the initiation of OM journals in 1980 (e.g. Walker et al., 2015), CT has been applied and operationalised in OM fields to enhance theory, managerial practises and routines. Contingency theory matches all five characteristics listed in Column A of Table 3.1 (Churchman, 1979).
Sousa and Voss (2008) distinguished three types of CT elements (they call them variables): contextual (i.e. environmental forces—C2), response (i.e. organisational and managerial actions—C5) and performance (i.e. results of the other two, representing the system objective—C1). On one hand, the environmental elements are beyond managerial control, and on the other hand, system resources (C3) and mediator elements are within the managers’ sphere of influence (Luthans & Stewart, 1977). Furthermore, CT involves multiple components, including organisational structures and subsystems (C4).

Following the CT, the interrelationships between environmental forces and organisational structures play significant roles in terms of fitness inheritance. Peng et al. (2011) distinguished between the fitness of internal and external subsystems within a firm in terms of contingency forces, and Venkatraman (1989) identified six types of organisational fits from which mediation fitness has been investigated in multiple CT applications (e.g. Chavez et al., 2015; Demeter et al., 2011; Peng et al., 2011; Shah & Ward, 2003). In terms of contingency, the more fit the organisational structures are to the environmental forces, the more efficient the organisation (Burns & Stalker, 1961; Lawrence & Lorsch, 1967). According to Tangen (2005, p. 43), who analysed and summarised multiple interpretations of productivity, ‘efficiency represents how well the resources of the transformation process are utilised’. Hence, we can assume that fit with respect to environmental forces increases productivity, because productivity entails the utilisation of resources.

By applying the CT view, the author follows Sousa and Voss (2008) who saw CT as a useful theoretical lens for OM issues, especially in areas where the theory was immature. Multiple studies have applied CT to OM studies in HRM (Youndt et al., 1996), performance measurement systems (Garengo & Bititci, 2007; Taylor & Taylor, 2014), TQM (Wiengarten et al., 2013; Zhang et al., 2012) and general managerial practices (Sousa & Voss; 2008). Multiple OM studies grounded in CT are often applied to performance management issues, while this dissertation focuses on productivity management. The author does not see this as a conflict when developing the initial framework as productivity is considered one performance dimension (Chavez et al., 2015; Orzes et al., 2017; Schmenner & Swink, 1998; Shah & Ward, 2003; Tangen, 2005).

### 2.8.2 Management control systems theory

MCS theory, which applies an organisational science model standing for both rational and natural open system views, supplies important insights into managerial intervention and their follow-up actions for achieving organisational goals. MCS theory, originally widely applied to accounting systems (Chenhall, 2003), provides insights into formal and informal systems and management needs and is the other theoretical lens applied to this dissertation. Same as CT, it is argued that MCS theory is a special kind of systems theory and therefore the characters are Churchman’s (1979) characters of a system are indicated (C1-C5).

The works of organisational theorists Max Webber and Frederick Winslow Taylor provided the theoretical bases for management controls (MCs; Hewege, 2012), whose central functions are to assure that organisational objectives are achieved (C1; Anthony, 1965). According to Merchant and van der Stede (2017), MCs include any management tool, devise, system (C4) or process that
helps ensure that employee behaviours are directed toward goal achievement (C5). The model entails converting theory into action.

Snell (1992) defined three MCs: input, behaviour and output. Input control refers to staff selection and training (C3) for task performance, which includes values development and organisational commitment. According to Snell (1992), behaviour controls include standard-setting and procedure creation, which are applied to ensure the accountability of employee actions and objective fulfilment (C5). Output controls emphasise the evaluation of goal achievement and subsequent rewards. Although the model of Snell (1992) includes only formal controls, Strauß and Zecher (2013) and Su et al. (2013) distinguished both formal and informal types. Formal controls are typically well defined, structured and documented in procedures, standards and guidelines and are enforced through monitoring and audits (Anthony, 1965; Merchant and van der Stede, 2017; Simons, 1994). In contrast, informal controls are not necessarily documented and rely on interpersonal relationships, social and cultural norms, are often implicit and are observed through interaction with people in an organisation (Ferreira & Otley, 2009). In organisations, often a combination of both, formal and informal control can be found and authors emphasise the effectiveness on control by applying both types in the right balance (Anthony and Govindarajan, 2001; Su et al., 2013).

Owing to the various types of MCs, the MCS literature is considered fragmented owing to its coexistent but divergent definitions and conceptualisations (Strauß & Zecher, 2013; Su et al., 2013). Nevertheless, after 2000, the field of management accounting and control experienced a new dynamic in terms of analytical MC concepts and frameworks (Strauß & Zecher, 2013). Within OM fields, productivity improvement controls were primarily explored under the umbrella of continuous improvement, focusing on lean principles and waste reduction (Demeter et al., 2011).

More recently, mainly driven by management accounting scholars, MCS has been examined based on its singular MC applications (e.g. performance management systems) and multiple management packages (Grabner & Moers, 2013; Malmi & Brown, 2008; Merchant & van der Stede, 2017). The idea of MCS as a package was developed as a response to the reductionist approach that assumed that MCs should be examined independently of others (Malmi & Brown, 2008). In response, the systems approach enabled the examination of combinations of MCS practices that should lead to alignment or congruence, which is considered as ‘fit’ (Grabner & Moers, 2013). This ‘fit’ involves ensuring that different components of an organisation, such as its strategy, structure, systems, processes, and controls, are harmoniously coordinated to support the achievement of its objectives, which is crucial for effective MC and overall organisational success. The interrelationships between the multiple MCS can be only studied in relation to a control problem and different context can trigger different control problems and the choice of MC practices managers apply (Bedford, 2020, Grabner & Moers, 2003).

The MCS theory and its frameworks provide a useful lens through which control problems can be measured, including productivity measures and targets. MCSs do not exist in isolation (Friis et al., 2015; Malmi & Brown, 2008); hence, the character of their interrelationships must be considered. MCs interact in positive, complementary or negative, conflicting ways (Friis et al., 2015; Grabner & Moers, 2013; Malmi & Brown, 2008; Van der Kolk et al., 2020). This
characteristic of MC interrelationships results in either synergies or trade-offs based on the efficacy of the MC in question (Friis et al., 2015). Hence, the interrelationships between MCSs can lead to positive or negative effects or even more complex interrelationships as literature indicates. Thus, tension complexity constitutes an interrelationship between MC elements that simultaneously enhance and reduce control effectiveness (Van der Kolk et al., 2020). Further, this tension can change over time that is called tension dynamics (Henri, 2006; Mundy, 2010; Van der Kolk et al., 2020). Simultaneously, differential effects result in aggregated effects (e.g. positive ones in which complementary effects outweigh competing ones or vice versa; Malmi & Brown, 2008; van der Kolk et al., 2020). The state in which MCs are aligned represents the maximum control efficacy (i.e. fitness or internal consistency; Grabner & Moers, 2013). Another applicable term for this state is ‘balanced’ (Van der Kolk et al., 2020). While tension between multiple MCSs is considered foremost negative and as a state that has to be managed and overcome, tension can have also positive aspects, and enhance performance of organisations since the tension makes conflicts transparent (e.g., Mundy, 2010).

In OM studies, the several types of productivity improvement controls have been largely neglected, besides few examples, that represent an increasing interest in OM to consider multiple MCSs (e.g., Bellisario and Pavlov, 2018; Nielsen et al., 2018; Pešalj et al., 2018). Although recent research has presented many valuable case studies on productivity improvement (e.g. Gunasekaran et al., 2000; Park & Li, 2019; Sáenz-Royo & Salas-Fumás, 2014), they mainly focus on one MCS at a time. Hence, the contributions do not reflect how different controls may potentially work symbiotically or in conflict.

Both systems perspectives that are correspondingly applied as theoretical bases for this research, are illustrated in Figure 2.3.

![Figure 2.3: Three correspondingly applied theoretical bases of this dissertation (Scott, 1992; Scott & Davis, 2016; Otley et al., 1995).](image-url)
2.9 Knowledge gap in the literature
In the previous sections it has been demonstrated that knowledge of multiple research streams contributes to the research question of this dissertation and productivity improvement research is anchored in OM. Notwithstanding, knowledge is missing on how managers apply tasks to manage manufacturing system elements and their interrelationships for productivity improvement. Often, OM literature reports on intervention, for instance of a layout optimisation or bottleneck elimination, and comparison of productivity results before and after. In some research, organisational barriers are still mentioned but the details of how these barriers have been identified and what specific tasks managers applied to mitigate them, stay widely neglected, besides a few examples (Broszeit et al., 2019; Naude & Nagler, 2018; Oudhuis, 2004). Therefore, this gap, arising from discussed research in the previous sections is elaborated in the next paragraphs.

Among many reasons, literature considers the management of productivity as one plausible reason productivity varies among manufacturing organisations. The specific quest to discover explicit differences in productivity in OM nowadays became quiet (Walker et al., 2015) and starting points that refer to the managerial capability to affect productivity are mentioned in OM and adjacent domains, for instance, poor management quality and practices, but a comprehensive understanding that refers to a construct of single managerial activities and tasks is still missing (Harris, 1994). There are only a handful of papers that have examined managerial actions in this manner, but they all focused on inter-factory results. The title of Hayes and Clark’s (1985) paper sought to understand ‘Why some factories are more productive than others.’ Unfortunately, this has not been fully determined to date. Hence, it must be asked again.

Productivity improvement is deeply rooted in OM, especially through research focussing on the application of management concepts such as Lean and team leadership, but still we miss details on the tasks on productivity management as explained as follows.

First, for the long-term success of Lean productivity initiatives, scholars have discovered that it takes more than the initial successful implementation of the tools; it requires implementing and living the Lean philosophy at all levels of the organisation (Minh et al., 2023). Scholars report, that attempts at Lean implementation are not successful because the understanding of the know-how culture of TPS is little, and only marginal gains are reached, or it may be that a change leads to worsening the situation (Amaro et al., 2021). For example, we should understand by now why lean method applications fail, and what managers do for instance when quality and engineering personnel disagree on optimisation plans. In addition, knowledge of managers’ daily decision-making and methods before applying improvement activities to the shop floor is missing (McCreery et al., 2004; Pagell & LePine, 2002) and which decision-making details make the biggest difference. Rahmani et al. (2018) said, ‘There has been less work on team leadership as it relates to a leader’s tactical decisions, that is, day-to-day management of a team to enhance its performance’ (p. 5236). According to Seth and Gupta (2005), implementations widely miss the linkage to an overarching framework that includes the organisation. Therefore, Womack and Jones (1996) emphasised strong teaching on Lean concepts, that skills of managers and workforce become internalised and retrievable.

Second, Lean manufacturing and team leadership offers a broad bouquet of concepts and tools that can enhance productivity. The majority of studies on productivity have focused on
research as one-time intervention projects, not on the reoccurring tasks of managers to keep the business running on a daily basis, in routines or meeting productivity targets day-by-day. Of course, there are Lean tools such as shopfloor management (SFM), a concept of the Lean toolbox also explored in OM (e.g., Wester & Hitka, 2022; Zondo, 2020) that emphasises the continuous tracking and visualisation of productivity improvement action. Even though SFM is a strong productivity shopfloor tool, it serves to visualise productivity measures and coordinate specific actions with the team. The research on SFM does not inform us what tasks managers do in detail and what the problems are to be managed when following up on productivity outcome in performing the daily routine of the team.

Third, a system approach is widely missing in productivity management and Lean implementations, as Negrão et al. (2017) discovered in their review: namely, Lean practice application is fragmented and often missing the systemic linkage necessary for Lean manufacturing to realise the full potential to improve operational and organisation management as whole, not only in some areas. Thus, a standard Lean model does not exist, and Lean has many forms that depend on context implementation and practices applied (Hasle et al., 2012). For making a successful change, Kosonen and Buhanist (1995) emphasised considering all systems parts, such as organisation, products, technology and management and includes multiple stages of production management on a daily, weekly or long-term basis (Minh, 2023). The alignment and integration of functions within a company (e.g. between marketing and manufacturing) and applied technology have been discussed in relation to productivity improvement (Demeter et al., 2011; Gunasekaran et al., 1994; Kao et al., 1995). Schoenherr and Narasimhan (2012) postulated that the alignment of production capabilities and priorities has a positive effect on productivity. Other management systems have been described quite thoroughly, and their elements, actors, goals and tasks have been well-annotated, including their interrelationships with HRM (Ahmad & Schroeder, 2003; Youndt et al., 1996) and performance management systems (Bititci et al., 2000; Neely et al., 1995). Unfortunately, productivity management systems (PMSs) have exceptionally low diffusion in the field of OM, and extant works integrate only a few of their aspects (e.g. IT, cybernetics and working studies).

Therefore, we can conclude that there is a lack of investigation in OM on details of the managerial tasks as they relate to productivity improvement and how managers identify and mitigate barriers arising in improving productivity, besides a few examples. Nevertheless, the multiple research streams discussed in this chapter have provided valuable clues to answering the research question; they just need to be coalesced into an actionable form: the purpose of this dissertation. A systems view, as applied in other management systems (e.g. performance management system, human resource management system) can help us to identify manufacturing system elements and interrelationships between them to identify the conflicting interrelationships that are fundamental to management for mitigating them.
Chapter 3: Philosophical assumptions, reasoning and methodology

This chapter traces the path from the original philosophical assumptions to the applied methodologies of the three appended articles. Section 3.1 explains the assumptions and position of the articles. Section 3.2 presents their rationale and methodologies, and Section 3.3 gives an introduction to the case study that provided a major source of empirical data used for the investigation of this dissertation. Finally, Section 3.4 lists the versions of the appended articles.

3.1 Applied philosophical assumptions and the position of the researcher

Ontology describes the philosophical assumptions of reality and existence, and epistemology describes how knowledge guides the method of research (Easterby-Smith et al., 2015). In the social sciences, most ontological standpoints reflect a realist view in which there is a single truth from which all other facts can be revealed. Alternatively, there are many truths and facts that depend on the viewpoint of the observer (Easterby-Smith et al., 2015). The perception of reality and methods of attaining knowledge depend on the author’s assumptions, which itself is an epistemology. Thus, in social sciences, epistemological standpoints can be positivist, ‘that the social world exists externally’, or social constructivist, ‘that many aspects of societal reality are determined by people rather than by objective and external factors’ (Easterby-Smith et al., 2015, pp. 51–52). Hence, research methodologies are often subjective (Harley & Cornelissen, 2022) and their ontological and epistemological perspectives were used to guide the methodology of this dissertation.

Manufacturing productivity allows one to assume a rational ontological standpoint that follows common understandings based on ratios of product output and resource input, which can be observed and measured in factory settings (Sickles & Zelenyuk, 2019; Tangen, 2005). Multiple calculation schemes are used to measure productivity, including ‘output quantity per shift for a given number of operators’, which provides clear positivist epistemological evidence of knowledge gained, and it does not investigate the outcomes of productivity. Hence, the management of productivity is grounded in an epistemological assumption of pragmatism.

The philosophical position of pragmatism assumes that knowledge and understanding can be deduced from direct experiences (Easterby-Smith et al., 2015). This can be understood as an alternative research paradigm to fundamental epistemologies and is often considered as a compromise position between internal realism and relativism: ‘it does not accept that there are predetermined theories or frameworks that shape knowledge and truth; nor does it accept that people can construct their own truths out of nothing’ (Easterby-Smith et al., 2015, p. 61). This ‘compromise position’ can be found in factories as illustrated by multiple examples. Thus, as an example, managers have job descriptions that can be understood as frameworks for their role, which comprises an internal realism position. Alternatively, managerial actions can be interpreted by employees and other managers, and the perceptions depend on this understanding (i.e. relativism). Hence, the actions of managers are characterised by a high dynamic, and manifold task mastery is expected to be brought to bear to measure their synthesised roles in the pursuit of productivity improvement.
Positivist and social constructivist philosophies have guided the methodology of this dissertation, and the relationship between researcher and research object plays a significant formative role in the research design (Easterby-Smith et al., 2015). Thus, the research style is located between detached and engaged relationships with the environment (Easterby-Smith et al., 2015). This describes the place where empirical data are gathered. However, the position sometimes conflicts with the perception ‘that researchers should strive to be independent and detached from the people and processes they are studying’ (p. 57). When studying social systems, positivist values are closer to the aspects they are studied (Easterby-Smith et al., 2015). Notably, the author was located at the research site 100% of the time dedicated to research. Hence, the general epistemological position of this dissertation can be understood as engaged; hence, the insider perspective is advantageous. Over time, a full-time on-site presence provides unique insights into productivity management; hence, the analytical structure of this dissertation is quite sturdy. Moreover, exclusive access to meetings and discussions provided unique data access. Hence, this is a revelatory case (Yin, 2003).

The philosophical relationship of the researcher to the object of study is differentiated slightly among the three articles included in this dissertation. In all three, a systems view was applied, which many researchers would classify as positivist (Easterby-Smith et al., 2015), for which a soft systems methodology on the constructivist side was suitable because of its concern with human rather than physical systems (Easterby-Smith et al., 2015). Hence, systems theory and pragmatism could not be used as fundamental epistemological positions; however, compromise-seeking was used to support the systems view.

Article 1 applied an inductive approach that applied a contingency view as the lens to investigate the elements influencing productivity, which required management action. Thus, the elements related to productivity outcomes were developed inductively from the literature as options to improve productivity. A detached researcher position was taken in contrast to the other two articles, which applied structured literature reviews. For Articles 2 and 3, a more objectivist position was applied (Goede, 2005), which relies on a weaker form of constructivism with an abductive approach to ground the analytical framework based on accounting MCSs in the OM context (i.e. productivity management). Klicken oder tippen Sie hier, um Text einzugeben.

3.2 Reasoning and methodology
This section explains the framing of the research question and the derivation of the philosophical assumptions underlying the methodology applied to each article. A key objective of any doctoral dissertation is the contribution of knowledge that supports extant or new theories based on the discipline (Easterby-Smith et al., 2015; Karlsson, 2009). A challenge with this endeavour was figuring out how theoretical conclusions could be derived from empirical data (Ketokivi & Mantere, 2010), and how to arrive at the theoretical claim (general) from the data (specific) which is classified as inductive, deductive or abductive reasoning (Mantere & Ketokivi, 2013). Deductive reasoning draws conclusions based on an initial set of propositions (Locke et al., 2008; Mantere & Ketokivi, 2013) that require validity and truth values. This method enhances the grounding of new theories (Harley & Cornelissen, 2022). In contrast, inductive reasoning draws conclusions from observations, meaning that there is a stark lack of deductive proofs (Locke et
al., 2008; Mantere & Ketokivi, 2013). Abductive reasoning relates to a process where researchers after being confronted with findings analysed from data try to develop the ‘best explanation’ that for the findings from several possible explanations (Harley & Cornelissen, 2022, p. 245). Abduction is a cognitive activity that often lands beyond the evidence, and it is not an algorithm or some computation (Ketokivi & Mantere, 2021).

The management of interrelationships for productivity improvement is sparse in terms of extant research, as discussed in Chapter 2. Hence, in this dissertation, knowledge creation was exploratory and inductive, and abductive reasoning was applied to knowledge creation. In general qualitative research, based on a variety of ontological, epistemological and methodological assumptions, different analytical methods and presenting styles are typically used (Harley & Cornelissen, 2022).

The choices of methodology for each article are explained next. As mentioned, multiple lenses were applied to supply a comprehensive, triangulated picture of managerial activities designed to create discrete productivity outcomes. The sequence of the articles is arranged from macro to meso to micro analytical levels (Trist, 1981), as illustrated in Figure 3.1. The macro-level lens includes the factory and external environment, the meso level focuses on the highest managerial level in the factory, just below plant manager (Trist & Bamforth, 1951), and the micro level focuses on the lowest managerial level. These differences allow for a well-stratified and detailed analysis.

![Figure 3.1: Levels of analysis applied to the three articles](image-url)
3.2.1 Article 1

The scope of Article 1 applies a macro view to factory managers. Notably, this dissertation takes the same view in relation to its analysis. Hence, a contingency view is applied in which the better the organisation adjusts to the external (in CT named contextual) environment, the better its performance (Burns & Stalker, 1961; Lawrence & Lorsch, 1967). For the Article 1 analysis, the task of management was assumed to include managing the effect of external elements and resources needed for productivity outcomes.

Using an exploratory approach based on inductive reasoning, the purpose of Article 1 was to contribute to the understanding of the options afforded to managers to improve productivity. Three were found: manipulating the elements that influence productivity, understanding their effects and visualising their interrelationships. Because it was relevant to identify the origins of this complexity and how managers dealt with it, the extant literature was found to highlight the manifold elements and their interrelationships from the previous 40 years (e.g. Thomé & Sousa, 2016) when structured and systematically reviewed and analysed.

Although the OM literature reflects a fragmented productivity theory, productivity efficiency in factories has been a difficult topic of study (Jin et al., 2016). A systematic literature review (SLR) was applied in Article 1 to assess empirical data sources, which contributed to answering the research question and provided novel insights into productivity management (Buer et al., 2018; Kapoor et al., 2021; Peron et al., 2022; Zheng et al., 2021). By applying SLR, knowledge is accumulated from a collection of studies from which the evidence is developed (Tranfield et al., 2003). Through this process, the research problem was synthesised in a ‘novel or particularly illuminating way’ (Easterby-Smith et al., 2015, p. 16). Differing from traditional narrative reviews, SLR requires rigorous reviewing and coding processes to minimise bias (Tranfield et al., 2003) and facilitate a ‘thorough and unbiased examination of literature’ (Denyer & Neely, 2004, p. 133).

3.2.2 Article 2

Article 2 focuses on managerial activities at the meso level (Trist, 1981; Trist & Bamforth, 1951), where factory and department managers execute formal and informal MCs. Because this dissertation investigates productivity management, MCSs were examined to determine how they provide the managerial controls that are most valuable to OM-related production management improvements. In OM, MCSs have primarily been analysed in reference to single MCs (Nielsen et al., 2018; Pešalj et al., 208). Hence, the investigation in Article 2 was an exploratory approach applied to a management accounting domain comprising multiple MCSs (Grabner & Moers, 2013; Malmi & Brown, 2008; Merchant & Van der Stede, 207).

Contrasting Article 1, an abductive rationale is applied in Article 2 using the management accounting literature, which compared OM productivity improvement tasks (Mantere & Ketokivi, 20(K. Notably, multiple MCSs were used to investigate OM management productivity. Thus, in this dissertation, we are interested in identifying the types of interrelationships arising from the use of multiple MCs (conflicting and complementary). Article 2 explains what managers do to mitigate conflicts that arise and promote MCS complementarities.
To investigate the multiple interrelationships of MCSs with respect to productivity management, deep insight into factory structure and life was essential. Hence, a case study was used as such processes are useful when developing, supporting or refuting grounded theory and a relatively thorough understanding of nature and complexity of the phenomenon is sought (Karlsson, 2009).

3.2.3 Article 3

Article 3 focused on the micro level of factory operations, for which value-added transformations were assessed (Rice, 1958; Trist & Bamforth, 1951). This article focused on the lowest hierarchical management position (i.e. line manager). In contrast to Article 2, only a single assembly line and its teams were in scope. The line manager is responsible for managing the team of operators in stages where productivity outcomes are visible and technical aspects of the equipment converge. Multiple MCSs view have been applied (Grabner & Moers, 2013; Malmi & Brown, 2008; Merchant & Van der Stede, 2017) as a lens to answer the research question about managing the control problems and the involved MCSs.

Article 3 followed an exploratory approach with abductive reasoning, which grounded the logic used to infer the explanations (Mantere & Ketokivi, 2013). Notably, the understanding of multiple MCs of Malmi and Brown (2008) provided the analytical framework. Hence, using a single case study, the tasks and control problems of line managers are facing to manage productivity outcome were investigated.

The methodological choice of the two articles are presented in Table 3.1.
Chapter 3 – Philosophical assumptions, reasoning and methodology

Table 3.1: Methodological choices of the three articles

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<tr>
<th>Article 1</th>
<th>Article 2</th>
<th>Article 3</th>
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<tr>
<td><strong>Managing productivity improvement in a complex manufacturing world: What we know from 40 years of operations management literature</strong></td>
<td><strong>Productivity improvement and multiple management controls: evidence from a manufacturing firm</strong></td>
<td><strong>Exploring the control problems and the interplay of management control systems for productivity on the assembly line</strong></td>
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<tr>
<td>Authors</td>
<td>Michael Güldenpfennig, Kim Sundtoft Hald</td>
<td>Michael Güldenpfennig, Kim Sundtoft Hald, Allan Hansen</td>
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<tr>
<td>Theoretical starting basis (from gaps)</td>
<td>Theory of the scope and structure of managerial actions on productivity improvement in manufacturing is fragmented in OM.</td>
<td>Theory of multiple management control systems is sparse in OM, but it provides a lens for focusing the managerial control task of productivity improvement.</td>
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<td>Knowledge creation</td>
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<td>Reasoning</td>
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<td>Theoretical lens</td>
<td>Contingency theory</td>
<td>Management control systems theory</td>
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<td>Design</td>
<td>Systematic literature review</td>
<td>Single case study</td>
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<tr>
<td>Research questions</td>
<td>(1) What variables for improving productivity in a manufacturing context have been identified in OM research across different productivity dimensions? (2) What interrelationships between productivity-enhancing variables do managers in a manufacturing context need to consider when handling complexity?</td>
<td>(1) Which MCSs operating within the manufacturing context affect the proper functioning of the PI System, and what are their interrelationships? (2) Which mechanisms do managers use to alleviate tensions and strengthen complementarities between these MCSs and the PI System?</td>
</tr>
<tr>
<td>Empirical material</td>
<td>60 included Articles from top-5 OM journals</td>
<td>21 interviews, multiple observations, company documents, access to company systems and on-site stay</td>
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3.3 The case
The empirical data of Articles 2 and 3 were collected from a single case of a global (German) automotive supply factory that produces complex systems for passenger cars. Because this case is central to the present dissertation, two important rationalities were applied to justify the choice of the single case (Yin, 2003). Second, additional information was provided to explain the structures and operations related to productivity improvement.

First, the selected factory provides a representative or typical case (Yin, 2003, p. 41). Like many other factories, the case factory belongs to a global organisation with a corporate governance structure that is physically distributed across multiple sites in North and South America, Europe and Asia. Several functions (e.g. Sales, R&D and IT) are organised at the European location, at which the corporate structure applies additional decision-making and communication processes. The corporate structure reflects the business units that represent certain product groups and the regions which were secondary to the investigation. The German factory employs ~400 people and is organised into departments, each controlled by a department manager and multiple subordinate managerial levels. The production department has a machining area with about 50 machines, an assembly area with seven assembly lines and additional sub-assembly islands. The company continuously undertakes long-term productivity improvements.

Second, the selected case factory provides a revelatory case (Yin, 2003, p. 42), and the author of this dissertation is a department manager at the firm with access to all relevant action plans, business documents and strategy, including access to management meetings and key decision-making venues. Furthermore, relationships across the global organisation, supply chain partners and customers provided deep insights into the multifarious and often complex interrelationships. Furthermore, exclusive access to engineering levels and the shop floor allowed for valuable technical and empirical data collection.

To become and remain competitive, productivity improvement is the focus of the factory’s daily work, which seeks to attain attractive price-wise customer loyalty while winning new customer projects. Thus, expanding the profit margin is not the only goal; however, it is an important metric used to justify new projects that may be fundamental to factory survival and growth. In the case factory, the profit margin is related to productivity improvement, and the efficacy of production operations is the major driver of productivity.

