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Doctoral Thesis

An Exploratory Study Of Perceived Complexity In IT Projects

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Declaration of Authorship

I, David Klotz, declare that this thesis titled, “An Exploratory Study Of Perceived Complexity In IT Projects” and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

Date:

"*I think the next century will be the century of complexity.*"

Stephen Hawking (2001)

Abstract

An Exploratory Study Of Perceived Complexity In IT Projects

by David Klotz

The considerable failure rate of information technology (IT) projects remains a problem for many organisations and impacts their ability to successfully participate in the digital economy. Previous root cause analysis identified project complexity as one of the key factors in and of IT project failure. The purpose of this research was therefore to critically examine complexity in IT projects. In contrast to earlier positivist research on complexity, this study was built on a critical realist perspective to better understand the underlying structures and mechanisms behind what individuals within IT projects perceive as being "complex".

A qualitative research design was chosen with a series of semi-structured in-depth interviews with IT project practitioners as the data collection method. The research identified four internal variables (experience, stress, frustration, and motivation) and three external variables (communication, expectations, and support) which interact with perceived complexity. These findings were synthesised into a conceptual model of perceived complexity in IT projects. In addition, the findings indicated that the role of an individual (project sponsor, project manager, project team member) influences perceived complexity.

Through the identification of previously hidden mechanisms within IT projects, the study extends the body of knowledge about IT project complexity. In addition, the identified mechanisms were combined with typical situations in IT projects. The outcome, which represents the study's contribution to practice, are practice-orientated guidelines for handling complexity in IT projects which aims to support IT project professionals and organisations to better manage complexity. The study therefore provides valuable contributions to the theory and practice of IT project complexity.

Acknowledgements

I am extremely thankful to the countless and highly valuable support which I have received from my supervisor team, Dr Richard Whitecross and Dr Sally Smith of Edinburgh Napier University. Not only have they been an inspiration to this work, it has also been a pleasure working together with them.

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This thesis was produced with LaTeX, and I am thankful to the huge and passionate community behind it. I am still amazed and proud about the fact that people build great tools like this and share it with the rest of the world for no charge.

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List of Abbreviations

CAQDAS	**C**omputer **A**ided **Q**ualitative **D**ata **A**nalysis **S**oftware
DOU	**D**ocument **o**f **U**nderstanding
ERP	**E**nterprise **R**esource **P**lanning
ICT	**I**nformation and **C**ommunications **T**echnologies
IT	**I**nformation **T**echnology
PC	**P**roject **C**omplexity
SOA	**S**ervice-**o**riented **A**rchitecture
STEM	**S**cience, **T**echnology, **E**ngineering and **M**athematics
TC	**T**ask **C**omplexity
WBS	**W**ork **B**reakdown **S**tructure

For Hettie and Josie

—in eternal love and in hope they will ever forgive me for turning down so many chances to play

Chapter 1

Introduction

1.1 Introduction To The Problem

Information Technology (IT) has become a vital part of many organisations and their business strategies—a trend which has recently been referred to as "digitalisation" (Eling & Lehmann, 2017; Denner, Püschel, & Röglinger, 2017; Schmidt, Möhring, Bär, & Zimmermann, 2017). Accordingly, organisations continuously adapt and evolve their IT landscapes as part of their business strategies, in order to be successful—or, as Carcary, Doherty, Conway, and Crowley (2017) put it, in order to survive. Since strategy-driven changes within the IT landscape are typically disruptive transformations, e.g. the implementation of new hardware platforms or of new software solution packages, the predominant way to carry out these transformations is in the form of projects. However, the IT industry is infamous for its rapid evolution which is well illustrated by *Moore's Law* (Seel, 2012). According to Gordon Moore's 1975 prediction, the number of transistors on an integrated circuit, i.e the capacity of IT hardware, would double every two years, as indeed it did between 1970 and 2010. Even though growth has slightly slowed since 2010, this is an impressive and unprecedented rate of technological progress. Fuelled by this exponential growth of hardware capacities, further inventions were made possible, e.g. the shift from mainframes to client-server computing, the internet and *big data*.

In a similar way, many observers claim that the complexity of IT solutions has grown steadily since their invention—although there is no factual evidence to support this claim, for reasons that will be discussed later in this thesis. Edsger Dijkstra, one of the industry's pioneers, warned in 1972 that the increasing complications will swiftly become unmanageable—a development he referred to as the "software crisis" (Dijkstra, 1972, p.861). Recently, these fears have been renewed (Fitzgerald, 2012; Vandierendonck & Mens, 2011; Hamilton, 2008). Factors suggesting a growing complexity of IT projects exist in the form of rising structural metrics like the volume of source code or the number of interfaces. However, this complexity is not merely caused by technology—the setup and execution of IT projects is equally a multi-faceted organisational endeavour. Evidence of this lies in the aforementioned authors pointing out the low success rates of IT projects, a problem that continues to persist within the IT industry, as recent reports confirm (Arcidiacono, 2017; Hidding & Nicholas, 2017). In an online article for the renowned IT analyst Gartner, Moore writes that "[d]espite more than 50 years of history and countless methodologies, advice and books, IT projects keep failing." (Moore, 2015). Although the reasons for IT project failure seem manifold (Sudhakar, 2016; Henderson, 2006; Stepanek, 2005), the overall growing complexity within the field has been identified to be a main challenge among researchers (Warren, 2016; Irvine & Hall, 2015; Whitney & Daniels, 2013) and practitioners (Moore, 2015; Kogekar, 2013). Therefore, as the IT industry has been heavily relying on projects as the preferred way to implement transformational changes, generating a better understanding about the complexities of these projects may help to improve their success rates.

The reasons for project failure—a problem that also exists beyond the IT industry—have been researched for as long as projects exist. Within this context, also complexity has been studied extensively. However, it can be observed that existing studies often exhibit the following characteristics:

- *Lack of Integration.* Despite the numerous studies related to the complexity of projects, the subsequent body of relevant knowledge seems rather thin. The majority of current studies do not build upon existing work but instead examine fundamental aspects; often with overlap to other studies. As an illustrative example, Vidal, Marle, and Bocquet (2011) have identified more than 40 different metrics to measure project complexity. Yet, alternatives models have been proposed since then, e.g. that of Mirza and Ehsan (2017). Another symptom of this limitation is reflected in the fact that suggested measurement models or frameworks have often been derived from theorisation and so lack empirical validation within wider sample data (Floricel, Michela, & Piperca, 2016).

- *Isolated Research.* Existing research seems to be focused on a specific scientific field and hence is often disconnected from findings within other disciplines. As an example, many of the findings from studies regarding task complexity, which has been derived from various disciplines like psychology and social sciences, seem relevant for project complexity too. Task complexity has been studied for a longer time than project complexity, thus integrating these findings into project complexity research appears reasonable but has seldom happened.

- *Management Focus.* The previous point might be caused by project management being a very practice-orientated field. Existing research reflects this through placing an inherent focus on a potential operationalisation of findings—typically by putting the project manager, or general aspects of management, into the centre of study (Cunha, Moura, & Vasconcellos, 2016). In contrast, less attention has been given to details outside the realm of project managers, such as task complexity which applies to everybody in the project team. To employ a representative, figurative example, there are many insights into how to coach a sports team, but little guidance for the individual players on how to actually play the game. Based on the researcher's experience as a practitioner in the IT industry, he believes that this overall tendency is problematic and misses the point that projects are a result of teamwork, or, as others have called it, "people business" (Werth, Greff, & Scheer, 2016; Druker, 2012). Ultimately, successful projects require the whole team to perform (Cicmil, Williams, Thomas, & Hodgson, 2006).

- *Dominance of Positivism.* As a consequence of the strong focus on project management, existing research is dominated by a positivist ontology and epistemology (Smyth, Morris, & Cooke-Davies, 2006; Williams, 2004). When applied to project complexity, this means that the majority of studies adopt a perspective that is called *descriptive complexity* (Schlindwein & Ison, 2004), presuming that complexity can be measured objectively. However, as multiple researchers have pointed out, complexity is also perceived by individuals (*perceived complexity*) and so the study of this perception promises to deliver new insights to deepen our general understanding of complexity in general (Geraldi, Maylor, & Williams, 2011; Winter, Smith, Morris, & Cicmil, 2006; Cicmil et al., 2006; Schlindwein & Ison, 2004). In the context of task complexity, some studies have confirmed that perceived complexity (also referred to as "subjective complexity" in these studies) is a stronger moderator on performance than objective complexity (W. Li, Lee, & Solmon, 2007; Maynard & Hakel, 1997). The point here is not to argue which of the two conceptions is the "right" one—the researcher personally believes both positions to be valid—but instead, to emphasise that perceived complexity exists in the real world and has implications on the outcome of projects.

This research study addresses the aforementioned limitations: Firstly, by building on previously generated knowledge, an integrated study would contribute to the current body of knowledge regarding project complexity. Specifically, Geraldi et al. (2011) have analysed existing literature for complexity drivers and compiled a comprehensive framework with, as they call it, *complexity dimensions*, as well as related complexity indicators as mentioned in the literature. This work is an excellent basis from which to continue the exploration of project complexity; the authors go as far as to suggest the validation of their findings with perceptions of complexity in the field: "First, we need go out into practice to gather more formal evidence on how practitioners perceive complexity to establish whether their perceptions align with these dimensions, and whether the dimensions are intuitively meaningful [...]" (Geraldi et al., 2011, p.984). Next, a synthesis of task complexity findings and project complexity findings might add value to the overall understanding of complexity in project organisations as, for example, indicated by Cunha et al., who noted with a reference to Högberg and Adamsson (1983) that projects are "a complex set of tasks largely based on human relations and the specific knowledge, experiences and cultural background of each individual" (Cunha et al., 2016, p.948). Similarly to the manner with which Geraldi et al. consolidated previous findings on project complexity drivers, Liu and Li (2012)

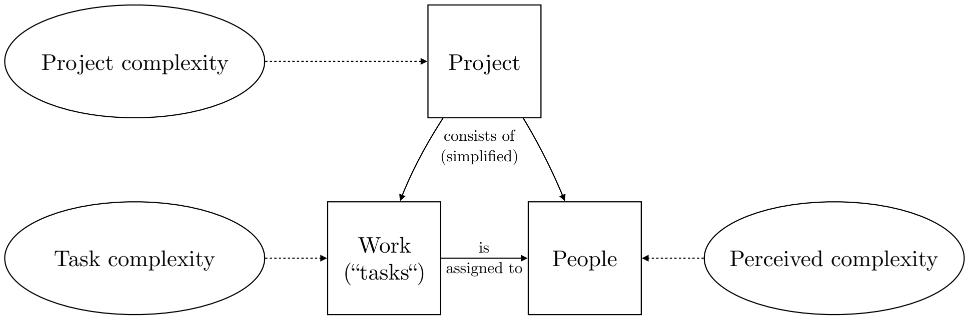


FIGURE 1.1: Relevant research streams for project complexity

did the same for task complexity. As a result of their research, they established a framework of 10 task complexity drivers. When briefly comparing this framework with that of Geraldi et al., one notices a number of overlapping elements. Hence, a detailed comparison of these two works—which are considered to represent the core of the body of knowledge in their corresponding areas—might be a first step in the merging of the findings of these different research streams. Since task complexity research does not have as strong a positivist tradition as project complexity, integrating its findings into project complexity may indeed add further knowledge to project complexity. Of course, before this is possible, a validation of the findings is necessary. This is why, thirdly, the call for validation with actual practitioner perceptions, as formulated by Geraldi et al. in their study should be answered (Geraldi et al., 2011).

By taking into account the lived experiences of individuals who have worked in IT projects before, a qualitative study that considers the three different research streams which are presented in figure 1.1 may help to shed some light on potential answers here.

In summary, it can be concluded that the complexity of IT projects is an important element, as it both directly influences a project's success or failure and, due to the growing strategic importance of IT in a globalised, digital economy, indirectly influences an organisation's success or failure. The groundwork for understanding actual project complexity has been completed from two different research streams, project complexity and task complexity. Historically, these started from contrasting positions yet now both seem to hold value when it comes to understanding project complexity. As discussed, linking the findings from the task complexity research stream to the project complexity stream seems promising. Combining these consolidated findings with the complexity perceptions of individual practitioners might reveal further important insights into the mechanisms behind project complexity, eventually informing practitioners about measures to optimise the results of IT projects.

1.2 Study Aims And Approach

The main goal of this study is to improve our understanding of complexity within IT projects. As discussed in the previous section, the key to improving this understanding lies in the lived experiences of IT project practitioners. By learning about their perceptions of complexity, this study hopes to reveal important factors that have remained previously hidden to the existing, mainly positivist, research conducted into project complexity to date.

For this purpose, the study is going to build upon existing knowledge, namely the comprehensive works of Geraldi et al. (2011) and Liu and Li (2012). The first step will see their frameworks reviewed and consolidated into a common collection of complexity drivers that have been identified from the two different research streams of project complexity and task complexity. Afterwards, qualitative data will be collected by conducting a series of interviews with practitioners who had previous involvement in IT projects. In order to learn about a potential influence of their roles within IT projects, the sample population will include participants with various roles. The qualitative data will then be analysed by matching each of the statements with the consolidated collection of complexity drivers which was produced in the first step. This validation does not aim to prove the correctness or completeness of the consolidated collection but it provides an important indication on (1) the importance of these drivers from the perspective of practitioners in IT projects, and (2) potential relationships and interdependencies between the different drivers, as expected by Geraldi et al. (2011). In addition, the collected data will be explored for further insights on the following aspects:

- When comparing the different practitioners' accounts, will a common definition of IT project complexity emerge? The lack of a general definition has been noted by many (e.g. Vidal et al., 2011; Erdi, 2008; Rosen, 1977) but no analysis regarding the more specific context of IT projects exists so far.

- The influence of the element *role* within an IT project on perceived complexity. Practical experience suggests that management roles (project managers and project sponsors) are, due to the nature of their work, set further away from potentially complex details, meaning that people in these positions may perceive the complexity differently to non-management project team members.

- Explore how practitioners react to complexity. The spectrum of potential reactions here ranges from the professional level (practitioners in IT projects) to the personal level, including emotions related to complexity. As an example, the relationship between complexity and stress is interesting, as stress is known to have negative consequences when it passes a healthy level.

The nature of this study is exploratory and follows a qualitative theory-building paradigm as described in Eisenhardt (1989). The reason why this kind of research has been chosen lies in the complex nature of complexity itself: multiple authors have noted the multi-dimensional nature of project complexity, and the majority of them even conceptualised complexity as being descriptive. Due to the intrinsic complications within human perception, it seems unpromising to develop hypotheses *a priori* on such detailed aspects stemming purely from theory. The option to hypothesise based on the practical experience of the researcher was dismissed too, as it would unnecessarily narrow the scope of this study to the experiences of a single person. Therefore, instead of testing specific hypotheses that would be speculative and/or subjective, this study is going to explore the perception of complexity in IT projects in the hope of identifying emerging patterns and themes which then can be tested in later follow-up studies.

