# 1 Introduction

*This chapter shows the practical relevance and provides the theoretical background of the research area of productivity measurement in production. Based on the background, the research problem, purpose, and scope are formulated. Furthermore, the research questions, research strategy, method, and process are presented. The chapter concludes with the thesis outline.*

## 1.1 Background

Paul Krugman, who received the Nobel Prize for Economics in 2008, once said:

*"Productivity is not everything, but in the long run, it is almost everything." (Krugman, 1997)*

Daniel A. Wren (1987) referred to labour productivity and the importance of managing human labour.

*"Achieving outstanding performance through the management of human resources is a practice that has existed in civilizations as long as people have tried to achieve common goals." (Wren, 1987)*

The importance and meaning of productivity for companies' competitiveness is unanimous (Tangen, 2005; Grossman, 1993), especially on the operational level, where value is created and customer orders are fulfilled (Slack & Lewis, 2008). Productivity can be described as a performance measure that quantifies the efficiency and effectiveness of processes (Neely et al., 1995).

Productivity is often misunderstood, however, or not fully understood and is often used as a substitute for similar terms such as efficiency, effectiveness, or performance (Tangen, 2005; Singh et al., 2000; Sink & Tuttle, 1989; Broman, 2004). Different understandings result in different approaches to measuring productivity. Several researchers have identified the problem and provide a shared vocabulary and definitions to ensure a shared understanding (Tangen, 2005; Dikow, 2006); however, the definitions are not sufficiently clear to be implemented and used as improvement drivers at the shop floor level (Andersson & Bellgran, 2015).

*"Even if productivity represents one of the most important basic parameters governing economic production activities according to Singh et al. (2000), measurement and improvement regimes are often built without a clear understanding of what is being measured and improved." (Andersson & Bellgran, 2015; Tangen, 2005)*

Regarding existing approaches to productivity measurement, the literature provides few overviews which regard non-uniformly structured collections of different approaches (Balakrishnan & Pushpangadan, 1998; Tangen, 2005; Card, 2006; Gidwani & Dangayach, 2017; Goel et al., 2017).

Gidwani and Dangayach (2017) provide a brief overview of performed productivity studies in India, including main productivity measures divided into types of input measures and output measures, a few factors influencing productivity, and an evaluation of thirteen productivity improvement methods. The primary result is an overview of 73 techniques for productivity measurement and improvement from 1983 to 2015 with their respective purpose and key findings.

To the author's best knowledge, the contribution of Gidwani and Dangayach (2017) represents the most comprehensive and up-to-date overview of techniques for productivity measurement or improvement.

Despite the large scope, their overview includes shortcomings: First, it only addresses two aspects of purpose and key findings in text form; second, different techniques are discussed individually without comparison or differentiation between individual techniques; third, the individual approaches are not classified besides the distinction between productivity measurement (PM) and productivity improvement (PI).

The existing overviews thus do not allow a comprehensive comparison and evaluation of existing approaches to productivity measurement. Furthermore, most approaches are too theoretical and complex to be applied in practice (Günter & Gopp, 2020).

## 1.2 Research problem, purpose, and scope

Companies struggle to measure productivity on the shop floor, especially labour productivity. Current approaches are simplified for practical use but insufficient to capture all essential factors influencing productivity. Therefore, the use of productivity as a key figure and improvement driver on the shop floor is not possible or only to a minimal extent.

The literature provides insufficient answers for productivity measurement, and there are no overviews that comprehensively present existing approaches. Therefore, it is not possible to uniformly compare and evaluate them.

This thesis provides an overview by presenting and classifying existing approaches to productivity measurement based on elaborated characteristics of productivity. The overview serves to identify the gap between productivity measurement in practice and the approaches presented in the literature. The goal is to close the gap by developing a new, unified approach to measuring labour productivity on the shop floor.