Productivity improvements in the case factory were classified by the productivity concept applied and the improvement assessment method. First, productivity improvements are driven by special initiatives via dedicated project teams with a responsible project leader. An example included a scrap reduction project for a pre-assembly production island. Factory priority projects require project presentations every two-to-four weeks led by the project lead to the management team. Constant follow-ups are also used to drive productivity during daily operations. Thus, the output and scrap of an 8-h production shift using machines, pre-assembly islands and assembly lines provide the central measures used for productivity follow-ups. For example, current outputs trending toward shift targets are displayed on screens above the assembly lines, by which teams are motivated to reach targeted shift outputs (Figure 3.2). Another example of constant follow-up is a scrap-and-rework review that takes place on the scrap table adjacent to the machines and assembly line.
The case factory applies multiple productivity concepts, including labour productivity, which is measured by output per shift and the performance rates of team members. Machine availability and quality rate are also factored into overall equipment effectiveness. Additionally, material productivity is followed up in the German case factory. The machining scrap rate is reported at the end of each shift using assembly department and factory balanced scorecards. Furthermore,

![Assembly line in the case factory](image)

*Figure 3.2: Assembly line in the case factory*

the material productivity of bought-in components is essential to the case factory management. Many components purchased from suppliers comprise a huge portion of overall product costs, and several machining steps are performed outside the plant, such as washing and deburring. To maintain competitive bills of materials, the purchasing department constantly monitors component costs while searching for strategies to reduce them and/or avoid increases.

Hence, although there is a risk of bias of the author being that engaged in the case firm, it is mitigated by the measures explained in the individual articles. Hence, the deep insights afforded by this case opportunity were extremely valuable.
3.4 List of appended articles

Chapters 4–6 provide the three articles used to investigate the research question of this dissertation, and each retains its respective abstract. Above, in Section 3, the methodology, the purpose and content of each article and its role in this dissertation has been described. Hence, the articles are not summarised separately. Additionally, the key references and statuses of the appended articles are presented in Table 3.2. Later, in Chapter 7, the overall findings of the three articles are interpreted in support of the analysis of this study.

**Table 3.2: Overview of appended articles**

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<th>Güldenpfennig, M.: Exploring the control problems and the interplay of management control systems for productivity on the assembly line</th>
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<tr>
<td>• Güldenpfennig, M.: Managing interrelationships for improving productivity on the shop floor: the roles of line managers</td>
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Chapter 4: Managing productivity improvement in a complex manufacturing world: What we know from 40 years of OM literature (Article 1)

Michael Güldenpfennig and Kim Sundtoft Hald

*Copenhagen Business School, Department of Operations Management*

**Abstract**

Understanding the elements that enhance productivity is important because it is related to the ability to manage productivity successfully. However, a comprehensive theory of how to manage these elements, their multiple interrelationships and the resulting complexity leading to productivity improvement remains missing. This study aims to deductively develop a set of elements that have been identified to enhance productivity in manufacturing. A systematic literature review is performed, and the subsequent analysis is based on articles published over the last four decades in top-ranked peer-reviewed operations management journals. A productivity management framework of productivity-enhancing elements is developed, including nine major themes and 83 elements. This novel framework enriches our understanding of productivity as a multifaceted managerial endeavour confronted with the challenge of handling complex choices to improve productivity in manufacturing. From the literature analysis, the interrelationships creating this complexity in the manufacturing setting are described, and managerial implications are derived. We call for more quantitative research to explore the identified interrelationships and to fully understand the complexities in improving productivity. For practitioners, the findings provide a deeper understanding of the opportunities and complexities involved in productivity improvement and of how interventions can be applied to address complexity in their work.

Keywords: productivity improvement; productivity management; operations management; complexity; manufacturing; systematic literature review
Chapter 4 – Managing productivity improvement in a complex manufacturing world – Article 1

1 Introduction

Productivity improvement (PI) is a fundamental aspect of the competitiveness, sustainability, growth and survival of manufacturing firms (Bernolak, 1997; Tangen, 2005). The importance of PI has increased with globalisation, automation, consolidation of industrial sectors and reshoring (Wacker et al., 2006; Walker et al., 2015). In the past, innovations, such as the moving assembly line; labour specialisation (Schmenner, 2015); and the application of management concepts, such as the lean philosophy or total quality management (Kosonen and Buhanist, 1995; Shaw and Ward, 2003), have led to major productivity gains. Today, the digitalisation of processes and the rise of Industry 4.0 play a key role in enabling opportunities for further PI (Hannola et al., 2018; Alavian et al., 2020).

All these developments have led to a high managerial complexity that we define as the management of ‘complex interrelationships of elements’ that enhance productivity outcomes (e.g. Greene and Sadowsky, 1984; Mohanty, 1988; Misterek, 1992; Jin et al., 2016; Park and Li, 2019). This is because there are so many opportunities for applying concepts and tools that might lead to PI individually or collectively. However, to effectively compete by implementing PI, manufacturers must understand the multiple productivity-enhancing elements that can potentially enable PI and how these elements are interrelated to either enhance or reduce the total effect on production productivity (Jin et al., 2016). Thus, the ability to understand, select, configure and apply different management intervention mechanisms in order to configure the manufacturing system for optimal productivity is becoming increasingly important. Middle managers who are confronted with senior management demands and are engaged in operationalizing objectives in practice on the shop floor (Floyd and Woolridge, 1997; Mantere, 2008; Spring and Unterhitzenberger, 2022) especially need guidance in handling this managerial complexity. The current study attempts to address this empirical challenge.

The existing literature on PI is comprehensive but fragmented. Multiple elements that influence productivity have been analysed using different research methods, such as surveys (e.g. Noble, 1997; Mapes, 2000) and case studies (e.g. Gunasekaran et al., 2000; Krishnan and Srinivasan, 2007), but an advanced theory of the elements leading to PI remains missing. To date, no study has aggregated the existing body of knowledge on PI within manufacturing. Furthermore, no study has sought to understand the managerial complexity involved. The few reviews on productivity that exist (Aggarwal, 1980; Schmenner, 2015; Jin et al., 2016) are valuable, as they provide insights into productivity topics and trends but do not analyse and consolidate the elements affecting productivity outcomes. This study aims to address these literature gaps by extending the theory of the interrelationships between productivity-enhancing elements and the complexities involved in a manufacturing context. This research contributes to the literature by providing an overview of productivity-enhancing or reducing elements and how they are understood to interrelate and have a collective effect on productivity (Güldenpfennig and Hald, 2019).

To categorise the identified productivity-enhancing elements and their interrelationships, we draw on contingency theory (CT) (Burns and Stalker, 1961; Lawrence and Lorsch, 1967). Sousa and Voss (2008) recommended CT as a useful theoretical lens for the study of operations management (OM) issues, especially for areas in which theory has not advanced far (e.g. Shah
and Ward, 2003; Demeter et al., 2011; Peng et al., 2011; Chavez et al., 2015). Based on these considerations, the following research questions are formulated:

- What elements for improving productivity in a manufacturing context have been identified in OM research across different productivity dimensions?
- What interrelationships between productivity-enhancing elements do managers in a manufacturing context need to consider when handling complexity?

A list of productivity-enhancing elements is identified through a systematic literature review of 60 articles published during the last four decades in the top five peer-reviewed OM journals. The elements are classified and coded based on CT understanding of diverse types of elements. The results show that nine major themes with 83 elements have an effect on productivity. A new productivity management framework highlighting the dimension of complexity that managers face in the pursuit of PI is also developed. Finally, a set of six mediating interventions managers can apply to reduce and handle the complexity of PI options is proposed for more effective productivity management.

Our article contributes new insights to PI in OM. Unlike existing reviews in the field (Aggarwal, 1980; Schmenner, 2015; Jin et al., 2016), it highlights several types of productivity-enhancing mechanisms and provides new insights into how they interrelate to form a complex influence on productivity outcomes. By sorting and aggregating existing evidence of how productivity can be improved within a manufacturing context, we hope that our work can spur future research that would explore how the elements identified in this study interrelate to affect productivity outcomes.

This article is structured as follows. Section 2 presents the theoretical stance of the presented research, Section 3 describes the methodology, and Section 4 presents our findings in the form of the identified elements, their structures and their effects. Section 5 provides the details of the complexity that middle management faces in managing PI and six intervention areas to address this complexity. Section 6 discusses the main contributions of the study and presents the conclusion, including the research limitations and future research avenues.

2 Theory

2.1 Productivity

The concept of productivity is broad and multidimensional. Although academics and practitioners agree that productivity is the ratio of the desired output in relation to the resource input (e.g. Brown and Mitchell, 1988; Tangen, 2005; Demeter et al., 2011), productivity has many forms and different understandings as found in the OM literature. The definition of productivity developed over time, as Tangen (2005) illustrated, and the definition by Bernolak (1997), who emphasised the resource side of productivity, reflects our understanding of it in relation to the purpose of this article:

‘Productivity means how much and how good we produce from the resources used. If we produce more or better goods from the same resources, we increase productivity. Or, if we produce the same goods from less resources, we also increase productivity. The same applies
to services. If we provide more services or better-quality services from the same resources, our productivity has increased. Or, if we provide the same services and just as well, from less resources, we also improve productivity’ (p. 204).

Various concepts are also associated with productivity. The OM literature reflects the applications of different kinds of productivity that can be distinguished by the type of input resources that are on focus (Baines, 1997; Demeter et al., 2011; Dorner, 2014), such as labour (Shah and Ward, 2003; Demeter et al., 2011; Orzes et al., 2017), capital and investment (Aggarwal, 1980; Misterek et al., 1992; Demeter et al., 2011), and material (Kamble et al., 2020; Sartal et al., 2020). In OM, the application of the labour productivity concept—the output quantity of products in relation to workforce use—is dominant (Noble, 1997; Skinner, 1986). For considering the entire range of resources used, the concept of total factor productivity (TFP) is also applied in OM (Jin et al., 2016), which is calculated as the value added divided by the total cost of capital and employment (Li and Hamblin, 2003). Neoclassical economic growth theory considers TFP as the rate of technological progress (Song et al., 2018).

This literature review does not limit the analysis to a certain productivity or resource type. Rather, multiple productivity and resource dimensions are considered part of the analysis.

### 2.2 Reviews on productivity in manufacturing

Although managing productivity is a major concern in OM, the number of articles with productivity as a central theme is low (Walker et al., 2015). Hence, we were able to identify only three comprehensive reviews of productivity-related research in the OM field (Aggarwal, 1980; Schmenner, 2015; Jin et al. 2016); the content of and gaps in these reviews are presented in Table 1. Aggarwal (1980) identified 99 elements (called them variables) influencing productivity from 27 case studies performed across industries in the US. A classification of productivity-enhancing elements into 10 clusters was presented. Among the clusters, Aggarwal (1980) identified five major PI contributors that can be influenced by management. Thus, there is a focus on management aspects and the inclusion of management practices. Schmenner (2015) described the innovations that occurred to improve productivity from 1776 to 1950, such as the moving assembly line (year 1913/1914) and lean manufacturing (from the 1940s onward). According to Schmenner (2015), these innovations are underlying concepts that further improvements can ground on and are successful across industries. He elaborated on the theory of swift even flow, which, according to Walker et al. (2015), is one of the few unique OM theories. Based on Schmenner’s idea (2015), PI can be successful by focusing on increasing throughput time and reducing variation, which is a foundation of many strategies leading to PI, such as the just-in-time (JIT) concept or changes in work cell layout. The third review we identified was a retrospective review by Jin et al. (2016), which aimed to discover the major trends in and issues of productivity and included 213 core productivity studies from the 1970s to 2013. Research from the fields of management, economics, engineering and sciences was included in the study. Nine productivity issues were identified and grouped into four categories: fundamental (labour, technology and information technology systems), additional (process, tool and method), environment (trade and regulations) and performance (business performance and operational performance). Thus, a set of
categories and a framework proposing the interrelationships between manufacturing system elements were presented.

However, although these studies present valuable insights into PI mechanisms and elements and thus provide a solid foundation for the present study, there are also gaps. Some elements in the OM literature are identified, but their effects on PI are neglected (Aggarwal, 1980), and the interrelationships between the identified productivity-enhancing elements are not explored. The current study addresses these gaps and identifies the elements that have been proposed in research to improve productivity in a manufacturing context. We explore how these elements are interrelated to affect productivity outcomes in a manufacturing context.

**Table 1: Overview of other reviews on productivity in manufacturing**

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Title</th>
<th>Journal</th>
<th>Contribution</th>
<th>Limitations/Gaps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggarwal, 1980</td>
<td>A study of productivity measures for improving benefit-cost ratios of operating organizations</td>
<td>International Journal of Production Research</td>
<td>A comprehensive list of factors (99) and categories</td>
<td>Limited to case studies (27) and US firms only, Study is more than 40 years old, No framework of elements</td>
</tr>
<tr>
<td>Schmenner, 2015</td>
<td>The pursuit of productivity</td>
<td>Production and Operations Management</td>
<td>Productivity innovations as underlying concepts</td>
<td>Affecting elements at a high aggregation level</td>
</tr>
<tr>
<td>Jin et al., 2016</td>
<td>Research issues and trends in industrial productivity over 44 years</td>
<td>International Journal of Production Research</td>
<td>Issues and factor cluster, Development of productivity themes, Broad focus (213 core articles in four fields)</td>
<td>Effects of elements not included in the scope, No framework of elements</td>
</tr>
</tbody>
</table>

### 2.3 Different types of elements in the complex interplay for productivity outcomes

Managers’ abilities to control the different elements influencing productivity differ depending on the variable type. Consequently, several types of elements must be considered when striving to improve productivity (Sousa and Voss, 2008). In their application of CT, Sousa and Voss (2008) distinguished between three types of elements (they call them variables): 1) contextual elements, which represent environmental forces; 2) response elements, which characterise the organisational and managerial action taken; and 3) performance elements, which measure the results of the fit of the contextual and response elements. Luthans and Stewart (1977) further distinguished between resources and management. Together, these elements may be understood as characterising the response (Sousa and Voss, 2008) to environmental forces. Managers’ abilities to control these distinct types of elements can be understood as follows.
First, the ability to influence and thus manage contextual elements is typically claimed to be limited and only possible over a long-term period and with substantial effort (Luthans and Stewart, 1977; Sousa and Voss, 2008). In addition, the OM literature reflects a distinction between external and internal contextual elements (e.g. Siggelkow, 2001; Pedersen and Sudzina, 2012; Zhang et al., 2012). While external elements represent forces that are not considered to be in the control range of an organisation and its managers, internal elements are within the responsibility of an organisation, but the possibility of control is dependent on the managerial level within the organisational hierarchy (Shah et al., 2013).

Second, the resource side of response elements (Luthans and Stewart, 1977) represents all tangible and intangible resources that management has direct control over and on which it can operate to drive the desired change (Luthans and Stewart, 1977; Dangayach and Deshmukh, 2001). The financial, informational, technological and human resources exemplified by, for instance, an operator’s skills or the organisational reputation within the industry, represent the wide spectrum of resource elements that management teams have the potential to influence (Dangayach and Deshmukh, 2001).

Third, the resource side of management elements (Luthans and Stewart, 1977) represents the active managerial control of PI. Following CT, performance improves if the organisational design fits the context (Drazin and Van de Ven, 1985). However, this requires active action and intervention—the objective of management (Anthony, 1965; Simons, 1990). According to Luthans and Stewart (1977), managers must consider contextual and resource elements, as well as their interrelationships, to initiate strategy changes, with the objective of establishing a fit resulting in improved performance outcomes.

3 Methodology

3.1 Systematic literature review

A systematic literature review organised in five steps was used to address the research questions (e.g. Tranfield et al., 2003; Easterby-Smith et al., 2015). First, relevant literature was selected based on a keyword search. Second, a quality assessment was performed based on the set inclusion criteria, which were applied to the selected literature sample. Third, the remaining articles in the sample were individually coded and classified based on CT. Subsequently, productivity elements and productivity effects were extracted. Fourth, the extracted productivity-enhancing elements were coded and clustered. Fifth, a productivity management framework was developed from the results of the systematic literature review, illustrating the complexity involved in managing productivity based on the contextual elements and the interrelationships of elements for PI.

3.2 Data collection and quality assessment

We applied the four steps of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol for the selection of the relevant literature (Moher 2010), as illustrated in Figure 1. For data collection purposes, the Scopus search engine was used to identify relevant articles (e.g. Walker et al., 2015; Jin et al., 2016).
With the goal of enhancing OM theory, the strategy was to select a short list of high-quality, peer-reviewed OM journals based on quality assessment criteria following the work of Petersen et al. (2011), Fry and Donohue (2013) and the Journal Quality List (Harzing, 2020). However, as many other journals also provide valuable contributions to the productivity discussion, we recognise the sample of journals selected to be a limitation of our research.

The search term ‘productivity’ and ‘manufacturing’ OR ‘production’ was applied to the article titles and abstracts to select relevant articles. A total of 751 English articles were identified from the top five selected OM peer-reviewed journals from 1970 to June 2021. As this research focuses on the manufacturing field and the dependent variable productivity, these terms were used as the initial screening criteria. The abstracts of the initial 751 articles were read to remove any articles belonging to sectors other than manufacturing and those not focusing on productivity as an outcome. Consequently, the sample was further reduced to 290 articles for analysis.

After the titles and abstracts of the remaining articles were reviewed, the inclusion criteria were further refined (Tranfield et al., 2003). Articles that contained information about one or more
productivity-enhancing elements were included in the final sample. We defined productivity-enhancing elements as any direct interrelationship between a variable identified from the literature to have an influence on PI, or a variable moderating or mediating a direct one, regardless of its direction of effect (positive, negative or none). Articles that did not focus on the interrelationship between a variable and PI were excluded. A final sample of 60 articles was obtained (Table 2).

Table 2: Selected peer-reviewed OM journal articles and their numbers in the final sample

<table>
<thead>
<tr>
<th>Selected peer-reviewed OM journal (alphabetical order)</th>
<th>Number of articles that contributed to the findings (Total 60)</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Journal of Operations and Production Management (IJOPM)</td>
<td>7</td>
</tr>
<tr>
<td>International Journal of Production Economics (IJPE)</td>
<td>18</td>
</tr>
<tr>
<td>International Journal of Production Research (IJPR)</td>
<td>20</td>
</tr>
<tr>
<td>Journal of Operations Management (JOM)</td>
<td>11</td>
</tr>
<tr>
<td>Production and Operations Management (POM)</td>
<td>4</td>
</tr>
</tbody>
</table>

3.3 Data analysis and coding

Once the inclusion criteria were applied, the selected articles were carefully read to identify all productivity-enhancing elements and their effects on productivity. Four kinds of productivity effects were recorded for each identified interrelationship: (1) no effect, (2) negative effect, (3) effect without a direction (neither positive nor negative, just reported effect) and (4) positive effect.

After the productivity-enhancing elements were identified and extracted, they were coded and sorted into categories to consolidate and compare their effects, which was a step deemed essential for increasing the generalisability of the results (Sousa and Voss, 2008). An initial coding scheme was developed based on a sample of five complementary studies (Aggarwal, 1980; Schmenner and Cook, 1985; Shah and Ward, 2003; Abdel-Maksoud et al., 2005; Sousa and Voss, 2008). However, because this initial scheme was unable to capture all the identified productivity-enhancing elements, it was supplemented with a button-up approach that identified additional categories and applied the principles of grounded analysis (Easterby-Smith et al., 2015, p. 191–197). To increase the validity of the category assignment, each author individually categorised each productivity-enhancing variable for subsequent comparison of the results obtained. If the elements were inconsistently categorised, the results were further discussed among the authors until agreement was reached. The highest aggregation level that clustered multiple categories was named themes.
4 Findings

4.1 Nine themes and their productivity-enhancing elements

Based on the literature analysis, 371 single interrelationships between productivity-enhancing elements and their corresponding effects on productivity were determined. From these, 83 unique independent elements were identified, and they were coded and clustered into nine themes. Table 3 summarises the identified elements, provides the analysed literature that contributes to the identified interrelationships and shows the consolidated effects of the variable on productivity.

The external environment represents the environment outside a manufacturing firm; the elements that fall into this category cannot be changed by management or can only be changed over the very long term with great effort (Spring et al., 2017). The organisational setting of the factory represents the context within an organisation and is characterised by elements such as firm size or existing company change culture. These elements can be changed by management in the long term. Both the external environment and the organisational setting of the factory are understood as contextual themes.

Resource elements are closest to management control (MC) (Luthans and Stewart, 1977), and the literature review identified five resource themes. First, the manufacturing process condition and outcome category characterises the manufacturing setting through elements such as capacity availability or reduction of throughput time and elimination of bottlenecks. Second, the product design and portfolio category clusters all elements describing manufacturing firm products. Third, the supply chain management category represents material management, as well as relations to supplier and customers. Fourth, the technology level category reflects the technological resources available at a manufacturing company. Finally, the workplace condition category defines the employee-related situation in the firm.

Two categories of elements represent active control for PI. First, the management theme includes elements describing managerial levers in manufacturing that are pursued, such as levels of functional and strategic alignment in a company or diversified direction and feedback towards employees. Second, the management concepts theme includes elements representing concepts that management implements to reach PI, such as lean concept maturity or total quality management and assurance (TQM/A) levels.
### Table 3: Nine themes identified from the analysis and their 83 elements, effects and references

<table>
<thead>
<tr>
<th>Theme</th>
<th>Elements</th>
<th>Overall effects on productivity</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External environment</strong></td>
<td><strong>9 elements in 36 single interrelationships</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contextual elements</td>
<td>• Country and region of the company</td>
<td>+ 0</td>
<td>Bhattacharya and Narayan 2015 (PS); Demeter et al. 2011 (SU); Farid and Neumann 2019 (CP); Jit et al. 2016 (LR); Lowe and Fernandes 1994 (CP); Mapes 2000 (PS); Mohanty 1992 (LR); Saldana et al. 2013 (PS); Schmenner and Cook 1985 (SU); Song et al. 2018 (PS); Spring et al. 2017 (CP)</td>
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<tr>
<td></td>
<td>• Demand volatility</td>
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<td></td>
<td>• Economic character of the environment</td>
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<td></td>
<td>• Environmental regulations</td>
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<td></td>
<td>• Industrial sector of the company</td>
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<td></td>
<td>• Laws and regulations for production</td>
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<td></td>
<td>• Poor health conditions of employees</td>
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<td></td>
<td>• Resource availability for the company</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• World market dependency</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Organisational setting of the company</strong></td>
<td><strong>14 elements in 38 single interrelationships</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contextual elements</td>
<td>• Activity mistakes and obstacles</td>
<td>+ 5</td>
<td>Abolhassani et al. 2018 (PS); Abolhassani et al. 2019 (PS); Bernolak 1997 (CP); Brown and Mitchell 1988 (SU); Cantor and Jin 2019 (AR/EX); de Menezes and Escrig 2019 (PS); Demeter et al. 2011 (SU); Fisher 2007 (CP); Garcia et al. 2014 (SU); Gunasekaran et al. 1994 (CP); Gunasekaran et al. 2000 (CS); Kao et al. 1995 (SU); Mapes 2000 (PS); Mohanty 1992 (LR); Noble 1997 (PS); Rantanen 2001 (SU); Sáenz-Royo and Salas-Fumás 2014 (CS); Schmenner and Cook 1985 (SU); Schmenner 1991 (SU)</td>
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<tr>
<td></td>
<td>• Age of firm and equipment</td>
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<td></td>
<td>• Change culture at the firm</td>
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<td></td>
<td>• Clean and structured facilities</td>
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<td></td>
<td>• Dedicated resources for improvement</td>
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<tr>
<td></td>
<td>• Existence of unions and work councils</td>
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<td></td>
<td>• Flexibility of the workforce</td>
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<td></td>
<td>• Foreign ownership of the company</td>
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<tr>
<td></td>
<td>• Frequency of launches and product changes</td>
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<tr>
<td></td>
<td>• Number of competitive priorities in place</td>
<td></td>
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<tr>
<td></td>
<td>• Number of management practices installed</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• Plant and firm size</td>
<td></td>
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<tr>
<td></td>
<td>• Poorly motivated workforce</td>
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<td></td>
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<tr>
<td></td>
<td>• Strike</td>
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<td></td>
</tr>
<tr>
<td><strong>Management</strong></td>
<td><strong>6 elements in 44 single interrelationships</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management elements</td>
<td>• Beliefs within the company</td>
<td>+ 3</td>
<td>Bernolak 1997 (CP); Demeter et al. 2011 (SU); Fisher 2007 (CP); Garcia et al. 2014 (SU); Güldenpfennig et al. 2021 (CS); Gunasekaran et al. 1994 (CP); Gunasekaran et al. 2000 (CS); Kao et al. 1995 (SU); Mapes 2000 (PS); Mohanty 1992 (LR); Roth et al. 2020 (CS); Schmenner and Cook 1985 (SU); Schmenner 1991 (SU); Schoenherr and Narasimhan 2012 (PS); Sting and Loch 2016 (CS)</td>
</tr>
<tr>
<td></td>
<td>• Diversified direction and feedback towards employees</td>
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<td></td>
<td>• Implementation level of a continuous improvement culture</td>
<td></td>
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<tr>
<td></td>
<td>• Lack of management support</td>
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<td></td>
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<tr>
<td></td>
<td>• Level of functional and strategic alignment within the company</td>
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<td></td>
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<tr>
<td></td>
<td>• Level of leadership skills of managers</td>
<td></td>
<td></td>
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<tr>
<td><strong>Management concepts</strong></td>
<td><strong>8 elements in 51 single interrelationships</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management elements</td>
<td>• Data management capabilities</td>
<td>+ 6</td>
<td>Abolhassani et al. 2018 (PS); Abolhassani et al. 2019 (PS); Bernolak 1997 (CP); Blind and Müller 2020 (PS); de Menezes and Escrig 2019 (PS); Demeter et al. 2011 (SU); Dostaler 2001 (CS); Fisher 2007 (CP); Garcia et al. 2014 (SU); Güldenpfennig et al. 2021 (CS); Gunasekaran et al. 1994 (CP); Gunasekaran et al. 2000 (CS); Kao et al. 1995 (SU); Mapes 2000 (PS); Mohanty 1992 (LR); Liu et al. 2021 (PS); Schmenner and Cook 1985 (SU); Schonberger 1982 (CS)</td>
</tr>
<tr>
<td></td>
<td>• Implementation level of flexible manufacturing systems</td>
<td></td>
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<tr>
<td></td>
<td>• Just-in-time/Kanban existence</td>
<td></td>
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<tr>
<td></td>
<td>• Lean concept maturity level</td>
<td></td>
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<tr>
<td></td>
<td>• Performance and productivity measurement</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• Statistical Process Control (SPC) and quality tools</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>• Total productive maintenance</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Total quality management and assurance</td>
<td></td>
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</tbody>
</table>
### Theme and Type of elements

<table>
<thead>
<tr>
<th>Elements</th>
<th>Overall effects on productivity</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manufacturing process conditions and outcomes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Resource elements</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 elements in 59 single interrelationships</td>
<td>+ 5</td>
<td>Abolhassani et al. 2018 (PS); Abolhassani et al. 2019 (PS); Battini et al. 2017 (CS); Bernolak 1997 (CP); Darayi et al. 2019 (CS); Demeter et al. 2011 (SU); Fisher 2007 (CP); Gunasekaran et al. 2000 (CS); Kao et al. 1995 (SU); Kovács 2020 (CS); Lorenz et al. 2021 (CS); Mapes 2000 (PS); Martinez-Budria et al. 2011 (PS); Miltenburg 2001 (LR); Mohanty 1992 (LR); Neumann et al. 2006 (CS); Noble 1997 (PS); Park and Li 2019 (CS); Rantanen 2001 (SU); Schmenner and Cook 1985 (SU); Schmenner 2001 (LR); Schmenner and Swink 1998 (CP); Schmenner 1991 (SU); Schmenner 2001 (LR); Telles et al. 2020 (AR/EX); Wacker 1987 (CP)</td>
</tr>
<tr>
<td>• Capabilities of planning, scheduling and control</td>
<td></td>
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<tr>
<td>• Capacity availability</td>
<td></td>
<td></td>
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<tr>
<td>• Changeover effectiveness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Competencies of process design and reengineering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Design of the layout of lines and cells</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Low process variability and dependability</td>
<td></td>
<td></td>
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<tr>
<td>• Poor quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Reduction of the throughput time and elimination of bottlenecks</td>
<td></td>
<td></td>
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<tr>
<td>• Use of production factors</td>
<td></td>
<td></td>
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<tr>
<td><strong>Product design and portfolio</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Resource variable</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 elements in 29 single interrelationships</td>
<td>+ 2</td>
<td>Abolhassani et al. 2018 (PS); Abolhassani et al. 2019 (PS); Demeter et al. 2011 (SU); Fisher 2007 (CP); Kao et al. 1995 (SU); Mapes 2000 (PS); Martinez-Budria et al. 2011 (PS); Mukherjee et al. 2000 (CS); Noble 1997 (PS); Schmenner and Cook 1985 (SU); Schmenner 1991 (SU)</td>
</tr>
<tr>
<td>• Application of product standardisation concepts</td>
<td></td>
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<tr>
<td>• Product breadth and complexity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Product design capabilities</td>
<td></td>
<td></td>
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<tr>
<td>• Product production volume and mix</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Product type</td>
<td></td>
<td></td>
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<tr>
<td><strong>Supply chain management</strong></td>
<td></td>
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<tr>
<td><strong>Resource elements</strong></td>
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<tr>
<td>7 elements in 21 single interrelationships</td>
<td>+ 3</td>
<td>Abolhassani et al. 2019 (PS); Fischer 2007 (CP); García et al. 2014 (SU); Kao et al. 1995 (SU); Lee et al. 2018 (CS); Mapes 2000 (PS); Mohanty 1992 (LR); Mukherjee et al. 2000 (CS); Schmenner 1991 (SU)</td>
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<td>• Competence level of suppliers and purchase management</td>
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<td>• Customer portfolio</td>
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<td>• Design of warehouse management</td>
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<td>• Degree of outsourcing of processes and work content</td>
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<td>• Low inventory and stock level</td>
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<td>• Delivery and shipping performance</td>
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<td>• Uncertainty of material supply</td>
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<td><strong>Technology level</strong></td>
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<td><strong>Resource elements</strong></td>
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<tr>
<td>7 elements in 33 single interrelationships</td>
<td>+ 4</td>
<td>Alavian et al. 2020 (CS); Bello-Pintado et al. 2019 (PS); Bernolak 1997 (CP); Demeter et al. 2011 (SU); Fisher 2007 (CP); Gunasekaran et al. 1994 (CP); Hannola et al. 2018 (CP); Jin et al. 2016 (LR); Kao et al. 1995 (SU); Martinez-Budria et al. 2011 (PS); Mohanty 1992 (LR); Noble 1997 (PS); Saldanha et al. 2013 (PS); Schmenner and Cook 1985 (SU); Schmenner 1991 (SU); Son 1994 (CS)</td>
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<td>• Automation and machine control level</td>
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<td>• Equipment and tool maturity</td>
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<td>• Information technology-enabled management information and decision support systems</td>
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<td>• Level of digitalisation and Industry 4.0 application at production</td>
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<td>• Level of technological alignment and training</td>
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<td>• Technological capability of the firm and innovation</td>
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<tr>
<td>• Use of IT-based data exchange and enterprise resource planning systems</td>
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4.2 The managerial role in improving productivity

From the analysis, we identified two themes that represent current knowledge of direct managerial influence and the ability to improve manufacturing productivity.