The expected contribution of this thesis to current knowledge comprises three concepts: (1) The existing frameworks from both project complexity and task complexity will be validated with reference to the lived experiences of practitioners in IT projects. Through this process, the study will improve the legitimacy, and therefore the quality, of previous findings. (2) The study aims to explore IT project complexity by improving our understanding of the ways in which practitioners perceive complexity. By analysing the lived experiences of participants, the author hopes for patterns and relationships to emerge which have previously been overlooked. One of these possible findings might be to establish an influence between perceived complexity and an individual's role, as mentioned above. (3) Through the two steps previously described, the study aims to validate which findings from the task complexity stream apply to IT projects and, particularly, which of them influence complexity. These three listed concepts contribute to theory and practice, as they may inform further research as well as assisting professionals in IT projects.

1.3 Motivation For This Work

The low success rate of IT projects (Arcidiacono, 2017; Hidding & Nicholas, 2017) remains to be a central problem for many organisations. From an economic perspective, the waste which is caused by IT project failure is enormous. As determined by a recent study of the Project Management Institute (2018), around 10 percent of all project-related investments (not specific to IT projects) are waste which is caused by poor project performance. One of the leading IT analysts, Gartner, expects the global IT spendings in 2018 to reach approximately £2.7 trillion (Gartner, 2018). An earlier spending analysis report of IT analyst Forrester indicated that around 20 percent of all IT spendings are directly allocated to IT projects (Lunden, 2013). When combined, this means that £54 billion are globally wasted due to IT project failure. Another study of 5,400 large scale IT-projects by the strategy consulting firm McKinsey shows the significant risk exposure for the corresponding organisations. According to the study, 17 percent of all large-scale IT projects are considered a threat to the existence of the company, if they fail (Bloch, Blumberg, & Laartz, 2012). These numbers underline the importance of the successful execution of IT projects from a financial and strategic perspective.

Complexity has been identified by multiple studies as being a key factor for project success (Warren, 2016; Irvine & Hall, 2015; Whitney

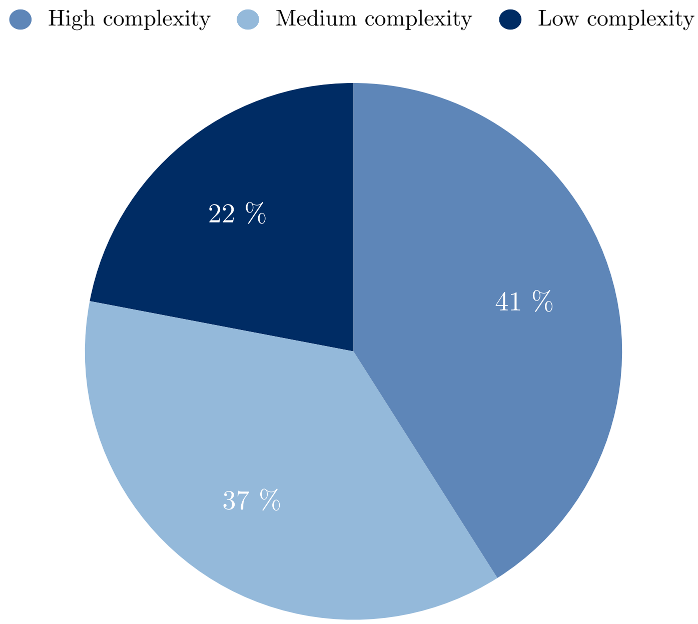


FIGURE 1.2: Occurrence of project complexities, according to a recent study among 4,455 practitioners (Project Management Institute, 2018)

& Daniels, 2013). As shown in figure 1.2, 41 percent of all projects are considered highly complex, according to a survey among 4,455 project practitioners (Project Management Institute, 2018). Therefore, addressing complexity in IT projects seems to be a promising lever in order to improve IT project failure and reduce the enormous waste which is associated to it.

In this context, it seems surprising that scientific findings on project complexity (and specifically IT project complexity) are not strongly reflecting the reality as perceived by the researcher in his role as practitioner. To begin with, existing studies primarily address project managers. Although this is certainly a crucial role for the success of IT projects, complexity is not only limited to project managers. Instead, the whole project team is exposed to complexity—quite possible every day that they work on a project—and so the existing findings on project complexity are of little help to them. As the consequences of a prolonged exposure to complexity can be severe and result in a burnout (Schaufeli & Enzmann, 1998), it can be deduced that there is a need for a more practitioner-centric research agenda regarding IT project complexity. Improving understanding of how individuals (such as practitioners in

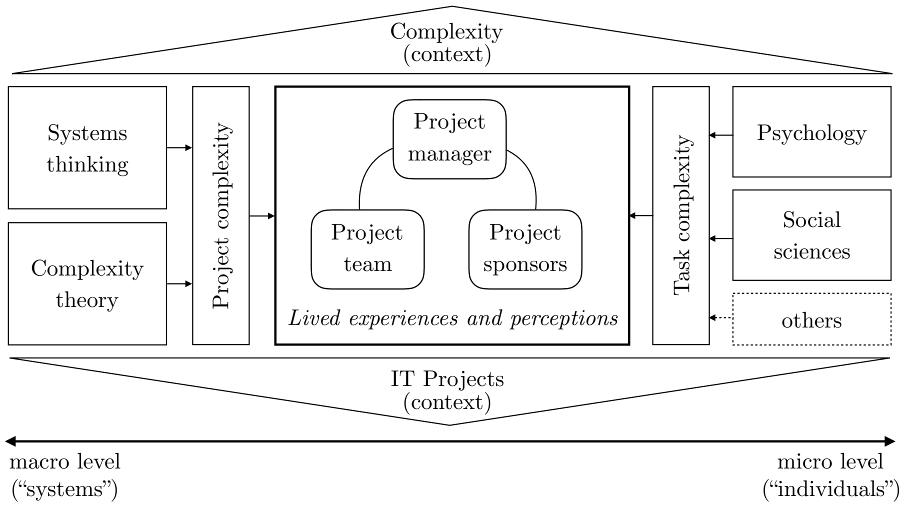


FIGURE 1.3: Conceptual framework

IT projects) perceive and respond to complexity is the first step in the researcher's move to achieve this.

In summary, the motivation for this work is driven by two aspects. Firstly, this study aims to improve the success rate of IT projects by providing insights into the perception of complexity from a practitioner perspective. Thereby, secondly, the study aims to support individuals with exposure to complexity in IT projects. It is hoped for this study to promote better methods of coping with complexity for organisations and individuals, and hence improve the likeliness for them to succeed with and within IT projects, so combatting what is one of the greatest challenges of the modern IT industry.

1.4 Conceptual Framework

The purpose of a conceptual framework is to identify the relationships between different concepts which inform a research study (Fain, 2017; Parahoo, 2014). As laid out in section 1.1, the subject of this research study, IT project complexity, is informed by multiple different concepts and research streams. Figure 1.3 shows the conceptual framework that will serve as a basis for this study, including the different fields which provide its theoretical context. Below, the elements of the framework are discussed:

- *Lived experiences and perceptions.* The core object of study in this research is a consideration of the lived experiences and perceptions of practitioners within IT projects. In regards to the practitioners, the three roles *Project manager*, *Project team*, and *Project sponsor* are conceptualised.

- *Complexity.* Represents the conception of complexity which serves together with IT projects (see next bullet) as the contextual background of this study. The inputs from this concept include, for example, the definition and epistemology of complexity which is used for this research.

- *IT projects.* Represents the conception of IT projects, which is twofold itself: With *projects*, the concept of a unique, temporary undertaking is embodied (Turner, 1990) and with *IT*, the scope of projects is narrowed to the subset of projects which focus on information technology. Inputs from this conception are, for example, the specifics of IT projects which are suspected to produce complexity, e.g. the internal complexity of software or the high degree of offshore work.

- *Project complexity.* Represents the research stream which has been studying project complexity mainly as the objective feature of a holistic social structure, i.e. the project. This stream was mainly influenced by systems thinking and complexity theory. Project complexity therefore is one main branch of inputs for the study of perceived complexity within IT projects.

- *Task complexity.* Represents the research stream which has been studying task complexity mainly as the feature of an individual work task. As projects are one way to organise the manner in which work is accomplished, task complexity applies to project work. As such, this is another main branch which informs the study of perceived complexity in IT projects. Task complexity itself is informed by numerous scientific fields, as it has been researched in various contexts. Two of the main fields which were identified from the literature review are psychology, where the cognitive aspect of task complexity has been studied, and social sciences, where task complexity has been mainly studied in the context of organisational studies.

To provide further conceptual context, the conceptual framework includes a virtual scale at the bottom which displays the different level of analysis. It spans from what the researcher have called the *macro level*, where the focus is on the holistic nature of IT projects as systems in the sense of systems thinking, to the *micro level*, where the focus is on individual actors within these systems. The ways in which different concepts have been arranged within the conceptual framework thus reflects the two main challenges for this study: along the vertical dimension, the challenge to apply the ambiguous concept of complexity to IT projects and along the horizontal dimension the challenge to synthesise the macro perspective of holistic systems with the micro perspective of individuals, as all of these concepts seem to influence the perception of complexity within IT projects. Investigating the exact nature of this influence is one of the aims of this study, and the conceptual framework serves as a blueprint for this investigation. Thus, it will be used throughout the different activities of this study: the literature review in chapter 2 will focus on previous findings from these areas, while the data analysis will validate the findings against the lived experiences of practitioners in the field. The results of the validation will be discussed in chapter 5.

1.5 Thesis Structure

The remainder of this thesis will document the research study which has been outlined in this chapter. In chapter 2, the theoretical background for this study will be discussed in greater detail within the literature review. The chapter concludes with an analysis of the gap in literature that this study aims to partially fill, and the research questions which have been derived from it. Next, chapter 3 describes the research methodology, including the research approach which outlines the ontology, epistemology and axiology of this study, and the details of the research design, e.g. the sampling strategy and details about the data analysis. Afterwards, chapter 4 presents the findings of the analysis. The fifth chapter contains a discussion of the findings and presents the contributions to theory and practise: a conceptual model of perceived complexity in IT projects and practice-orientated guidelines for handling complexity in IT projects. Finally, chapter 6 summarises the study and reflects upon the study's success with regards to the initial aims by discussing the contributions to knowledge and practice, as well as study limitations and the need for further research.

Chapter 2

Literature Review

2.1 Introduction

In order to demonstrate the theoretical background of the current study, this chapter presents the findings from the literature review. The literature review covers the different elements of the conceptual framework as discussed in section 1.4. In order to facilitate navigation through this chapter, the building blocks of the conceptual framework have been mapped to the sections of the literature review in figure 2.1.

The sequence of the building blocks is as follows: First, the two contextual concepts, complexity and IT projects, are discussed in sections 2.2 and 2.3. Then, the two research streams which feed into the research object, project complexity and task complexity, are covered in sections 2.4 and 2.5. Afterwards, the findings will be summarised and gaps in the literature identified and discussed in section 2.6. Based on these literature gaps, this section will present the research questions for this study and so conclude this chapter.

With consideration of the domains which inform this study, the primary library catalogues accessed for this literature review are ScienceDirect, SAGE Journals, ACM Digital Library, Wiley, Scopus, and IEEE Xplore. In addition, where references were not found in these catalogues, the online catalogues of Edinburgh Napier University library, WorldCat, and Google Scholar were used. The literature review was not restricted to a certain period of time.

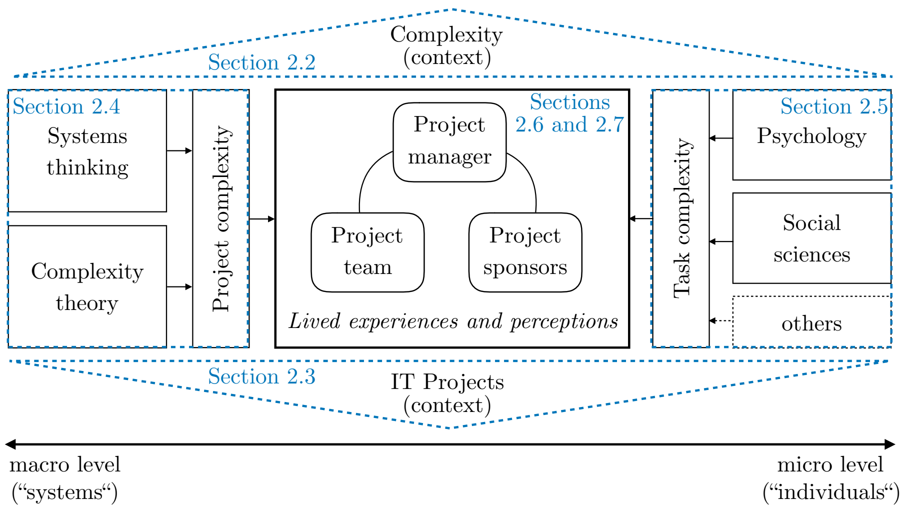


FIGURE 2.1: Breakdown from conceptual framework to literature review

2.2 Complexity

2.2.1 Overview

The phenomenon of *complexity* has been the subject of many research projects, both in natural and social sciences (Erdi, 2008), with a significant body of literature that addresses complexity from its conception to current state. Complexity is an abstract entity—although complexity, and more specifically, complexity theory, are relevant in the context of many natural sciences (e.g. physics and biology), it is not a natural (i.e. physical) object itself. In contrast to concrete objects, abstract constructions cannot be directly experienced by humans but rather represent an idea or concept. As such, the notion of complexity requires a definition in order to avoid ambiguities and misunderstandings which could potentially lead to false conclusions.

While there may be a rough general consensus as to what complexity is, its abstract nature has prompted the creation of various detailed interpretations. The lack of a common definition has been noted by many researchers (Erdi, 2008), and already pointedly illustrated in 1977 by Rosen, who noted that "our views regarding the concept of complexity have tended to be as richly varied as complexity itself" (Rosen, 1977, p.228). The following subsection will present the most widely held conceptual definitions of complexity and their origins.

2.2.2 General Definition

According to the Oxford English Dictionary, the word "complexity" is derived from the Latin word *complexus*, which literally translates to "embracing" or "surrounding" (Oxford Dictionary of English, 1997). The Oxford English Dictionary further defines complexity as "the quality or condition of being complex" (ibid.). The word "complex" in turn is defined as "A whole comprehending in its compass a number of parts, *esp.* (in later use) of interconnected parts or involved particulars; a complex or complicated whole." (ibid.).

The dictionary definitions of both complexity and complex are generic, with reflexive elements—complexity is defined as *something complex*—and neither specify details other than referencing the composite, constructed nature of complex objects. Azim et al. claim that this generic dictionary definition is "[t]he only definition of complexity which is widely accepted" (Azim et al., 2010, p.389). However, even this claim is debatable, as the dictionary definition of *complex* provides grounds for debate regarding the ambiguity that is caused by using "complicated" as a synonym for complex, as will be discussed in subsection 2.2.4. This lack of cohesion illustrates how varied the conceptual definitions of complexity are; even on the most generic level, there is no consensus about the concept.

2.2.3 Context-Dependent Definitions

The study of complexity by modern scientists started in the 1940's. Since then, many diverse disciplines such as mathematics, computer sciences, astronomy, biology, physics and finance (Hatt, 2009; Ziemelis, 2001; Mainzer, 2007) have explored and offered insights into the concept of complexity within their scientific contexts. However, the absence of an agreeable and detailed common definition of the term has forced researchers to introduce their own context-dependent conceptual definitions (Mainzer, 2007; Morel & Ramanujam, 1999). Whitesides and Ismagilov accordingly conclude, with reference to Mainzer (2007), that " 'Complexity' is a word rich with ambiguity and highly dependent on context." (Whitesides & Ismagilov, 1999, p.89).