The scope of this thesis is limited to labour productivity measurement on the shop floor in existing production systems with processes performed by human resources. Thus, the developed approach is intended for manual and semi-automated processes on the shop floor; however, a possible adaptation to automated processes is discussed at the conclusion.

## 1.3 Research questions

The research questions are formulated based on the background, research problem, purpose, and scope presented in the previous chapters:

1) *How can existing approaches to productivity measurement be classified and presented in an overview to allow comparison and evaluation?*
2) *What approaches do companies use to measure productivity for manual and semi-automated work, i.e., labour productivity, on the shop floor?*
3) *How can labour productivity be measured on the shop floor prospectively?*
    a) *What key factors and aspects should labour productivity measurement include?*
    b) *How can these factors and aspects be mathematically expressed to model a new, unified approach to labour productivity measurement on the shop floor?*

## 1.4 Research strategy, method, and process

This thesis focuses on productivity management and particularly labour productivity measurement. The basic fundamental research theory for productivity management is interdisciplinary.

On the one hand, productivity management is based on operations management (OM) research, which is a part of management sciences research. Management sciences research provides knowledge for the effective management of an organisation. This knowledge can be applied to a variety of real-world management and business problems and situations (Machado & Paulo Davim, 2019; Karlsson, 2009).

OM research is a "[…] problem-solving discipline, seeking to create knowledge by interacting with the real world" (McCutcheon & Meredith, 1993; Lewis, 1998). Therefore, OM aims to "[…] develop valid and relevant knowledge that can directly or indirectly support managers' problem-solving efforts" (Tang, 2015; Boyer & Swink, 2008). The research area regards operations that include both services and manufacturing (Karlsson, 2009).

On the other hand, productivity management is based on engineering research, more specifically on industrial engineering (IE) research. IE, which has consistently pursued the optimisation of work systems and processes since its historical beginnings, plays a

particular key role in increasing labour productivity (Spanner-Ulmer, Hensel & Höhnel 2011). In the understanding of modern IE, it is important to consider the productivity development, of company processes in a systematic and management-oriented context (Dorner, 2014, Stowasser, 2011). Therefore, productivity management is a core task of modern work organisation and IE (Stowasser, 2011).

Concluding, there is a strong connection between productivity management, OM, and IE.

Like most management sciences research, OM is based on an explanatory research strategy, which aims to explain the present or past to understand the casual model by focusing on relations between causes and outcomes (Van Aken et al., 2016).

Other research strategies are used in OM research, such as the design science research (DSR) strategy which focuses on improving the present and can be described as follows:

*"DSR is conceptualized as a research strategy, aimed at knowledge that can be used in an instrumental way to design and implement actions, processes or systems to achieve desired outcomes in practice. DSR is driven by field problems or opportunities; instrumental knowledge is developed by deep engagement with these real-life OM problems or opportunities." (Van Aken et al., 2016)*

DSR is widely used in other academic disciplines, represents the main research strategy in engineering, and can be regarded as an engineering approach to OM. The approach contains the following steps: "Analyze the problem, design a solution, and develop it further in cycles of testing and redesign" (Van Aken et al., 2016).

Although explanatory research and DSR might be viewed as opposites, both research strategies are considered as complements.

*"DSR […], in fact, consist of two components, respectively descriptive/explanatory and design/testing. The first provides a solid foundation for the second by cultivating a deep understanding of the field problem for which the second component produces improvement-oriented knowledge." (Van Aken et al., 2016)*

Two other research strategies are similar to DSR: Action Research has similar characteristics but has "[…] important differences, mainly that most action research projects aim for case-specific improvements. DSR, by contrast, seeks to develop generic knowledge to support organisational improvement actions" (Van Aken et al., 2016). As a second strategy, Evaluation Research "[…] normally tests the effectiveness of a given system or process, while field testing in DSR also has a crucial function in optimising and generalizing a design" (Van Aken et al., 2016).

A final distinction should be made between DSR as a research strategy and consultancy.