First, the analysis finds strong support for a bi-directional interrelationship between the management theme and the five resource themes. On the one hand, management is influenced by the resource elements, and, on the other hand, management gives direction and moulds resource elements as part of the efforts to improve productivity. The dominant interrelationship in the literature is between management and workplace conditions in relation to PI. One example is the interrelationship between managers’ diversified direction and feedback towards employees (Bernolak, 1997; Gunasekaran et al., 2000; García et al., 2014; Gülpenfenig et al., 2021) and empowerment of the workforce (Gunasekaran et al., 2000; Demeter et al., 2011; García et al., 2014), which all authors in the examined literature positively relate to PI.

Second, the analysis revealed that another stream of research explicitly directed at understanding the managerial role in improving productivity is how management concepts mediate the ability to improve productivity. Multiple management concepts are identified as PI enhancers that are applied to the five resource elements. Hence, management that promotes a high implementation level of continuous improvement and related management concepts (Bernolak, 1997; Mapes, 2000; Demeter et al., 2011), such as zero defects (Fisher, 2007), can actively influence PI. The literature indicates that the application of management concepts is strongly
related to PI in manufacturing firms. In addition, the literature points out that the number of installed management concepts is also relevant to PI (Demeter et al., 2011). The management concepts identified in the literature include the elements known from the Toyota production system, such as total productive maintenance (Mohanty, 1992; Gunasekaran et al., 1994; Kao et al., 1995; Fisher, 2007), TQM/A (Mohanty, 1992; Liu et al., 2021) and JIT/Kanban existence (Gunasekaran et al. 1994 and 2000; Fisher 2007; Garcia et al. 2014), as well as concepts like data management capabilities (Kao et al., 1995; Blind and Müller, 2020) and implementation level of flexible manufacturing systems.

4.3 Managerial challenges and complexity in improving productivity

Our findings demonstrate one possible approach to analysing the existing productivity literature, which allows us to derive an understanding of a complex set of elements and their interrelationships that affect management’s ability to improve productivity (Figure 2). Our analysis did not result only in identifying the 83 elements clustered in nine themes. Each of the nine themes is also related to and involved in management’s pursuit to improve productivity in a manufacturing setting, and each theme plays a different role in this regard, which is explained in the next sub-chapters. As a result, a finer-grained understanding of the complex managerial task of PI is developed. Based on our literature analysis, we propose that management must deal with the following three dimensions of complexity when trying to improve productivity in a manufacturing context (Figure 2):

1. Complexity originating from the external environment.
2. Complexity originating from the organisational setting of the factory.
3. Complexity originating from the interrelationships of resource elements.

![Figure 2: The complex managerial task of improving productivity.](image)
4.3.1 Complexity originating from the external environment
The first dimension creating complexity for managing PI stems from the external environment and arises here in two ways. First, although external environment elements are out of management’s control (besides some exceptions, e.g. Spring et al., 2017), management still needs to consider them in the decision making for PI actions in the firm. We identified nine external elements relevant to consider for PI actions: country and region of the firm (Mapes, 2000; Demeter et al., 2011), size of the firm (Schmenner and Cook, 1985; Mapes, 2000), unemployment level, education and management skills, cost of living (Mohanty, 1992), labour regulations and industrial relations policies (Mohanty, 1992; Bhattacharya and Narayan, 2015), and economic character of the region (Mohanty, 1992; Lowe and Fernandes, 1994; Mapes, 2000). These hold direct implications for a manufacturing firm’s ability to improve productivity. Second, the literature reflects that these external environment elements influence productivity, but in 78% of the extracted interrelationships, the direction of the effect is not indicated, which results in high uncertainty regarding management’s PI tasks. A possible explanation for this finding is that this theme represents elements for which the desired effect is not simply a higher or lower result but one that describes complex desired outcomes. Examples of such elements are resource availability for the company (Mohanty, 1992; Bhattacharya and Narayan, 2015) and world market dependency (Mohanty, 1992). The effect of the complexity created from the external environment on the internal work of the organisation is illustrated in the following example. Given the required volume flexibility, manufacturing firms keep a certain number of temporary workers because labour laws are rather rigid, as Sáenz-Royo and Salas-Fumás (2014) found in their case study of a Spanish car manufacturer. They reported that the market legislation in Spain requires that a temporary worker become automatically permanent after being on payroll for longer than nine months. To maintain worker flexibility, the case firm rolled off temporary workers after nine months, which required the placement of new temporary workers and related training. Therefore, Sáenz-Royo and Salas-Fumás (2014) established the negative impact of output and the reduction of productivity.

4.3.2 Complexity originating from the organisational setting of the factory
The second dimension that creates complexity for the task of managing PI is the organisational setting of the factory. In contrast to the external environment, this setting can be influenced by management in the mid and long terms to improve productivity. The complexity that arises is twofold. First, 13 different elements from the literature that are related to PI and subject to be considered by management for PI were identified. Second, although the character of these elements is currently given, it can be changed. Thus, included in the task of managing PI is the consideration of not only how the current variable configuration affects productivity but also the potential to change these elements in the mid or long term. Hence, management needs to decide whether to consider the elements of the theme of organisational setting of the factory just as a contingency or to change them with a rather sophisticated plan over a longer period. Examples of such elements are workforce flexibility (Gunasekaran et al., 1994; Mapes, 2000; Demeter et al., 2011), a clean and structured facility (Mapes, 2000; Fisher, 2007) and the existing shift system running two or three shift teams (Sáenz-Royo and Salas-Fumás, 2014).
4.3.3 Complexity originating from the interrelationships of resource elements
The third dimension of complexity arises from the manifold resource elements and their complex interrelationships. The complexity arises here in two ways. First, managerial complexity is created by the opportunity for the sheer number of potential managerial interventions. We identified five different themes of resource elements represented by 46 single elements potentially affecting the managerial endeavour to improve productivity, and these themes and elements add high complexity to the managerial task of coordination and decision making. Hence, management is urged to find ways to handle or reduce such a complexity in order to effectively control the resource elements to drive PI. Second, there are also interrelations between the elements of different themes that increase complexity. Our analysis of the literature identified 108 single interrelationships between the five resource themes, as Table 4 illustrates.

Table 4: Interrelationships of the resource elements with one another in relation to productivity improvement (a total of 108 from the literature)

<table>
<thead>
<tr>
<th></th>
<th>Manufacturing process conditions and outcomes</th>
<th>Product design &amp; portfolio</th>
<th>Supply chain management</th>
<th>Technology level</th>
<th>Workplace conditions</th>
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<tr>
<td>Manufacturing process conditions and outcomes</td>
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<td>Product design &amp; portfolio</td>
<td>17</td>
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<tr>
<td>Supply chain management</td>
<td>12</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Technology level</td>
<td>24</td>
<td>2</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workplace conditions</td>
<td>21</td>
<td>2</td>
<td>0</td>
<td>3</td>
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</table>

Table 4 depicts the multiple examples of the interrelationships between resource elements. One example is the interrelationship between manufacturing process conditions and outcomes and product design and portfolio. The way in which a product is designed influences how it is manufactured and how productive its manufacturing process is. As Fisher (2007) stated, in relation to PI, involving the manufacturing department in the product design process, in addition to the sales department, is essential to creating a manufacturable product. Another example of an
interrelationship between different resource elements is between manufacturing process conditions and outcomes and workplace conditions. According to Schmenner and Cook (1985), the flow of materials throughout the process needs to be simplified, and dedicated cells should be allocated to each customer (Gunasekaran et al., 2000). This autonomous production cell arrangement may encourage greater worker involvement and result in improved inventory control by having parts arrive directly at a cell (Gunasekaran et al., 2000).

5 Managerial interventions to cope with the complexity of productivity improvement
Managers’ understanding of how complexity arises through the manifold elements related to productivity (Table 3 and Figure 2 in Section 4) is an important prerequisite for addressing and handling complexity effectively. The manifold interrelationships analysed in Section 4 provide high complexity to managers’ tasks of improving productivity, which makes it difficult to select where to focus on. From the literature analysed, we deduced six mediating interventions that managers implement to reduce or handle the complexity that arises by improving productivity in the manufacturing setting (Table 5). Therefore, managers’ influence is limited to the elements they have control over and to the resources within the company (Luthans and Stewart, 1977; Dangayach and Deshmukh, 2001). As contextual elements from the environment and the organisation affect the resource elements, the literature indicates that they need to be considered as well by managers. The purpose of this section is to reflect on these six options for middle management in the factory to reduce or handle the complexity arising from the elements involved and their interrelationships in the pursuit of PI.
Table 5: Six mediating interventions by managers for productivity improvement

<table>
<thead>
<tr>
<th>Managers’ mediating interventions</th>
<th>Effects of the interventions on reducing or handling complexity</th>
<th>Examples of references</th>
</tr>
</thead>
</table>
| Balanced set of tight and loose control (vertical and horizontal) | • Employee empowerment enhances the self-responsible management of activities at the employee level to relieve managers from complexity.  
• A smaller portfolio of activities results in less complexity. | Gunasekaran et al., 1994; Kovács, 2020; Neumann et al., 2006; Sting and Loch, 2016 |
| Implementing integrated and joint optimisation | • Reduced tensions  
• Shortening the time of interference | Gunasekaran et al., 2000; Dostaler, 2001; Neumann et al., 2006; Battini et al., 2017; Roth et al., 2020; Kovács, 2020 |
| Operator empowerment from the beginning of initiatives and their voluntary participation | • Turns conflicting interrelationships into supporting ones  
(Refers to the employees of the resource theme) | Gunasekaran et al., 2000; Dostaler, 2001 |
| Controlling line managers’ work allocations | • Delegation to the shop floor level results in less complexity because vertical alignment is reduced. | Krishnan and Srinivasan, 2007; Kovács, 2020 |
| Using management concepts | • Using standards for resource configuration  
• Standards = many elements’ attributes are set to a certain level | Schonberger, 1982; Gunasekaran et al., 2000; Dostaler, 2001; Alavian et al., 2020; Rantanen 2021 |
| Installing technological solutions for productivity improvement (PI) information evaluation | • Information is automatically transferred where it is needed  
• Less effort on information evaluation for management  
• Faster and more concentrated information of PI-relevant data | Alavian et al., 2020; Lee et al., 2018; Lorenz et al., 2021 |

**Balanced set of tight and loose control** – Evidence in the literature suggests that managers can benefit from a balanced configuration of two dimensions of control—the horizontal dimension, which is across functions and departments, and the vertical dimension, which is within the hierarchical layers (Sting and Loch, 2016). According to Sting and Loch (2016), a balanced configuration aligns creativity and compatibility: ‘Namely, tightening one of the two coordination dimensions can ensure that creativity and compatibility are balanced in operations strategy implementation; tightening both dimensions risks suppressing creativity, and loosening both risks losing direction’ (p. 1192). When there is a balance between the two dimensions of coordination, the complexity arising from too many PI ideas is reduced and becomes manageable, and employees do not feel repressed to present new ideas and even implement them on their own. Hence, keeping creativity high helps stimulate PI ideas and empowers employees to identify and

69
implement PI options at their level, resulting in less complexity at the managerial level. Tightening horizontal coordination ensures a consistent direction and a smaller portfolio of PI initiatives that can also configure complexity towards certain interrelationships (Sting and Loch, 2016). The coordination of control can involve small steps in daily PI initiatives. Kovács (2020) reported in their case study that the most important design goal required by management is minimising the duration of the entire process improvement project for implementing a new layout and re-arranging cells to make the impact on other resources as short as possible. Hence, management coordinates the time resources that can be allocated to this PI activity.

*Establishing an integrated and joint optimisation* – Instead of sequentially optimising elements with respect to PI individually, managers can install harmonised improvement activities by analysing their interrelationships up front. Research has proposed that optimising the elements of different resources themes reduces the tension and complexity resulting from the interrelationships of individual elements (Roth et al., 2020), which helps to reach a higher stage of productivity (Dostaler, 2001). The analysed literature reflects on multiple dimensions of this integrated and joint optimisation approach that can be harmonised. One dimension is the constraints of improvement activities that arise at multiple resources simultaneously, such as space requirements for manufacturing layout change or material supply like a Kanban supermarket of supply chain resource (Kovács, 2020). Ergonomic constraints can also be considered, and evidence suggests that managers can benefit from ensuring that not only process design teams but also product design teams are involved in contributing to ergonomics (Neumann et al., 2006). A second dimension to be considered for harmonisation is timeframe. Gunasekaran et al. (2000) emphasised the importance of long-term changes, such as redesigning the plant layout and reducing non-value-adding activities. A third dimension is the interrelationships of processes. For instance, PIs in manufacturing require supply chain management processes that are connected with manufacturing processes; for instance, a redesign of the cell layout ‘has to be looked at as a part of the whole system’ (Gunasekaran et al., 2000, p. 330).

*Operator empowerment from the beginning of initiatives and their voluntary participation* – The approach of this intervention is addressing the interrelationships between conflicting employee-related resources and turning them into complementary and supporting interrelationships. As a result, managers deal with less conflicting interrelationships. After the intervention, the interrelationship between the two resources to be optimised continues to exist but is neutralised. The focus on the entire system requires managers to mobilise employees for PI activities. As Gunasekaran et al. (2000) observed during improvement activities at the automotive part supplier Valeo, employees are convinced about PI activities when they are involved in the implementation of supply chain concepts. The key is to motivate employees for PI initiatives and involve them from the beginning, when the activities start to create acceptance for the intended changes. If possible, they should be motivated to participate voluntarily in such initiatives (Gunasekaran et al., 2000). Involvement can also be enhanced by allowing employees to implement changes by themselves or by relaying employee feedback on improvement potential to engineers and leaders (Gunasekaran et al., 2000). One key element, according to Dostaler (2011), is that employees...
perceive hostility in the environment, and the reaction to it is what is called a survival path; they ‘act as if they are shared the risk taken by the employer … especially in those regions where unemployment is high’ (p. 491).

Controlling line managers’ work allocation – This intervention has been identified from the literature on work content at the lowest managerial level in a factory—the line leader or supervisor level. Krishnan and Srinivasan (2007) analysed the work content in their case study and found that despite the capital-intensive manufacturing environment of a carmaker factory in the US, the labour and time inputs of the supervisor significantly explained productivity outcomes. One interpretation of this result is that a portion of PI can be decided at the shop floor level, where the supervisor is working with a team of operators (e.g. Gunasekaran et al., 2000). In this case, the indirect effort, such as facilitating and coaching, helped increase productivity levels compared with the direct effort (Krishnan and Srinivasan, 2007). Thus, from the perspective of middle managers, a certain portion of productivity gains can be generated on the shop floor directly through the daily work of supervisors and their interactions with team operators. Hence, the literature provides evidence that middle managers could allocate supervisors’ work accordingly, giving them sufficient room for supporting their team.

Using management concepts – Mistakes and obstacles in plant operations can be the results of missing management concepts (Rantanen, 2001). In established organisations or in corporate divisions, the application of management concepts has been found to be higher than in start-ups and smaller firms (e.g. Dostaler, 2001; Gunasekaran et al., 2000). From the literature analysis, we identified a strong positive tendency towards PI of the management concepts implemented. Our findings lead to the conclusion that management concepts function as moderators of management’s work and can be understood as universal aids in enhancing manufacturing productivity. Management concepts can be understood as standards for a certain resource configuration receiving limited and negative effects from contextual factors (e.g. Schonberger, 1982; Kovács, 2020). Kovács (2020) even learned about the simultaneous application of multiple management concepts in the case study, as ‘these methods have logical, thematic and causal relations’ (p. 2928). Hence, for management, the alignment tasks of coordinating between multiple resources in the factory and coordinating outside elements are reduced. In difficult firefighting situations, the application of a management concept also allows managers to select from a set of established concepts and tools to reduce uncertainty and create stability (Gunasekaran et al., 2000).

Installing technological solutions for PI information evaluation – Management can reduce complexity by promoting the implementation of technological solutions for PI information evaluation. First, with the use of technology, information can be relayed to recipients directly, such as engineers and the technical staff involved in PI, and middle managers do not need to process and forward it. Second, by implementing and using technology, managers can obtain a more focused view of PI-relevant data, and they can receive these faster. From the analysis of the literature, we deduced three areas in which technology for PI-relevant data processing is applied.
One area refers to information flow-related aids, such as an innovative warehouse management system with an integrated fuzzy logic technique to enhance order picking, reduce process lead times and increase fulfilment accuracy (Lee et al., 2018). The second area refers to PI-relevant information from the shop floor. From the case study of two different manufacturing environments, a high-volume automotive body shop and a small galvanisation plant, Alavian et al., (2020) observed the application of a smart production system that can be understood as an Industry 4.0 software system that monitors and analyses manufacturing process elements. The third area for technological aids for PI-relevant information refers to the tracing of products through processes. Lorenz et al. (2021) analysed an advanced monitoring system for process data mining that records product positions at the assembly line in real time. This technology can be understood as a dynamic value stream mapping system at Geberit, a large manufacturer of sanitary products in Switzerland.

6 Discussion and conclusion
This section presents the main contributions of the study, the managerial implications, research limitations and avenues for future research.

6.1 Main contributions
Our findings show how multiple contextual, resource and managerial elements have been identified as affecting the ability to improve productivity in a manufacturing context. The research also provides insight into new emerging themes within the study of PI in manufacturing. As a final but central result, our work shows in detail how not only the individual elements but also the different configurations of the complex interrelationships affect the ability to improve productivity. Based on these results, the study develops an understanding of management complexity for PI outcomes. Our findings make three main contributions to the literature.

First, we contribute new knowledge on the elements that influence manufacturing organisations’ abilities to improve productivity. We highlight how productivity is affected by multiple elements and how these elements differ in how they can affect productivity and be influenced by production managers. This adds to the literature exploring PI (e.g. Schmenner and Cook, 1985; Gunasekaran et al., 1994; Mukherjee et al., 2000; Park and Li, 2019), as no other contribution has comprehensively synthesised and categorised the elements affecting productivity outcomes. Thus, one central contribution of this study is providing an overview of the existing pool of knowledge on how productivity in a manufacturing environment is understood as affected not only by a multitude of resource elements but also by contextual and managerial elements. The application of CT to categorise and synthesise such elements is new and adds a holistic view of the complex interrelationships within manufacturing that influence productivity. This provides an opportunity to develop a new theory that explains the complex interrelationships leading to productivity outcomes in a manufacturing context. The review and literature synthesis further complement other reviews in the field (e.g. Aggarwal, 1980; Schmenner, 2015; Jin et al., 2016).

Second, the presented research has implications for our understanding of changes and trends in the study of PI in manufacturing. Jin et al. (2016) found that the notion of productivity has had different connotations over time. From 2000 until the present, they classified this period of
productivity as *competitiveness*. We complement this classification by taking a detailed look of the productivity-enhancing elements that have been suggested in the literature since 2010. Consequently, our review identified three new themes. First, an environmental focus in relation to productivity is identified as a new theme and is represented by two elements that have opposite effects. On the one hand, within MC, the *level of installation of environmental, health and safety (EHS) programmes* represents the application of EHS programmes. For environmental programmes, Demeter et al. (2011) and Treacy et al. (2019) reported the positive effects of established environmental programmes and standards, such as ISO 14000, on productivity. According to this finding, companies that implement environmental programmes and environmental training for the workforce experience improvements in productivity (Treacy et al., 2019). On the other hand, out of MC, the contextual variable *environmental regulation* has a negative effect on productivity, as summarised by Jin et al. (2016), because of related additional investments in new technology.

Third, social programmes found their way into productivity research after 2010. The resource variable *social accountability certification* brings into focus the culture-forming elements of a company. Orzes et al. (2017) identified a positive effect on productivity when companies establish social accountability standards, such as SA8000. This positive effect is primarily explained through the reduction of information asymmetry between management and employees, as well as through the mitigation of moral hazards (Orzes et al., 2017). Third, the *technology level* category summarises elements that entered PI research after 2010, as identified in recent research (e.g. Schmenner, 2015). The resource variable *level of digitalisation and Industry 4.0 application in manufacturing* is identified as an emerging variable. Hannola et al. (2018) discussed digital advancements as productivity enhancers, especially in knowledge-intensive production environments. Alavian et al. (2020) reported positive effects from the automated decision making of smart production systems—the production system 4.0. Hence, the variable *level of digitalisation and Industry 4.0 application in manufacturing* supports PI by handling the complexity of the production process.

Fourth, the presented research develops a new understanding of the complex task of managing for productivity outcomes. This adds to the sparse literature that explicitly discusses how managers in the factory manage to achieve productivity outcomes (Oudhuis, 2004; Broszeit et al., 2019). The findings show how the managerial task of improving productivity is complex because it needs to consider not only the effects of individual elements but also how a portfolio of elements interrelates and may collectively be understood to influence productivity. Another contribution is the identification of three dimensions of complexity that a production manager must deal with when managing to achieve PI outcomes. Although the existing literature acknowledges the complexity in managing for productivity outcomes (Greene and Sadowsky, 1984; Jin et al., 2016), it does not conceptualise the complexity of the PI task. As a result, a finer-grained understanding of the complex managerial task of PI is developed. We suggest that this insight holds the potential to enable a better understanding of why improving productivity beyond a certain threshold is very difficult (Hayes and Clark, 1986; Van Reenen, 2013).
6.2 Managerial implications

For practitioners, the current research has three implications. First, it provides an extensive catalogue of different types of elements and their potential effects on productivity (Table 3) that practitioners can use. The catalogue can provide them with inspiration to develop PI strategies in the future within their designated management areas of responsibility. Second, the managerial interventions to cope with complexity that have been developed in this study serve as a useful resource from which to operationalise PI initiatives. These interventions that managers can apply are meant to balance tight and loose control, establish an integrated and joint optimisation, empower operators from the beginning of initiatives and do it on a voluntary basis, control line managers’ work allocations, use management concepts and install technological solutions for PI information evaluation. Third, this review presents a comprehensive overview of opportunities for managing productivity for certain functions (resources) within an organisation, which are 1) manufacturing process conditions and outcomes, 2) product design and portfolio, 3) supply chain management, 4) technology level and 5) workplace conditions.

6.3 Research limitations and avenues for future research

Our analysis of the literature shows the extent and diversity of productivity-related research in the OM field. However, we could only identify a few academic contributions that set out to consolidate and structure this research arena, the findings of which provide the current study with both an overview and a direction (Aggarwal, 1980; Schmenner, 2015; Jin et al., 2016). With the productivity management framework for PI presented in this research, there is now a foundation for a potential renewed research interest in adopting a holistic view of the interplay between PI and its many complex managerial mechanisms. However, the framework presented here and its relations could be empirically re-assessed in different types of manufacturing environments and can be examined using different research methods. In particular, there is a need for more quantitative research of the interrelationships identified and whether the identified mitigation of middle managers is applied across manufacturing.

As with any other research, this study also has some limitations. One is related to the fact that we mirrored the OM literature in our review, but we did not empirically verify the interrelationships of elements. Another limitation relates to the presented clusters of elements. The initial coding scheme is grounded in five studies that assign elements into clusters, which is only one available method; other congregations could be possible. Furthermore, the consolidated effects of each variable take each finding equally into consideration, regardless of the type of research method used (survey and case study), the particular concept of productivity applied, the sample size and the significance level.

Future research should empirically verify the interrelationships identified in the developed productivity-enhancing framework. As Luthans and Stewart (1977) pointed out, the complexity of a multidimensional matrix with millions of characteristics can only be handled by a computer system. Today, we have such systems, which Luthans and Stewart (1977) could probably never have imagined. Hence, developing a database to record the interrelationships of elements discovered for certain contextual combinations would make the findings more comparable and would help further develop theory in the field. More research is also needed on how productivity
could have different sets of implications for its management. What is unique about productivity management compared with the management of other performance dimensions? Does productivity management lead to more sustainable organisations? These are some of the questions that future research could explore.

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No potential conflict of interest is reported by the authors.

**Data availability statement**
The authors confirm that the data supporting the findings of this study are available within the article.

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**References**


Chapter 4 – Managing productivity improvement in a complex manufacturing world – Article 1


Chapter 5: Productivity improvement and multiple management controls: evidence from a manufacturing firm (Article 2)

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Department of Operations Management, Copenhagen Business School


Abstract
Purpose – The present paper explores the multiple management control systems (MCSs) involved in productivity improvement (PI) in manufacturing and how they interrelate. Research has largely neglected the multiplicity and interrelationships of these MCSs.
Design/methodology/approach – Drawing on an abductive case study approach, the authors collected empirical data from a global automotive supplier that produces complex systems for passenger cars. Recent PI activities are analysed to identify and explain the interrelationships among the multiple MCSs affecting these activities.
Findings – The study shows how a broad range of MCSs are involved in PI. The study identifies and explores both complementary and conflicting relationships among the MCSs and demonstrates how managers rely on a set of mechanisms to alleviate tensions and strengthen complementarities among these MCSs.
Research limitations/implications – As this paper is based on a single case study, future research can contribute further generalisations (analytical and statistical) with respect to the MCSs involved in PI, how they are interrelated and which mechanisms managers use to manage their interrelationships.
Practical implications – Managers seeking to control and improve productivity should consider the complete control package and its interrelationships instead of focusing on each MCS separately. Originality/value – The present paper contributes to the knowledge of the multiplicity and interrelationships of MCSs involved in PI and the type of managerial work required to manage their interrelationships.
Keywords Management control systems, Productivity, Manufacturing
Paper type Research paper
1 Introduction
The decade-long drive for productivity improvement (PI) within manufacturing is intense. Consequently, multiple technological innovations and innovative PI systems have emerged (e.g. Schmenner, 2015; Park and Li, 2019; Abolhassani et al., 2019), and they have helped to increase productivity levels in practice and advanced the development of the operations management discipline (Schmenner and Swink, 1998).