Table 2.1 displays selected scientific disciplines and examples of how the concept of complexity is interpreted within their specific contexts

TABLE 2.1: Complexity in the context of selected scientific disciplines

Discipline	Complex object of study	Context-specific conception of complexity
Physics	Thermodynamic systems	Entropy
Chemistry	Organic substances	Structural complexity
Biology	Neuronal networks of the brain	Structural complexity
Computer Sciences	Algorithms	Computational complexity classes, Kolmogorov Complexity
Information theory	Graphs	Shannon Complexity
Economics	Markets	Economic fluctuations

(Mainzer, 2007; McCauley, 2011; Meyers, 2011; Whitesides & Ismagilov, 1999; Grünwald & Vitanyi, 2004). The table illustrates that, across various scientific disciplines, complexity is interpreted as structural complexity and depends on the internal structure of the whole, which consists of many interconnected parts, as discussed in subsection 2.2.2, where the generic dictionary definition was presented. Concrete structural interpretations of complexity include, for example, the atomic structure of molecules in chemistry, the neuronal network of the brain, consisting of neurons and synapses, or population dynamics (Erdi, 2008). Other disciplines, such as physics and economics, maintain a systemic interpretation of complexity that is inherent to closed systems (e.g. thermodynamic systems or markets) and reflects the level of disorder, uncertainty and randomness within these systems (Ebrahimzadeh, 2016; Ellerman, 2016; Fontana, 2010). Sherrington notes that "indeed complex cooperative behaviour can arise with even very simple individual units and very simple interactions." (Sherrington, 2010). This view eventually led to the emergence of a whole new scientific field: complexity theory.

Driven by the research of complex systems within sciences like physics, ecology, or sociology, researchers began to examine the causes and effects of these complex systems (Cooke-Davies, Cicmil, Crawford, & Richardson, 2007). Soon, similar patterns were discovered across different sciences, leading to overall doubts concerning the "basic assumption of linearity" (Cook et al., 2015, p.52) which had been accepted and employed for three centuries. Instead, it was determined that: "[t]he non-linear and nonadditive nature of the interactions require[d] the study of the system as a whole." (Ganco, 2013, p.131). It was a computer-based simulation created by meteorologist Lorenz in 1960, who was simulating weather systems, that led to the discovery of a phenomenon that has become famous under the name *butterfly effect* (Lorenz, 1963). In his work, Lorenz recognised that non-linear systems are very sensitive towards initial conditions (Hilborn, 2004) and that minimal changes in the primary configuration could lead to significantly different and unpredictable outcomes. This discovery fascinated many researchers and eventually sparked the formation of a whole new academic field: chaos theory (Nowlan, 2017). Hite explained chaos theory as "an attempt to understand this secret order of nature." (Hite, 2009, p.71).

Over time, chaos theory led to other complexity-related fields of study, such as the study of edge of chaos or emergence, and eventually evolved into a wider field referred to as *complexity theory*. The Encyclopedia of Management Theory defines complexity theory as "a body of research concerned with explaining emergent patterns in physical properties or social behaviour that cannot be explained by studying the individual building blocks in isolation but rather emerge from their interactions." (Ganco, 2013). With the increasing interest in the study of complex systems, the need for clear definition arose. Different criteria were proposed, including circular causality, feedback loops, and unpredictability (Cilliers, 1998; Erdi, 2008; Mainzer, 2007; McDaniel & Driebe, 2005). Although these criteria allow for the identification of complex systems within a variety of different disciplines, they must also be considered contextual, for they are only valid to describe complex systems and so cannot be generalised to describe complexity itself. This lack of generalisability has been pointed out by Morin, who introduced two distinct categories of complexity which he referred to as "restricted" and "general" complexity (Morin, 2006). The former summarises all context-driven interpretations of complexity, and mainly those from natural sciences and mathematics, while the latter represents an over-arching, context-free version of complexity. Morin argues that restricted complexity is bound to the reductionist paradigm which is predominant in natural sciences. However, he posits that: "complexity requires that one tries to comprehend the relations between the whole and the parts", and only by overcoming this restriction can the "laws of complexity" be studied (Morin, 2006, p.6).

2.2.4 Practical Definition

Besides the increasing relevance for use within numerous scientific disciplines, the word "complex" has found its way in our daily lives. As a symptom, the word produces almost 900 million results in Google™ Search (as of December 2017). It is being used in various contexts, such as to describe something difficult or, even broader, something that is not easy. The rising popularity of the word seems to be coupled with the perception that many things in our lives during the era of digitalisation appear to be more complex than they used to be, be it trivial things like our telephones, dishwashers or cars, or more significant aspects like our employment history or family life (e.g. as patchwork family). As a concrete example, the relatively well-ordered system of the two (biological) sexes has evolved into as many as 63 different social genders in recent discussions (aPath.org, 2000)—a development that has overwhelmed many people and so has been widely met with ignorance. Regardless of what we may think of this development, it is likely that many people would agree to the claim that 63 genders adds significant complexity to their lives. This example was chosen to demonstrate the difference between the scientific definition of complex—which was already vague enough—as opposed to the use of the word complex in everyday language, which subscribes to an even fuzzier definition. The question of how exactly the existence of 63 genders would make anyone's life more complex will likely not be easy to answer.

A few researchers have noted that complex is often used as a synonym for complicated (e.g. Richardson, 2005; Gidado, 1993; Poli, 2013; Geraldi et al., 2011). To make things more convoluted, both words share the same antonym: simple. Accordingly, the question has arisen of whether complex actually means the same as complicated. As with the search for a generic definition of complexity, this question has been mainly discussed within a scientific context producing manifold answers, yet none which give sufficient justice to the usage in a practical context.

The majority of authors argue that there is indeed a difference between the two terms. For example, Oehmen, Thuesen, Ruiz, and Geraldi establish that: “[...] in order to advance our understanding of complexity, it is important to draw a clear distinction between these two ideas.” (Oehmen et al., 2015, p.5). Cilliers, meanwhile, advocates for a difference to be recognised between the two words, stating that complicated systems lack the integrative and holistic nature that characterise true complexity and therefore can be understood through decomposition, while complex systems cannot. A few scientists have been subscribing to this notion, e.g. Poli (2013) or Snowden and Boone (2007), with the latter offering an alternative explanation: “In a complicated context, at least one right answer exists. In a complex context, however, right answers can’t be ferreted out.” (Snowden & Boone, 2007, p.5). Poli, who is in agreement with Cilliers regarding the inability to understand complex systems by decomposition, argues that complex systems and complicated systems are of completely different types. He goes on to conclude that: “a complex system is *not* a system that is remarkably more complicated than a customarily complicated system” (Poli, 2013, p.143). This notion is rejected by others, who either argue that many complex objects are simply complicated (Baccarini, 1996; Remington & Pollack, 2012) or that complexity needs to be contained so that it does not become complicated (Oehmen et al., 2015).

However, the whole concept of distinguishing between complex and complicated has been receiving criticism, such as that from Taborsky: On the one hand, there is doubt as to whether non-complex objects truly lack integration—very much like complexity itself, the concept of integration also seems context-dependent and hence not generalisable. On the other hand, Taborsky argues that “[w]hether one is able to characterize an entity as integrated or not may well hinge on one’s decision to view the object as complex or complicated” (Taborsky, 2014, p.54). He concludes that “neither complexity nor complication is a transparent property; their application depends on a great deal of prior interpretation.” (Taborsky, 2014, p.54).

Hence, for the remainder of this work, the position of Geraldi et al. will be adopted. They argue that the differentiation between the two is a rather theoretical debate and for the purpose of a practice-oriented study, “the term ‘complexity’ will follow common usage, and therefore include both 'complicatedness' and theoretical complexity." (Geraldi et al., 2011, p.968).

2.3 IT Project

In this section, the nature of IT projects, as far as is relevant to this study, will be discussed. For this purpose, the term should be deconstructed into its components *IT* and *Project*. Firstly, the term Information Technology (IT), sometimes also referred to as Information and Communications Technology (ICT), comprises all kinds of hardware and software technology which can be used to process, store and retrieve data (Davis, Ein-Dor, R King, & Torkzadeh, 2006). While the invention of computational machines can be traced back to the 17th century, the term IT emerged in the 1980s and has been in consistent use until today (e.g. by McGee, 2018; Wang, Wang, and McLeod, 2018). Although the term *IT project* is widely used (e.g. Ghapanchi, 2015; Cerpa and Verner, 2009; Belout and Gauvreau, 2004), there is no common definition provided for it which may lead one to wonder what exactly makes a project specifically an IT project. For the remainder of this work, an IT project will refer to a project which is primarily concerned with introducing or updating an IT solution, where IT solution includes hardware and/or software which is used to process, store and retrieve data, as defined above (Davis et al., 2006).

Secondly, a definition for the term *Project* which has often been cited is the one from Turner and Cochrane (1993):

> An endeavour in which human, material and financial resources are organized in a novel way, to undertake a unique scope of work, of given specification, within constraints of cost and time, so as to achieve beneficial change defined by quantitative and qualitative objectives (Turner & Cochrane, 1993, p.94).

Other authors (e.g. Cunha et al., 2016; Turner and Müller, 2003; Cleland and Kerzner, 1985) emphasise the fact that projects are temporary organisations. Although individual IT projects may have further, more specific roles, literature describes the following three roles as being present in the majority of IT projects and as being critical factors for project success:

- *Project Manager.* Typically represents the project team and is responsible for the successful execution of the project. Various definitions exist within the literature; for this work, the definition of Jurison (1999) will be used, which states the project manager as being responsible: “to direct and coordinate all activities to meet the objectives of the project within budget and schedule.” (Jurison, 1999, p.22). The importance of the project manager role for project success has been highlighted by many (e.g. Whitney and Daniels, 2013; Müller, Geraldi, and Turner, 2012; Yanwen, 2012; Sauer and Reich, 2009; Cicmil et al., 2006).

- *Project Sponsor.* Typically represents the executive management within internal projects or the client organisation in projects which have been fully or partially outsourced. This role includes project approval, funding, and staffing (NASA/Langley Research Center, 2007). A few authors have pointed out the importance of proper project sponsor involvement and a good relationship between project sponsor and project manager for the success of a project (Kloppenborg & Tesch, 2015; NASA/Langley Research Center, 2007).

- *Project Team Members.* As the literature on project roles typically focuses on leadership roles, there is no explicit definition of the project team member role, e.g. they are simply called *resources* (Turner, 2014; Cleland & Kerzner, 1985). In the context of this study, the role will be defined as any person who is (fully or partially) deployed to a project and performs work for it (excluding the project manager). Williamson (1995) advocates that the success of an organisation depends on the ability to attract resources.

Each of these roles might be staffed by multiple persons for a single project although, in practice, that is rarely the case for the project manager role. Also, these roles are disjunct, i.e. one person cannot hold multiple roles for a single project.

IT projects, as defined above, exhibit a number of specific features, in comparison to general projects. For example, the pace of technological progress is unmatched—the abstract nature of IT project deliverables, that is IT solutions, makes it practically impossible to clearly specify all details upfront, hence leading to frequent (and occasionally significant) changes during project execution. Also, the high degree of task outsourcing, specifically offshoring, which is enabled through the distinctive feature that (semi-)finished products, that is software, can be moved instantly, without costs, around the globe (Davis et al., 2006). Therefore, Hinchey and Coyle conclude that "[c]omparisons with other engineering disciplines are deceptive." (Hinchey & Coyle, 2012, p. ix).

The enormous pace of technological advancement within the IT industry means that personal (as well as organisational) knowledge expires rapidly. Consequently, it becomes challenging for organisations to staff their IT project teams adequately, as sourcing experienced IT professionals for hot skills is not easy. For long-lasting IT projects, the need to potentially integrate technology innovations, e.g. new technology stacks or software upgrades, during the run time of the project poses an additional challenge. Both of these aspects likely add to the complexity of IT projects. Furthermore, the current industry trend to produce an open and loosely-coupled, component-based software architecture, e.g. based on microservices (Iribarne, Corral, Criado, & Wang, 2017; Villamizar et al., 2017), leads to an increased structural complexity concerning the overall architecture. The IT industry has been trying to control the inherent structural complexity of IT solutions for decades, with the result being an almost overwhelming number of tools, frameworks, libraries and methods that each aim to reduce complexity and improve software quality, but also add to the overall complexity in doing so. As an effect, developing and maintaining these IT landscapes becomes more sophisticated, with an increasing need for the involvement of highly specialised experts—a negative impact on project complexity already described by Baccarini (1996)—and, in addition, a further narrowing of the potential human resource pool.

In contrast to other project-driven industries, e.g. construction and engineering, the IT industry typically invites more ambiguity in its specifications (Rivera & Kashiwagi, 2016; Thakurta, 2011). Even though not considered best practice, IT projects are still occasionally initiated with a very vague description of the final project deliverable. An illustrative example is provided in Verner and Abdullah (2012), where a £48 million IT project contract was signed based on the sole project goal that the client organisation "wanted a strategic CRM system"

(Verner & Abdullah, 2012, p.874). Contracting an engineering or construction company in a similar way, to just “build a bridge” or “build a house” for the same amount seems unimaginable. Although this can be considered an extreme case, poor requirements management within IT projects remains one of the mostly stated reasons for IT project failure (Yang, Chen, & Huang, 2012). This may partially be caused by the abstract nature of IT solutions and the typically wide gap between business experts who specify IT requirements and the IT experts who formalise them. Hinchey and Coyle note that the transfer from natural language into a formal notation can mean a significant increase in project complexity (Hinchey & Coyle, 2012).

Another challenge of IT projects is the extensive use of outsourcing models, caused by the aforementioned challenge for many organisations to attract talented IT experts. In addition, many organisations recognise the temporary nature of projects and hence do not want to staff projects with permanent hires. With regards to IT project complexity, a particular case study indicates that the outsourcing of complex projects is problematic (Verner & Abdullah, 2012). Here, the authors argue that outsourcing increases the amount of uncertainty in a project, hence adding to its overall project complexity. In addition, the authors claim that outsourcing to another country, that is nearshoring or offshoring, increases project complexity too. Another study, Jørgensen (2014), uses the geographical distance between client and contractor as input parameter for a model to predict the success or failure of small IT projects, without explicitly linking it to complexity. Since the case study covers a single case only, further research on the relationship between complexity and nearshoring or offshoring would be required in order to gauge accuracy.

In response to these challenges, the IT industry has been looking for alternatives to traditional project management approaches in the past decade. A few alternative models emerged, with Scrum and Lean Management being among the most popular ones (Rivera & Kashiwagi, 2016). All alternative models, often in sum referred to as *agile methodologies*, are based on the Agile Manifesto (Beck et al., 2001), a document published by a number of IT professionals who rejected the way software was produced at the present time in 2001, and subsequently inspired most of the alternative models.