*"DSR aims to improve, like also consultancy does. However, consultancy aims to improve a local context through case-specific designs, while academic research aims for generic knowledge that can be transferred to various contexts within a specified application domain." (Van Aken et al., 2016)*

It is important to emphasise that DSR is a research strategy and not a specific research method and therefore does not provide fixed rules but can be operationalised in different ways (Van Aken et al., 2016).

Because DSR is a real-world problem-solving research strategy, a suitable practice-oriented research method, i.e., one triggered by a practical problem, must be applied. The research method is thus based on Ulrich's research process as the foundation for applied research, because Ulrich's interdisciplinary research approach is practical, open, and integrative, and it regards the interactive combination of practical experience and empirical observations using basic and formal sciences (Schuh et al., 2013; Ulrich, 1984).

*"In the applied sciences, the generation of practical knowledge is at the forefront. The problems of the applied sciences are the result of the practical context, especially in the case of practical problems for which scientific knowledge is not yet available." (Ulrich, 1984)*

The research process begins with a practical problem, which is initially captured and described (Ulrich, 1984). This corresponds to the procedure in DSR, where the problem is captured, described, and analysed in a first step.

Problem-relevant theories, concepts, and solutions are subseqeuently examined in the literature to determine which provide answers to the described problem. For problem aspects which lack answers, new solutions are developed and applied (Ulrich, 1984), which corresponds to the framework of DSR involving the development of a generic solution.

The results are examined and practical recommendations are given (Ulrich, 1984), which corresponds to DSR, where the developed solution is tested and, if necessary, further developed.

Ulrich's (1984) research process is described in Figure 1, and the individual steps are adapted to the research approach applied in this thesis.