We now know a great deal about how PI within manufacturing is affected by a complex combination of contextual variables (Spring et al., 2017), resource variables (Abolhassani et al., 2019; Park and Li, 2019), management practices and management concepts such as lean (Gunasekaran et al., 2000; Abolhassani et al., 2019), and leadership and communication (Sting and Loch, 2016). However, we know less about the combination of different types of management control systems (MCSs) that are involved in and affect PI activities (Jin et al., 2016; Güldenpfennig and Hald, 2019). Although some studies have explored the complexities of measuring productivity in manufacturing environments (e.g. Mohanty and Rajput, 1988; Jagoda et al., 2013), little attention has targeted the multiplicity of management controls affecting employees in their work with PI, how they interrelate and what the implications are for managers and their work.

The present paper draws on an insight from management control research (Malmi and Brown, 2008; Grabner and Moers, 2013; Laguir et al., 2019) that has received relatively little attention in operations management: no MCS exists in isolation; rather, a combination of multiple MCSs (e.g. strategic performance measures, quality management procedures, manufacturing principles, budgets, company culture, etc.) determines the achievement of an organisation’s goals (e.g. productivity improvement). This implies that the effectiveness of an MCS is determined by its interrelationships with other types of MCSs in the specific organisational setting. Further, the MCSs can interact in both complementary and conflicting ways in this endeavour (Grabner and Moers, 2013; Van der Kolk et al., 2020). This makes control tasks complex and directs attention to the mechanisms and the managerial work required to deal with these interrelationships.

The objective of this study is to address the lack of knowledge regarding the multiplicity of management controls affecting employees in their work with PI. We operationalise this objective by focussing on the MCS that is used to control employees’ PI activities on the factory floor and explore its interrelationships with other MCSs in the manufacturing context. Other research has studied this type of MCS (e.g. Siegel, 1980; Pritchard, 1990; Baines, 1997), which we refer to here as the PI system. But whereas other research has studied it primarily in isolation, we pursue the aspiration in management control theory. By advancing our understanding of how this MCS interrelates with other MCSs, we aim to gain more knowledge of how the efficacy of the PI system is conditioned by its interrelationships with other MCSs.

Thus, to address this objective, we formulate the following research questions:

1. Which MCSs operating within a manufacturing context affect the proper functioning of the PI system, and what are their interrelationships?
2. Which mechanisms do managers use to alleviate tensions and strengthen complementarities between these MCSs and the PI system?
Drawing on a case study approach, we collected empirical data from a case company. A global automotive supplier gave us the opportunity to study the specific MCSs involved in its PI activities. Our in-depth single case study concentrates on the PI system that in the case company is considered the engine driving PI at the plant. This MCS, the PI system, is the point of departure in our study of PIs, MCSs and their interrelationships.

We analyse recent PI activities to identify the interrelationships among the multiple MCSs affecting these activities, and we explore how these interrelationships are conditioned and shaped within the individual organisational setting. In particular, the data demonstrate how the interplay of multiple MCSs creates managerial work involving a set of mechanisms that managers apply to exploit the complementary interrelationships and reduce tensions in the conflicting relationships.

This paper makes three major contributions. First, it contributes to the PI research, which typically focuses on one MCS at a time, such as a performance measurement system (e.g. Mohanty and Rajput, 1988; Jagoda et al., 2013), when studying PI. We demonstrate how multiple MCSs are also involved in managing the improvement. Second, the paper contributes to the still sparse but growing body of literature concerned with the interrelationships between MCSs within the operations management discipline (e.g. Nielsen et al., 2018; Pesalj et al., 2018) by providing a deeper insight into how the interrelationships between MCSs essential for operations management emerge in an individual organisational setting. In this respect, we corroborate the system of systems perspective (Bourne et al., 2018), which is a research perspective that encourages the explorations of the specific organisational conditions shaping the interrelationships between MCSs in the individual organisational setting. Third, the paper contributes to MCS research in more general terms (e.g. Malmi and Brown, 2008; Grabner and Moers, 2013; Gerdin et al., 2019; Van der Kolk et al., 2020). In particular, our study contributes to case study MCS research that already focuses on MCS interrelationships and their construction in other types of organisational setting (e.g. Pfister and Lukka, 2019; Van der Kolk et al., 2020). We shed further light on the organisational complexity of MCS interrelationships by demonstrating the impact of a broader range of MCSs, compared with what has previously been studied and by illustrating that the interrelationships can take both complementary and conflicting forms (e.g. Friis et al., 2015). The paper also contributes to our understanding of what has also been referred to as “tension complexity” (Van der Kolk et al., 2020) by identifying the mechanisms managers use to release tensions and develop complementarities.

The remainder of the paper is organised as follows. First, it presents relevant theory on PI and multiple MCSs. The applied research design and methods are then explained. In the analysis section, the identified MCSs and their interrelationships are illustrated. Finally, the paper presents the discussion and conclusion as well as managerial and theoretical implications and limitations.

2 Theory: multiple management control systems for productivity improvement

2.1 Productivity improvement

Researchers argue that PI is essential to the operations management discipline (Schmenner, 2015) and is a fundamental outcome of the continued development and growth of society (Krugman, 1994, as cited in Schmenner, 2015, p. 314). Thus, activities directed at improving productivity are
fundamental and have been the object of research for decades (e.g. Jin et al., 2016). The term “productivity improvement system” has been used in operations management research to refer to a system that entails measuring productivity as a starting point for improvements and for pursuing PI programmes (e.g. Siegel, 1980, p. 15; Pritchard, 1990; Baines, 1997).

The research on PI is rich, and it has identified a broad range of factors that affect such improvement. These factors can be classified into four groups (Güldenpfennig and Hald, 2019): (1) external environment and organisational context, such as the location of the firm, industry type and law and regulations (e.g. Demeter et al., 2011; Spring et al., 2017); (2) different types of resource variables concerning labour and the workplace (e.g. degree of employee empowerment, annual working days), processes and product design (e.g. planning and control, layout of lines and cells, standardisation) and technology (e.g. automation level, equipment maturity) (e.g. Schmenner and Cook, 1985; Gunasekaran et al., 2000; Abolhassani et al., 2019); (3) factors of leadership and communication skills, such as culture feedback, motivation and appreciation (e.g. Schmenner and Cook, 1985; Demeter et al., 2011; Sting and Loch, 2016); and (4) different types of management practices/concepts, such as the lean system and the total quality management system (e.g. Gunasekaran et al., 2000; Demeter et al., 2011; Abolhassani et al., 2019).

Another important stream of research shows how accounting practices moderate the relationship between lean manufacturing initiatives and their effects (Kennedy and Widener, 2008) and how management accounting and control practices work together as a package in a lean manufacturing environment (Fullerton et al., 2013). Previous research has also proposed that the management of improvement activities in manufacturing may require changes in accounting practices, and this can lead to tensions between old and new forms of control that need to be managed (Tillema and Van der Steen, 2015).

Thus, the PI research is rich, and it illustrates how multiple factors (e.g. Güldenpfennig and Hald, 2019), including those representing accounting practices and MCSs (e.g. Fullerton et al., 2013; Kennedy and Widener, 2008), affect PI. However, there is limited knowledge about how multiple MCSs simultaneously influence PI activities in organisations and interrelate in individual organisational settings. The relationship between PI activities in the manufacturing context and the MCSs related to them is highly complex and needs more attention. This is the objective of the present study.

2.2 Multiple management control systems

Recently, the operations management literature has started to recognise different types of control in relation to performance management in general, but we still need more insight into PI. Smith and Bititci (2017) analyse the intervention effect of social controls on technical controls, which results in employee engagement and improved performance. Nielsen et al. (2018) consider three different types of control – social, behavioural and output control – in relation to lean management and their effects on firm performance. They analyse the complementary effects of different MCSs and recommend an integrated control system. Pesalj et al. (2018) consider four types of control – beliefs, boundaries, diagnostics and interactivity – while focussing on the tension created by short- and long-term goal achievements. Thus, although much has been achieved, more research is needed to understand the complex interplay of multiple MCSs operating in the same operations.
management setting and in particular the interrelations at stake when it comes to PI activities within manufacturing.

In our study, MCSs are conceptualised according to Merchant and Van der Stede (2017) as any management tool, device, system, or process that ensures employee behaviour is directed towards goal achievement. Furthermore, when it comes to producing knowledge of MCSs in organisational practices, we draw on the idea that it is important to direct attention towards “the individual, molecular units of organisational control (e.g. standards, policies, norms) that are applied to control processes” (Cardinal et al., 2010, p. 57, as cited in De Jong et al., 2014, p. 1704). This idea recognises that “examining MC [management control] practices at a too aggregated level [. . .] results in overlooking these subtleties in MC design” (Grabner and Moers, 2013, p. 415) as well as the proposition that “gaining a deeper understanding of the interdependence between MC practices may require an analysis of more specific attributes” (Bedford et al., 2016, p. 23).

To gain a deeper understanding of MCSs and their interrelationship, we draw on research that explores how the interrelationships between multiple MCSs are constructed and conditioned by the contingencies and actors within specific organisational settings (e.g. Friis et al., 2015; Pfister and Lukka, 2019; Van der Kolk et al., 2020). This approach provides a useful lens for analysing a PI system and its interrelationships with other MCSs in a specific manufacturing organisation.

As MCSs do not operate in isolation (Malmi and Brown, 2008; Friis et al., 2015), the character of interrelations among MCSs should be considered in order to understand the efficacy of the single MCS. MCSs can interrelate in both a positive, complementary way and a negative, conflicting way (Malmi and Brown, 2008; Friis et al., 2015; Van der Kolk et al., 2020). Thus, the character of interrelationships can result in either synergies or trade-offs concerning the efficacy of an MCS (e.g. Friis et al., 2015). Interrelations among MCSs that involve conflicts can lead to tensions (i.e. tension complexity) (Van der Kolk et al., 2020), thereby impairing the “fit” (Gerdin et al., 2019), “internal consistency” (Grabner and Moers, 2013), or “balance” (Van der Kolk et al., 2020) among the MCSs.

Our study considers how this balance is achieved, and we apply the concept of mechanisms to conceptualise what managers do to exploit the complementarities and mitigate the tensions. In this respect, we follow others (e.g. Elster, 1989; Hedström and Swedberg, 1998) and use the concept of mechanisms to understand “the cogs and wheels” (Elster, 1989, p. 3) that bring causal relationships into existence in a social setting (Hedström and Swedberg, 1998, p. 7). Thus, a mechanism is a causal relationship in which managers believe – a management principle – and that they pursue to manage the interrelationships among MCSs; the principle of empowerment or trust building is one such principle (Miller, 2003). These mechanisms appear in both general and more specific versions in social settings (Hedström and Swedberg, 1998). For example, the principle of empowerment has a general character, whereas expanding an employee’s responsibility in a given project is a specific mechanism the manager can apply to execute the general mechanism, that is, empowerment.
3 Research design and methods

Our understanding of the interrelationships among multiple MCSs related to PI is at an early stage, and the theoretical conceptualisations need further development. Therefore, our research is exploratory and necessitates qualitative methods (Eisenhardt and Graebner, 2007). To address the formulated research questions, we adopt an abductive approach. Thus, our approach rests on the logic of inference to explanations (Mantere and Ketokivi, 2013) and involves our attempt to modify the logic of the general theory in order to reconcile it with the observed contextual idiosyncrasies (Ketokivi and Choi, 2014). Specifically, the MCS typology of Merchant and Van de Stede (2017) and the understanding of interrelations among MCSs conceptualised by Malmi and Brown (2008) and Grabner and Moers (2013) represent our starting point for identifying and observing which of the multiple MCSs operating within the explored manufacturing context are affecting the proper functioning of the PI system. We further interpret our data to develop the best possible explanation of the mechanism used to alleviate tensions and strengthen complementarities between these MCSs and the PI system.

A single case study is chosen to describe a phenomenon in detail (Siggelkow, 2007). Thus, we can deeply elaborate on the interrelationships as well as the mechanism involved and can compare evidence on the interrelations of MCSs by including multiple data sources that need to be considered in the specific organisational setting.

3.1 Case selection and company profile

The case firm is located in Germany and is a manufacturing plant of a global automotive supplier that produces complex systems for passenger cars. The firm has about 400 employees, and the plant is organised into departments, each of which is controlled by a department manager. The production department is separated into manufacturing and assembly areas, both led by a group leader. Each group leader is responsible for a cross-functional team, one for assembly and one for manufacturing. Below the group leaders, there are shift leaders, who are responsible for the shift teams across the entire production department (assembly and manufacturing). Functions such as sales, research and development, and information technology (IT) are organised centrally at a site responsible for the entire European region. To stay competitive and maintain long-term relationships with customers, PI is an important part of the plant’s daily work. The company continuously undertakes long-term PI initiatives, which are operationalised by multiple PI projects.

This case plant was selected because it is heavily and continuously involved in PI projects and initiatives and employs a PI system to manage its PI. The control of individual PI projects and initiatives as well as their prioritisation and portfolio management within the organisation will be referred to as the PI system. Both managers and employees interpret this system as the driver of PI. Furthermore, the site belongs to a global organisation with a corporate governance structure and formal MCSs. Thus, the case firm is embedded in a structure characterised by complex decision-making and communication processes, which makes it an ideal location for studying the interrelationships among multiple MCSs. For confidentiality reasons, we name the company AutoComp.
3.2 Data collection
To gain deep insights into the interrelationships between the PI system and other MCSs in the organisational setting as well as to enable data triangulation, multiple types of data were collected at the case firm (see Table 1).

First, semi-structured interviews (e.g. Kvale and Brinkmann, 2009) were conducted with representatives of different levels and functions at the case plant. We aimed for diversity and obtained responses from department managers, group leaders, supervisors and engineers to capture different perceptions within the case plant. Respondents were selected on the basis of their involvement in PI initiatives or projects and their overall understanding of the plant processes. In addition to the initial interview, follow-up interviews and discussions of the initial findings were conducted. Most of the interviewees could contribute insights into more than one initiative or project.

Table 1: Empirical data sources

<table>
<thead>
<tr>
<th>Data Sources</th>
<th>Time frame</th>
<th>Quantity</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-structured interviews</td>
<td>Mar–Apr 2020</td>
<td>19</td>
<td>Interviews with 10 different managers, group leaders, supervisors, and engineers</td>
</tr>
<tr>
<td>– first round</td>
<td></td>
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<td></td>
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<tr>
<td>Semi-structured interviews</td>
<td>Sep–Dec 2020</td>
<td>2</td>
<td>Interview with two department managers</td>
</tr>
<tr>
<td>– second round (clarification)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>Oct 2019–Sep 2020</td>
<td>8</td>
<td>Department-manager meeting, partly with project reporting on productivity projects</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>3 Extended management meeting</td>
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<td></td>
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<td></td>
<td>2 Long-range planning/business plan meeting</td>
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<td></td>
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<td>2 Meeting with work council</td>
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<td></td>
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<td>2 BSC review meeting</td>
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<td></td>
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<td></td>
<td>1 Meeting with external auditors for IATF16949 standard</td>
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<td></td>
<td></td>
<td></td>
<td>1 Compliance training</td>
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<td></td>
<td></td>
<td></td>
<td>1 Meeting with president of business unit</td>
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<td></td>
<td></td>
<td></td>
<td>1 Communication action</td>
</tr>
<tr>
<td>Company documents</td>
<td>2019–2020</td>
<td>2</td>
<td>Plant BSC 2019/2020</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 Department BSC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 Management review 2019</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 Plant FCST 2020</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 Business plan 2020–2021</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 Culture survey 2018</td>
</tr>
<tr>
<td>Access to company systems</td>
<td>2019–2020</td>
<td>1</td>
<td>HRM IT system (Performance Appraisal System)</td>
</tr>
<tr>
<td>On-site stay of one author</td>
<td>2019–2020</td>
<td>1</td>
<td>100% at company</td>
</tr>
</tbody>
</table>
We structured interviews around loosely defined themes, which allowed the respondents to explain themselves and prompt greater information sharing and elaborations (Barratt and Choi, 2007). The interview instrument is included in Appendix 2.

In total, 21 interviews were conducted, and all interviews were audio recorded. We stopped collecting additional data when we reached the point of theoretical saturation. We determined this point to be “when three further interviews have been conducted with no new themes emerging” (Francis et al., 2010, p. 1234). Concerning the identification of relevant MCSs, the saturation point was reached after five interviews, at which point no new MCS related directly to the PI system was identified. Concerning the interrelationships between the PI system and other related MCSs, theoretical saturation was reached after 19 interviews. At this point no new interrelationships and mechanisms were identified. We then conducted two additional interviews to clarify details related to interrelationships and mechanisms.

Second, company documents were reviewed to understand the defined measures and targets as well as the planning process. Thus, for instance, the business plan and the balanced scorecards (BSCs) of the plant and departments helped us understand the linkage between the company’s strategic goals and the nonfinancial measures and objectives for PI initiatives. In addition, a formal IT system intended to track and follow up on individual targets and personal development was reviewed to understand its influence on employees’ feedback and PI.

Third, we deployed participant observation, another key source of data, which enabled an insider perspective and complete contextual embeddedness (Tracy, 2013). The first author’s job as a logistics manager in the case company enabled access to observations of meetings at the plant and provided insights into the activities and procedures connected to follow-ups on the productivity initiatives and related discussions. Several types of meetings were attended, such as regular meetings of the plant management team, BSC review meetings and strategy meetings that shed light on the goal deployment in relation to PI projects. Another example was attendance at working-council meetings, which contributed to the understanding of tensions between employers’ initiatives and perceptions of the working-council members. The first author’s full-time presence throughout the project further helped us capture the nuances and meanings of employees’ utterances within the business environment. This author’s familiarity with company-specific concepts and abbreviations facilitated the data collection and analysis processes. However, the caveats and dangers regarding the objectivity of participant observations were acknowledged (Bennett et al., 1992). Regular project reviews were held to ensure that the degree of participation was not hindering objectivity.

3.3 Data analysis

Data collection and analysis were performed as a dynamic process whereby we began analysing data as they were collected. To trace the development of constructs, the data and analysis results were organised into the case study database (Eisenhardt and Graebner, 2007) and analysed using NVivo software. To enable the analysis, the interviews were transcribed and the observations, notes and documents were enclosed and sorted.

To identify the multiple organisation-wide MCSs that are interrelated with the PI system, we first applied open coding (Corbin and Strauss, 2008) of the interviews by grouping phrases,
sentences or paragraphs into codes and categories. We looked for traces of the planning and control process related to the PI activities.

On this basis, we proceeded with axial coding. This step was specifically designed to provide more detail about the nature and workings of the identified MCSs and about their interrelation with the PI system. The type of control enabled by each identified MCS was developed using theoretically grounded codes based on the work of Merchant and Van der Stede (2017). To examine the interrelationships among the identified MCSs, we initially adopted the frameworks developed by Malmi and Brown (2008) and Grabner and Moers (2013). However, our data analysis also allowed new types of interrelationships to emerge (Corbin and Strauss, 2008). Thus, a code represents an element of an interrelationship or a mechanism (Table A1). The first category of a code represents the type of interrelationship – either complementary or conflicting – and the second category links the interrelationship to the MCS.

Throughout the data collection and data analysis processes, we applied strategies to improve the reliability and trustworthiness of the data. First, the full-time presence of one of the authors during the project and this author’s familiarity with the company’s operations helped to capture nuances and meanings, which improved the data reliability. Second, all authors discussed the coding scheme. This process also helped reduce the risk of bias potentially originating from the inclusion of an insider perspective. Third, multiple types and sources of data were collected, which enabled triangulation and helped reduce bias. Concerning informants, we included organisational actors from different hierarchical levels, functional areas and groups, which helped us view the phenomena from diverse perspectives (Eisenhardt and Graebner, 2007).

### 4 Analysis of the multiple management control systems involved in productivity improvement

We identified five MCSs that interact with the PI system. Our analysis found that these MCSs play important roles in PIs at AutoComp:

1. The productivity improvement system
2. The strategic performance measurement system
3. The compensation system
4. The performance appraisal system
5. The standards control system
6. The company culture

Table 2 summarises the key characteristics of the six MCSs. Furthermore, we classify the six MCSs according to Merchant and van der Stede’s (2017) management control framework, illustrating the scope of MCSs involved in controlling PIs in the case company [1].

#### 4.1 The productivity improvement system

The company’s PI system controls the PI initiatives and projects (i.e. PI activities). It is an operational MCS that was referred to in the interviews as the “engine” driving PI activities. This includes the control of individual projects and initiatives as well as their prioritisation and portfolio management within the organisation. The MCS ensures the accountability of actions on
the shop floor, which is needed to improve productivity; therefore, we also classify this MCS as an action control system, which is a MCS used to ensure “that employees perform (do not perform) certain actions known to be beneficial (harmful) to the organization” (Merchant and Van der Stede, 2017, p. 86).

The procedures and practices for controlling the PI activities show significant similarities across the different departments at the plant, leading us to regard this type of control as one system. The PI activities are performed by cross-functional teams that are typically led by a manufacturing or an application engineer. What is common to all PI activities at the plant is the tracking of actions in a continuous, running and open-item list. In addition to meetings in the cross-functional teams, there are daily morning meetings in the factory’s various manufacturing units to review the status of production of the previous 24 h. These meetings address productivity issues. A new productivity initiative can be triggered or feedback regarding already-established improvement initiatives can be provided. For example, the reported downtimes at a workstation of an assembly line or the rework rate provide rapid feedback to the participating engineers.

Whereas the majority of priorities and overall goals for improvement are determined within the plant’s management team, the initiation and execution of specific improvement activities are led by the cross-functional teams. This indicates the substantial decentralisation of the organisation when it comes to operationalisation of the PI process. AutoComp engages in multiple PI activities. One example is the improvement of the output of products per shift from a newly installed assembly line contributing to a major portion of the plant’s turnover. Equipment downtimes as well as barriers to the optimal human–machine interfaces are addressed and countermeasures are installed.
<table>
<thead>
<tr>
<th>Purpose of the MCS</th>
<th>The productivity improvement system</th>
<th>The strategic performance measurement system</th>
<th>The compensation system</th>
<th>The performance appraisal system</th>
<th>The standards control system</th>
<th>The company culture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls the activities in cross-functional teams planned to improve productivity</td>
<td>Conducts overall performance planning and control in the manufacturing system and ensures strategic (financial and nonfinancial) accountability and responsibility</td>
<td>Manages the compensation/reward structures of the individual employees</td>
<td>Facilitates individual performance feedback and development of shop-floor workers</td>
<td>Ensures compliance with standards, such as customer requirements, quality, and product reliability, as well as laws, regulations, labour rights, and institutions</td>
<td>Initiates and regulates employees’ behaviour through corporate and firm’s formal beliefs, conscious and unconscious habits, and values</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Elements constituting the MCS</th>
<th>Purpose of the MCS</th>
<th>The productivity improvement system</th>
<th>The strategic performance measurement system</th>
<th>The compensation system</th>
<th>The performance appraisal system</th>
<th>The standards control system</th>
<th>The company culture</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Cross-functional teams</td>
<td>(1) Multidimensional performance metrics and targets</td>
<td>(1) Salary level</td>
<td>(1) Individual performance goals and feedback</td>
<td>(1) Product and production standards from multiple stakeholders (customers, unions, industry, etc.)</td>
<td>(1) Norm of collaboration</td>
<td>(1) Norm of equality</td>
<td></td>
</tr>
<tr>
<td>(2) Team-based targets</td>
<td>(2) Budget applications</td>
<td>(2) Pay differentials</td>
<td>(2) Competence development plans</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) Decentralisation (high degree of freedom)</td>
<td>(3) Pay-for-performance versus fixed salary ratio</td>
<td>(3) Pay-for-performance versus fixed salary ratio</td>
<td></td>
<td></td>
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</tbody>
</table>

| Major function in relation to productivity improvement | The system can be understood as the “engine” driving productivity-improvement actions involving employees and the managerial layer of the firm | The multidimensional performance measurement system sets budget targets for both financial and nonfinancial dimensions that are important for productivity improvement | Rewards affect the attraction, retention, and motivation of employees, which are important for improvement activities | Development of competencies and skills as well as individual performance feedback are critical for productivity improvements | Compliance with productivity-improvement actions is ensured to avoid negative effects and prevent harm to the firm (e.g. quality complaints, loss of skilled labour) | Cultural norms play important roles in the social control of employees regarding productivity improvement |

<table>
<thead>
<tr>
<th>Classification of MCS type</th>
<th>Action control</th>
<th>Result control</th>
<th>Personnel control</th>
<th>Personnel control</th>
<th>Action control</th>
<th>Cultural control</th>
</tr>
</thead>
</table>
4.2 The strategic performance measurement system

AutoComp’s strategic performance measurement system also plays a significant role in managing PIs. Strategic performance measurement systems specify, decompose, implement and adjust strategic goals. They provide top managers with decision information and align actions and decisions throughout the organisation (e.g. Hanson et al., 2011). AutoComp’s strategic performance measurement system is a combination of a BSC (Kaplan and Norton, 1992) and a budgeting process. These two performance measurement systems create an organisation-wide framework that conveys both financial and nonfinancial targets, which function as long-range plans. Therefore, we categorise AutoComp’s strategic performance measurement system as a result-control system (Merchant and Van der Stede, 2017).

The strategic performance measurement system focuses on controlling three types of resources. First, investment in new equipment is central when beginning the production of new customer products. Here, the use of equipment for multiple products to increase volume flexibility is a challenge. Second, as only major components are manufactured in-house, control of material productivity is essential for offering a competitive product price. Third, human resources (HR) are essential for productivity, and the control and facilitation of labour productivity are a major concern. The output per shift and the labour rate are overall measures capturing the productivity of labour, machines and assembly lines.

To reach the planned operating income, the plant management team defines targets associated with all selected financial and nonfinancial measures. The selected measures and their targets are summarised in the BSC, which contains multiple productivity measures, such as labour productivity rate, overall equipment efficiency and the plant’s overall productivity status. The operational departments – assembly, machining, logistics and quality assurance – have their own local BSCs, which include both measures from the plant’s BSC and measures defined within the department.

If departments plan to utilise planned investments or costs, an approval process must be followed. This process ensures that the spending is within the planned budget and is necessary. It is possible to request additional investments that exceed the planned budget if these investments and costs relate to an improvement project and meet return-on-investment targets.

4.3 The compensation system

The compensation system is another MCS (Malmi and Brown, 2008) that is important for PI at AutoComp. According to Merchant and Van der Stede (2017), the compensation system plays a key role in attracting and retaining the right group of employees and is hence a key element in the company’s personnel control strategy (p. 368). The design choices regarding this MCS, which are administered by AutoComp’s HR department, are multiple and include the salary level (Gerhart and Newman, 2020), the weight put on extrinsic versus intrinsic rewards (Gagné and Deci, 2005), pay-for-performance proportion of total salary (Osterloh and Frey, 2002) and pay differentials among employees (Zenger, 2016). Each of these choices may have significant effects on employee behaviour and organisational goal achievement.

Our analysis offers some key insights into the multiple facets of this MCS. First, employees involved in PI activities at the plant are well paid compared to the local labour market, which
makes it possible to attract and retain well-qualified employees in this market. Nevertheless, this MCS cannot ensure that all AutoComp employees are well qualified (see the discussion of the performance appraisal system). Second, interviews reflect a high level of intrinsic motivation among employees involved in PI at AutoComp, and managers consider it an important reward component. Thus, the latest employee satisfaction survey (from 2018) confirmed that AutoComp has an 11% higher engagement index compared to the country average. Third, our analysis reveals that the employees’ pay-for-performance proportion is practically non-existent. Finally, the compensation system is characterised by a low pay differential, meaning that employees are paid the same for the same job. For instance, for positions at an assembly-line station, there are only two available salary grades, one for a position with less complexity and one for a position with more complexity. This is a result of a negotiation between AutoComp and the work council, which was supported by the union and the employers’ federation.