Although agile methodologies are still relatively new, a few research studies have already been conducted—unfortunately, with rather inconsistent and sometimes conflicting results. A part of the problem is that the phrase "agile methodologies" serves as an umbrella term for a number of approaches which differ significantly. For example, while Lean Management mainly focuses on the organisation of work, and is well embedded into a traditional project approach, the Scrum methodology is more radical and rejects the idea of projects altogether. Hence, comparing traditional project approaches, e.g. the waterfall methodology or the V-model, to the totality of agile methodologies (as done, for example, in Serrador and Pinto, 2015; Raschke et al., 2015; Tarhan and Yilmaz, 2014), may be misleading, as far more differentiation regarding the individual agile methodologies is required.

In terms of the relationship between agile methodologies and complexity, a few papers have been published. While for some, it is already established that agile methodologies are the silver bullet against the "infinitely complex world" of software developers (Denning, 2015), there is little scientific proof to back up this claim. Serrador and Pinto performed an empirical study into the relationship between project success and the application of agile methodologies, across multiple industries, including IT (Serrador & Pinto, 2015). The results confirmed a positive effect of agile methodologies on the project success rate. The research also examined the moderating effect of project complexity, with the outcome being that there is none and complex projects are equally successful with agile methods as less complex projects are. Sohi, Hertogh, Bosch-Rekveldt, and Blom (2016) however, conclude that lean and agile practices positively influence complex projects within the construction industry. While there is little scientific evidence regarding the relation of project complexity and agile methodologies, there is no shortage of recommendations and decision frameworks in the field, which unsurprisingly demonstrate conflicting contents. For example, in contrast to the findings above, some advocate to use agile methodologies for small and simple projects only (Smartsheet, Inc., 2017; Lonergan, 2016), while others do not consider complexity a relevant factor at all when choosing a project methodology (Lotz, 2013; Base36.com, 2017). Furthermore, Mishra and Mishra (2011) argue that agile methodologies have negative implications on overall IT architecture in the long-term.

Clearly, further research would be helpful to bring more clarity to this question. As a practical consequence, organisations often choose to mix traditional and agile approaches (e.g. Hopkins and Harcombe, 2014).

2.4 Project Complexity

With the growing popularity of project management since the 1990s and the ongoing trend of ever-increasing project complexity, project management researchers and professionals have been focusing on complexity for more than two decades. From the perspective of project management practitioners, the pivotal question has been how to successfully manage complex projects and, in the light of a high number of failed projects (Arcidiacono, 2017; Hidding & Nicholas, 2017), the answer to this question is yet to be found. However, despite the inability to provide *the* answer to this question—if it even exists—researchers have been studying the complexity of projects, the findings of which will be briefly presented here.

As established in section 2.2, different scientific disciplines have developed highly contextualised understandings regarding complexity. When looking at project management literature that addresses complexity, it is crucial to consider this underlying context. Cooke-Davies et al. describe—with reference to Thomas Kuhn who introduced the term “paradigm” into scientific discourse in 1962 (Kuhn, 2012)—that project management embodies a very rich paradigm which some authors describe as rational (Lundin & Söderholm, 1995), normative (Melgrati & Damiani, 2002; Packendorff, 1995), positivist (Smyth et al., 2006; Williams, 2004), and reductionist (Koskela & Howell, 2002). Cooke-Davies et al. further claim that project management researchers typically (but not exclusively) follow an objectivist epistemology and positivist ontology (Cooke-Davies et al., 2007). Consequently, the majority of complexity-focused research in the project management discipline has been conducted through such an epistemological and ontological perspective, leading to a dominance of the descriptive conception of complexity.

Project complexity studies have been mainly informed by two scientific fields: systems thinking and, in particular, complexity theory.

Although the idea behind *systems thinking* has been applied for millenia (Allen, Maguire, & McKelvey, 2011), the term itself was introduced by Richmond (1987) and is defined as "the art and science of making reliable inferences about behavior by developing an increasingly deep understanding of underlying structure" (Arnold & Wade, 2015, p.671). One main aspect of systems thinking is to view systems as an "integrated whole made up of interconnected parts" (Allen et al., 2011, p.4), in a holistic way (Gharajedaghi, 2011), assuming that "the whole is more than the sum of its parts" (Erdi, 2008, p.353). Thus, systems thinking rejects the traditional, Cartesian-Newtonian paradigm which emphasises on reductionism. A number of researchers who focus on the management of complex projects advocate for the application of systems thinking for project managers (e.g. Sheffield, Sankaran, and Haslett, 2012; Kapsali, 2011; Cicmil, 2009; Dombkins, 2008; Remington and Pollack, 2012; Williams, 1999). The *Complex Project Manager Competency Standards*, a practical-orientated publication of the International Centre for Complex Project Management, also follows this recommendation, arguing that systems thinking is the approach to holistically manage a complex project, including its organisational context (Dombkins, 2012). Those who support systems thinking argue that a project is a system that cannot be entirely understood by mere decomposition, but rather by considering the larger context of the whole (Allen et al., 2011).

In the second half of the twentieth century, researchers started to study the nature of complex systems. In addition to the general definition of systems given above, complex systems were characterised as nonlinear and non-deterministic (Erdi, 2008; Mainzer, 2007). The study of these systems has been called *complexity science* and is considered by many to be an evolution of systems thinking (e.g. Allen et al., 2011; Castellani and Hafferty, 2009; Mainzer, 2007). Scientists from various disciplines began to apply the new principles of complexity science to conceptualised models that formed complex systems within their fields, for example models of market dynamics and organisational models. One of the first scientific disciplines to apply the ideas of complexity science was organisation theory (e.g. Simon, 1962; Thompson, 1967). Soon, this kind of thinking expanded to other fields within business and management research, mainly general management, strategy, and leadership (McKergow, 1996). With the later increased importance of project management and risk management, complexity-related research was further applied to these areas (e.g. Williams, 1997; Shenhar and Dvir, 1996; Thamhain, 2013).

It must be noted that multiple scientists have described a hype in the way complexity science was applied to management approaches in the late 1990s. The criticism includes claims regarding unscientific methods and the obscure use of scientific terms which resulted in labelling these practices a "fad" and "management guru witch-doctoring" (Maguire & McKelvey, 1999; McKelvey, 1999; Strogatz, 2003). Others, like G. Chapman reject the idea of complexity science altogether, calling it a "loose assemblage of ideas" instead (G. Chapman, 2007, p.1070). Nevertheless, complexity science is still a vital research field, as a recent study indicates (Padalkar & Gopinath, 2016), and complexity remains an important aspect of business and management research, as recent publications show. For example, complexity-related research areas in the management field cover a range of topics, including knowledge management (Eskola, 2017), sustainability (Espinosa & Walker, 2017), decision making (Montserrat-Adell, Agell, Sánchez, & Javier Ruiz, 2018), leadership theory (Uhl-Bien & Arena, 2017), tourism expenditure (Olya & Mehran, 2017), and corruption (Faruq, 2017). Another interesting field of recent research is the mutual reinforcement of internal, organisational complexity and external, environmental complexity. While the general causality has been known for many years (e.g. Galbraith, 1973 and Scott and Meyer, 1984), a recent study explored *collaborative* complexity, that being how organisations collaborate with other organisations, in response to environmental complexity (A. Schneider, Wickert, & Marti, 2017).

In the context of complex project management, the question of whether complexity science is helpful in order to gather a better understanding is subject to ongoing debate. While some authors argue in favour of it (e.g. Xiong, 2011; Castellani and Hafferty, 2009), others insist that there is no evidence to support this claim (Geraldi et al., 2011) or reject the suggestion altogether (Stacey, Griffin, & Shaw, 2004). It is not within the scope of this study to resolve this debate. However, where helpful, conceptual ideas from complexity science will be used in this work.

Table 2.2: Sample aspects of project complexity, as defined in Baccarini (1996)

Type of complexity	Differentiation	Interdependency
Organisational complexity	Number of different occupational specialists required to do the work	Degree of operational interdependencies and interaction between the project organisational elements
Technical complexity	Number and diversity of inputs and/or outputs	Interdependencies between tasks or within a network of tasks

Due to the context-specific nature of complexity, a good amount of the research on complex project management is bound to a specific, typically industry-driven, context. Naturally, industries where project-based work is a common work style are more prominent, for example information technology (IT), construction and engineering, complex products and systems (CoPS), research and development (R&D), and organisational projects (Geraldi et al., 2011; Tyssen, Wald, & Spieth, 2014). Publications which address complexity in the project management discipline mainly focus on two aspects: firstly, the question of what defines a complex project and how complexity can be quantified, and secondly, how this complexity can be managed. These aspects are not mutually exclusive; instead, there is an interdependency between them, with each informing the other.

In regards of the first question of what defines a complex project, a multitude of explanations have been provided. Among the first to address this question and to provide a systematic answer was Baccarini, who analysed the complexity of construction projects (Baccarini, 1996). His suggestion was to use the factors of differentiation and interdependency to operationalise the term complexity, showing how to apply them to "organisational complexity" and "technical complexity". Examples of Baccarini's taxonomy can be found in table 2.2.

The work of Baccarini laid the foundation for many other researchers who refined his taxonomy of project complexity (e.g. Williams, 1999;

Edmonds, 1999; Austin, Newton, Steele, and Waskett, 2002) or adapted it to fit their specific industry, such as engineering (e.g. Bosch-Rekveldt, Jongkind, Mooi, Bakker, and Verbraeck, 2011; Lutz and Ellegaard, 2015; Shenhar, 2001) or information technology (e.g. Raschke et al., 2015; Sauer and Reich, 2009; Hass, 2008). Meanwhile, the growing number of different models and complexity measures has been noted by a few researchers (e.g. Edmonds, 1999; Nassar and Hegab, 2006) and a research article by Vidal et al. (2011) counted as many as 42 different measures, noting that there seems to be no consensus as to what project complexity actually is among the project management community (Vidal et al., 2011). In the same year, Geraldi et al. published a systematic and comprehensive review of the different aspects that contribute to project complexity (Geraldi et al., 2011). In response to the criticism of Vidal et al., this paper shows that the previous findings can be synthesised into a common framework, as displayed in table 2.3 (Geraldi et al., 2011, p.976). The table also contains the main works which have described the corresponding complexity dimensions and attributes, as identified by the authors. Yet, researchers are still producing new quantification metrics for project complexity today (e.g. Mirza and Ehsan, 2017).

As Geraldi et al. add, the framework is not considered complete and "[t]he complexities identified are broad categories and the associated indicators provide a good, but certainly incomplete, list." (Geraldi et al., 2011, p.982). A similar study has been published by Bakhshi, Ireland, and Gorod (2016), whereby another systematic review of project complexity drivers within the literature is executed. The result of this study is a list of almost identical complexity drivers, with slightly different categorisation. Since the categorisation proposed by Geraldi et al. seems more intuitive to the researcher, this work is going to use their framework of complexity drivers. Geraldi et al. also acknowledge that the identified complexity dimensions are interdependent and that, in practice, projects will typically exhibit different dimensions with different strengths.

Based on the observations here—the lack of a common definition and the existence of numerous and varied models and frameworks—it can be concluded that the integration of research in this area is relatively low. Rather than building upon existing knowledge, project

TABLE 2.3: Attributes of dimensions of complexity

Dimension	Attributes
Structural complexity	Size (or number) (Crawford, Morris, Thomas, & Winter, 2006; Dvir, Sadeh, & Malach-Pines, 2006; Geraldi & Adlbrecht, 2007; Green, 2004; Hobday, 1998; Maylor, Vidgen, & Carver, 2008; Müller & Turner, 2007; Shenhar, 2001)
	Variety (Baccarini, 1996; Eriksson, Lilliesköld, Jonsson, & Novosel, 2002; Geraldi & Adlbrecht, 2007; Maylor, Vidgen, & Carver, 2008)
	Interdependence (R. Chapman & Hyland, 2004; Hobday, 1998; Little, 2005; Maylor, Vidgen, & Carver, 2008; Williams, 1999; Xia & Lee, 2005)
Uncertainty	Novelty (Shenhar, 2001; Tatikonda & Rosenthal, 2000)
	Experience (Maylor, Vidgen, & Carver, 2008; Mykytyn & Green, 1992)
	Availability of information (Geraldi & Adlbrecht, 2007; Hobday, 1998; Maylor, Vidgen, & Carver, 2008)
Dynamics	Change in (Maylor, Vidgen, & Carver, 2008)
Pace	Pace of (Dvir, Sadeh, & Malach-Pines, 2006; Shenhar & Dvir, 2007; Williams, 2005)
Socio-	Importance of (Maylor, Vidgen, & Carver, 2008)
political complexity	Support to (project) or from (stakeholders) (Maylor, Vidgen, & Carver, 2008)
	Fit/convergence with (Maylor, Vidgen, & Carver, 2008)
	Transparency of (hidden agendas) (Maylor, Vidgen, & Carver, 2008; Benbya & McKelvey, 2006; Cicmil & Marshall, 2005; Cooke-Davies, Cicmil, Crawford, & Richardson, 2007)

Note. Reprinted from "Now, let's make it really complex (complicated)", by Geraldi, Maylor, and Williams, 2011, International Journal of Operations & Production Management, 31(9), p. 966–990.

complexity researchers rather seem instead to dismiss them and set out to create other *original* findings. An illustrative example is the study of Bakhshi et al., 2016, which more or less replicates the work of Geraldi et al. (2011). Consequently, research in this area is primarily built upon theories which are—often by the same authors—tested in narrow contexts but lack a validation within a wider sample.

The second focus area of project management publications, how to manage complex projects successfully, has traditionally been taken from the side of the practitioner. The first publications with specific focus on the management of complex projects appeared in the the late 1990s (e.g. Williams, 1997) with authors focusing mainly on pragmatic, proven best practices for project managers, with a tendency to neglect scientific rigour where it appeared too theoretic. As a result, early attempts to define normative standards and competencies (e.g. Dombkins, 2012; Hass, 2008) faced criticism from the academic world (Whitty & Maylor, 2009; Cooke-Davies et al., 2007; Hodgson & Cicmil, 2008), for example concerning the lack of a common definition of what constitutes a complex project and what exactly distinguishes them from other, non-complex projects.

This branch of project management is still fairly young and researchers have been studying various aspects about the management of complex projects until today, so gaining significant knowledge (Geraldi & Söderlund, 2018). As presented within the literature review, the areas displayed in table 2.4 have surfaced as being areas inviting increased attention in the past decade. As the number of recently published articles (e.g. Davies, Dodgson, Gann, and Macaulay, 2017; Wu et al., 2017; Williams, 2017; Fisher, Pillemer, and Amabile, 2017) suggests, complex project management is still a vital research topic and the difficulties faced by practitioners during the execution of these kinds of projects underline the need for further research in this area.