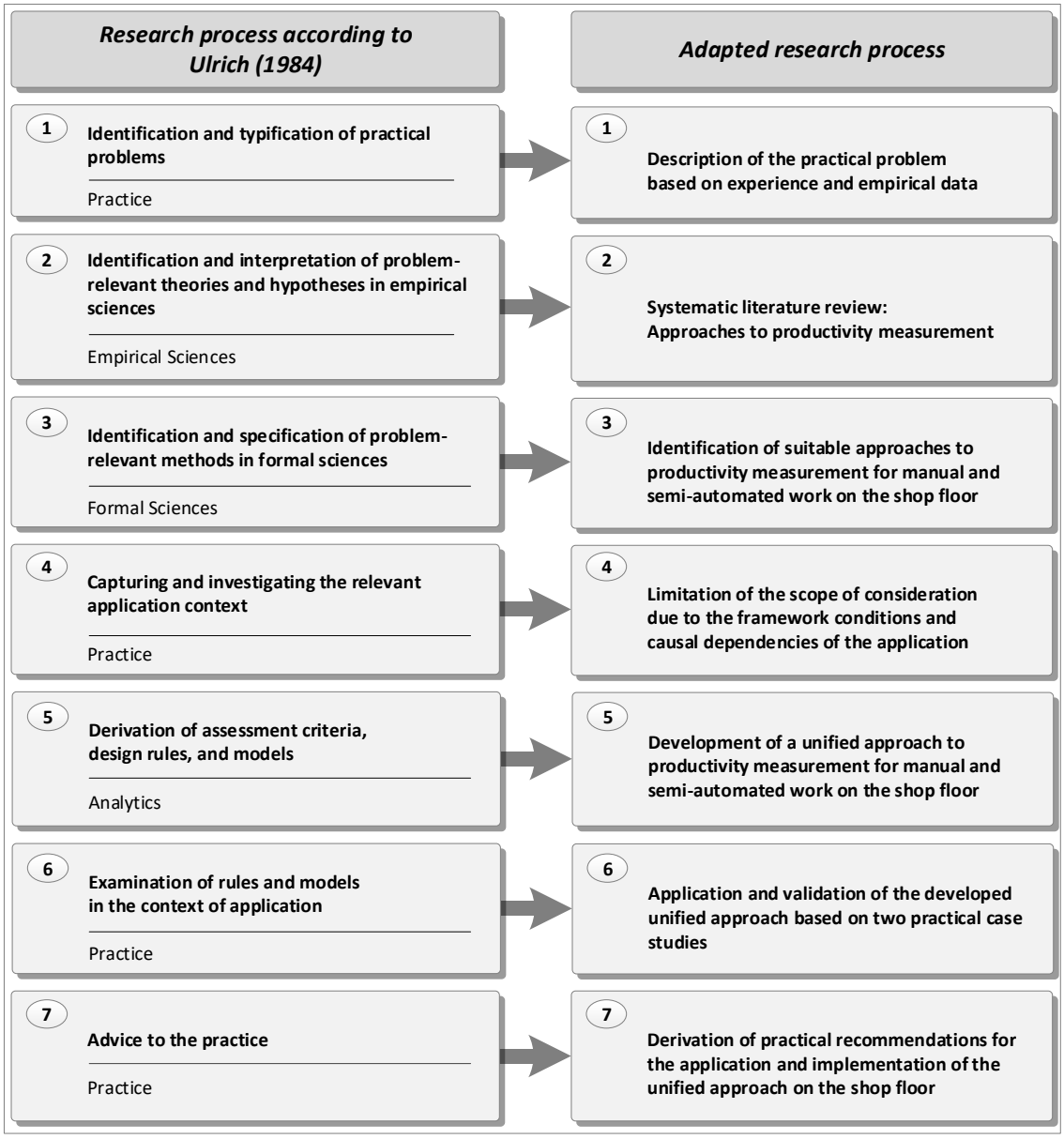


**Figure 1: Adapted research process (Ulrich, 1984)**

For a better understanding, the research process with all research activities is shown chronologically in Figure 2.

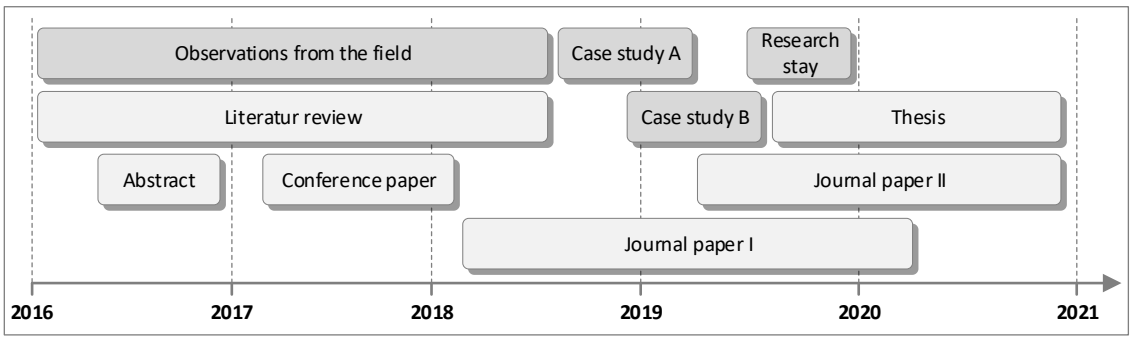


**Figure 2: Research activities in chronological order**

## 1.5 Thesis outline

This thesis is structured according to the adapted research process of Ulrich. In the second chapter, the central characteristics of productivity are described, while the third chapter presents and classifies existing approaches, based on the criteria developed in Chapter 2, along with suitable approaches for measuring labour productivity. Chapter 4 shows how labour productivity is currently measured in practice, while Chapter 5 develops a new, unified approach to measuring labour productivity on the shop floor. The developed approach is validated based on two case studies in Chapter 6. Chapter 7 presents a conclusion, provides answers to the research questions, and indicates possible limitations and suggestions for future research.

The thesis outline is shown in Figure 3.