4.4 The performance appraisal system
The HR department administers yet another type of personnel MSC (Merchant and Van der Stede, 2017) that affects PI at AutoComp. It is a performance appraisal system (Murphy and Cleveland, 1995) that helps managers set goals for employees and provide performance feedback. This system is intended to play a facilitating role and is not used for rewards and incentives, as is the case in some organisations (Cappelli and Tavis, 2016). Therefore, although AutoComp’s performance appraisal and compensation systems are both administered by HR, they are in fact distinct MCSs. The facilitating role follows two tracks: (1) competence development and (2) individual performance feedback and goal setting. HR is responsible for the design and facilitation of this MCS, but the execution of system procedures is the responsibility of department managers.

This MCS defines the development objectives for an employee according to the competencies needed to perform the job or to develop the employee’s ability to perform new tasks or fill a new position. Examples of such development objectives include attending a seminar to improve skills that are important for PI activities or developing the social skills needed for working in cross-functional teams. As for individual performance goals, the department managers and team leader define objectives and targets in collaboration with their employees for the running year. These objectives and targets relate to individual performance issues as well as competence development that is relevant for PI. Once the objectives are set, the employee registers them in the company-wide HR software tool, and the objectives serve as the employee’s work priorities for the current year.

For both individual performance goals and competence development, reviews of progress towards the objectives are performed mid-year and at the end of the year. In these reviews, the employee’s overall performance is assessed by their immediate superior, and barriers to reaching the targets are discussed. The assessment compares the employee’s performance with expectations and the job description of that particular position.

4.5 The standards control system
The standards control system ensures that the firm is operating within boundaries that protect the firm from harm and foster its survival. The aim of this MCS is to guarantee that actions taken to
improve productivity comply with existing standards, general rules and policies. The standards control system is a specific type of action control focused on internal control and documentation and legitimisation for outside stakeholders (Merchant and Van der Stede, 2017).

Although this system contains numerous standards, laws and rules, our analysis identifies three standard controls related to PI. The aim of these controls is to ensure that PIIs lead to no harm for employees and the company:

1. The formalised international quality norm of IATF 16949
2. Internal product and process standards
3. Labour and working standards

First, the major quality standard is the international quality norm of IATF 16949, which presents the product and process requirements of major car manufacturers. The entire company is encouraged to ensure that product and process quality meets this norm. Second, AutoComp develops internal product and process standards over time. The most prevalent of these are working instructions describing administrative and manufacturing processes and the use of corresponding standard forms. Third, our analysis identifies labour and working standards as highly important for AutoComp’s PI. In addition to the working rights represented by labour law, employees’ rights are protected by agreements between the employers’ federation and the union as well as the Work Council Constitution Act. The work council must approve changes in the work environment and work content, and such changes are often initiated by PI initiatives.

Measures for both the quality and work standards are implemented and traced. For quality, the process capability of relevant product measures is traced. In addition, the number of customer complaints is continually assessed. For work standards, the number of working hours without a safety incident is assessed.

4.6 The company culture

Cultural control, embedded in values and norms, has a profound effect on employee behaviour in organisations (Merchant and Van der Stede, 2017, p. 67). It is another type of MCS as opposed to a measurement system, because it rests on deviations from values and norms rather than metrics. We identify two cultural norms that influence PI at AutoComp: collaboration and equality. Collaboration is promoted as the most significant value by AutoComp’s global formal value catalogue, which represents the beliefs of the entire corporation. Our analysis shows that managers and employees underline high dependency and the need to collaborate in relation to PIIs. Equality, which is historically embedded, is encouraged by management and the union, and workers have traditionally been seen as equal and paid equally.

5 Exploring the interrelationships between the PI system and other management control systems

This section analyses the interrelationships among MCSs. To address research question 1, we place the PI system at the centre of our analysis and explore its relation to the remaining five MCSs. We highlight how the five MCSs complement the PI system and enable the firm to cope with multiple aspects of PI. However, to address research question 2, we also identify the tensions and conflicts in this “system of systems” (Bourne et al., 2018) and acknowledge that the
complementarities among the MCSs do not arise by themselves but need to be crafted by AutoComp managers. This requires significant managerial work and decision-making, and in the analysis, we outline the important mechanisms used by the managers to exploit the complementarities and mitigate the tensions among the MCSs involved in PI at the plant.

### 5.1 Relationship to the strategic performance measurement system

There are clear complementarities but also conflicting relations between the PI system and strategic performance measurement system. In terms of the complementarities, we identify two major enhancing effects: the coordination effect and the motivation effect.

First, the strategic performance measurement system conveys the strategic goals that are important for coordinating the PI activities to ensure organisational value creation. The PI system operationalises planned actions to achieve these strategic goals. In principle, all nonfinancial measures from the strategic performance measurement system can serve as goals for the PI system. Recently, and based on top-management decisions, focus has been placed on the scrap rate (material productivity), material cost rate (material productivity), downtime (equipment productivity) and output per shift (labour productivity). The strategic performance measurement system also offers guidance concerning financial resources with the objective of meeting the budget established for the year and for each customer product. This coordination effect makes it possible to prioritise when dealing with multiple initiatives and to devise a portfolio of projects/initiatives that ensures the highest possible level of strategic goal achievement.

Second, the communication of strategic measures, goals and financial constraints is found to have a positive effect on employees’ intrinsic motivation (Osterloh and Frey, 2002). Thus, the strategic goals are internalised by individual employees, and the strategic performance measurement system provides employees working with PI a broader picture, a sense of belonging and commitment (Gagné and Deci, 2005). Thus, employees find that their own improvement activities are closely tied to the organisation’s broader goals (e.g. profit, quality improvement, winning customer projects, savings requested by the customer). A department manager provided the following example:

> At the beginning [of the project], it was clear. Everybody started off with the understanding that we need cost reduction; otherwise, we lose that project.

Our analysis identifies three mechanisms that managers activate to foster these complementarities between the PI system and the strategic performance measurement system. First, the department budget planning meetings highlight the limitations of funds and the effect of these limitations on AutoComp’s operating profit. Second, the BSC reviews, performed once a month in the management meeting and within department meetings, emphasise the importance of employees’ contribution to the BSC measures. Third, the quotation process for new products underlines that even a few cents in a product calculation can determine whether the company wins or loses a customer.

Our analysis also reveals two types of tensions between the interfaces of these two MCSs. The first relates to the problem of aligning the PI activities with the strategic goals (Hanson et al.,
2011). Even when the relationship between the strategic goals and PI activities is initially clear and well defined, the directions that the activities subsequently take are not always well aligned with the strategic goals. A department manager explained this phenomenon as follows:

There, . . . it’s not really one-to-one. Because, I think, we have such a break [disruption], at least in my view, between what I think we should do and what we actually do and consider as appropriate.

The managerial work required to ensure alignment, according to managers at AutoComp, occurs at the shop-floor level, where daily walk-throughs and meetings are needed to review scrap, output and downtime in production areas. The participants are the production manager, group leader, assembly line leaders, maintenance technicians and supplier quality engineers. Another practice undertaken to ensure managerial adjustment opportunities is to elevate a project to the status of “plant topic”, which spotlights the project as one of the most important projects at the production site. Projects with this status receive reporting during plant management meetings once a month and presentation on the canteen TV.

The second type of tension consists of resource constraints that are considered barriers to PI, such as a perceived lack of funds for the technical equipment needed for plant and improvement projects. AutoComp managers have put a specific mechanism in place to deal with financial constraints. A detailed and well-grounded business case is conducted to grant funds for technical equipment or changes to the product that enhance productivity and have a short payback time. However, preparing a convincing savings calculation takes time, expertise and practice, and employees consider this a barrier to implementing improvement ideas.

5.2 Relationship to the compensation system
The compensation system complements the PI system in two ways. First, the compensation system ensures that AutoComp can attract and retain well-qualified employees, which is critical for the PI activities. Second, the compensation system supports the feeling of equality, which is important for employees’ intrinsic motivation and the effort they devote to the PI activities.

First, AutoComp managers are aware that they pay their employees “good salaries” or a “competitive market salary”. The salary level is the result of negotiations between the union and the employer’s association and is considered very competitive in the region. This ensures that the firm is able to attract and retain highly qualified employees from the local/regional labour market. There are limits to how many competencies and how much knowledge AutoComp can attract from the external labour market. There are at least two explanations for this. (1) Recruiting external competencies and knowledge from the labour market would be too expensive for AutoComp, given the shortage of highly qualified engineers in the market in general. This implies that AutoComp would end up competing in the national labour market and with larger German automakers, and it is considered unrealistic to reach beyond what the local/regional market offers. (2) The competencies and knowledge that can be recruited from the outside easily become too general, as PI requires firm-specific knowledge and competencies. These constraints explain not only why internal competence development is important for AutoComp as explained in the next
section, but also how important it is to master the labour market mechanisms to not only attract but also retain a critical mass of engineers to perform the PI activities.

Furthermore, AutoComp’s compensation package is designed to support the sense of equality among employees. This is also a result of negotiations between the union and the employer’s entailing a low pay differential among employees involved in the PI activities. Equality is also supported by the decision not to activate the pay-for-performance component of the employee’s salary. The decision to eliminate these significant extrinsic reward mechanisms from the compensation system, which could potentially lead to crowding out (Osterloh and Frey, 2002), matches our finding and shows that AutoComp managers perceive employees’ intrinsic motivation as a much more important driver of PIs.

5.3 Relationships to the performance appraisal system

We identified two complementary interrelationships between the PI system and the performance appraisal system. First, the individual performance feedback and individual goal setting that the performance appraisal system provides complement the PI system’s team-based performance goals and feedback, because they guide individual employees in the cross-functional team and may have a positive effect on their motivation. Second, the performance appraisal system’s focus on individual employees’ competence development is critical to the success of PI activities. Although such complementarities may seem obvious, they do require significant managerial work to achieve.

Although the focus on individual performance goals and feedback does not inherently complement the PI system, it does so when AutoComp managers are successful in facilitating individual employees’ work processes and support their motivation by means of the performance appraisal system. Individual performance appraisals can easily produce a crowding-out effect that undermines the intrinsic motivation of individual employees (Osterloh and Frey, 2002). Managers at AutoComp, however, are oriented towards a crowding-in effect, which is a mechanism by which individual goal setting and feedback processes aim to stimulate feelings of competence, autonomy and relatedness among employees to support their intrinsic motivation (Gagné and Deci, 2005) and encourage them to better perform their work processes. A department manager underlined that the face-to-face performance appraisal meetings with every employee play a significant role in this regard:

Yet I think that the talk is good because I believe that my employees count on my opinion and want feedback, and we are pretty honest in dealing with each other in the department. . . . I believe they value simply having time, talking with each other.

In addition, keeping a clear focus on the competence development of individual employees in the cross-functional teams is also a key resource for supporting intrinsic motivation, because it stimulates the feeling of competence.

The second complementary effect between the two MCSs relates to competence development. Again, the success of the effect requires significant managerial work. In this case, it is because performance appraisal systems are often (or only) used for individual reward (i.e.
pay-for-performance) (e.g. Murphy and Cleveland, 1995). For decades, scholars have underlined that performance appraisal systems too often aim to work as both a reward mechanism and a development mechanism (McGregor, 1960; Cappelli and Tavis, 2016) and, by doing so, fail to succeed in either respect. The fact that AutoComp has invested substantial work and resources in designing the performance appraisal system as a competence development mechanism and that managers refrain from using performance appraisals in monetary reward decisions explains the complementary relationships.

5.4 Relationship to the standards control system
There are clear complementarities but also conflicting relationships between the PI system and the standards control system.

Regarding the complementarities, our analysis identifies one major enhancing effect: legitimacy via compliance. It is important for AutoComp to comply with industry and broader institutional rules and standards related to, for example, safety and the environment. The standards control system ensures the required legitimacy of the PIs in this respect. Thus, the interrelationship with the standards control system enables institutional support and enables AutoComp to deliver to global automakers.

However, from a PI perspective, legitimacy via compliance is not achieved without tensions and conflicts. In terms of conflicting relationships, our analysis identifies two major tensions: verification-effort inertia and working-council objections. PI actions lead to changes that must be verified in regard to product and process standards, and this is a tedious process that creates inertia. Our data show that this is a conflicting interrelationship with fast and effective goal deployment, because extra time and effort are needed and costs increase. Thus, mechanical engineers, who are responsible for installing technical components to improve cycle time, cannot simply install them at the assembly line. Instead, they need to initially start a release process for changes in which several other functions, such as quality engineers, need to verify their changes. In this way, the Standards Controls System requires mechanical engineers to start a sometimes long-lasting verification process that could discourage them from initiating PI initiatives.

Another tension identified in our analysis is caused by the complexity involved in managing work organisations’ laws and rules, which are monitored by AutoComp’s work council. This engagement of the work council is identified as conflicting with appropriate targets for the output quantities of the assembly lines. Our analysis indicates that work council members are sometimes critical of raising the output targets for each shift, even if new technical equipment and actions to increase the cycle time on the assembly line would allow for meeting these targets. They argue that operators have no piecework wage and are paid for working time. According to the work council, giving employees a performance target would place unnecessary pressure on them. Thus, group leaders, who are responsible for the output in their production area, face an exhausting process in which they must convince work council members to agree on a higher output target. We found that some group leaders, because they anticipated this burden, decided to accept a lower assembly line output target.

One mechanism that AutoComp deploys to manage verification-effort inertia is to achieve as much alignment with technical standards as possible. In many cases, the institutional demands are
converted to technical standards for the PI teams. However, we also find that the cross-functional team structure is a mechanism designed to mitigate this negative interrelation, because quality and application engineers are part of the improvement teams and can directly judge effects, effort, interference and potential barriers. This helps to speed up the alignment process and reduce long-term risks.

Concerning working-council objections, the weekly meetings between the work council and department managers and group leaders are the first venue in which changes related to PIs are presented and discussed. Extra meetings or site inspections are planned by the responsible department manager or group leader to present the intended changes to work council members.

5.5 Relationships to company culture
The PI system is complemented by the cultural norms presented in Section 4 – that is, collaboration and equality. However, management by culture/norms does not happen on its own. Like management by numbers, it requires extra work.

Collaboration among the employees is expected, and it supports a key element of the PI system – namely the cross-functional teams that perform PI activities at the plant.

For individual workers, the task of collaboration is not directly measured by any of the MCSs involved in PI activities at AutoComp. It is regulated through cultural norms by means of monitoring and enforcement by managers and the cross-functional group members. A department manager formulated the importance of collaboration as follows:

> It is all about the common good of AutoComp, if I can express it that way. It’s like on the bazaar [market] sometimes, everybody starts with exaggerated requirements and, in the end, we always find a compromise that is best for the whole [team].

The norm of equality makes it easier to develop and undertake group work, and it strengthens the PI system’s ability to fulfil its management control tasks (Miller, 2003). Furthermore, our analysis reveals that both norms support employees’ intrinsic motivation. Both norms stimulate employees’ sense of belonging, which is one of the three basic psychological needs that, according to self-determination theory, support intrinsic motivation (Gagne and Deci, 2005).

However, executing this cultural control requires AutoComp managers to pull the triggers of social monitoring and enforcement of cultural norms. This is achieved by walk-throughs on the production floor and through the broad set of meetings they have with employees as well as through the informal rewards and recognitions that managers use to enforce cultural norms (e.g. breakfast and cake celebrations). It is important to note that managers do not do this alone. Employees also play a significant role in promoting and monitoring cultural norms. This highlights the underlying collective effort needed to succeed and develop strong cultural norms.

Figure 1 summarises the configuration of MCSs involved in AutoComp’s PI activities.

6 Discussion and conclusion
To understand the management control of PI at AutoComp, focussing on the PI system is essential. This MCS is highlighted as the driver of PI in the case company, but our study demonstrates that
the effectiveness of this MCS is closely interrelated with various other MCSs, which are important for explaining how the firm achieves PIs.

6.1 Understanding productivity improvement through a multiple- rather than a single-MCS perspective

The PI system plays the key role in terms of managing PI activities on the shop floor. Although this MCS is characterised as the engine driving PI at AutoComp, other MCSs are also important for guiding, equipping and motivating the employees performing PI activities. The strategic performance measurement system provides strategic guidance and priorities. The standards control system provides information about quality and industry and customer standards. The performance appraisal system, an MCS designed by the HR department for personnel control, ensures individual performance accountability, which clearly complements the team-based accountability mobilised by the PI system. It also adds competence development, which is important for the PI activities. The compensation system is yet another type of personnel control in play, and it allows AutoComp to attract and retain employees who play essential roles in PI activities. Finally, the company culture complements the PI activities with important norms of collaboration and equality, which facilitate work within the cross-
functional teams. In this respect, five MCSs in the case company contribute important complements to the control of the PI activities and the functioning of the PI system.

6.2 Three types of general mechanisms involved in managing MCS interrelationships

Our findings also highlight that the complements originating from MCSs that interrelate with the PI system do not arise on their own. Managerial work involving a range of mechanisms ensures the presence of these effects and mitigates tensions. We summarise our findings by theorising three types of general mechanisms used by AutoComp managers. We further propose that these mechanisms play important roles in balancing multiple MCSs in other settings. We refer to them as communication, internalisation and socialisation mechanisms. We argue that managers’ combination of the three types of mechanisms ensures that the complementarities of the MCSs are exploited. Furthermore, each type of mechanism is decomposable into a range of submechanisms, which supports the findings of studies on social mechanisms in general (Elster, 1989; Hedström and Swedberg, 1998). In our case, the submechanisms further specify how the managers exploit and balance interrelationships among the MCSs.

6.2.1 Communication mechanisms. Communication aims to create understanding, and our study demonstrates that understandability is vital in linking operational activities with strategic goals and priorities (Merchant and Van der Stede, 2017) For example, the alignment pursued by the strategic performance measurement system is challenged by the tensions that arise between the strategic and operational levels of the organisation when decentralised team members take PI efforts in directions that were not necessarily intended by the top managers (see also Johnston and Pongatichat, 2008). At AutoComp, it is obviously important for management to communicate not only the significance of the strategic goals and financial constraints conveyed by the strategic performance measurement system but also how employees should understand the competence development mobilised by the performance appraisal system. It is also clear that managers’ meetings with employees, walking around and coaching are important mechanisms by which managers communicate and create a common understanding between themselves and employees regarding the strategic goals, competencies and skills important for AutoComp.

6.2.2 Internalisation mechanisms. Our study also demonstrates that the managers’ attempts to foster employees’ internalisation of the MCSs play an important role in exploiting their complementarities. Internalisation refers to when individual employees “take in” the external regulation that an MCS represents (Gagne and Deci, 2005) and the extent to which employees are intrinsically motivated to act accordingly (Osterloh and Frey, 2002). Thus, internalisation adds yet another layer to the kinds of mechanisms with which AutoComp managers work. Whereas the communication mechanisms are about creating understandability, the internalisation mechanisms are about supporting employees’ intrinsic motivation. Parallelling Osterloh and Frey’s (2002) argument that intrinsic motivation is important for knowledge-intensive and creative tasks, our case study highlights that intrinsic motivation is important for AutoComp’s PI activities. This explains why AutoComp managers focus so much on what work psychology calls the crowding out and crowding in of intrinsic motivation (Osterloh and Frey, 2002; Gagne and Deci, 2005). For
example, the coaching approach used in the performance appraisals and the weight put on both 
the facilitation of individual accountability and competence development are important for 
supporting intrinsic motivation. Moreover, the design of the compensation system, which features 
low pay differentials and the absence of pay-for-performance, reduces the risk that the 
compensation system will produce perceived inequality on the shop floor, which can give rise to 
perceptions of unfairness and subsequently reduce intrinsic motivation (Osterloh and Frey, 2002).

6.2.3 Socialisation mechanisms. Our case also demonstrates that cultural norms are important 
facilitators of PI work. This requires socialisation and managers’ involvement in monitoring and 
enforcing the social significance of these norms (Miller, 2003). In this respect, our study of 
interrelationships among MCSs provides more insight into what it takes to exercise social or 
cultural control in a company’s operations (Smith and Bititci, 2017). It is clear from the study that 
cultural control does not happen on its own. It requires managers to communicate norms, 
encourage mutual monitoring and enforcement of these norms and prioritise socialisation in their 
work (Miller, 2003). This is done, for example, through meetings between managers and 
employees and informal events, such as team breakfasts and celebrations. Our analysis 
demonstrates the importance of these softer mechanisms in cultivating the interrelationships 
among MCSs and in ensuring PI.

6.3 Advancing insights into the interrelationships among MCS involved in productivity 
improvement

The present paper contributes to the operations management literature by demonstrating how 
multiple MCSs are involved in PI. It underlines that PI is a complex endeavour. Consideration of 
a single system in isolation would ignore the fact that other controls play important roles. We 
illustrate how multiple MCSs in combination play important roles in PI work in a manufacturing 
environment. This finding complements the research on performance management of 
productivity, which has focused mainly on devising appropriate productivity measurement 
frameworks (e.g. Mohanty and Rajput, 1988; Jagoda et al., 2013).

The present study also complements the relatively sparse body of literature exploring MCSs 
within the operations management domain (Smith and Bititci, 2017; Bourne et al., 2018; Nielsen 
et al., 2018; Pesalj et al., 2018). It provides an empirical account that corroborates the system of 
systems perspective (Bourne et al., 2018), as six MCSs interrelate to form a complex system of 
control systems that can enable or constrain opportunities for management and the control of 
productivity. Our study also complements the work of Pesalj et al. (2018) by providing an 
alternative explanation of which types of MCSs interrelate in a manufacturing setting. Our case 
study offers a fine-grained description of the interrelationships of five MCSs with the PI system, 
thereby complementing studies of more generic MCS types, such as Simons’ four levers of 
control.

Furthermore, the identified interrelationships and mechanisms provide new insights into what 
it takes to ensure continuous improvement work in manufacturing (e.g. Kennedy and Widener, 
2008; Fullerton et al., 2013; Tillema and Van der Steen, 2015). The identified mechanisms also 
contribute to research and provide new insights into the dynamics of MCSs’ interrelationships in
practice (Grabner and Moers, 2013; Pfister and Lukka, 2019) and what it means to achieve a balance and fit between MCSs (Friis et al., 2015; Van der Kolk et al., 2020). Finally, empirical studies on MCSs have primarily focused on the interplay between two types of MCSs, such as value-based and result-based controls (Gerdin et al., 2019), technocratic (administrative) and socio-ideological controls (Alvesson and Kärreman, 2004), or accounting and structural controls (Bedford et al., 2016). Our study contributes to the research on interrelationships between MCSs by illustrating how the functioning of a broad range of MCSs converges on PI.

6.4 Practical implications
This case study has several implications for practitioners’ ability to manage and improve productivity. The interrelationships identified here should be a valuable resource for practitioners seeking to understand the complexities and opportunities involved in managing and improving productivity. One implication is that managers seeking to control and improve productivity should consider the complete control package instead of focusing on each MCS in isolation. That is, we recommend that managers seek to understand the entire system of systems and how the different control elements interrelate to collectively control productivity projects and initiatives. Specifically, operations managers should identify both complementary and conflicting interrelationships between MCSs and consider the three types of mechanisms that, according to our theory, help resolve conflicts and increase complementarity. This involves designing and applying effective communication, internalisation and socialisation mechanisms. Details from this case study should be helpful in such endeavours.

6.5 Research limitations and potential avenues for future research
This study has some limitations, which provide potential avenues for future research. First, our study is based on a single case study, limiting the generalisability of our findings. Thus, we call for other researchers to conduct multiple case studies and survey-based research to provide empirical evidence of the configurations and generalised structures that exist among MCSs in PI work. In addition, more in-depth case studies conducted in other types of industries and operation contexts are needed, as these can help us understand whether the identified MCSs and their interrelationships are similar in other settings. Second, the case company was selected because of its comprehensive involvement in PI initiatives. Firms involved in less comprehensive applications of productivity control and those with a different and less collaborative corporate culture may display other types of MCSs and interrelationships among them. Third, quantitative studies converting the findings of this study into a set of testable hypotheses are needed to substantiate the identified interrelationships. Fourth, the causality between the complementary and conflicting MCS interrelationships and productivity performance outcomes should be explored further. One central question that remains is as follows: What are the effects of specific frictions identified in the control package on productivity performance outcomes? We call for future research to address this and similar research questions, as such efforts will highlight the importance and potential of managing MCSs as a control package.
Note
1. Throughout our analysis, we use the terms for the MCSs introduced in this section rather than Merchant and Van der Stede’s (2017) terms. We do so because Merchant and Van der Stede’s classes of MCSs are more general than ours, which implies that there are, in some cases, more than one MCS of the same class according to Merchant and Van der Stede’s framework. Consider, for example, that framework’s personnel and action management control class. Using more specific terms, which are also used extensively in the literature, makes it easier for us to clarify what type of MCS we are referring to in our explanations.