As visible in table 2.4, the vast majority of research in this field focuses on management aspects. This reflects the Cartesian-Newtonian paradigm which is embodied by project management (Cooke-Davies et al., 2007) and the belief that the complexity of the whole, i.e. the project, can be broken down to smaller components of complexity in order to operationalise the process of *managing* complexity. Due to the hierarchical nature of projects which places the project manager at

TABLE 2.4: Complex project management research aspects

Aspect	Sample publications
General discussions of complex project management and best practices	Davies, Dodgson, Gann, and Macaulay (2017), Cooke-Davies and Crawford (2011), Ahern, Leavy, and Byrne (2014), Bosch-Rekveldt (2011), Oehmen, Thuesen, Ruiz, and Geraldi (2015), Geraldi (2009), Cicmil (2009)
Organisational aspects of complex projects	Geraldi (2008)
Required leadership competencies and qualities for managers of complex projects	Sauer and Reich (2009), Müller, Geraldi, and Turner (2012), Yanwen (2012), Whitney and Daniels (2013)
Planning aspects for complex projects	Sharon and Dori (2015), Chartered Institute of Building (2011), Pierce (2013)
Change management for complex projects	Whyte, Stasis, and Lindkvist (2015), Saynisch (2010)
Social interactions in complex projects	Fisher, Pillemer, and Amabile (2017), Antoniadis, Edum-Fotwe, and Thorpe (2011), Geraldi and Adlbrecht (2007), Marle, Vidal, and Bocquet (2010)
Risk management for complex projects	Williams (2017), Qazi, Quigley, Dickson, and Kirytopoulos (2016), Bannerman (2008), Charrel and Galarreta (2007)

the top, it is no surprise that this role is mainly expected to address project complexity within the literature. As mentioned in this study's introduction in chapter 1, it can be concluded that project complexity research is dominated by a positivist and reductionist world view that puts *management*, and thus the project manager, into the centre of studies.

2.5 Task Complexity

Task complexity is defined as “the degree of complicated actions needed to complete a task.” (Nugent, 2013). Compared to project complexity, task complexity has been researched for a much longer time; the first studies were published in the 1950s (Bourne Jr., 1957; Stotsky, 1957; F. G. Brown & Archer, 1956). The concept originated from the field of psychology, where it was mainly researched as a moderator for the effectiveness of human cognition. Later, the concept became multi-disciplinary, with research in neurosciences (Ruprecht, Taylor, Wolf, & Leising, 2014; Hughes & Rutherford, 2013), physics and biology (Huizenga, van Bers, Plat, van Den Wildenberg, & van Der Molen, 2009; Gell-Mann, 1995), organisational studies (Wildemuth, Freund, & Toms, 2014; Andrews & Boyne, 2014), education (Zalbidea, 2017; Kim & Taguchi, 2015), engineering (Liu & Li, 2016a, 2016b; Podofillini, Park, & Dang, 2013), and information technology (Reychav & Wu, 2016; H. Li, Gupta, Luo, & Warkentin, 2011). Among the most relevant findings of task complexity research is the influence of task complexity on decision-making (Tversky & Kahneman, 1981; Payne, 1976) and on the effectiveness of goal-setting (Campbell, 1991; Wood, Mento, & Locke, 1987).

Since its conception, researchers have been pondering the question of whether task complexity is an objective or subjective concept. Those who claim it to be objective (e.g. Hackman, 1969; Wood, 1986; Campbell, 1988) argue that only task characteristics moderate task complexity, explicitly denying any influence stemming from the task performer. In contrast, another group of researchers (e.g. Hærem, Pentland, and Miller, 2015; Gonzalez, Vanyukov, and Martin, 2005; T. M. Brown and Miller, 2000; Byström and Järvelin, 1995) oppose this view, arguing that task complexity is primarily perceived by humans, and that some of their properties (e.g. their cognitive or physical abilities), indeed influence task complexity. These opposing views and the subsequent discussion resembles the general distinction between descriptive (or here: objective) complexity and perceived (subjective) complexity, as introduced by Schlindwein and Ison (2004) and covered in section 2.2.

The research streams of task complexity and project complexity have a few things in common. Liu and Li describe the role of *tasks* as being “[...] one of the most crucial components in the study of human performance and behavior." (Liu & Li, 2012, p.553). However, they also add that, similarly to the concept of project complexity (or complexity in general), there is no consensus as to the definition or characteristics of a task, which has led to the emergence of a number of different definitions (e.g. Hackman, 1969; Wood, 1986). Another similarity is that researchers of both streams point out the growing importance of project and task complexity research, with reference to the overall trend of rising complexity in their fields (Hærem et al., 2015; Liu & Li, 2012). Lastly, as with project complexity, task complexity research has also been criticised for its lack of systematic validations of conceptual theories (Carey & Kacmar, 1997) and of integrated research, leading to sometimes contradictory results (Wood et al., 1987).

Driven by the desire to consolidate the manifold definitions for task complexity and the drivers which add to it, Liu and Li (2012) reviewed previous works which contain different definitions for task complexity, including that of Gill and Hicks (2006) and Campbell (1988). Analogue to the review of project complexity drivers in Geraldi et al. (2011), the research of Liu and Li (2012) also contains an analysis of complexity drivers for task complexity. In their study, the authors identified the following three "viewpoints" of task complexity:

- *Structuralist Viewpoint.* Defines task complexity from the structure of the task.
- *Resource Requirement Viewpoint.* Defines task complexity from the resources which are required to perform the task.
- *Interaction Viewpoint.* Defines task complexity as the result of the required human–task interactions.

As noted by Liu and Li, the first two viewpoints are typically based on the assumption that task complexity is objective, whereas the last viewpoint assumes subjective task complexity. Furthermore, the authors went on to build a framework of task complexity components which they have extracted from existing definitions of task complexity. Lastly, the authors analysed which complexity drivers (called "dimensions") are associated with the different complexity components. The result is a list of complexity dimensions, as displayed in table 2.5.

2.6 Summary

2.6.1 Gap Analysis

The aim of this literature research was to present relevant concepts, theories and findings from the literature for this study. The theoretical context for the literature review has been taken from the conceptual framework which has been discussed in the previous chapter (section 1.4). As outlined in the introduction, the existing knowledge about perceived complexity of projects, and specifically IT projects, is thin. The core assumption of the conceptual framework, that perceived complexity combines elements of project complexity and task complexity,

TABLE 2.5: Complexity dimensions

Dimension	Definition
Size	Number of task components.
Variety	Diversity in terms of the number of distinguishable and dissimilar task components.
Ambiguity	Degree of unclear, incomplete, or non-specific task components.
Relationship	Interdependency (e.g., conflict, redundancy, dependency) between task components.
Variability	Changes or unstable characteristics of task components.
Unreliability	Inaccurate and misleading information.
Novelty	Appearance of novel, irregular and non-routine events (e.g., interruption) or tasks that are not performed with regularity.
Incongruity	Inconsistency, mismatch, incompatibility, and heterogeneity of task components.
Action complexity	Cognitive and physical requirements inherent in human actions during the performance of a task
Temporal demand	Task requirement caused by time pressure, concurrency between tasks and between presentations, or other time-related constraints.

Note. Reprinted from "Task complexity: A review and conceptualization framework", by Liu and Li, 2012, International Journal of Industrial Ergonomics, 42(6), p. 564.

is still to be validated through this study and will be later addressed by one of the research questions (see subsection 2.6.3).

As some of the findings which have been presented here came from recent studies, it can be concluded that the research areas are generally vivid and that research in these areas is considered relevant. With respect to the complexity of IT projects, two research streams have been presented which inform this object of study: project complexity and task complexity (see also figure 1.1). As discussed above, the two streams exhibit a few similarities, although task complexity has been researched for a longer time and so seems to be more mature. For both streams, a compilation of complexity drivers from existing literature has been created (Geraldi et al., 2011; Liu & Li, 2012). A brief comparison of these inventories shows an overlap, indicating that the two streams are both relevant for the study of IT project complexity.

From the literature review, the following gaps can be identified:

- *G1. Lack of a common definition.* Although efforts have been undertaken by various researchers to consolidate the multitude of definitions and models (e.g. Geraldi et al., 2011; Liu and Li, 2012), both streams lack a *commonly accepted* definition.

- *G2. Lack of validation.* As discussed above, both streams have been found to mainly build their models and frameworks based on theory, with a lack of validation in practice.

- *G3. Isolation of research streams.* Although task complexity findings seem, to a certain extent, relevant for project complexity, they are typically not considered.

- *G4. Lack of perceived complexity conception.* As shown, researchers in the project management field typically adopt the conception of descriptive complexity which has led to there being a lack of research with a conception of perceived complexity. In particular, the influence of the role within an IT project on the perception of complexity has not so far been investigated. As a result, other than for project managers, there is no guidance for practitioners in IT projects on how to cope with the increasing complexity they are exposed to.

2.6.2 Research Objectives

By addressing the four gaps which have been identified in the previous subsection, this study aims to improve our understanding of complexity in IT projects. Thereby, a key motive of this work is to provide an alternative perspective into complexity which has not been given much attention in previous studies: the subjective perceptions of practitioners regarding complexity. By introducing such an alternative perspective into complexity, it is hoped that new insights for theory and practice can be generated. As outlined in chapter 1, the need for a better understanding of complexity in IT projects is driven by the intention to improve the failure rate of IT projects, where complexity has been identified as being one of the main factors for IT project failure (Warren, 2016; Irvine & Hall, 2015; Whitney & Daniels, 2013).

2.6.3 Research Questions

This study aims to address the four gaps identified above in subsection 2.6.1. Therefore, a series of research questions were derived from the gaps.

> *Q1. Is there a common understanding regarding IT project complexity among practitioners?*

The first research question focuses on the prospect of whether the lack of a common definition for IT project complexity only exists in theory. Due to the lack of validation of previous findings with perceptions of practitioners, this question has not yet been answered. Hence, research question *Q1* addresses the research gaps *G1* and *G2*.

> *Q2. How do practitioners in IT projects perceive complexity?*

Research question *Q2* has been deliberately formulated in this open manner so as to reflect the explorative nature of this study. The motivation behind this question is to gain a better understanding about (1) *what* practitioners in IT projects perceive as being complex and (2) *how* they experience this complexity. The first aspect aims to learn about the situational context that is perceived as complex, and the different factors which drive perceived complexity within these situations. The second aspect focuses on immediate and unintentional responses to it, i.e. it explores how practitioners *feel* in this situation. Note that reactions to complexity are not included in the scope of this question, but in the scope of *Q5*. The motivation behind this is to separate the perception, and the immediate sensation that follows it, from more intentional responses. Research question *Q2* mainly addresses gap *G4*.

> *Q3. Are the complexity drivers identified in the literature relevant for perceived complexity among IT project practitioners?*

In addition to the intention of exploring perceived complexity in a broad way, as formulated in *Q2*, research question *Q3* is very specific and aims to validate the complexity drivers which have been identified in the previous literature. As outlined above, this question will be looking at literature from both streams, project complexity and task complexity, hence addressing literature gaps *G2* and *G3*.

> *Q4. Does the role of a practitioner in an IT project influence the way complexity is perceived?*

This question aims to understand the relationship between the role an individual practitioner has in IT projects and the perception of complexity. As this aspect has not previously been investigated in the literature, the intent of *Q4* is to explore whether patterns can be recognised from the accounts of practitioners. It addresses gap *G4*.

> *Q5. How do individual practitioners in IT projects respond to perceived complexity?*

The motivation behind this question is to learn about the different strategies which individual practitioners apply in order to respond to complexity in IT projects. Similar to *Q2*, this question also has a very explorative character, in the hope of finding patterns of practice-proven, successful strategies. As the focus of existing literature on complexity is mainly on project managers, *Q5* emphasises all roles within an IT project, specifically the under-represented roles of project team members and project sponsors. The research question addresses gap *G4*.

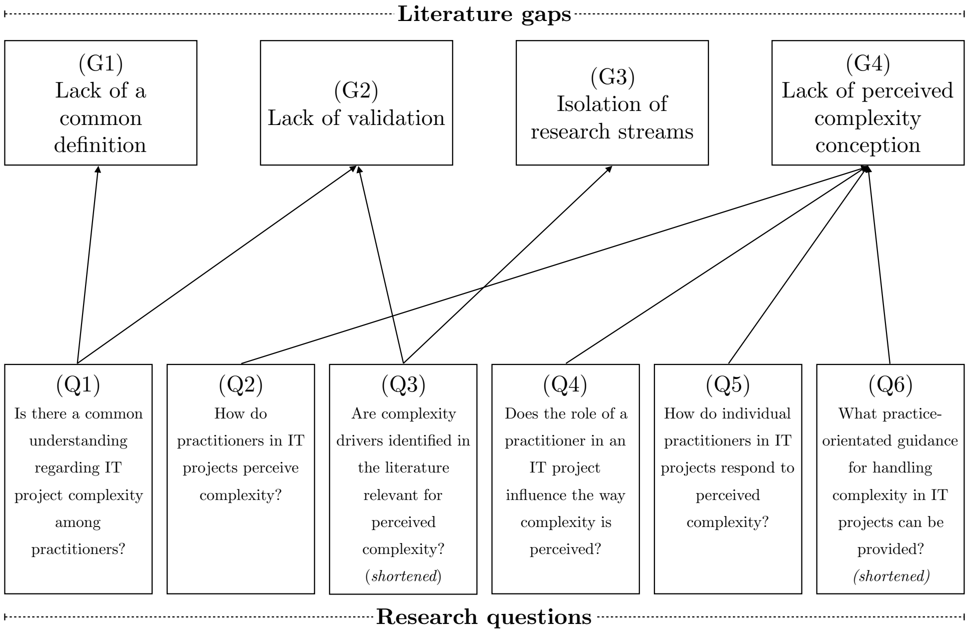


Figure 2.2: Literature gaps and research questions

> *Q6. What practice-orientated guidance for handling complexity in IT projects can be provided to individuals and organisations?*

Lastly, this question examines whether it is possible to identify practice-orientated guidelines which help individuals and organisations to cope with complexity in IT projects. These guidelines would be informed by answers to the previous research questions and would represent a *best practice* approach to complexity in IT projects. Furthermore, the guidelines could be used to raise awareness about complexity among practitioners. As this question primarily aims to offer practical guidance to practitioners, it is related to literature gap *G4*.

2.6.4 Conclusions

From the literature review in this chapter, four literature gaps have been identified and six research questions have been derived in order to address these gaps. As visualised in figure 2.2, all of the identified literature gaps are covered with research questions.

The above discussed research questions represent the scope of this study, and so the remainder of this thesis will describe the process of finding answers to these questions. Next, chapter 3 will detail the methodology which has been applied for this research project.

Chapter 3

Research Methodology

3.1 Introduction

According to Lapan, Quartaroli, and Riemer, the term *research methodology* refers to “the blueprint or set of decisions and procedures that governs a study and renders it understandable to others and is subject to inquiry, critique, and replication or adaptation to other settings.” (Lapan et al., 2012, p.70). The purpose of this chapter is to provide this transparency. This includes a presentation of the research philosophy which underpins this study in section 3.2. Afterwards, section 3.3 will discuss the research design which has been chosen for this study, based on the research philosophy. The discussion will cover all steps of the research design, including data collection and analysis. Finally, section 3.4 concludes this chapter.