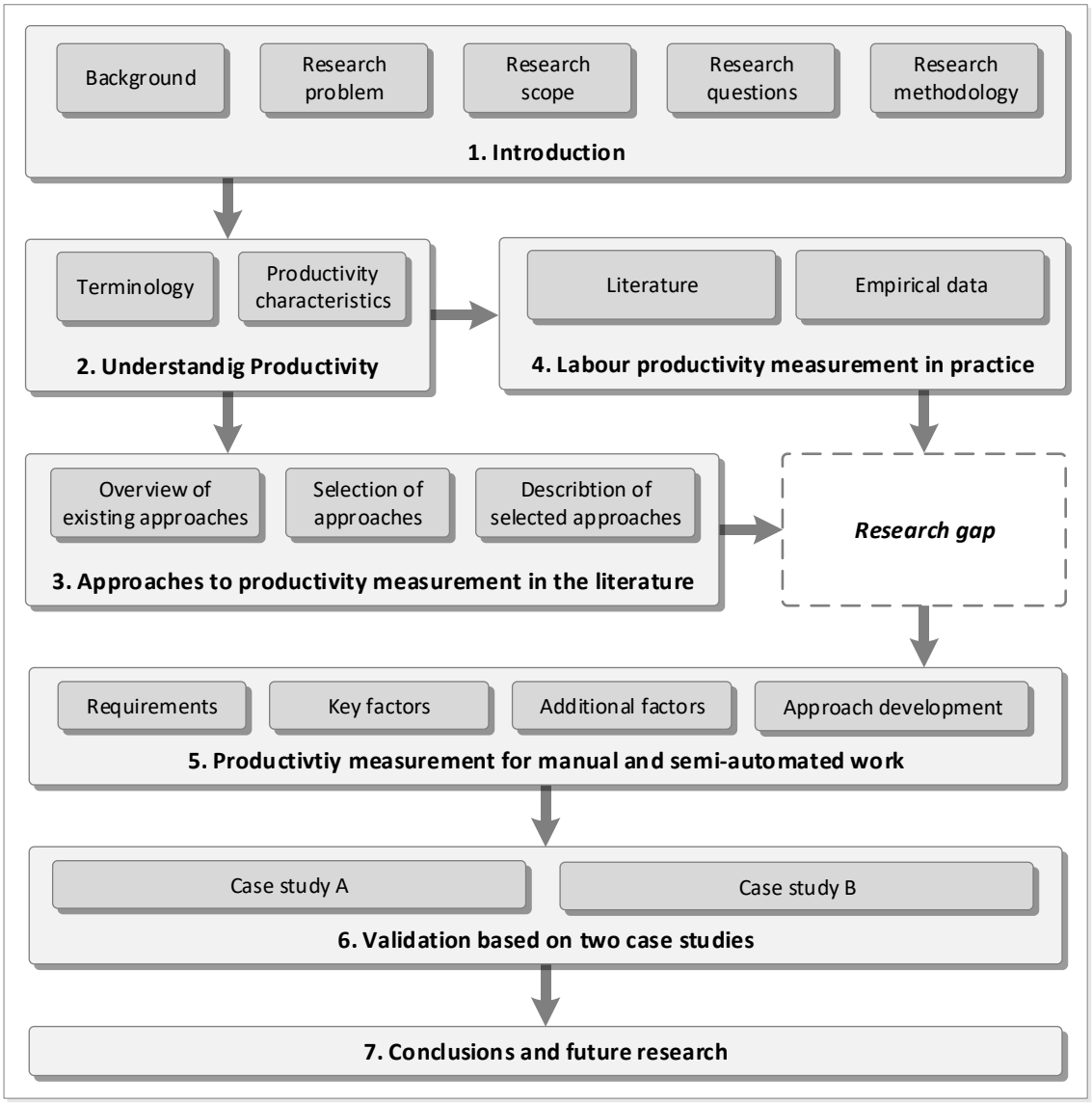


**Figure 3: Thesis outline**