References


### Appendix 1

Table A1. Illustration of coded data

<table>
<thead>
<tr>
<th>TYPE</th>
<th>CODE</th>
<th>QUOTE (Examples)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Relationship with the Strategic Performance Measurement System</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complementary interrelationship</td>
<td>The coordination effect</td>
<td>“At the beginning [of the project], it was clear. Everybody started off with the understanding that we need cost reduction; otherwise, we lose that project.”</td>
</tr>
<tr>
<td></td>
<td>The motivation effect</td>
<td>“… everybody receives their money [salary], … thus, one can expect from himself or from others that they do the job that is in their job description, done in the right way. And cost reduction projects belong to it. … And those two, I have in mind, they think the same way: It’s their job, they get their money and they like to work at AutoComp, and that’s why … they come to see working at AutoComp as fun.”</td>
</tr>
<tr>
<td>Mechanism for complementarities</td>
<td>Department budget planning</td>
<td>“I would basically appreciate hiring an optimiser in manufacturing, at least temporarily especially for such projects. … I think it would pay off.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“I want a new device for 60,000 [example] and, for sure, I do not get it. … However, because you actually know that you will not get it, you are not planning with a new device for 60,000, and instead, you are using what you have and optimise that.”</td>
</tr>
<tr>
<td></td>
<td>BSC reviews</td>
<td>“We have the monthly reporting for this, actually, also with the countermeasures … about the balanced scorecard, but also about the plant topics. Basically, with the next steps, there is the visualisation of the target and the progress. And they are showing where we are currently as well as the countermeasures.”</td>
</tr>
<tr>
<td></td>
<td>Quotation process</td>
<td>“Especially in the last weeks, [manufacturing engineer] could not work on his assembly line, because he had to calculate many hours on a new project [new customer quotation].”</td>
</tr>
<tr>
<td>Conflicting interrelationship</td>
<td>The alignment problem of PI activities</td>
<td>“There, … it’s not really one-to-one. Because, I think, we have such a break [disruption], at least in my view, between what I think we should do and what we actually do and consider as appropriate. “We are always good at initiating things, …, and then we are thinking it is running alone [the initiatives]. That is not working; that is lunacy.”</td>
</tr>
<tr>
<td></td>
<td>Resource constraints</td>
<td>“For 15 years now, I am used to it, to work how AutoComp is doing things: With the minimum of employees, with the minimum costs, and so on, and it is working always. Thus, actually, AutoComp is not doing anything wrong. … The point is, if I could wish something, I would wish for fewer resource constraints, you understand?”</td>
</tr>
<tr>
<td></td>
<td>Mechanism to resolve alignment problem</td>
<td>Management attention</td>
</tr>
</tbody>
</table>
2. **Relationship with the Compensation System**

### Complementary interrelationships

| Mechanism to resolve resource constraints problem | Detailed and well-grounded business case presentation | “What I have learned at AutoComp is that if you document things with numbers, data, and facts – for instance, I need one employee more …, because of this and this, etc. – I will save that [certain money], then I will get them. … The same, if I need a device and can prove it with numbers, data, and facts and can argue and explain, then I will get this money.” |

### Feeding equality

| Attract and retain well-qualified personnel | “Well, I really believe that somebody who thinks about what you have [salary level] at ‘AutoComp’ has this in mind, even there are people who do never get enough. … I have really many friends they are hairdresser, tiler, working somewhere else, if I see what they have been going through, and how much money they get for it, in comparison to somebody working on the line [at AutoComp] it’s actually a huge difference.” |

### Intrinsic motivation

| “And in addition, what I had never seen in other companies before, we have an extremely uniform salary and wage structure. Others [companies] also have pay scale grouping but with graduations within the payment group. With us [AutoComp], on the shop-floor level, … and on the engineering level, everything is fixed as well, without any graduations.” |

### Conflicting interrelationship

| Insignificant financial rewards | “Technicians, they feel really happy about resolving a problem.” |

### In that sense, primarily it’s [my] own motivation. Here, regularly, I throw material away. Bringing that, ideally, to a zero level [scrapping].” |

3. **Relationship with the Performance Appraisal System**

### Complementary interrelationships

| Individual performance feedback and goal setting | “Yet I think that the talk is good, because I believe that my employees count on my opinion and want feedback, and we are pretty honest, dealing with each other in the department. … the talk, I believe they value simply having time talking with each other.” |

### Employees’ competence development

| “What is actually done, if there are employees that stand out by good performance, they will be talked about, and these employees, as long they are interested, are considered for other jobs. There is definitely potential by doing that [recognition of performance].” |

### Mechanism for individual performance feedback and goal setting

| Supporting individual employees’ work progress | “Our manufacturing engineers as well as the quality engineers, they influence by their actions these objectives significantly. Because I believe in it, my employees receive single targets, which contribute to the company objectives in the end.” |

4. **Relationship with the Standards Control System**

### Complementary interrelationship

| Legitimacy via compliance | “Of course, it is also [dependent] on the customer approval, that he will approve it and also the tests. If I do a process change, I need to follow a change management process and in the change management process, all relevant functions need to agree. And possible side effects, …, need to be avoided.” |
| Conflicting interrelationships | Verification-effort inertia | “Partially, it is dependent on the design. The design departments, the application engineering, and the Technical Design Centre, for final approval, if I need that for a welding seam change, I am dependent on other departments and other functions, [and] I am dependent on the product design.” |
| Working-council objections | “At our place, there is a work council. There is one or the other topic that doesn’t meet with approval. … If it does concern an employee, and an employee might need to operate other tasks to increase the output, it can come to conflicts, that the work council does not agree, because the workload is considered too high. …That can include everything [of tasks], that in the available time, more tasks are considered to be assigned.” |
| Mechanisms to resolve problem of verification-effort inertia | Focus on increased alignment with technical standards | “It is all about the common good of AutoComp, if I can express it that way. … Everybody starts with, it’s like on the bazaar [market] sometimes, everybody starts with exaggerated requirements and in the end, we always find a compromise that is best for the whole [team].” |
| Cross-functional team structure | “That is really the great advantage of the cross-functional team structure, that you have many departments [functions] with direct communication in one place. That makes it more efficient working.” |
| Mechanism to resolve problem of working-council objection | Interaction with the work council | “By now, we always find solutions also for the satisfaction of the work council. But it is a factor that needs to be considered. I do not know a situation where we could not do something because of the objection of the work council.” |

5. Relationship with the Company Culture

| Complementary interrelationships | Norms of collaboration | “It’s not that somebody has the project by themselves and is influencing the objective alone with their activities. These people need to be led and, in some cases, investments are necessary to make processes more robust. … What I want to say is, the objective is not dependent on a single person and that this person is doing a good job. It is, rather, teamwork and a leadership task.” |
| Norms of equality | “Everything is fixed without any graduations. One the one side, no bonus system, and on the other side, …, we have a performance appraisal system that does not provide financial differentiation and a uniform salary system.” |
| Mechanisms supporting the complementary interrelationship | Social monitoring and enforcement of cultural norms | “They would probably feel more involved. If you do always some tests and you do not get a result, I think, it is not motivating. But if they involve you and say ‘the test has been running good from your side’, …, it is somehow an appreciation or involvement.” |
| Informal rewards by managers and employees | “I think that the single actions should be better documented or communicated, … to the management. I do not say, what we do to reduce the scrap, …, do not get information even when I am asking, …, needs to be tidier, …, not more often, but more clear reporting …, and regular, and with a clear intention.” |
| | “Mostly, there are verbal rewards. … In the cross-functional team, sometimes, when a project has been finished successfully, the department manager donates a breakfast.” |
Appendix 2

Interview instrument

(1) What initiatives and projects do you recognise that are targeting productivity improvement within this plant?

(2) For each of the named initiatives/projects, consider the following elements and provide some examples:

- Is the initiative/project connected to a formal management system of the plant? If yes, to what system?
- Who is the owner of the initiative or project?
- Please explain the initiative/project in relation to goals, definitions and measures.
- Which control mechanisms are connected to the initiative/project?
- To what extent are the objectives related to the initiative/project accepted?
- What can be improved in relation to this initiative/project? Why?
- Linkages and consistency (cause and effect relationships, actions of others, etc.)
- Conflicts and barriers (resources, etc.)
- Efforts
- Incentives (formal rewards, informal rewards, etc.)

(3) When you review the last years:

- What initiatives and projects concerning productivity improvement have been successful? Why?
- What initiatives and projects concerning productivity improvement have been unsuccessful? Why?

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Chapter 6: Exploring the control problems and the interplay of management control systems for productivity on the assembly line (Article 3)

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Abstract
Purpose: This paper aims to provide insights into the control problems which line managers face when trying to influence productivity on a semi-automated assembly line in day-to-day production. Furthermore, it explores how multiple management control systems are activated by line managers’ tasks to manage these control problems and how they interrelate.
Design/methodology/approach: Using an abductive case study, empirical data are collected from a global automotive supplier that produces complex systems for passenger cars. Recent line managers’ tasks on a U-shaped assembly line are analysed using the management control theory to study the control problems and interrelationships between the involved management control systems.
Findings: This study contributes to productivity management literature by giving insights into what the three major control problems are that line managers must handle to improve productivity on the shop floor. By dissecting these three control problems, the study explains the tasks involved and the management control systems mobilised for more productivity. Furthermore, this study adds to the research on management control theory by explaining how management control systems dynamically interrelate in a complementary, conflicting and complex way on the shop floor.
Research implications/limitations: As this paper is based on a single-case study, future research can contribute further generalisations with respect to the controls problems, management control systems and different manufacturing settings needed for productivity.
Practical implications: This study presents details on how shop floor managers can actively influence productivity in their daily work and senior managers can assess their strategic priorities with respect to productivity.
Keywords: productivity, shop floor manager, manufacturing, assembly, management control theory, single case study
Paper type: Research paper
1. Introduction
Today’s assembly lines are highly automated, and operators often follow the cycle times of line stations for productivity. Manufacturing engineers do their best to balance the cycle times of single stations and avoid idle periods. Additionally, applied management concepts, such as total productive maintenance (TPM), are used to address machine breakdowns and preventive actions to avoid unforeseeable interruptions in manufacturing environments. In these technically optimised settings, one would assume that there is little to manage among operators. Hence, the tasks of line managers (LMs) are expected to be largely administrative, entailing creating productivity reports or scheduling shifts and vacations. However, it seems relevant to investigate if and how managers on the shop floor actively influence productivity outcomes even in a semi- or highly automated production environment. In that sense, it would be helpful to know what the control problems are that managers face and what management control systems (MCSs) are involved in managing the team at the assembly line every day for productivity.

The management of productivity on the shop floor has always been a concern in operations management (OM) research (Jin et al., 2016), and we now have a sound understanding of many aspects of operational productivity management.

We know about the complexity of contextual and resource variables (Spring et al., 2017; Park and Li, 2019; Güldenpfennig and Hald, 2019, Giardili et al., 2023) and the behavioural adjustments shop floor managers apply (Pagell and LePine, 2002; Oudhuis, 2004; Kathuria et al., 2010). Furthermore, we know about the management of productivity outcomes and applied measurement, for instance, the hours-per-vehicle measurement (HPV) (Abolhassani et al., 2019). Moreover, the concept of lean manufacturing and Toyota Production System (TPS) has provided a valuable and broadly applied approach for improving productivity on the shop floor. Most of the research on productivity has been done on the implementation and results of the lean manufacturing concept (Shah and Ward, 2003; Park and Li, 2019; Tortorella, 2021), for instance on the visual management methodology 5S, Shop floor management (SFM), TPM with overall equipment effectiveness (OEE), or Value Stream Mapping (VSM). Despite of all the research that has been done on productivity improvement, we widely do not have, besides a few examples (Cai et al., 2018; Moon et al., 2022), an understanding of the specific controls problems and tasks shop floor managers go through to continuously improve productivity outcomes in day-to-day operations on the shop floor. Knowing the control problems, the multiple controls to address them and the task to be managed would help managers to understand why certain manufacturing environments fail to meet productivity objectives.

The examination on MCSs mobilised for productivity is still sparse in productivity management literature. Research has been done on other MCSs, for instance on performance management systems (McCreery et al., 2004; Ohlig et al., 2020). In the new millennium, the concept of multiple MCSs has received increasing interest in OM, but explicit research on MCSs for productivity management on the shop floor stayed widely neglected. Scholars of OM have started to apply the concept of multiple MCSs, for instance, for its complementary effects on lean MCSs (Nielsen et al., 2018), multiple MCSs in manufacturing (Pešalj et al., 2018) or the effectiveness of accounting top-down-based and operations-based controls (Bellisario and Pavlov, 2018). Güldenpfennig et al. (2021) attempted to discuss having multiple MCSs for productivity
improvement at the meso level (department manager level) of a factory, but only touched the shop floor level. However, there is still limited knowledge about how different MCSs interrelate to control productivity outcomes on the shop floor (Delbridge and Barton, 2002).

This study draws on MC theory and, specifically, on the research on multiple MCSs (Malmi and Brown, 2008; Grabner and Moers, 2013; Friis et al., 2015; van der Kolk et al., 2020). The research on multiple MCSs and MCSs packages implies that interrelationships between MCSs can be complementary or conflicting (Grabner and Moers, 2013; Van der Kolk et al. 2020) or, being complex by having positive and negative aspects to their interrelationships (Friis et al., 2015; Van der Kolk et al., 2020). Furthermore, research on MC theory has discovered that tension between MCSs is dynamic, referring to the constant changes in the interrelationships between MCSs over time (Mundy, 2010; Van der Kolk et al., 2020).

To address the three gaps and draw on the theory of multiple MCSs (Malmi and Brown, 2008; Grabner and Moers, 2013; Laguir et al., 2019), the following research questions guide this article’s examination of the ‘productivity outcome’ phenomenon:

RQ1: What are the control problems line managers face for productivity on the shop floor and how are the management control systems mobilised to manage them?

RQ2: How do the multiple management control systems interrelate on the shop floor to enhance productivity?

Based on an abductive case study, empirical data from a global automotive supplier factory site are collected. The different types of MCSs are drawn from Malmi and Brown (2008) because their study includes a detailed but broad set of MCSs. The unit of analysis is one U-shaped assembly line in the factory with its 3 shift teams. The in-depth case study concentrates on the tasks LMs use to manage productivity.

This article makes three contributions. First, it contributes to productivity management research (Cai et al., 2018; Moon et al., 2022) as it demonstrates the three major control problems shop floor managers must handle for productivity. The deconstruction of the three control problems into 12 tasks provides deep insights into the mechanism of coordinating and motivating the shop floor teams for productivity outcome. Second, this paper contributes to the research on MCSs in OM (Bellisario and Pavlov, 2018; Nielsen et al., 2018) as it explained how multiple MCSs, five in total (Malmi and Brown, 2008), are mobilised on the shop floor for productivity outcomes. It describes the complementarities and tensions that arise, for instance through factories’ labour flexibility strategy or non-financial measures being omni-present on the shop floor. Third, the study contributes to MC literature (Henri, 2006; Mundy, 2010; Stouthuysen et al., 2017; Van der Kolk et al., 2020), as it elaborates on a new type of dynamics about how MCSs interrelate. For practitioners, the paper provides direction about where to focus on in managing productivity outcomes on the shop floor. Furthermore, the described methodology to analyse control problems and tasks can help to critically assess and trade-off strategic decisions related to productivity.

The rest of this article is structured as follows: Section 2 describes what we know about managing productivity on the shop floor and MC theory. In Section 3, the methodology of this case study is explained. Section 4 presents the findings, which explain the identified control
problems and related tasks, the MCSs mobilised and the dynamics arising from different control problems. Section 5 elaborates the overall conclusions, limitations and future research directions recommended.

2. Theory

2.1 Managing productivity on the shop floor in OM

The management of productivity on the shop floor has been always a concern in OM research (Schmenner 2015, Jin et al., 2016). We know about the complexity of contextual variables to be considered (Spring et al., 2017; Güldenpfennig and Hald, 2019), the resources to be managed (Abolhassani et al., 2019; Park and Li, 2019) and the multiple behavioural aspects to be considered such as delegation or helping behaviour (Pagell and LePine, 2002; Oudhuis, 2004; Kathuria et al., 2010). Additionally, the productivity outcome of manufacturing settings is part of the research on OMs’ productivity, for instance, the effect different plant managers have on productivity outcome (Giardili et al., 2023) or how hours-per-vehicle (HPV) can be enhanced in automotive production (Abolhassani et al., 2019).

In OM, productivity management has been primarily explored under the umbrella of lean concepts and waste reduction (Demeter et al., 2011). The implementation and results of lean management tools, for instance 5S, VSM, TPM with OEE, Total Quality Management (TQM) and assembly line balancing and Heijunka has been examined and scholars as well as practitioners widely agree on the strong potential these tools have on shop floor productivity (Güldenpfennig et al., 2019). For the long-term success of lean management productivity initiatives in manufacturing, known as lean manufacturing, scholars have discovered that it takes more than the initial successful implementation of the tools. It takes implementing and living the lean philosophy at all levels of the organization (Minh et al., 2023). Furthermore, as a consequence for generating long-term effects of lean manufacturing on productivity, a continuum following the lean philosophy would be required. That contrasts part of the research on productivity involving lean manufacturing concepts, as these studies primarily focus on one-time intervention initiatives and not on the reoccurring tasks of managers to keep the assembly line running and meeting daily productivity targets. Of course, a continuum can be found in lean manufacturing tools as well. One example is Shop floor Management (SFM), a concept of the lean toolbox explored in OM (Zondo, 2020; Wester and Hitka, 2022) that emphasises the continuous tracking of productivity improvement. Even though SFM is a strong productivity tool, it serves, as most likely intended, primarily to visualise productivity measures and coordinate specific actions with the team. The research on SFM does not inform us about what tasks shop floor managers do in detail and what the problems to be managed following up on productivity outcomes in performing the daily routine of the team.

In OM, detailed descriptions on the tasks and mechanisms, and why they are applied by managers to control daily productivity outcome, are rarely represented aside from a few examples. For instance, Cai et al., (2018) examined process interruptions on the shop floor and therein contribute on the microlevel of productivity determinants. In their study, they explain how shop floor managers compose and assign operator to stations and how they assist their team to be more productive. The study is limited to the investigation on process interruption as a problem to be
managed for productivity. Moon et al., (2022) investigate the problem of worker turnover and staffing and its effect on productivity. They analysed managers alternatives and found out that, even though the work in the manufacturing environment is standardized, productivity is still reliant on shop floor managers’ coordination of the workforce (Moon et al., 2022). Indeed, the term ‘control problem’ is applied in OM, but predominantly used to define and address the problem of production control (Rivera-Gómez et al., 2016; Delpla et al., 2023) or inventory control (Jakšič and Fransoo, 2015; Manafzadeh Dizbin and Tan, 2020).

Hence, the literature in the OM domain on managing productivity on the shop floor holds a plethora of lean management-based studies that provide sound knowledge and examples of how to implement productivity improvement solutions on the shop floor, especially on productivity improvement projects representing the Kaizen philosophy, the evolutionary process of step-by-step improvements. Also, research on what can create long-lasting effects in lean management and what makes a lean productivity project successful is represented in OM (Seth and Gupta, 2005; Hasle et al., 2012; Amaro et al., 2021; Minh et al., 2023). However, there is little research concerning the details of the specific tasks to manage control problems and why shop floor managers apply them to improve the productivity of their teams for day-to-day operations.

2.2 Management control systems in productivity management
The changing manufacturing environment, characterised by flexible machines, low inventories, or production to order, requires different demands on MCs in the manufacturing environment (Van Veen-Dirks, 2005). This requires an alignment of the multiple MC mechanisms in the organization (Pešalj et al., 2018).

OM researchers draw on the MC research that originally stems from the management accounting domain. Thus, Bellisario and Pavlov (2018) analysed multiple MCs in the context of performance management and found out that the controls closest to the frontline are the most effective, strategic and operational controls that need to be aligned. Furthermore, in the context of performance management, Pešalj et al. (2018) also investigated an Small and medium-sized enterprises on multiple control levers within the performance management system. They found that senior management had a strong influence, majorly on interactive and beliefs controls reaching down even to the shop floor team. While the tension between multiple controls was a focus of the former two studies, in their survey, Nielsen et al. (2018) analysed 368 manufacturing facilities which employ the lean philosophy, including social, behaviour and output controls. They discovered that some of the interrelations between interdependent lean MCs complement each other beyond their additive effects and should be understood as an integrated control system. They also found that behaviour and social controls not only enhance firm performance, they enable financial and non-financial output control.

2.3 Management controls systems theory
This study draws on MC theory. MC theory provides important insights into managerial intervention and its connected actions for achieving organisational goals. In this study, MC is conceptualised in accordance with Merchant and van der Stede (2017), who postulated that MC includes any management tool, device, system or process that helps to ensure that employee
behaviours are directed toward goal achievement. In the new millennium, the field of management accounting and control experienced a new dynamic in terms of analytical MC concepts and frameworks (Strauß and Zecher, 2013), and the concept of multiple MCSs recently gained traction. Mainly driven by management accounting scholars, MCSs have been examined based on multiple MCSs packages (Malmi and Brown, 2008; Grabner and Moers, 2013; Merchant and van der Stede, 2017). This approach and its frameworks provide a useful lens through which control problems can be measured, including productivity measures and targets. In this case study, the concept of multiple MCSs from Malmi and Brown (2008) will be applied as a lens to study the interrelationships between different MCSs, because it includes a detailed but broad set of MCSs.

Moreover, a set of MCSs needs to be aligned in organisations to be effective. That is the starting point of investigating the combination of multiple MC mechanisms (Grabner and Moers, 2003). Hence, MC mechanisms interrelate for a certain problem, and interrelationships can be only studied in relation to a control problem (Grabner and Moers, 2003). According to Grabner and Moers (2003), different context can trigger different control problems and the choice of MC practices managers apply (Bedford, 2020). Bedford (2020) emphasises to consider multiple control problems since the effects of one MC practice can be different on a single control problem. Thus, an MC practice can independently affect one control problem while other MC practice relate jointly to other control problems (Bedford, 2020). The concept of multiple MCSs implies that MCSs do not exist in isolation (Malmi and Brown, 2008; Friis et al., 2015) and the character of their interrelationships must be considered. MCSs interact in positive and complementary or in negative and conflicting ways (Friis et al., 2015; Grabner and Moers, 2013; Malmi and Brown, 2008; van der Kolk et al., 2020). Thus, the characteristic of MCSs interrelationships results in either synergies or trade-offs based on the efficacy of the MCS in question (Friis et al., 2015). Hence, the interrelationships between MCSs can lead to positive effects, negative effects or tension complexity, and temporal changes are labelled ‘tension dynamics’ (Van der Kolk et al., 2020).

Additionally, research on MCSs has discovered a dynamic of interrelationships between MCSs, that refers widely to what Van der Kolk et al. (2020) relate to the changing character of interrelationships between MCSs over time. They found out that the tension in one department has been quite stable, whereas in another department, the tensions were shifting over time, a phenomenon they called tension balance. Furthermore, Mundy (2010) also investigated the dynamics of MCSs and referred to the fact that the dynamics of interrelationships arise through updated information and shifting priorities, hindering managers from balancing control. The investigation of other types of dynamics on the interrelationships between MCSs elements, for instance, the dynamics that might arise depend on the different control problems in the same manufacturing environment, were neglected in MCSs research.
3. Methodology

3.1 Research design and case selection

To gain a deeper understanding of the control problems LMs are facing and how they manage by them, this study draws on research that explores how the interrelationships between multiple MCSs are constructed, conditioned and vary within specific organisational settings.

Since the details on LMs’ control problems and tasks remain largely unknown and the theory basis for examining the problem is sparse, a single case-study approach using an abductive methodology is applied to answer the research questions. Single case studies are useful for describing phenomena functionality in detail (Siggelkow, 2007). Thus, the details of the LM tasks involved in managing control problems are extracted from multiple data sources so that the tasks and interrelationships can be extensively and concisely elaborated for specific settings.

The selected case company is suitable for three reasons. First, standard and measurable productivity measures (e.g., output per shift) are readily available. Second, the company enjoys a long-lasting and compelling reputation with productivity improvement results. Third, it maintains a multi-level operating environment characterised by round-the-clock shop floor operations comprising multiple shift teams. Moreover, each assembly line is led by an LM who reports to the shift leader and is responsible for shift employees. Usually, two or three shift teams are assigned to an assembly line to cover 16– or 24–hour operations. The firm used in this case is a site belonging to a German manufacturer of automotive supplies and complex passenger car systems, providing global products.

To understand control problems and tasks, it is important to first visualise the manufacturing setting in scope at the case firm. The firm employs ~400 employees, and the production department consists of a manufacturing and an assembly area, each managed by a group leader. Below the group leaders are shift leaders. The assembly line is a semi-automated U-shaped configuration in which multiple workers operate one or two stations adjacent to one another. The product being manufactured is transported on a carrier driven by a small belt placed ergonomically ~80 cm high from station to station. The assembly jobs involve assembling components on the carriers and checking them based on the product’s configuration and capabilities with semi-automated quality checking devices. At the end of the line, an automated testing island is used to functionally test the assembled product and identify defects. If there are defects, they are either fixed or ejected from the testing centre, depending on the scale. After testing, an operator places the finished product into a packaging tray. Component materials are supplied from external sources and arrive on the line in racks or boxes. Some of the supplied components come pre-assembled from centres that are also under the supervision of the LM. The assembly line operates all day with three rotating shifts, resulting in 15 total shifts per 5-day week. The first team’s shift begins at 22:00 Sunday night. The LM is the lowest managerial level in this configuration and reports to the shift leader, who is responsible for all LMs per 8-h shift. The shift-leader reports to the assembly manager, who reports to the production manager, who works for the plant manager.

3.2 Data collection

To gain deeper insights into the control problems of the LMs and tasks involved, data from multiple sources were collected from the case firm to support triangulation.
First, unstructured interviews (Kvale and Brinkmann, 2009) were conducted with representatives at various levels and functions. Interviewees were asked to describe how LMs are distinguished in terms of motivating their teams to achieve productivity results and what LMs do to increase productivity. The resultant conversations involved re-asking questions after providing full explanations to participants to validate the interpretations (Kvale, 2007). In order to triangulate perceptions, responses from group leaders, shift leaders, LMs and their team members were obtained. In total, 16 interviews were conducted and audio recorded. The saturation point (Francis et al., 2010) of added information was met after 11 interviews, and the five extra interviews were used to add details and make confirmations. Since the author was familiar with the teams and scenarios at the case firm, owing to 100% attendance at the site, interviews were managed very effectively.

Second, several observations, meetings and walk-arounds were conducted so that unique insights into the activities and procedures of factory productivity could be ascertained. The author’s full-time presence throughout the project also aided in capturing even tiny details of employees’ utterances within the factory. The author’s familiarity with company-specific knowledge, processes and abbreviations facilitated the data collection and analysis.

To capture the productivity outcome, two data sources were used. First, to understand the productivity measures, archival data from multiple spreadsheets representing Overall Equipment Effectiveness (OEE) recordings, including high detail numbers the OEE consists of, was analysed. Second, in the interviews, the importance of multiple productivity measures was sensed and analysed.

3.3 Data analysis
Data collection and analysis was performed using a process in which analyses were updated continuously. To follow up on the development of constructs, results of the analysis were organised in a database and analysed with NVivo software (Eisenhardt and Graebner, 2007).

![Figure 1: Steps of the analysis](image-url)
The interviews were transcribed and associated documents and observations were enclosed. The analysis follows three steps presented in Figure 1: For identification of choices made by LMs related to team productivity outcome, open coding (Corbin and Strauss, 1990) was applied after grouping phrases, sentences and paragraphs. First, elements related to productivity improvement were identified and clustered under LM tasks. Second, axial coding was applied (Corbin and Strauss, 1990), and multiple tasks were connected to a control problem. In theory, a set of tasks defines a control problem. This analysis resulted in a detailed description of each task and therewith of the entire control problem. In the next step, an abductive approach was applied to identify the most rational type of MCS presented by Malmi and Brown (2008), and the best fits resulted in reasonable empirical mappings connecting the mobilised MCS type with the task elements of LMs. In a third step, interrelationships between MCSs have been identified from the empirical maps and characters of interrelationships has been compared to identified dynamics of them.

4. Findings

4.1 The control problems, its tasks and their management
LMs were discovered to manage three major control problems to improve productivity in the case firm in daily re-occurring operations. Each control problem is managed though several tasks the LM must handle. Thus, several tasks are required to manage one control problem. The mechanisms of how the tasks are applied to manage the control problems are described in this section.

4.1.1 Control Problem #1: Assigning team members to working stations
The purpose of managing control problem #1 is to assign the available team members to the working stations to reach the best combinations for maximum productivity. Since the work content is largely determined by the design of the assembly line, which is a result of long-term collaborations between engineers and equipment suppliers, managing control problem #1 is much larger than a singular task. For the first control problem, ‘assigning team members to working stations’, five tasks of LMs have been identified and are described. One of the five tasks is to simply assign an operator to a station, while the other four are designed to support the orchestration of said station.

Sensing line situation (Task 1.1)
The analysis revealed that, the better the overview of LM of line situation, the better the issues hindering a successful shift period can be addressed. The setting of the assembly line, determined by the availability of operators, work progress of sub-assemblies and current interruptions of machines and stations, is different at the beginning of each shift. The LM captures this setting, which influences the decisions made during the next 8 hours. Notably, initial operator placements take place within the first 10 minutes. The LM is the first team member to arrive at the assembly line meeting with the previous shift operators and LM. At this meeting, crucial shift and system
information is exchanged, which the new shift’s LM uses to assign positions. The shift operators arrive a few minutes prior to the shift, and the LM completes the evaluation and assignment process. One LM (LM01) stated that, at the beginning of a shift, he checks what operator is present, what operator is tired, and if that operator can bring 100% performance. Notably, moods and attitudes are important states to consider as an LM:

If I know my people very well, then I know exactly ‘Oh, this guy I do not need to approach on Monday morning because he is in bad mood’, then I will put him there [station], where he cannot get on somebodies’ nerves. (PP01)

One LM (LM03) stated, “Today, two people were missing and I had to quickly re-coordinate the workers to make sure that all the important stations had someone assigned to them.”

Operator training (Task 1.2)
Important to aligning operators and their stations is adequate and proper training. For operators, qualifications and certifications allow them to perform tasks with confidence and low stress, and it bolsters the overall team’s performance and belonging. The objective of this task is to increase operators’ skill and knowledge levels, which results in higher output quantity, less malfunctions and breakdowns. There are two types of training that apply to this scenario: initial training (German: ‘Erstunterweisung’) and follow-up training. Initial training follows a standardised process that entails detailed visualised instructions and a practical training exercise at a ‘blocked parts table’ of the line at which the LM or deputy supervises the test and follows up with quality feedback. Second, the LM takes the operator through a ‘walkalong’ from station to station. Afterwards, the LM and trainee sign an official training document that codifies the new qualification and is stored in a database. The operator then begins work at an easy station, shadowed by the LM or another skilled operator. Interviews reflected that the team members to the left and right of a novice identified the need for support to prevent a slowdown at this station.
Figure 2: Control problem #1: Assigning team members operator to working stations
Team member selection (Task 1.3)
Although LMs do not have the authority to hire and fire workers, they play a significant role in influencing team assignments. It is immensely important for LMs to be able to evaluate team members’ capabilities and preparedness, which not only includes physical strength and acuity, but also intellectual understanding and intuition. One shift leader pointed out that this ideal situation requires that LMs consistently engage with their team members and get to know them. Although operator training is an effective way to elevate team member qualification levels, interviewees understood that the new operators must also bring certain desirable capabilities and personality traits that support learning and teamwork. Hence, LMs strive to obtain the best operators through their recommendation channels. One method of selecting new team members is to approach the shift leader and ask for their help. One respondent admitted that not all inquiries are considered, whereas others are prioritised to favoured LMs. In any case, the shift leader ostensibly intends to equalise team strengths.