3.2 Research Philosophy

3.2.1 A Research Philosophy For The Study Of Complexity

The importance of the research philosophy for the subsequent choice of research methods has been emphasised by multiple authors (e.g. Saunders, Lewis, and Thornhill, 2016; Maxwell, 2013; Benton and Craib, 2010). Therefore, this thesis section aims to provide transparency about the research philosophy, i.e. the ontological, epistemological and axiological positions underpinning this study. According to Saunders et al., the research philosophy “relates to the development of knowledge and the nature of that knowledge.” (Saunders et al., 2016, p.107). In the context of this study, the subject of research and the research questions already have a profound implications on the research philosophy. Nevertheless, for the researcher as a doctoral student and, hence, a "newcomer" to scientific research and research philosophies, the process of reflecting on his personal beliefs about the nature of knowledge and explicitly aligning these with the way the researcher perceives complexity was challenging: As outlined by Schlindwein and Ison with reference to Ison (2004), research on complexity should make the "fundamental epistemologist choice" between seeing complexity either:

> 1. "as something that exists as a property of some thing or situation; and that therefore can be discovered, measured and possibly modeled, manipulated, maintained or predicted; or
> 2. as something we construct, design, or experience in relationship to some thing, event, situation, or issue because of the distinctions - or theories - we embody." (Schlindwein & Ison, 2004, p.31)

While Schlindwein and Ison diplomatically avoid taking sides here, the researcher found himself forced to do so, in order to conduct this study into complexity. The choice between the two positions mentioned above, however, was a difficult one—particularly because many authors have well argued their cases for each position, e.g. Rescher (1998) for the first, and Cilliers and Preiser (2010), Heylighen, Cilliers, and Gershenson (2006), Morin (2006) for the second. As the researcher's knowledge about complexity grew during the literature review, he found himself torn between the two positions, agreeing with specific arguments from both sides. A further complication here was that the different fields which inform this study have been maintaining a strong tradition to certain ontological and epistemological positions: project management towards positivism, social sciences towards interpretivism.

The core motivation of this study, due to its focus on perception, is strongly leaning towards subjectivism. At the same time, the ideas of positivism, and in particular realism, could not entirely be dismissed. For these reasons, the researcher adopted a critical realism philosophy for this study. According to Saunders et al., critical realism accepts the existence of an external reality, independent from the observer, but also acknowledges that "what we experience are sensations, the images of the things in the real world, not the things directly." (Saunders et al., 2016, p.115). This dualism is a central aspect of critical realism. As McLachlan and Garcia describe it, "[e]ssentially, critical realism seeks to make a distinction between our ontological and epistemological understanding of the social world." (McLachlan & Garcia, 2015, p.197). Thus, critical realism combines ontological realism with epistemological relativism (Bhaskar, 1979, 1978). Furthermore, a critical realist research philosophy also emphasises emancipation and "a questioning of the status quo" (Wilson & Greenhill, 2004, p.667). This element is reflected in the research insofar as the dominance of a positivist conception of complexity is challenged.

In the context of this work and the object of study, applying a critical realism research philosophy means that complexity is assumed to exist independently of the observer, but we can only interpret this reality "through our own subjective, conceptual schemas" (McLachlan & Garcia, 2015, p.197). In the researcher's eyes, this philosophical stance fits well with the planned research project, as its ontological realism does not defy the positivist element that lies in *descriptive complexity*, but at the same time emphasises the need for a deeper understanding of the subjective aspects that influence how we perceive this reality, i.e. *perceived complexity*. As highlighted by Bhaskar: "We will only be able to understand what is going on in the social world if we understand the social structures that have given rise to the phenomena that we are trying to understand." (Bhaskar, 1979, p.31). In addition, a few authors (e.g. A. Brown, 2014; A. Brown and Roberts, 2014; Maxwell, 2012) have noted that the use of critical realism within management research and, in particular, qualitative research: "has become increasingly accepted." (McLachlan & Garcia, 2015, p.197). Hence, it can be concluded that critical realism fulfils the requirements for a research philosophy to be "appropriate to the nature of the object under study and the purpose and expectation of the study", as advocated by Sayer (2010).

3.2.2 Ontology

This subsection aims to describe the ontology which has underpinned this research, or, in other words, provides an answer to the question of how the researcher views the world. Research philosophy textbook authors, e.g. Saunders et al. (2016), Benton and Craib (2010), Crotty (1998), provide two opposite ontological positions as possible answers: objectivism and subjectivism. The former claims that a single and indisputable truth exists independently of our knowledge of it. The latter, in contrast, rejects the concept of an absolute truth and claims that reality is always subjective and based on interpretation. As laid out in the previous subsection, both positions have been maintained by different authors in relation to complexity and, according to the categorisation introduced by Schlindwein and Ison, the objectivist conception is called descriptive complexity, and the subjectivist conception is called perceived complexity.

Following the position of critical realism as described in Bhaskar (1979, 1978), the researcher subscribes to the ontological view of realism which advocates that an external reality exists, independently of our knowledge of it, with the only way for us humans to interpret this reality being through the subjective concepts and ideas we embody (McLachlan & Garcia, 2015). This subjective element provides a strong justification for the research aims. While the complexity of IT projects may exist, independently from any observer, the only way to experience it is through the subjective lens of individual observers, in this case the people who are directly associated with a project. So, in order to improve our understanding of IT project complexity, it is necessary to explore these perceptions. This argument is reflected by Saunders et al. who note that especially with regards to business and management research, a merely empirical view of the observed phenomena seems inadequate in order to gather a complete understanding of the social reality (Saunders et al., 2016). With a link back to the positivist tradition of management, he concludes that critical realism therefore is "much more in line with the purpose of business and management research which is too often to understand the reason for phenomena as a precursor to recommending change." (Saunders et al., 2016, p.115).

Another important ontological aspect of critical realism is the notion of seeing the social world as layered, consisting of structures, mechanisms and emerging powers, as displayed in figure 3.1 (Sayer, 2010). For critical realists, events are the phenomena we can observe. What we cannot directly observe, and so need to investigate through corresponding research methods, are the mechanisms and structures which

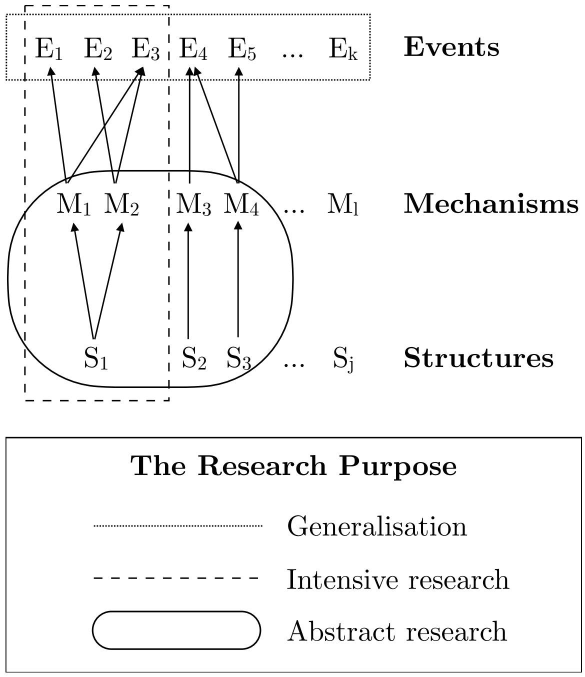


FIGURE 3.1: Layered social reality (based on Sayer, 2010, p.11)

entail these events (Bhaskar, 1989). Therefore, critical realist research emphasises the need for multi-level studies, e.g. at the level of the individual and the level of the organisation (Saunders et al., 2016). This aspect fits well also to the planned study, whereby the complexity of IT projects will be explored from two different angles: the *macro level* on the one hand, where the entire project organisation is considered and theoretical underpinnings are taken from the project complexity research stream, and the *micro level* on the other hand, where the focus is on individual persons and findings from the task complexity stream will serve as theoretical underpinning.

3.2.3 Epistemology

According to Saunders et al., “[e]pistemology concerns what constitutes acceptable knowledge in a field of study.” (Saunders et al., 2016, p.112). Put simply, an epistemological position defines how new knowledge is created in an acceptable way. As outlined above, the research philosophy of critical realism has been adopted for this study, and this choice has implications on the epistemology. In the eyes of critical realists, the knowledge we create is “a result of social conditioning [...] and cannot be understood independently of the social actors involved in the knowledge derivation process" (Saunders et al., 2016, p.115 with reference to Dobson, 2002). Hence, critical realism implies an interpretative and relativistic epistemology (McLachlan & Garcia, 2015; Benton & Craib, 2010; Dobson, 2002).

The first aspect, interpretivism, can be directly linked to the definition of critical realism, where an emphasis on the subjective element is embedded. The second aspect, relativism, acknowledges that, due to the inherent subjective element of a critical realist ontology, all claims we can make about the world are context-dependent. According to Hales, knowledge can be relative to one or multiple of the following contexts (Hales, 2011):

- time
- place
- society
- culture
- historical epoch
- conceptual schemes or frameworks
- personal training or conviction

The author expands upon the meaning of the relation between knowledge and the above listed contexts as "what counts as knowledge (or as true or justified) depends upon the value of one or more of these variables." (Hales, 2011). Applied to the concept of complexity, a few of these variables intuitively seem to fit, e.g. the historical epoch: one can easily imagine tasks that were more complex in earlier times than they are now. Hence, the epistemological notion of relativism seems to fit well to the object of study.

As a consequence of underpinning epistemological relativism, as pointedly argued by Baghramian and Carter (2017), the researcher is not "chauvinistically" maintaining the superiority of my epistemic system but instead acknowledging that findings in this study are indeed dependent upon multiple of the variables mentioned above and hence not universally valid. While the researcher would not try to rule out a dependency on any of them, based on his practical experience in IT projects, he would rather emphasise a dependency to conceptual schemes or frameworks, personal training or conviction, and culture, for the complexity of IT projects. However, this study will be sensitive to all of these elements and corresponding indications to contextual dependencies from the research data will be brought forward in the findings chapter.

Another epistemological aspect is derived from the ontological notion of viewing reality as a layered construct (see figure 3.1). As outlined by Saunders et al., "[e]ach of these levels has the capacity to change the researcher's understanding of that which is being studied." (Saunders et al., 2016, p.115). However, depending on the nature of the research with different focus areas among these layers, Sayer sees a varying need for multi-level studies. Thereby, he distinguishes between the following three categories, as described by Dobson (2002):

- *Generalisation.* Mainly concerned with the question of how different events are related across different situational settings and tries to find similarities and common patterns.
- *Intensive research.* Looks at particular contexts and combinations of isolated structures, mechanisms and actual events.
- *Abstract research.* Focuses on mechanisms and structures and does not specifically deal with events apart from as possible outcomes.

This study fits into the categories of generalisation and intensive research, as it tries to identify commonalities and patterns in the different situations that are perceived complex within IT projects, while also trying to understand the mechanisms behind these perceptions and the structures which entail them. As outlined in the previous section, since the study scope explicitly defines a multi-level study, considering individuals and project organisations, this aspect of critical realism is covered from an epistemological perspective.

Sayer's categorisation also informs another critical aspect for this research: the question of whether an inductive or deductive reasoning approach will be used. Due to the motivation of the research to seek an understanding of the emergent events, this research instead explores the different layers in order to understand the relationships between them, rather then testing a specific hypothesis. According to Saunders et al. (2016), such studies can be summarised as *exploratory studies*. However, if possible, the observations of this study can be used to develop theories about these mechanisms in an inductive way.

3.2.4 Axiology

Saunders et al. define axiology as “a branch of philosophy that studies judgements about value.” (Saunders et al., 2016, p.116). They stress the great importance of a researcher’s values on the research, throughout all of its stages. In order to acknowledge this importance and to provide transparency about my own values, as suggested by Heron (1996), this subsection contains “a written statement of personal values in relation to the topic” (Heron, 1996, p. 47).

The researcher has been working as a practitioner in IT projects for almost 15 years. Thus, not only is the author of this study adopting the role of the researcher, but also taking on the role of a stakeholder who is potentially going to be affected by the findings of this research. So when deciding to address the complexity of IT projects in a research study, the researcher was driven through the ambition to help himself, his fellow co-workers, and ultimately the industry to better cope with complexity. By conveying his personal motivation, the researcher aims to underline that:

- The researcher associates complexity or, more specifically, an excess of complexity, with something negative.

- The researcher respects and values his co-workers—both the group that he knows through personal interaction, as well as the much larger group of professionals that he has not met. The aim is to give something of value back to the industry through this study.

Secondly, when reflecting upon the IT projects the researcher worked for and their complexity, he can identify two different kinds of complexity: *necessary* complexity and *unnecessary* complexity. Obviously, this distinction is subjective and value-laden; and a scientific definition for it cannot be offered (nor is the researcher aiming to). However, for every task, the researcher believes that there is a certain inherent complexity that cannot be avoided, given the environmental factors of the task. On top of necessary complexity, there is a second component of complexity which adds to the overall complexity and basically represents *waste*. In the researcher's experience, unnecessary complexity can be caused by a wide array of reasons, the most common ones include: unrealistic planning in terms of time and budget, a lack of following known best practices, and political reasons, and among them specifically, career opportunism. The researcher is fully aware that the necessary–unnecessary complexity distinction is more a subjective belief system than a scientific categorisation, and there is no intention of introducing or proofing this distinction into the scientific discourse. It is hoped that the study findings might help to reduce the amount of unnecessary complexity.

Finally, the researcher believes projects to be team efforts. As a consequence, he is convinced that every individual person in a project team is important. It is this value which has led the researcher to oppose the currently dominant, project-manager-centric way of looking at project complexity. To the researcher, as far as project complexity is concerned, everyone within a project team is exposed to complexity, and hence everyone should be taken equally seriously. Therefore, a key element of this research study is attempting to give a voice to those who go largely unheard.

The critical realist perspective acknowledges that research is value-laden. By extension, researchers, knowingly or unknowingly, influence the research results. Given his personal background as a practitioner in IT projects, and his strong personal opinions about the complexity of IT projects, the researcher is aware of the challenge this imposes on the research, but remains yet committed to conducting his study in a valid way.

3.3 Research Design

3.3.1 Overview

As noted by various authors, the choice of a research philosophy, as presented in the previous section, has strong implications on the research design (Saunders et al., 2016; Benton & Craib, 2010; Crotty, 1998). To summarise the research scope and philosophy which has been discussed until this point: the research is an exploratory study which aims to expand our understanding about the complexity of IT projects through a critical realist lens.

The key to broadening our comprehension of the research subject lies in the perceptions of practitioners within IT projects. As a critical realist, the researcher favours qualitative over quantitative methods in this context, as quantitative data is not expected to provide the required richness that is necessary to grasp the relationships between the different levels of the layered social reality of IT projects. Within the qualitative methods, a case study approach with in-depth interviews has been chosen as the data collection method. A few authors, e.g. Saunders et al. (2016), McLachlan and Garcia (2015), Eisenhardt (1989) note that a case study approach with interviews typically fits well with exploratory studies. In addition, interviews hold two practical advantages: firstly, they allow the researcher to follow-up certain answers in a flexible way, which seems beneficial for the exploration of something as complex as the complexity of IT projects. Secondly, due to the researcher's numerous contacts within the IT industry, the accessibility of potential participants seemed unproblematic.

Figure 3.2 displays the research design in the form of a flow chart. At the centre of the study was the data collection (II) which was carried out through interviews, as outlined above. In order to prepare the interviews and the later data analysis, a consolidation of the complexity drivers which were mentioned in the literature (I) has been done. After the data collection, the collected data was analysed (III). The analysis consists of five sub-components III-a to III-e, representing the research questions *Q1* to *Q5*. Even though there were interdependencies between these data analysis tasks, they could be performed in parallel. In contrast, the final analysis task, the identification of practice-orientated guidelines for handling complexity in IT projects (IV) could only be done after the other data analysis tasks had been completed. The following subsections discuss the details of the different activities.