Assigning workstations (Task 1.4)
LMs make daily team assignment decisions at the beginning of shifts. The objective is to quickly reach an optimised configuration of operator assignments that leads to maximum output. Many respondents reflected that the work pace, physical demands and complexity vary at different stations, which can lead to bottlenecks. The best available operators are, therefore, placed at the busiest stations. Others were found to be intellectually or conditionally limited to simple stations. A shift manager pointed out the following:

“Do I keep him here or use him for something else? I have an operator who is the best at the pre-processes and management of his work. However, as soon as we take him to the line, he fails. He doesn’t understand how to manage the working sequences.” (SM01)

Understandably, some workers often show up in a bad mood and require a station with low pressure and few interactions. However, operator assignment optimisation can lead to conflicts, such as when operators refuse to work at specific stations. Hence, LMs must be able to manage the situation and convince the worker to take the job.

Facilitating job rotation(Task 1.5)
Many respondents reflected on the importance of job rotation for improved productivity and considered this issue to be of importance to LMs. First, job rotations are known to reduce absenteeism and training deficiencies. Additionally, LMs in this situation are not needed as much to personally augment team members at their stations, and there are more options for operator assignments, resulting in better team member skill and requirement fitness. Hence, the outcomes are ultimately designed to optimise organisational and LM needs. Although secondary to other LM demands, job rotations support powerful aspects of workforce motivation and training. Apart from receiving new knowledge and advanced tasks, operators enjoy increased engagement and motivation. Most respondents reflected that, when encouraged by the LM, most team members rotate daily. Although some LMs determine station assignments at the beginning of shifts, others plan these things days in advance, and some rotate members automatically in a clockwise direction daily.
4.1.2 Control problem #2: Managing process interruptions

The analysis thus far shows that LMs react to process interruptions based on the capabilities of the operators and maintenance staff. Such interruptions reduce product assembly times during the shift. Interruptions like station breakdowns and technical malfunctions or mistakes, such as entering safety light curtains or wrongly assembling components, can shut down the line. Otherwise, smoking, lunch and restroom breaks can create excessive interruptions. On the other hand, planned team meetings and shift handovers are planned interruptions and teams are provided two official 15-minute breaks as well as small individual allowances during which the LM must take over. It was also found that missing pre-processed materials lead to interruptions, and LMs must mediate and/or fix them by aligning the needs of organisation and operators. During an 8-hour shift, each second a station spends in a non-production state significantly reduces the desired output. To mitigate the second control problem, ‘managing process interruptions’, four tasks were identified (Table 1).

Recognising interruptions (Task 2.1)

Recognising breakdown-related interruptions on the assembly line is the initial task for achieving correct and timely responses when mitigating productivity losses. Respondents noted that every second spent mitigating a breakdown and its assessment is meaningful. One LM noted that he watches the line computer monitors constantly when processing rework, and interruptions appear only after a few seconds. One operator ironically stated that this LM is often present ‘even before the breakdown arises’. Another way to recognise breakdowns is by operator notification.

Addressing micro-stops (Task 2.2)

Micro-stops are short breakdowns that do not require maintenance personnel. They appear many times during a shift, adding up to a relevant portion of downtime. Therefore, it is crucial that LMs manage their teams using good tactics to deal with micro-stops. One interviewee stated that breakdowns are annoying because they interrupt the flow of work (i.e., ‘Takt’). Although small buffers exist between stations, they only allow for 1- or 2-minute gaps between activities. Hence, LMs and operators aim to fix small problems which lead to micro-stops as quickly as possible. One respondent added that the maintenance LMs’ skills and an overall willingness to build up expertise are advantageous. Hence, the findings indicated that this scenario relies on proactive LM decisions and the ways in which the acquired technical knowledge is mobilised.

Engaging maintenance personnel (Task 2.3)

If an operator or LM cannot resolve a breakdown, maintenance staff is called in. Many observations gleaned from meetings at the case firm showed that several of the longest breakdowns could have been addressed much faster if the maintenance staff were professionally trained. In fact, only one or two maintenance people were experts on the assembly line in focus. In some of these cases, the line remained down until the next shift up to 8 hours later. Furthermore, when capable staff are available, problems or preventive maintenance on other lines can delay emergency repairs. Fast resolution of breakdowns leads to low allocations of maintenance
personnel and less productivity loss. Good personal relationships between LMs and maintenance personnel make a stark difference:

You always need to try with maintenance to be friendly, nice, to encourage expeditious communication. If you are saying ‘Please, please, I have problems on the line, please come here’ then he will try to resolve it quickly. I learnt and recognised that by observing another LM. He has problems with the maintenance [staff] and then he [maintenance person] says ‘Make an order, I will come soon’. He is not being too formal. Therefore, you get the best results by being nice to the maintenance person.

(LM01)

Interviewees explained that the co-operative relationships between LMs and maintenance staff are strengthened by the expert maintenance staff being on the same shift as the LM’s team and having a good relationship with the LM. Notably, the helpful behaviours of the LM can make a difference. One LM reported that helping maintenance personnel at the problem station can reduce downtime.
Chapter 6 – Exploring the control problems and the interplay of MCSs for productivity – Article 3

Figure 3: Control problem #2: Managing process interruptions.
Work assignment during interruptions (Task 2.4)
During longer breakdowns, owing to short buffers between stations, entire lines may stop, and the full team will be forced to stand by idly. However, good LMs will quickly find ways for idle operators to perform other useful jobs. Such jobs are expected to accelerate production after the line returns to operations, even if it must wait for the subsequent shift. Station and equipment cleaning is a useful go-to task in these situations, for instance cleaning sensors that have the potential to fail due to dirt. Pre-process stations can also be prepared for upcoming sub-assemblies, thus increasing their immediate buffers and mitigating situations in which operators may be out sick in single shifts. Testing, rework and training are other vital activities. When the breakdown has been resolved, the LM can then motivate team members to catch up and perhaps rotate stations.

4.1.3 Control problem #3: Ensure the motivation of the team
At the case company, for productivity improvements, LMs mobilise either consciously or subconsciously three tasks increasing the motivations of team members and function as enhancers of two other control problems.

Role model for motivation and care (Task 3.1)
Team members copy the behaviour of their LM and LMs are important for forming a company culture of mutual assistance and support. Team members value the strong presence and assistance of LMs. One LM stated a recipe for a good functioning team:

If they see that a line manager or a deputy is motivated and wants to work and they are employees that are not apathetic, then they will become like the LM. Actually, they think by copying the LM, they’re helping. …. And when they see that you try to motivate the line [the team members] a little, helping back and forth, then they respond in kind. But if they see, that you do not care about anything, then it doesn’t work. Then they try to work slow. (LM01)

One team member mentioned keeping an eye on the current station and the monitoring screens of the co-workers to their left and right just to be ready if problems occurred. Another reflected on being a new operator and how direct communications with the LM and the other operators were greatly beneficial. Hence, this person had applied for an LM position. A group leader mentioned that friendly discussions are important to an LM, but that corrective feedback is necessary when appropriate so that operators can improve. In contrast to motivating behaviours, in the case
Control Problem #3: Ensure motivation of the team

3a) Role model for motivation and care
- Cultural controls
  - Being present at stations to help to fix problems
  - Seeks direct communication and discussion
  - Solicits to solve problems by themselves (LM)
- Recognizes role model actions
- Capping
- Helping colleagues left & right on station
- Operator

3b) Holding team meetings to elevate operators
- Shift leader
  - Encourages line manager
  - Provides information
  - Sometimes do not take place
  - Team members do not raise questions
- Line manager holds weekly meeting
- Planning
- Projecting perspective
- Elevate team member
- Operator
- Cultural controls
  - Appreciates operating effects
  - Team member part of something bigger
- Rewards & Compensation

3c) Promote strong, consistent and self-reliant teams
- Has experienced advantages of a strong team
- Cultural controls
  - Measures of productivity
    - Output, downtime
    - Good results
    - Appreciation rewards: line manager
  - Appreciation rewards: line manager
  - Administrative controls
  - Requirements of standard control system:
    1) Certain % of temp worker
    2) Temp worker can stay max 24 month, better less (nonrenewing payments)

Figure 4: Control problem #3: Ensure motivation of the team.
company, a respondent reflected on a rather negative role model behaviour they witnessed from an LMs. Thus, LMs vary in their characteristics, and some do not delegate and prefer to solve problems all by themselves. This situation does not create trustful environments and hinders operator development.

Holding team meetings to elevate operators (Task 3.2)

LMs are encouraged by their superiors, the group and shift leaders, to conduct formal team meetings once per week to communicate valuable information and receive feedback. For these sessions, LMs receive information from their shift leaders that they relay to their teams. This process holds valuable symbolic meaning, reflecting that the team members are part of something bigger than their group of people. Another LM mentioned making efforts to elevate certain team members during the meeting. The interviews indicated that these meeting were mobilised to motivate team members, but they have the potential to be used more effectively. Sometimes the meeting is skipped, and valuable feedback is not provided. On these teams, operators tend to raise concerns more seldom than on other teams. Apart from formal team meetings, two LMs mentioned that they occasionally brought their teams together at the end of shifts when the issues from the shift were still vivid in their memories; hence, the team members tended to be extra appreciative. Several team members reflected that a simple ‘Thank you’ from the LM at the end of a successful shift was helpful. Exceptional shift productivity is not commonplace; hence, extra attention and appreciation is greatly valued.

Promote strong, consistent and self-reliant teams (Task 3.3)

The empirical data of shift results showed that teams with strong LM governance and those which had long-term memberships, lasting longer than a year, were the strongest. Notably, they often develop strong non-verbal communication capabilities that enhance collaboration. Furthermore, the strongest teams’ members can cover all workstations whenever necessary. Hence, total assembly line breakdowns are exceedingly rare. This ideal working mode tends to reflect strong LM leadership and solid team member understandings of operational elemental interrelationships. The plant and production manager described a well-functioning assembly line team, stating, ‘It looks like a special choreography how people run this line’. As it was a U-shaped line, operators inside the line were familiar with helping teammates stationed adjacent to them, and they felt as if they understood one another without words. This strong level of ‘choreography’ is not achieved very quickly; it is the result of a strong, enduring team.

Sometimes, owing to various human resource strategies, temporary workers cycle into teams when regular workers are out. One shift leader bragged that some teams are so self-reliant that they do not need an LM. To strengthen team member self-confidence, the LM may provide forms of appreciation:

In our team we have this [award]. When you, for instance, reached the output target in the shift, then you go to your team members and pat them on the back, ‘thank you, thank you. That was a very good job today. Thank you.’ Or when I receive an E-Mail from the plant manager or shift leader, ‘Thank you, very good performance’ then I go to the assembly line and tell them [team members]. (LM01)

In any case, an LM is responsible for building and sustaining stable teams.
4.2 The mobilised management controls

Based on the analysis at the case firm, the mobilisation of MCSs distinguishes between the three identified control problems in the same manufacturing setting – the selected U-shaped assembly line. However, similarities were found between the MCSs mobilised for each control problem. The analysis of the control problems on a task based level provided the possibility to capture the mobilised MCSs involved. Every task of the three control problems involved at least one type of MCS. For the execution of the single tasks, not all of the five types of MCSs (from Malmi and Brown, 2008) were mobilised, but for each whole control problem (#1-3) all five types are mobilised as shown in Table 1. Furthermore, the analysis elaborates, that the mobilised MCS either supports (+) the LMs in managing the control problem, hinders (-) the LMs, or both; the type of MCS used may help support a specific task and cause conflict in another (+/-). The majority of the analysed MCSs support (+) the tasks when applied by an LM to achieve productivity outcomes as Table 1 illustrates.

Describing all identified MCS-tasks-combinations would go beyond the scope of this article. Therefore, the description of how and why a MCS is mobilised is summarized across the three control problems and examples are pulled that substantiate the findings. In contrast to Section 4.3, only the mobilisation of the MCSs is considered in this section, regardless of the interrelationships between MCSs.

4.2.1 The two-sided dependence on cultural- and administrative controls

In contrast to the other three MCSs, cultural and administrative MCSs show a rather a two-sided mobilisation (positive and negative) influence on productivity outcomes when mobilized by LMs. An example of administrative controls is the standardized trainings that partly function as procedures that doubtlessly support the initial trainings. Conversely, interviewees report that some operators develop their own working procedures that contrast the standard procedures but allows the workers to operate their stations faster. Thus, the administrative control of standard working procedures can hinder a more productive operation, when ‘lessons-learned’ are not assimilated into the standard. Further, missing administrative controls, such as, the aforementioned procedures, which are hindering productivity outcomes have been identified in the case firm. Thus, there is a missing administrative control that represents a standard of a maintenance agreement for on-call personnel, for instance on night shifts. Hence, expert advice cannot be obtained by phone after hours, due to the labour agreements with the works’ council, which is a representative body elected by the employees of the factory and serves as a forum for employees to discuss workplace issues, negotiate labor agreements, etc.

Concerning cultural controls, which are represented in the case firm’s values and employee behaviour, the interviewees identified training issues. Some LMs considered it a major task to qualify new team members, and others expressed their lack of eagerness to follow up with them. Multiple interviewees reflected that it is crucial that LMs have sufficient time during the shift for training. Notably, proper planning for training requires extraordinary organisation. Most LMs regularly support team members at stations; hence, recognising breakdown interruptions is easier. Interviewed team members reflected that they were motivated while also being confused by their
LM’s behaviour and that there were significant motivational differences among LMs. Respondents identified multiple situations in which the LM role-model behaviours were intermixed, which can be both motivating and off-putting. Aside from the LMs, the team’s operator’s values and behaviours in leadership can either enhance productivity or hinder it. Breakdowns are not always caused by technical issues. One LM reflected that they sometimes appear when the operator loses focus. A former LM, who is now a deputy shift leader, misses the shared awareness with his team members.

Further, related to operator behaviour is an insensibility. Noting that micro-stops are merely warning alerts, the station operator can confirm the alarm and continue with the process with corrections made. These alerts can appear hundreds of times during a shift, and the LM will not receive any indications. The root causes of these alerts (e.g., dirty sensor) often go unrepaired and will persist from one shift to another. Some respondents reflected that there are LMs who are very eager to resolve the issues with the intent to get the line running as fast as possible while also allowing others to learn appropriate problem-solving skills.

4.2.2 Action planning control at the manufacturing environment
The control of Planning is widely positively related to the tasks for managing the control problems at the case firm. Even though the tasks of LMs relate to day-by-day running of the assembly line and not process optimization, there is action planning involved in numerous tasks (see Table 1).

For instance, the control mechanism called planning control is mobilised through LMs’ actions concerning team member selection and recruitment. Team members who learn fast and fit well on the team help produce higher output. Assigning friends to the same team improves morale. A shift leader reported that when operators ask to switch stations, the LM only sometimes agrees. One LM reported that he responded to reports of physical problems by placing certain operators at less physically demanding workstations. The LM added that after the impaired workers returned to good form, the other team members would be thankful for the return to optimal team performance.

Also, for team building, actions are planned and applied for rotating temporary workers from station to station. Respondents expressed the benefits of maintaining a consistent team for long periods, which requires planning by LMs. Temporary workers are provided when core operators take vacations or sick leave. Furthermore, the temporary workers can augment teams during low employment periods. Therefore, LMs must quickly assess a temporary worker’s performance and adjust accordingly.
Table 1: The tasks of control problems and mobilised controls
(+supporting, - conflicting, +/- complex)

<table>
<thead>
<tr>
<th>Controls by Malmi and Brown (2008)</th>
<th>Cultural control</th>
<th>Planning</th>
<th>Cybernetics</th>
<th>Rewards and compensation</th>
<th>Administrative controls</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control problem #1: Assigning team members to working stations</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1a) Sensing line situation</td>
<td>+</td>
<td></td>
<td>+</td>
<td></td>
<td></td>
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<tr>
<td>1b) Operator training</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+/-</td>
<td></td>
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<tr>
<td>1c) Team member selection</td>
<td>+/-</td>
<td></td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1d) Station assignment</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
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<tr>
<td>1e) Job rotation</td>
<td></td>
<td>+</td>
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<td></td>
<td>-</td>
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<tr>
<td><strong>Control problem #2: Managing process interruptions</strong></td>
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<tr>
<td>2a) Recognizing interruptions</td>
<td>+</td>
<td></td>
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<tr>
<td>2b) Addressing micro-stops</td>
<td></td>
<td>+</td>
<td></td>
<td>+</td>
<td></td>
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<tr>
<td>2c) Engaging maintenance personnel</td>
<td>+/-</td>
<td></td>
<td>+</td>
<td></td>
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<tr>
<td>2d) Work assignments during interruptions</td>
<td></td>
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<td>+</td>
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<tr>
<td><strong>Control problem #3: Ensure motivation of the team</strong></td>
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<tr>
<td>3a) Role model for motivation and care</td>
<td>+/-</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>3b) Holding team meetings to elevate operators</td>
<td>+</td>
<td></td>
<td>+</td>
<td>+</td>
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<tr>
<td>3c) Promote strong, consistent and self-reliant teams</td>
<td>+</td>
<td></td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

4.2.3 Supporting cybernetic control and rewards and compensation
Both, *cybernetics* and *rewards and compensation* are supporting controls in the case firm and mobilised are mobilized through multiple management tasks (see Table 1).

*Cybernetics control* is tracked via non-financial metrics, primarily, downtime minutes and the shift output quantity. These are tracked by the LM over the shift and entered in a database for eventual evaluation for OEE reporting. The *cybernetics control* which is tracked by non-financial measures is always monitored by the LMs; it is like a ticking clock that leads to fast reactions from LMs. One team member reflected on a rather positive example and stated ironically that the supervisor had already been present at the station during a breakdown and immediately lent help. Thus, the overall presence of an LM is a motivational factor on the line and some LMs can transfer
this *cybernetics control*, the ticking clock, to their team members, and respondents report that it motivates a strong drive for speed and output. In addition, *cybernetics controls* tracked by non-financial measures support operator training. Based on observations at the case firm, well-trained operators can process their stations faster with fewer faults, resulting in higher output per shift (i.e., higher productivity). The required tracking of non-financial measures lets the LM focus on two items, first, the effectiveness of stations and the mental condition of operators for certain stations that are distinguished by the complexity of tasks required. Nearly all respondents reflected that reactions to station breakdowns are essential to reaching high productivity targets, and it is the LM who influences the speed and efficacy of the reaction. The faster the problem is recognised, the faster it is addressed and the less productivity is lost.

The *control by rewards and compensation* is not as heavily involved in the assembly line as the *cybernetics control*, but at least for one task of each control problem its mobilization has a positive mobilised influence. Thus, the assignment of new stations gives employees the chance to either receive a long-term contract with the firm, instead of a temporary worker assignment, or receive a higher payment level. Another example are the rewards received for catching up on production volumes after a breakdown; LMs appreciate the team and shift leaders’ efforts and production managers notice this performance. Such appreciation is also relayed in the weekly meetings as an element of motivation.

### 4.3 The dynamics of interrelationships between the management controls

The analysis at the case factory revealed that interrelationships between MCSs are dependent on the control problems addressed by the LMs for productivity outcomes (Figure 5). This takes place in the same manufacturing setting, the selected U-shaped assembly line, and is known as the ‘dynamics’ of MCSs. However, there are also similarities between certain interrelationships.

The analysis of interrelationships is based on the findings on the mobilised MCSs presented in the previous Sections 4.1 and 4.2. An interrelationship of MCSs exists, when two mobilised MCSs are connected. This is illustrated by the three detailed maps of control problems in Section 4.1 (Figure 2-4). Based on the interview data, some of the interrelationships seem to be more important than others which is indicated by the size of connecting arrows in Figure 5.

The dynamics of interrelationships is described below for the three control problems.
4.3.1 Interrelationships of MCSs for Control problem #1
Two interrelationships of MCSs for Control problem #1 (Assigning team members to working stations) related to productivity outcomes, are relevant in the case firm.

Even though the employee fluctuation in the case company is low, team members need to be replaced from time to time. The reason for this is a situation that arises through the existence of two controls. First, the planning control of long-range planning requires a certain percentage of temporary workers to react efficiently to volume volatility of customer orders for the next five years. Second, an administrative control, an agreement between union, working council and employer allows a maximum employment of temporary workers for 24 months, with increasing wages from 13th month on. Hence, both controls in combination have a negative effect on Control problem #1 and on productivity outcomes, since LMs need to substitute skilled temporary workers and train new ones. Numerous interviewees underlined the importance of a skilled teams with long-term co-workers for high shift output and few process interruptions due to operators’ mistakes. Another conflict situation reflects the technical organisational payment structure, an administrative control of working council regulations. Naturally, company leadership does not wish to employ too many high-salary personnel (long-range planning control), whereas the work
council seeks to coerce the firm to employ as many high-salary personnel as possible. Many operators truly desire highly skilled personnel, even if they were to not receive the higher pay. Notably, the work council does not support this scenario.

The second interrelationship of MCSs refers to cybernetics control via non-financial measures (output per shift and downtime minutes per shift) and LMs’ action planning control to make station assignment decisions. This interrelationship is supports LMs’ goals to improve productivity outcomes. Both non-financial measures are omni-present to the LMs when making the station assignment decision. Thus, LMs monitor the speed of each single operator at different stations and place most skilled ones at the operational bottlenecks or technically critical stations.

4.3.2 Interrelationships of management controls for Control problem #2
For Control problem #2 (Managing the process interruptions) four interrelationships between MCSs could be identified through the analysis and two of them are described in this section.

First, is the relationship between the LMs and the maintenance staff which is very important for productivity outcomes in the case firm. This interrelationship is between cultural control of values and behaviour and action planning by LM for prioritization of proper action when managing interruptions. Notably, good personal relationships between LMs and maintenance personnel makes a stark difference, as interviewees stated, and their co-operative relationships are strengthened by the expert maintenance staff being on the same shift as the LMs. Notably, helpful behaviours from the LM can make a difference and can reduce downtime since staff is willing to react fast. Notably, as interviewees explained, this interrelationship can strongly support LMs in managing Control problem #1, but if the relationship between the LM and maintenance personnel is stressed, this interrelationship turns out to be conflicting, which is why this is labelled as a complex interrelationship (+/-).

Second, interviewees explained that standard rules exist in the case firm (administrative control) that regulate what positions of operators are allowed to fix what types of micro-stops on the assembly line. Thus, the LMs must decide whether they will personally resolve minor breakdowns or delegate. One respondent reflected that a rule exists in which team members can try to resolve a problem on their own trying to fix the malfunctions for 1–2 minutes and inform the LM afterward. The actions (planning control) to fix the micro-stops are strongly selected based on the length required to fix the problem. Thus, both controls support each other for managing productivity outcomes, because it prevents non-skilled operators from improperly fixing the problems and causing much longer breakdowns.

In addition, a similarity to Control problem #1 could be analysed, a positive interrelationship that exists between planning and cybernetics control. The non-financial measures (Planning) are also salient to the LMs when managing the process interruptions. Thus, the LM is judging the possible alternatives to manage an interruption by the effect it has on the breakdown minutes and output (cybernetics control).

4.3.3 Interrelationships of management controls for Control problem #3
In the case firm, for managing Control problem #3 to ensure the motivation of the team, four interrelationships exist between MCSs and two of them are elaborated below.
Planning and cultural controls interrelate positively for managing productivity outcomes. First, while planning and organizing weekly team meetings and pop-up meetings after a successful shift, LMs project values and perspectives to the team that underline importance of reaching shift targets. Thus, they appreciate team effort and individual performance and indeed were able to develop an intrinsic motivation. During the interviews, some operators reported that they enjoyed working at bottleneck stations because of the high pace, which satisfied their competitive nature.

A second, twofold positive interrelationship exists between Planning and Rewards and compensation control. Thus, in the planned team meetings sometimes single team members are elevated by the LM for extraordinary performance at the stations and are therewith rewarded. Furthermore, the planned and executed development and training results in good productivity results of a shift and the LMs themselves are rewarded by superiors for the outreaching shift results, which makes the LM visible and can be the base for promotion.

Furthermore, similarities of interrelationships have been investigated. An important conflicting interrelationship discovered for Control problem #1 is also present for Control problem #3 – the required exchange of temporary operators due to labour regulations which contrast with the labour flexibility requirements of the company to handle demand volatility.

5 Discussion and conclusion
For the objective to improve productivity outcomes on the shop floor, it is essential to understand first, how the multiple MCSs of the factory are mobilised through shop floor managers’ tasks and second, how the dynamics between these MCSs unfold dependent on the control problem. This study contributes to understanding these in multiple ways.

5.1 Understanding the specific control problems and related tasks for productivity outcome
Shop floor managers continuously handle multiple controls problems while improving the productivity outcomes of the assembly line team. The findings from this case firm suggest that shop floor managers influence productivity outcomes by managing three major control problems in daily recurring operations, which are, 1) assigning the team members to working stations, 2) managing process interruptions and 3) ensuring the motivation of the team. The findings show that the control problems which affect productivity outcomes can be understood through the analysis on task level. In this case, 12 tasks were analysed to capture the details of how managers make decisions and take actions for productivity improvement. This analysis has been widely neglected in OM research. Thus, this study contributes to the productivity management literature of OM and investigates what managers do to improve productivity outcomes in three ways. First, it expands the understanding of improving productivity, not only focusing on single improvement projects but also on the steady day-by-day management decisions on which productivity outcomes primarily depend. Second, this study agrees with Cai et al. (2018) and Moon et al. (2022) that the worker staffing problem (Control problem #1) and interruption problem (Control problem #2) are also relevant for improving productivity outcome in other factories. For both problems the study adds multiple details on management mechanisms. One example is that labour turnover, which reduces productivity, is not always an operator decision but forced by the firm to maintain worker flexibility.
5.2 Understanding productivity through interrelationships of multiple management controls

For improving productivity outcomes on the shop floor, not a single control in isolation but multiple types of MCSs are mobilised and are interrelated when applied by the shop floor task managers. The findings suggest that five types of MCSs identified by Malmi and Brown (2008) need to be considered for managing the three control problems related to productivity on the shop floor. These MCSs are, 1) Cultural controls, 2) Planning controls, 3) Cybernetic controls, 4) Rewards and compensation and 5) Administrative controls. For the single tasks, that constitute a control problem, many of them have multiple controls involved in their management but not all of them do (Table 1).

The identified conflicts and complementarities between the multiple MCSs provide a clue on why productivity outputs aims are not met. For instance, to name one conflicting example, based on the case findings, the tension between strategic and frontline controls predominantly arises through strategic labour flexibility which the firm needs to react to volatility of demand, and its conflict with union labour regulations which demand that temporary workers can only be held for 24 months without become fulltime employees. That creates tension for the LMs, since they permanently need to train new operators preventing them from having a stable team that generates higher productivity outcomes. Furthermore, the current study adds to the research of Bellisario and Pavlov (2018) that emphasised the closeness of operational controls to frontline but missed the details, as it explains what specific actions can be taken to control worker engagement, which are that LMs actively engage in their ‘role model role’ since operators copy their helpful behaviour, fostering strong, self-reliant teams. Another, complementary example from the case study partly confirms the findings of Nielsen et al. (2018) who identified that non-financial measures supplement social and behaviour control. The findings suggest that the salient presence, to LMs and team members, of the two productivity measures, output per shift and downtime per shift, complement the MCSs of rewards and compensation since they are the driver for activities on the assembly line; positive results can lead to promotion or just appreciation, fostering intrinsic motivation.

5.3 The dynamics of management control systems on the shop floor

This article contributes to the MC literature by elaborating how the MCSs are differently interrelated depending on the control problem to be addressed. The evidence suggests that the interrelationships between MCSs are dynamic in the same manufacturing setting and for the same objective, in our case, improving productivity output. Whereas previous studies tended to investigate only ‘tension dynamics’ – the dynamics on tension between MCSs that changes over time (e.g., Henri, 2006; Mundy, 2010; Stouthuysen et al., 2017; Van der Kolk et al., 2020) – this study examines dynamics arising from changing control problems, and can be labelled as ‘control problem dynamics’. Depending on the control problem managed, the dynamics are characterized by first, changing MCSs that interrelate and second, the character (complementing, conflicting, or both) between control problems. With this examination, the study contributes to knowledge on methodology for investigating the dynamics of MCSs. Only the fine-grained analysis of the single tasks, that constitute the control problems, allowed to identify the MCSs which are mobilised, which again was necessary to investigate the interrelationships between the MCSs. This aligns
with the understanding of Grabner and Moers (2003) that a mobilised set of MCSs always has an underlying control problem.

5.4 Contributions for practitioners
For practitioners, the study offers multiple details on how to actively influence productivity in daily operations as a foundation for specific competency training. Hence, the 12 tasks required to manage the three shop floor controls problems can be used for LMs assessment and promoting team members to LM position. The interrelationships between the MCSs identified highlight multiple options on how to remove barriers to improved productivity outcomes. Furthermore, the pursuit of improved interrelationships is key to LMs providing straightforward and timely training so that operators can improve productivity. In addition, this study contributes to strategic decision making of manufacturing firms and certain decisions could be put to test, for instance, the trade-off between keeping labour resources flexible but incurring daily obstructions to productivity outcomes.

5.5 Limitations and further research
As with any study this research has some limitations. Although multiple teams and job positions were included in the interviews, only a single factory case study was considered, which limits the generalisability of the results. Another limitation is that the LMs helped identify the team members who participated in the interviews. Nevertheless, they participated voluntarily.

Concerning future research, more research is needed on what managers do to improve productivity in daily operations. The three identified control problems for managing productivity on the shop floor could be evaluated in additional case studies in different factory environments with different lines and machine layouts, for instance machine groups. Further, the identified character between the multiple MCSs related to productivity improvements in manufacturing should be verified with additional surveys, and stronger empirical support or rejection; this would improve the generalisability of productivity improvement theory. Further, the identified dynamics of varying characters of interrelationships between MCSs need more descriptive research to adequately substantiate these types of dynamics in MCSs theory. That requires a definition of when varying characters of interrelationships between MCSs can be considered as ‘control problem dynamics’.

References


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Chapter 6 – Exploring the control problems and the interplay of MCSs for productivity – Article 3


Chapter 7: Discussion and conclusion

In this chapter, the findings derived from the three articles are summarised and discussed, and conclusions are drawn. In Section 7.1, the three dimensions of interrelationships that must be managed for productivity improvement are summarised. In Section 7.2, the findings of the theory (Article 1) are compared with the case findings of Articles 2 and 3. In Section 7.3, the relationships of the three dimensions are discussed, and implications are drawn for managing productivity in the factory, as a whole, from shop floor level up to the plant manager.

After the theoretical contributions are explained in Section 7.4, the benefits for practitioners are presented in Section 7.5. In Section 7.6, the methodological contributions are summarised. Section 7.7 provides the limitations, and Section 7.8 suggests future opportunities and research directions.

7.1 The three dimensions of managing productivity (Figure 7.1)

7.1.1 Dimension 1: Managing the interrelationships between the environment and resources

The first interrelationship dimension has a scope that extends beyond the factory and includes those of the external environment. This invokes the contingency view, in which organisations must adjust to external forces to be successful (Burns & Stalker, 1961; Lawrence & Lorsch, 1967). From this perspective, 83 elements were identified as affecting productivity improvement, and they were clustered into four element types: contextual (i.e., external environment and organisational), resources and management concepts (e.g., Lean concepts) and managerial elements (i.e., manager characteristics).

The interrelationships among the elements are characterised in multiple ways. First, they have value, with diverse positive or negative effects (or no effect) on productivity improvement. Second, interrelationships are distinguished by their ability to be controlled by management (Luthans & Stewart, 1977). The elements are interrelated, and many interrelationships exist between all four element types. Thus, many elements from the external environment (e.g., federal laws or raw material prices) affect factory operations and resource consumption, leaving the overall impact mostly outside the factory managers’ control. Additionally, interrelationships exist among the resources, product designs, manufacturing and sales. Understanding and managing these are essential to manufacturing a product (Fisher, 2007).
7.1.2 Dimension 2: Managing interrelationships among multiple MCSs

The second dimension of interrelationships was investigated, and according to the productivity improvement initiatives and projects examined in the case study of Article 2, six MCSs were found to interrelatedly affect productivity improvement. These MCSs are the major elements of manufacturing systems (Mintzberg & Quinn, 1996), and they consist of single elements. From the case study, we identified 13 single elements belonging to one of the identified MCSs. Thus, a single element of one MCS interrelates with the elements of other MCSs.

For the managerial task of productivity improvement, multiple examples of different types of interrelationships were identified and investigated, being complementary, conflicting or show tension complexity (Friis et al., 2015; Malmi and Brown, 2008; and van der Kolk et al., 2020) as three examples illustrate: First, a complementary interrelationship arise for example, when the strategic goal of the factory OEE measure, an element of the strategic performance management system, is seized by an leading engineer, and triggers productivity improvement actions (as part of PIS) for instance, forming a team for cycle time reduction on an assembly line. Second, MCS interrelationships may demonstrate conflicting characteristics, such as when cycle-time balancing actions cannot be realised because quality standards (part of a standard control system) are not followed, for instance by eliminating a quality check. Third, examples of tension complexity (Van der Kolk et al., 2020) were identified between three of the six MCSs at the case firm, for instance, between the strategic performance measurement system and the PIS: on the one side, the complementary goal setting process of BSC is initiating productivity projects, but on the others side, funds for capital-intensive productivity enhancements on the machines are judged in a difficult release process, slowing down improvement initiative. Therewith, the latter is an example, as the tension complexity creates finally an advantage for overall profitability of the factory.
7.1.3 Dimension 3: Managing the interrelationships arising through the control problems on the shop floor

The third dimension of interrelationships for productivity improvement was investigated in the context of a factory shop floor. The findings of the case study indicated that productivity improvements are predominantly not pursued by whole initiatives and projects. Instead, they are applied through daily work via value-added tasks that address three major control problems.

For this dimension, the major manufacturing system elements are working stations, process interruptions and the motivating elements of line managers, as well as mobilised MCSs. The interrelationships among these elements can be viewed as a network of tasks, conditions and decisions synthesised as the management of control problems. To pursue productivity improvements, the case study showed that the interrelationships between the mobilised MCSs are characterised by dynamics—the dynamics arising through different control problems.

7.2 Similarities and differences between theory and the case findings

7.2.1 The relationship between CT elements and MCS elements

One difference between Articles 1 and 2 and 3 is the applied theoretical lens, for the former one the CT and for the latter two MCS theory. Hence, the notion of system elements is different, helping in understanding how the major elements identified in Article 1—the nine themes—relate to Articles 2 and 3’s MCSs. Although the understanding of contextual variables can be assumed as common for both system theories of all three articles, the management variables and resource variables of Article 1 need to be linked to the MCSs of Articles 2 and 3.

Thus, the five resource themes of (1) manufacturing process condition and outcome, (2) product design and portfolio, (3) supply chain management category, (4) technology level and (5) workplace conditions can be understood as elements of MCSs. Hence, they and their antecedents (the single variables) can belong to any type of MCS, for example, informal-, formal-, input-, behaviour- or output control, and can relate in a complementary, conflicting or complex manner in the pursuit of productivity improvement.

In contrast, the two management variables represent the active control of managers through their intervention to manage the interrelationships between MCSs for productivity improvement (PI). First, the management theme represents the managerial actions in manufacturing that are pursued to alter and change elements such as levels of functional and strategic alignment in a company or diversified direction and feedback towards employees. Second, the management concepts theme includes elements representing concepts that management implements to reach PI, such as Lean concept maturity or total quality management and assurance (TQM/A) levels.

7.2.2 Complexity

The comparison of complexity between theoretical findings (Article 1) and case studies (Articles 2 and 3) suggests that the complexity managers face for improving productivity depends on the managerial level of the manager and has multiple dimensions inherent within it.

The SLR in Article 1 identified 83 variables that relate to productivity and 108 interrelationships that exist between resources variables; hence, it is reasonable to assume that
there was an all-over high complexity that managers are facing in their endeavour for PI. The two case studies provided a more differentiated picture. Thus, on the one hand, the complexity that line managers faced on the shop floor, as examined in Article 3, here as determined by the quantity of different control problems they must manage, was low. They had to manage only three control problems. On the other hand, the complexity at the shop floor level arose through the high social interactions that managing the control problems requires. LM needed to sense the mental situation of their team members and assign working stations accordingly. LM needed to maintain and manage a friendly relationship with the maintenance staff so that their assembly line is quickly served. Further, LM needed to sense who the skilled team members were within the plant to bring onto their team, first convincing their superiors. Thus, the complexity for shopfloor managers is a social one.

For managers on the meso level in the case firm, as examined in the case study of Article 2, the empirical data suggest that complexity arose through the multiple interrelationships to be managed among the six MCSs, including, in total, 13 connecting elements. Thus, it was about keeping the improvement initiatives running and managing conflicting interrelationships, for instance, fighting for funds for improvements on the equipment that ensure a higher productivity outcome afterwards, convincing the working council to approve higher cycle times at certain assembly line stations or select a team and convince members to be responsible for an improvement project, for instance, for an output increase or scrap reduction. Hence, for meso-level managers, complexity had a broader character than for line managers on the shop floor because of the different problems they need to address.

### 7.2.3 Applied interventions to manage complexity

A major finding of the SLR in Article 1 was the six interventions managers apply to reduce the complexity they are facing in managing productivity. These interventions are mirrored through the interventions in the two case studies of Articles 2 and 3, which used the theoretical findings as a departure point. The case studies provided examples of how all six interventions discovered in the SLR could be found in practice (Table 7.1). Their realisation in the case firm added interesting findings on these interventions, as the following discussion on the six interventions illustrates.

Thus, on the alignment of controls, as the case studies have shown, managers at the meso level, who tended to be department managers, the plant manager and leading engineers, had a different understanding of balanced control. Thus, the alignment among the managers could be seen as a new aspect. Thus, one department manager perceived the vertical control of another manager as a way to loose, emphasising a stronger vertical control towards the fulfilment of action plans. On the micro level, line managers on the shop floor practice a control that could be understood as balanced. On the one hand, they were present at the team member stations as soon interruptions appeared, almost shadowing team members. On the other hand, as an example of the ‘loose’ aspect of control, they tried to consider the wishes of their team members regarding assignments during the shift.
Table 7.1: Comparison of theoretical and case findings on managers’ intervention

<table>
<thead>
<tr>
<th>Managers’ mediating interventions of theory</th>
<th>Managers’ mediating interventions in the case</th>
<th>Managers’ mediating interventions in the case</th>
</tr>
</thead>
<tbody>
<tr>
<td>On the macro level (Article 1)</td>
<td>On the meso level (Article 2)</td>
<td>On the micro level (Article 3)</td>
</tr>
<tr>
<td>All levels of managers</td>
<td>Plant manager, department manager, engineers</td>
<td>Assembly line manager (Shop floor level)</td>
</tr>
<tr>
<td>• Balanced set of tight and loose control (vertical and horizontal)</td>
<td>• Different understanding of a manager what is the right balance of alignment</td>
<td>• Balanced towards team members</td>
</tr>
<tr>
<td>• Implementing integrated and joint optimisation</td>
<td>• Managers need to consider multiple MCSs when improvement initiatives</td>
<td>• Continuous swaps between three control problems, which are many every day</td>
</tr>
<tr>
<td>• Operator empowerment from the beginning of initiatives and their voluntary participation</td>
<td>• The internalisation mechanism shows a high intrinsic motivation for improving projects</td>
<td>• Line manager are minorly involved by daily work throughs</td>
</tr>
<tr>
<td>• Controlling line managers’ work allocations</td>
<td>• Widely no evidence that production managers actively decide LM work allocations</td>
<td>• This level is the receiver of this intervention</td>
</tr>
<tr>
<td>• Applying management concepts (e.g., Lean concepts)</td>
<td>• 5S, TPM, OEE, line balancing, Lean Six Sigma for scrap reduction</td>
<td>• LM has time to support team members</td>
</tr>
<tr>
<td>• Installing technological solutions for productivity improvement (PI) information evaluation</td>
<td>• OEE database available, MES missing</td>
<td>• OEE database and dynamical line Board about line output and trend</td>
</tr>
</tbody>
</table>

Both case studies contributed details on integrated and joint optimisation for productivity. Although the theoretical findings widely referred to involving multiple departments and initiatives in the activities, the findings suggest that managers at the meso level needed to consider the conflicting interrelationships between MCSs to mitigate them. One such mitigation method was the cross-functional teams in place, where barriers to improvement were discussed, for instance, quality constraints for a technical change at line cells.

Empowerment of employees was another complexity-reducing intervention, and theoretical findings have shown the empowerment of people to participate voluntarily in improvement projects. At the meso level of the case firm, empowerment happened by dedicating improvement projects to engineers or technicians who were responsible for managing the improvement project independently. These people gathered other employees around them to run the improvement project, requiring high intrinsic motivation. Although the improvement projects were delegated to the engineers and technicians, two theoretical interventions were combined. First, the employees were involved from the beginning, and second, their time allocations for productivity projects were ensured. On the micro, shop floor level, in the case firm, line managers did not run
improvement projects but made proposals for improvements. They were widely not part of an improvement team but were consulted for their opinions. Hence, the management level decided on the type of bottom-up contributions made for PI.

The theoretical findings emphasise that managers should apply *standardised management concepts* (e.g., tools from Lean), reducing the complexity because ready concepts do not need to be developed. Although the literature has suggested the implementation of numerous tools, the managers in the case firm applied only a selection of these tools. In the case firm 5S, elements of TPM with OEE and line balancing were applied, as well as Lean Six Sigma, to reduce scrap and improve materials productivity. The respondents in the case study pointed out that the usage of Lean concepts could even be extended with dedicated Lean personnel who could introduce Lean concepts into the factory.

### 7.3 The relationship between the three dimensions of managing productivity

By comparing the findings of the SLR (Article 1) and case studies (Articles 2 and 3), the three dimensions of managing productivity were found to be related. Based on the four connecting elements, this is exemplified in Figure 7.2.

![Diagram](image)

*Figure 7.2: Examples of the relationships of three dimensions of interrelationships managed for productivity.*
First, at the macro level, the management of resources and involved complexity was a central finding in the SLR of Article 1. Here, 108 interrelationships were identified among resources at the macro level. According to Article 1, it was the task of manager who had to align contextual elements and resource elements. At the meso level, in Article 2, we found this coordination between resources and context in the management of interrelationships among the six MCSs. One example was the mitigating element of cross-functional teams. Different resources and functions in a factory were improved cross-functionally and together because most initiatives were interrelated. At the micro level, we found the management of resources, especially labour, in managing control problem #1, that is, assigning team members to working stations.

Second, the example of the ‘labour laws’ elucidates how the management of a contextual variable, first identified in the SLR of Article 1 at the macro level, connects the macro and micro levels. At the micro level, as analysed in Article 3, the existing ‘labour laws’ led to conflicting interrelationships between the ‘planning controls’ and ‘administrative controls’ of control problem #1 because the labour laws required that temporary workers be exchanged the latest after 24 months of employment to avoid an unlimited contract. An unlimited contract for all employees would prevent the case firm from having a certain labour flexibility to adjust to volume fluctuations. For this reason, the line manager, at the micro level on the shop floor, needed to mitigate the problem by regularly training new employees who could reach the required productivity level.

Third, the SLR identified management concepts at the macro level as beneficial for managing complexity. The analyses at the meso level revealed that the case firm held monthly management team meetings to review BSC cards, including productivity measures such as production OEE, which is part of the Lean concept of TPM. The analysis at the meso level showed that OEE was also reported outside the plant in corporate management, and there were corporate standards for how to measure OEE. The case study at the micro level revealed that the presence of productivity measures, such as output and breakdown minutes, were omni-present and major drivers for managing control problems #1 and #2. This illustrates how the three dimensions were connected and how even an intermediate dimension, the corporate level, was connected.

Fourth, the decomposition of the productivity improvement systems (PISs) into control problems underlines the connectiveness of meso and micro levels. Thus, as identified regarding the meso level in Article 2, the PIS was the central MCS, working as the engine to drive actions and manage productivity improvement in the factory. At the micro level, three control problems related to productivity were the point of departure to be managed by the line manager on the shop floor. Thus, the PIS was not necessary at this level, and action planning was instead dedicated to ‘cybernetics control’.

Hence, the findings of the SLR and case studies suggest that managing PI needs to be understood as an integrated concept involving three dimensions of management at the macro, meso and micro levels, which are related at not independent. Furthermore, the corporate level, as an intermediate level, seemed to be relevant in managing global productivity, especially through strategic priorities, corporate goals and corporate standards.
7.4 Theoretical contributions

7.4.1 Understanding multidimensional productivity management

The present dissertation conveys a new understanding that productivity management must be understood as a multidimensional responsibility of managers in the manufacturing system, showing how it involves highly individual decision-making opportunities that result in differentiated activities and tasks. The findings suggest that the three dimensions of interrelationships (macro, meso and micro levels) can be considered as related and that managers at the different levels must deal with the same control problem at their stage. Hence, managers’ activities and tasks depend on the dimensions of the interrelationships that lead to different approaches for management. However, managing PI in the factory must be understood as multidimensional.

For the three dimensions, the managers experienced managing productivity as a complex network of numerous tasks and decisions involved in aligning the elements of the system, such as the assignment of a working station and capability of team members (Article 3). In another dimension, the meso level, the managers faced multiple MCSs, in our case six different MCSs, and focused on the mitigation of a single conflicting interrelationship between two MCSs (Article 2), for instance, to foster a cross-functional team to work together on a productivity improvement initiative. In addition, the managers were confronted with numerous options to control resources from the external environment, for instance, when managers initiated the involvement of the manufacturing department and sales department in the product design process, which was essential for creating an effectively manufacturable product (Article 1).

We can conclude that three major responsibilities fell on managers to manage productivity improvements in the factory. First, six mediating interventions, those that could be found at the macro-, meso- and micro level of the factory, were described as being able to reduce and handle the complexities that could arise from the multiple options to improve productivity and the manifold interrelationships between resources and functions. Second, the activities of managers to remove barriers of conflicting interrelationships and foster complementary ones were identified, leading to the application of three general management mechanisms: communication, internalisation and socialisation (Article 2). Third, three major control problems that managers handle on the shop floor to enhance the productivity outcome of their teams were identified (Article 3). This contributes to the sparse research on control problems and tasks involved in the day-by-day management of productivity outcomes (Cai et al., 2018; Moon et al., 2022).

7.4.2 Systems view for managing productivity in factories

Furthermore, the present dissertation provides a systems view for managing productivity in factories, which has been underaddressed in OM literature. The key is the identification of conflicting interrelationships between manufacturing system elements that have been hidden before and that now become transparent through the multidimensional systems view applied. These new insights add knowledge to the manufacturing system elements, the interrelationships between them and the managerial actions and tasks implied for mitigating the conflicting interrelationship with the aim of accelerating productivity growth. This contributes to the almost
30-year-old and widely unanswered call of Harris (1994) for more insights into the organisational linkage of interrelationships concerning productivity.

From a systems perspective, the current dissertation further adds to the understanding of manufacturing systems elements. To manage productivity in factories, at least 83 single manufacturing system elements must be involved, which adds many improvement options for managers. Managers can include elements in their considerations that are quite heterogeneous in nature. Hence, five different types of manufacturing system elements can be managed: factory resources (Articles 1, 3), MCSs (Article 2), management concepts, for example, Lean (Articles 1–3), the elements of the organisational context (Articles 1, 2) and the external environment (Article 1). Manufacturing system elements exist, even in a hierarchy that has been described in other fields like management accounting but has been widely neglected in OM. Elements such as a MCS comprise elements that are interrelated with the elements of another MCS. This contribution to the character of elements adds to the research of Rantanen (2001), who identified internal obstacles to PI that can be controlled by managers; the present dissertation explains what these elements are.

7.4.3 Understanding the complexity of managing productivity in factories

The findings of the current dissertation convey a detailed understanding of the complexity of the endeavour to improve productivity in factories. Generally, high complexity emerges for managers because of the up to 83 elements involved, resulting in numerous options to improve productivity and the manifold interrelationships between resources and functions that need to be managed. Further, complexity can increase when a conflicting and complementing interrelationship of MCSs come together. Low complexity could be found in the low amount of different control problems. In total, line managers engage in three control problems on the shop floor to manage their teams for PI. In contrast, on the assembly line, high complexity for shop floor managers arises from the many tasks connected to the single control problems involved in one of the three roles that result in a task network determined by the social engagement of the manager; for instance, sensing team members’ needs, as discussed in Article 1. Hence, complexity to the manager is heterogenous in managing productivity in the factory.

7.4.4 Understanding of middle managers in factories

The present dissertation adds to the literature on middle management regarding their roles and the hierarchical levels of the factory in the pursuit of PI. Concerning roles, although the management literature has predominantly focused on translating upper management strategies into operations (Balogun & Johnson, 2004; Mantere, 2008; Wooldridge & Floyd, 2017), the current dissertation offers a less obvious view in which the elements of the strategic orientation of the firm are elements of line managers’ understanding (Article 3). Hence, their managing role in relation to PI is to keep improvement activities running in a step-by-step manner. To drive continued productivity, middle managers must routinely gather their team to define and follow up on action plans and determine how to overcome barriers and resolve conflicts (Article 2). Hence, daily management is what realises PI, not necessarily the direct implementation of the strategy. The current dissertation answers the call of Rahmani (2018), who stated that there is limited research
in OM examining the day-to-day management of teams. Apart from middle management roles, the present dissertation adds to the understanding of hierarchical management levels in factory settings. The findings from the case studies showed that there were multiple levels of management and multiple hierarchical levels of middle managers, such as production managers as department heads and production area managers for assembly and machining. Below them, there was shift leader, followed by line managers. Although scholars have referred to different managerial levels when discussing middle management, the fact that middle management itself is stratified within a single organisation is important. In this case, four management layers between plant managers and operators were found (Articles 1 and 3).

7.4.5 Contribution to the management control literature
The present dissertation contributes to the MC literature in two ways. First, it has examined how and why multiple MCSs interrelate at the shop floor level, the lowest managerial level that has been sparsely represented in the research on multiple MCSs. Second, it has elaborated on a new type of dynamic on the interrelationships between MCSs, a dynamic that comes from multiple control problems addressed in parallel in the same manufacturing setting and for the same objective, in our case improving the productivity output, which could be termed ‘control problem dynamics’. Studies on dynamics in MCS research have mainly focused on investigating ‘tension dynamics’—the dynamics on tension between MCSs that change over time (e.g., Henri, 2006; Mundy, 2010; Stouthuysen et al., 2017; Van der Kolk et al., 2020).

7.5 Contributions to practitioners
Because productivity management is central to this dissertation, it provides multiple contributions to factory managers.

First, the present dissertation illustrates that, for both middle managers and senior managers, PIs must be understood as a complex task involving multidimensional interrelationships. Considering these interrelationships at the macro (i.e., factory and environment), meso (factory) and micro (shop floor) levels, managers now have improved guidance on selecting the proper actions. As such, senior managers must provide the necessary resources for extensive productivity assessments, including the funds and time to train managers and operators, as opposed to turning to branded models (e.g., Lean).

Second, the catalogue of 83 elements is structured into nine themes that display the influence on productivity so that line managers can leverage them to improve productivity outcomes (Article 1). Importantly, six managerial intervention methods were identified to handle the complexities of facing numerous options. From this perspective, the current dissertation provides major managerial benefits via its deep insights into how managers can effectively manage and organise their resources for PIs.

Third, the findings highlight the general management mechanism of socialisation as a grounding function for actions. Thus, a principal element of managing productivity is fostering a strong work culture and norms to increase the intrinsic motivations of employees (see Article 2). Article 3 explained the concrete steps managers can perform to achieve improved socialisation among team members, such as sensing social and technical problems and being sensitive to the
individual needs of team members. Furthermore, LMs should work to assist team members in
developing their skills and abilities.

Fourth, to manage productivity, the technical aspects of the production equipment are
relevant, which can be seen in the results in Articles 1 and 3. Thus, the layout of an assembly line
should be tailored to support or hinder communications. A U-shaped design in which operators
work on the inside allows them to monitor and support each other; moreover, nonverbal
communications can be improved by proximity. Assembly lines with separate stations and remote
operator functions offer little interaction, rendering self-help and teamwork more unlikely.

Fifth, the current dissertation adds to the discussion of identifying relevant productivity
measures for manufacturing environments. Although the OM literature has highlighted OEE and
hours-per-vehicle for car assembly production (Abolhassani et al., 2018, 2019), the findings of
the present dissertation show that labour productivity is also relevant in other sectors, which come
with their own useful metrics, such as output per shift and downtimes minutes. Furthermore, the
findings indicate that not only labour productivity alone, but also material productivity, provides
significant value to factory productivity evaluations.

7.6 Methodical contributions
The methodological contribution of the present dissertation refers to the application of theories in
which we applied an established theory in a new way in the given domain and combined
theoretical perspectives to achieve new insights.

First, the theory of multiple MCSs, which was developed in the management accounting
domain (Otley et al., 1995), was specifically applied to the OM field for PI. This is a novel twist
in that, normally, a single MCS perspective is presented. By applying a multiple MCS perspective,
important dimensional interrelationships were identified as helping identify conflicts between
MCSs in factories that hinder PI and allow managers to mitigate issues. This approach also goes
far in describing the PIS in the case firm, which can be understood as the engine of productivity
improvement.

Second, applying multiple systems views combined with CT and MCS theory assisted in the
construction of a brand-new picture of productivity management. The resultant three-system view
allowed for taking advantage of a systems perspective that reduced complexity and improved
understanding (Checkland, 1981). On the other hand, by applying two different systems views of
three dimensions to the problem, additional nuances were identified that probably would have
remained hidden. Hence, the multiple systems view provided a new picture so that we could
increase the understanding of the problem while receiving sufficient details that allowed
meaningful differentiations of meaning.

7.7 Limitations
The first interrelationship dimension (i.e., environment and resources) was based on a systematic
literature review of the top five OM journals over the past 40 years. Hence, a broad base of
empirical data was included, which offered reasonable generalisability. However, the findings of
the second and third dimensions were based on a single case study. Hence, the major limitation
of the present dissertation is the unique case that provided all of the empirical data used for
analysis. This unique and revelatory case (Yin, 2003) provided deep insights into strategy, structure, functions, processes, meetings and employee dialogue, which would have been otherwise inaccessible to other researchers.

However, in real work, factory characteristics differ, and some emphasise productivity improvement less than the case factory. Additionally, managerial hierarchies differ. These and other elements will lead to variations in the elements and their interrelationships; hence, various other managerial tasks will emerge. Therefore, the overall generalisability of these results is limited.

7.8 Future research

Future studies should explore the different interrelationship types involved in productivity improvement, such as with scenarios with two MCSs, in which managerial tasks are required to simultaneously align multiple productivity improvements. To increase the generalisability of these findings, additional cases should be examined to provide deeper insights. Moreover, surveys should be considered, in addition to interviews to capture and mobilise the many detailed factory settings involved in productivity measurement. Quantitative methods based on archival data containing real productivity outcomes should be studied and compared across multiple shopfloor teams. Hence, individual line managers’ effectiveness can be assessed and differences identified.

Another way to expand the current research is to examine additional productivity management methods for factory settings. The present dissertation explored the elements and interrelationships involved in managing factory productivity from the perspective of systems views, and important managerial tasks were described based on the three dimensions of productivity improvement. In turn, these findings should provide a solid foundation for constructing new productivity management system methods for sparse and single-sided OM studies on this type of system.

Finally, although the current dissertation suggested reasons for productivity slowdown that are often not recognised or wrongly managed and the conflicting interrelationships among manufacturing system elements were highlighted, future studies should aim to explicitly determine the reasons why productivity grows and declines in manufacturing settings and in OM in general.
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