3.3.2 Consolidating Complexity Drivers

The first activity included the consolidation of existing complexity drivers which had been mentioned in the literature. As discussed in chapter 2, there are two different research streams, project complexity and task complexity, both of which apply to the perceived complexity in IT projects. Both streams have analysed complexity drivers from their perspectives and, thanks to the work of Geraldi et al. (2011) and Liu and Li (2012), findings in both streams were consolidated and put into a common collection of complexity drivers.

As discussed in chapter 1, the conceptualisation which has been underpinning this research (see figures 1.1 and 1.3) assumes that perceived project complexity is affected by two dimensions: the task dimension which mainly represents the complexity for individuals to do "their" work (micro level) and the complexity that on project level (macro level) stems from the organisation of multiple tasks and the difficulties which they entail, e.g. prioritisation conflicts. Thus, in order to prepare interview questions and perform the data analysis, the findings from both streams were consolidated into one common collection of perceived project complexity drivers, as displayed in 3.3. Note that, due to the general nature of the underlying frameworks, these drivers

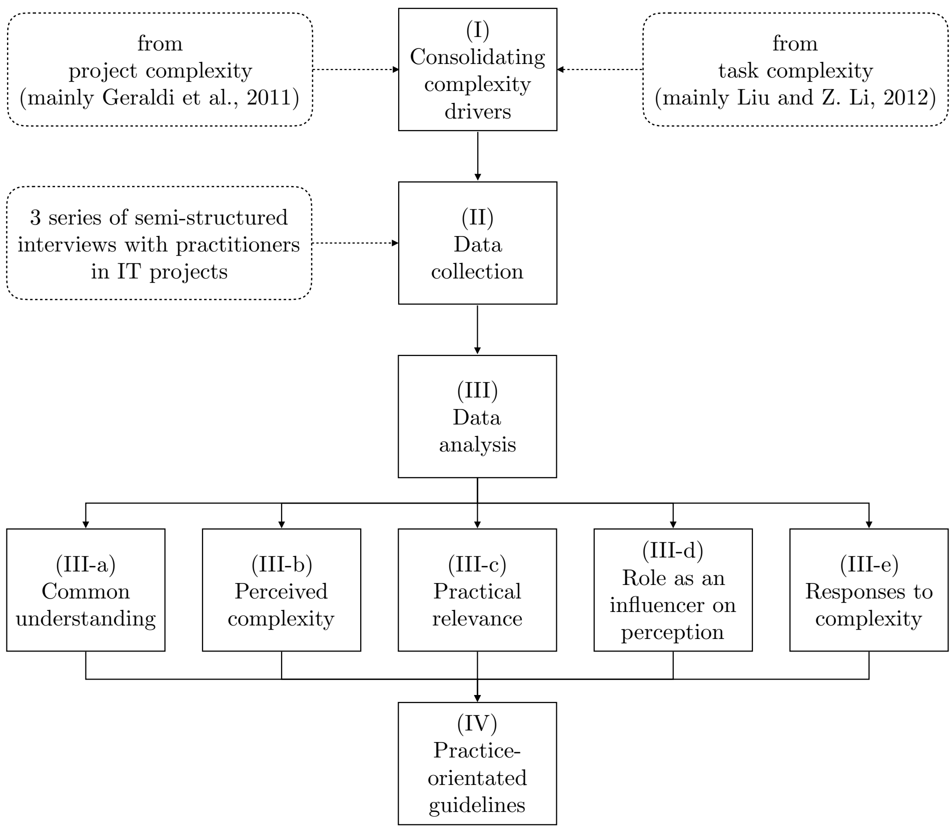


Figure 3.2: Research design

are not specific to IT projects, but represent drivers from across all industries. As part of activity III-c, the relevance of these drivers in the specific context of IT projects is analysed.

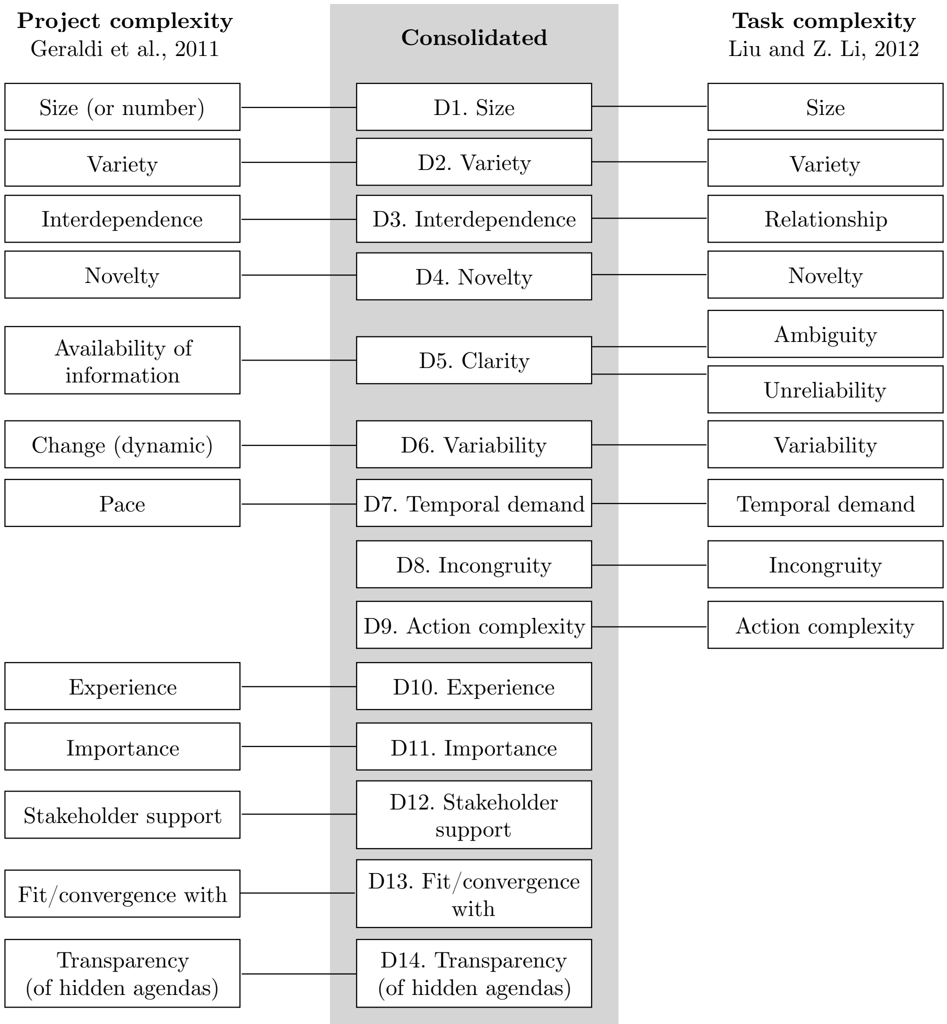


FIGURE 3.3: Consolidated collection of complexity drivers

The consolidation included the identification of similar items, despite a slightly different terminology having been used. If two items were considered to address the same aspect of complexity, they were merged into a single item within the collection. If there was no match, entries were also added to the consolidated collection. Mathematically speaking, the consolidated collection is the union of the project complexity and task complexity frameworks. Table 3.1 displays the number of total

TABLE 3.1: Framework consolidation statistics

Source framework	Number of items	Common items	Unmatched items
Project complexity	12	7	5
Task complexity	10	8	2

items per source framework alongside how many of the items corresponded with an item from the other framework. Note that two items from the task complexity framework, *Ambiguity* and *Unreliability*, were merged into the broader category *D5. Clarity* in the consolidated collection, in order to match it with *Availability of information* on the project complexity side. Hence, the total number of items in the consolidated collection is 14. It should be emphasised that a match between the two source frameworks does not imply identical meanings. Even though addressing similar aspects of complexity, both sides have varying themes that they emphasise. A detailed description of the consolidated drivers can be found in appendix A.

The results of the consolidation supported the conceptual assumption that task complexity findings are indeed relevant for project complexity. Out of ten complexity drivers in the task complexity driver framework of Liu and Li (2012), eight could be matched to drivers of the project complexity framework of Geraldi et al. (2011). This lined up well with the assumption that task complexity is a component of project complexity that represents the complexity on micro level. Therefore, the validity of the approach, which included using the consolidated complexity driver collection as an input for defining interview questions and for analysing the interviews, seemed legitimate.

3.3.3 Data Collection

The data collection for this study was divided into three phases, as displayed in table 3.2. The purpose of each of these phases is described below.

- *Pilot Study.* A limited pilot study was supposed to confirm the overall research project and approach. Conducting a small scale pilot study would reduce the risk of failure, as supported by various authors (e.g. Saunders et al., 2016; Benton and Craib, 2010).

Table 3.2: Data collection phases

Data collection phase	Participants
Pilot study	3
Main study I	7
Main study II	5

Therefore, the data collection during the pilot phase included three interviews and a critical review of the approach.

- *Main study I.* Due to the exploratory nature of this study which requires the researcher to remain flexible and willing to adapt to change (Lapan et al., 2012; Taylor & Wallace, 2007), the main study data collection has been split into two phases. The purpose of the first phase during the main study was to collect further data, based on the learnings of the pilot phase. In total, seven interviews were conducted during this phase.

- *Main study II.* After ten interviews had been conducted in the previous two phases, the researcher reviewed the data collection approach once again, as suggested for example by Saunders et al., who note: "If you are conducting exploratory research you must be willing to change your direction as a result of new data that appear and new insights that occur to you." (Saunders et al., 2016, p.140). Due to the chosen sampling strategy (see below), themes in the data emerged relatively early in the data collection process. In order to explore some of the themes in more detail, the interview framework was slightly adjusted for the second phase of the main study (see appendix B). Furthermore, the researcher chose to improve the validity of the data in the last phase by interviewing practitioners he had not met before and who were identified through snowball sampling (see below).

The most methodical aspects remained consistent across all data collection phases and only a few parameters were adapted. The different aspects of data collection will be detailed below. Unless explicitly limited to one of the phases, the descriptions below apply to all phases.

Interview Structure And Setup

From the different interviewing techniques, semi-structured interviewing was chosen, as it seemed a good compromise in terms of ensuring a certain comparability of the different interviews while at the same time allowing for a follow up on interesting aspects in a flexible way during the interviews (Tashakkori & Teddlie, 2006). Therefore, an interview framework was prepared with the main questions considered to be important. The questions were formulated in an open way in order to support the exploratory study approach. The basis for defining relevant questions was, on the one hand, the consolidated collection of complexity drivers which has been produced during the previous step (see subsection 3.3.2) and, on the other hand, determined by the researcher's personal judgement in terms of factors that were deemed most critical within IT projects. This subjective element seemed unavoidable, given the limited time frame for the interviews. Therefore, each interview was concluded with the question of whether participants would like to address any other aspects they deemed important in relation to the research subject.

The interview framework was first used during the pilot phase. In the critical reflection which followed the pilot study, the framework was adjusted with minimal changes, mainly in order to adapt the sequence of questions to improve the overall flow of the interview and to add further questions to better address some unexpected topics. In total, the number of questions on the framework increased from 38 to 43. Between phase I and II of the main study, the framework was slightly adjusted again. This time, a few questions which seemed irrelevant in terms of the study aim and had not yet produced valuable insights, where dropped from the framework. Therefore, the number of questions fell back to 38 for the third data collection phase. All interview questions and the phase in which they were used as part of the interview framework can be found in appendix B. Furthermore, excerpts from three interviews can be found in appendix D.

Interviews were either held face-to-face or via telephone. The latter was necessary in order to minimise the cost of interviews, especially with participants who were located further away. Since the study was not geographically limited, participants from different countries, e.g. USA, India, and Brazil, were interviewed. The participants received a handout, either electronically or on paper, which informed them about the main aspects of the research (see appendix C). The document specifically covered ethical aspects of the study, for example it explained how the data would be used and assured confidentiality. However, it did not provide too many theoretical details about the field of study as this might have interfered with the interviewees' understanding of complexity and hence compromise the study results. Based on the information in the handout, all interviewees had to provide written consent about their participation. All participants were asked whether they found the handout useful and whether they were missing any information afterwards.

During the main study, interviews lasted approximately 60 minutes on average. However, the interviews of the pilot phase lasted approximately 120 minutes on average, reflecting both the rather wide interview framework and the critical case sampling. All interviews were fully recorded (audio only). Participants were granted the right to pause the interview at any time. Where the interviewee spoke German and felt comfortable with it, interviews were conducted in German; otherwise in English. At the end of each interview, participants were asked whether anything important in relation to the complexity of IT projects was missed. Furthermore, they were asked for feedback on the interview and the research project in general after the microphone was turned off. Most of the feedback was positive, which was reassuring. A common theme in the feedback was the appearance of statements like: "Great that finally someone is investigating this.". None of the participants questioned or challenged the research approach in general, but the chance for giving constructive feedback was used occasionally and considered by the researcher.

After the data had been collected, it was necessary to transcribe and, where held in German, translate the interviews. All these activities were executed exclusively by the researcher. While these steps were separated for the pilot phase, the researcher decided to combine them into a one step approach for the main study in order to be more efficient. The full transcripts were electronically sent to the participants, together with a request to confirm the statements made in the interview. With a few minor changes to the transcripts in two interviews, all the transcripts were confirmed.

Sampling And Sample Size

Since it was obviously not possible to interview the whole population of practitioners working in IT projects, sampling was chosen as a pragmatic alternative, as suggested by many authors (Saunders et al., 2016; Benton & Craib, 2010; Crotty, 1998). The literature available knows many different sampling methods and, for the context of this work, the taxonomy introduced by Saunders et al. as displayed in figure 3.4 will be used. Due to the lack of a potential sampling frame, probability sampling was dismissed. Hence, options from the group of non-probability sampling methods had to be considered.

In order to maximise the validity of the data, the three different data collection phases followed different sampling strategies. The goal of the pilot study was to certify the research approach and design, thus, selected samples focused on critical cases. This strategy provided rich results which allowed for the determination of whether modifications in the research design were necessary. During the first phase of the main study, the primary focus was to talk to a wide variety of persons. As outlined in Patton (2015), heterogeneous sampling is the preferred approach for describing and explaining key themes from the collected data, which well reflects the research aim. According to Patton, with regards to heterogeneous sampling: "any patterns that do emerge are likely to be of particular interest and value and represent the key themes." (Patton, 2015, p. 74). Therefore, heterogeneous sampling has been chosen for the first phase of the main study. As variation criteria, the variables of age, gender, and experience were used. Cases which had already been covered during the pilot study were considered during the sampling process, so that similar cases were not selected again. Lastly, the second phase of the main study had an additional function, and that was to validate the data collection process. Hence, for this phase, a combination of heterogeneous sampling and snowball sampling was used. Previous participants were asked to refer further participants if they wanted to and if they knew a person who would fit well into the variation scheme. Out of five participants within the final data collection phase, four were referred through participants. These four participants were used as a control group in terms of the representativeness of the overall data, a known potential weakness of purposive sampling

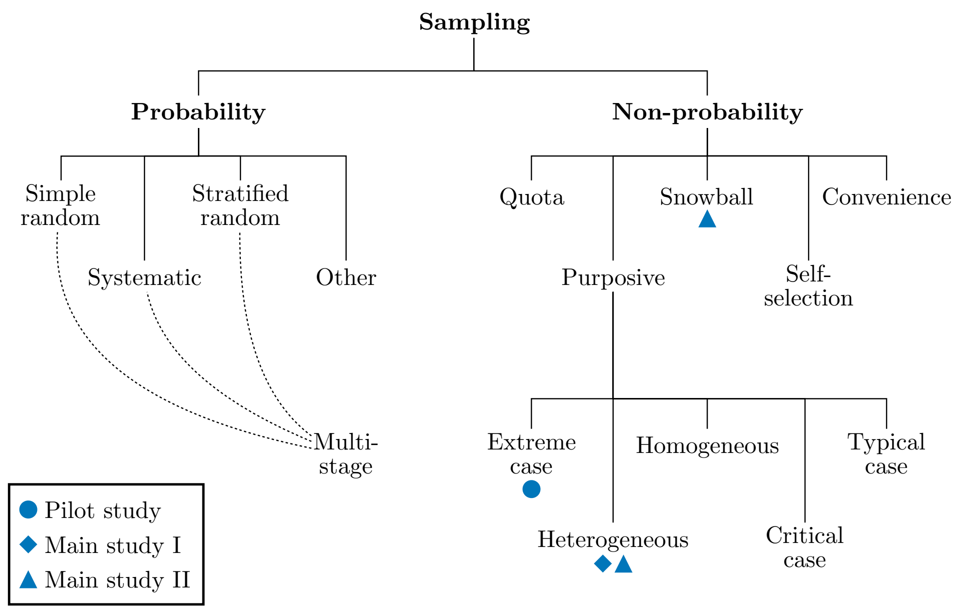


FIGURE 3.4: Sampling strategies, adopted from Saunders, Lewis, and Thornhill (2016, p.213)

(Saunders et al., 2016; Benton & Craib, 2010). Figure 3.4 shows the different sampling strategies which have been used within the taxonomy of Saunders et al. (2016).

The sample size was not limited when the data collection started. The motivation behind this decision was again the need for flexibility within an exploratory study. Therefore, interviews were held until data saturation was met. Nevertheless, in order to plan and organise the remainder of the study, the researcher considered the sample size recommendations within the literature (McLachlan & Garcia, 2015; Benton & Craib, 2010; Crotty, 1998). Saunders et al. advocate that for studies with semi-structured interviews, the minimum sample size should be between 5 and 25 interviews (Saunders et al., 2016, p.297).

Overall, for this study, 18 persons were approached and asked to participate, either through personal interaction or through e-mail; 15 of them accepted and did participate while 3 declined or did not respond. Table 3.3 provides an overview of the study participants. Note that the names displayed in the table and throughout the remainder of this thesis will be fictional in order to maintain confidentiality of the participants. The overall sample size hence is well within the limits specified by Saunders et al. (2016). Also, in terms of the variance in criteria age, gender, and experience, the targets of the sampling strategy were considered met. Data saturation was assessed through analysing

Table 3.3: Study participants (names are fictive)

Name	Age cluster	Gender	Years of IT project experience	Data collection phase	Referred by
Andrew	40-49	male	21	Pilot	
Mark	30-39	male	8	Pilot	
Steven	30-39	male	10	Pilot	
Carol	30-39	female	4	Main study I	
Sophie	20-29	female	2	Main study I	
Paul	20-29	male	3.5	Main study I	
Frank	40-49	male	19	Main study I	
Anne	30-39	female	7	Main study I	
Jane	40-49	female	19	Main study I	
Walter	40-49	male	23	Main study I	
Edward	40-49	male	20	Main study II	
Edith	30-39	female	15	Main study II	Mark
Sangeetha	40-49	female	17	Main study II	Frank
Richard	50-59	male	23	Main study II	Jane
Nathalie	20-29	female	7	Main study II	Walter

the interviews which took place in parallel to the data collection process. As part of the analysis process, which themes emerged in which interview were tracked, and a single theme was considered "saturated" after it appeared in three or more interviews—although many of them did appear in more than three and the data was analysed as a matter of course. This procedure was necessary due to the sampling strategy; with critical case sampling in the pilot phase, many of the emerging themes were mentioned early in the data collection process, so tracking the mere emergence of new themes would have meant that saturation had already been met after the pilot. While it was thought that the pilot results provided valuable insights, further value was seen in moving into the main study and so improving the representativeness of the study through further interviews. Table 3.4 provides an overview of the data saturation throughout the different interviews and further details can be found in appendix E.

Data Validity

The crucial role of data validity and reliability within the research process has been emphasised multiple times in the literature (Saunders et

Table 3.4: Data saturation

Interview number	Newly emerging themes	Saturated themes	Unsaturated themes
1	13	0	13
2	1	0	14
3	0	9	5
4	0	11	3
5	0	12	2
6	0	13	1
7	0	14	0
8	0	14	0
9	0	14	0
10	0	14	0
11	0	14	0
12	0	14	0
13	0	14	0
14	0	14	0
15	0	14	0

al., 2016; Benton & Craib, 2010; Thiétart, 2001) and still seems to lack a clear methodical framework (McLachlan & Garcia, 2015; Alasuutari, Bickman, & Brannen, 2008). Validity can be broken down into multiple components; this research opted to follow the suggestion of Thiétart (2001), which will be used as a framework to discuss the validity of this study below. Thiétart distinguishes four different components of validity:

1. *Construct validity.* The degree to which the chosen research methodology allows for the answering of the research questions.

2. *Validity of the measuring instrument.* The degree to which the measuring instruments—in the context of qualitative research: the process that enables us to establish a relationship between abstract concepts and empirical indicators (Carmines & Zeller, 1979)—are valid and reliable.

3. *Internal validity.* The degree to which the study investigates what it is meant to according to the research questions.

4. *External validity.* The degree to which the research methodology is transferable and generalisable.

Through the pilot study, which has been conducted with a smaller sample size before the research went into the main phase, the above mentioned components were addressed. The data collected during the pilot was very rich, in part also due to the critical case sampling. The measuring instruments—i.e. the process of gathering data from the interviews, translating and transcribing it, and analysing it—have been tested during this pilot study and the results were deemed satisfactory. Yet, as Miles, Huberman, and Saldaña note: “the problem is that there are no canons, decision rules, algorithms, or even any agreed upon heuristics in qualitative research, to indicate whether findings are valid” (Miles et al., 2014, p.230). Many of the aspects that would potentially undermine the validity of measurement instruments lie in the hands of the researcher in qualitative research (Thiétart, 2001), e.g. with the transcription and translation process steps. From the pilot study, it appears confirmed that these steps did not significantly harm validity, based on the result.

Another potential problem regarding the validity of the measurement instruments was introduced through the specific method of data collection, i.e. interviewing. As noted by Malterud, there are multiple ways in which the validity of interview data can be compromised, e.g. through misunderstandings or misinterpretations (Malterud, 2001). While the potential of these risks was addressed by sending the written transcripts to participants and asking them for confirmation, there is no guarantee that all the questions were answered truthfully. Furthermore, as the interviews were focusing on perceptions and lived experiences, there was no external criterion of validity available (Thiétart, 2001). However, the risk for intentional misinformation being given by the participants was deemed low, as there was no potential gain or harm from the research to them personally, and all interviewees participated voluntarily. Altogether, no reason was found to question or challenge the accounts received during the interviews.

Lastly, due to an epistemological relativism, which is part of the study’s critical realist research philosophy, the claims expected to be made from this research were relatively modest in terms of transferability and generalisability. In particular, the latter has not been the primary motivation of this research, as discussed in section 3.2. The primary aim of this study was to explore individual perceptions concerning the complexity of IT projects, which has a subjective, and hence hardly generalisable, notion centrally embedded in it.

Ethical Considerations

The researcher has been highly committed to conducting research in an ethically proper way. In the context of qualitative research, this means that the research population should not be subject "to embarrassment, harm or any other material disadvantage." (Saunders et al., 2016, p.160). Naturally, the study was executed in full accordance with the "Code of Practice on Research and Knowledge Transfer Ethics and Governance" of Edinburgh Napier University. Specifically, the following ethical aspects concerning the research design were considered:

- Participation in the pilot study was strictly possible on a solely voluntary basis. Consequently, the researcher did not ask an executive sponsor to use his or her organisational power to convince or even force persons to participate in the study. Equally, no incentives were granted for participation.

- Study participants had to be fully informed about the planned research and how their data was going to be used. This had been ensured by sharing a handout prior to the interviews (see above). All interviewees had to provide written consent regarding their participation before the interviews were held. In addition, the transcripts were shared with the participants after the interviews and they were asked to confirm their statements. If interest was expressed, participants were offered receipt of a copy of the later results of the study.

- Participants were granted full confidentiality and anonymity. They were assured that in case individual statements from the interviews would be cited, these statements would be quoted anonymously, according to the Data Protection Act 1998 (Parliament of the United Kingdom, 1998). This measure was intended to provide a protected space for interviewees, and hence to increase their openness to also share more private information, e.g. feelings of stress or anxiety.

- The researcher remained aware of the potential power differences between his own position and that of the participants of the study. To minimise the danger of possible data contamination from power differences, no persons were interviewed who had previously been reporting to the researcher or who the researcher had been reporting to (also in an indirect way, e.g. in project teams).

3.3.4 Data Analysis

A typical way in which to analyse qualitative data, and particularly interviews, is through coding and categorising the collected data (Flick, 2008; Crotty, 1998). This subsection provides details about the different steps of the data analysis process. In addition, appendix F provides a few metrics regarding the data collection and analysis process.

Preparation

In order to efficiently analyse the audio recordings of the interviews, transcription was required. In addition, since a few of the interviews were conducted in German, these interviews needed to be translated. While the two steps were initially separated for the first data collection phase (3 interviews), they were combined in a one-step approach for the main study. The implications of the translation process to the data as mentioned in the literature (e.g. Saunders et al., 2016; Bryman and Bell, 2011) were considered. As someone who speaks English as a second language, the researcher tried to preserve the meaning of the original statements, consulting with native speakers in case of questions. As the main focus of this analysis is on semantic rather than linguistic details, the translation process did not damage the validity of the data.

The transcripts were saved electronically and in an anonymous form on an encrypted hard drive. For the data analysis, the transcripts were loaded into Microsoft Excel™. The rationale behind using Excel and not a dedicated computer aided qualitative data analysis software (CAQ-DAS) package (Saunders et al., 2016) was mainly driven by researcher experience. An evaluation of NVivo™ did not reveal any critical features which were not available in Microsoft Excel™ as well. The main benefit of NVivo™, its collaboration features, was irrelevant for this study. Hence, it was decided to use Microsoft Excel™ for the data analysis.

Each interview question and the corresponding answer were entered into a separate row, together with further information: e.g. an identifier for the interview and a sequential number for cross references. Emerging themes (see below) were organised in columns. Where an answer needed to be linked to a theme, further details were added into the corresponding cell. By using the spreadsheet column filters, efficient navigation was provided through the data, leading to clear identification of commonalities across interviews.

Data Analysis And Coding

As displayed in the research design (see figure 3.2), the data analysis consisted of five different subcomponents *III-a* to *III-e* which matched the research questions *Q1* to *Q5*. The different analysis tasks will be described below.

- *Common understanding (III-a).* Participants were explicitly asked to define complexity in the context of IT projects. The question was asked in the introductory section, so that there was no potential bias from earlier interview questions. In addition, if participants made later statements which contained further details about their definitions of complexity, these statements were also considered in the analysis.
- *Perceived complexity (III-b).* From the answers given in all the interviews, statements which provided deeper insights into perceived complexity were analysed. Following the exploratory nature of the associated research question *Q2*, the analysis did not start with any predefined codes but rather tried to identify emerging themes and related codes within every interview. As a result, the analysis for this subcomponent was an iterative process and whenever a new theme or code emerged from an interview, previous interviews were re-analysed for any further occurrences which may have been overlooked or did not seem significant at the time of original analysis.
- *Practical relevance (III-c).* The purpose of this task was to match statements from the interviews about complexity drivers to those

drivers identified in project complexity and task complexity research. Since drivers often have a pairing inhibitor which stems from the same aspect, e.g. bad communication as a driver and good communication as an inhibitor for complexity, mentions of such pairing terms have also been analysed. All the appearances of drivers from the consolidated collection (see subsection 3.3.2) were identified. The total number of mentions of a particular driver was analysed, but relevance was not merely calculated this way; since each interview is unique, quantitative comparisons across different interviews would mean to treat interviews as if they were surveys. Instead, other factors, e.g. the importance participants have assigned to certain factors, have been considered as well.

- *Role as influencer on perception (III-d).* Any accounts with relation to role, either explicit or implicit, were analysed in order to identify situations where role seemed to have an influence on perceived complexity.
- *Responses to complexity (III-e).* The different strategies of practitioners to deal with complexity have been identified and analysed from the interviews.

The data analysis process started already immediately after each interview, when the researcher took some time to reflect on the interview and make notes about the aspects found noteworthy. Similarly, incisive statements were marked and further notes made during the translation and transcription process. Each interview was analysed in full concerning all the aspects mentioned above: i.e. every single statement that had been said by participants was scanned for relevant content regarding the five analysis tasks. As mentioned above, when new themes emerged from later interviews, previous interviews were scanned again for occurrences of this particular theme. This procedure ensured that every interview was analysed with every theme.

The analysis process was tracked using the aforementioned Microsoft Excel™ document. While questions and answers were arranged in rows, emerging themes were added as columns. Hence, colours were used in individual cells to track whether the analysis has already been done. This allowed for the ensuring of the completeness of the data analysis in terms of screening all answers against identified themes and search tasks.

3.3.5 Guidelines Creation

The last activity of the research design aimed to produce practice-orientated guidelines for handling complexity in IT projects from the data analysis by linking the findings of the different data analysis sub-tasks back together. With respect to the addressees of the guidelines—practitioners within IT projects—the researcher decided to use a situational format to present the guidelines since it allows practitioners to easily identify applicable situations in the field. The guidelines were intended to describe specific situations and to provide guidance on recommended approaches for addressing the complexity of the situation.

Consequently, situational elements with relation to complexity in different interviews were coded in order to find similarities and distinguish common patterns. Following a critical realist research philosophy, the situational aspects were mapped to the three different layers of reality, according to critical realism: events, mechanisms and structures (Sayer, 2010). This allowed to identify the causal relationships between these layers. The identified situations were filtered; only the ones with substantial data to describe the situation and best practice outcomes were considered. The remaining situations were assessed regarding their expected value in practice, which is conceptualised as a combination of (figure 3.5):

- the occurrence of the situation in practice,
- the potential benefit from the suggested response(s),
- and the likeliness to successfully operationalise the response(s).

With this assessment process, six different situations were chosen and consolidated into practice-orientated guidelines. Section 5.4 will present the situations and recommended responses to them.

3.4 Conclusions

This chapter discussed how the study aims to answer the research questions raised in the literature review. Due to the great impact on

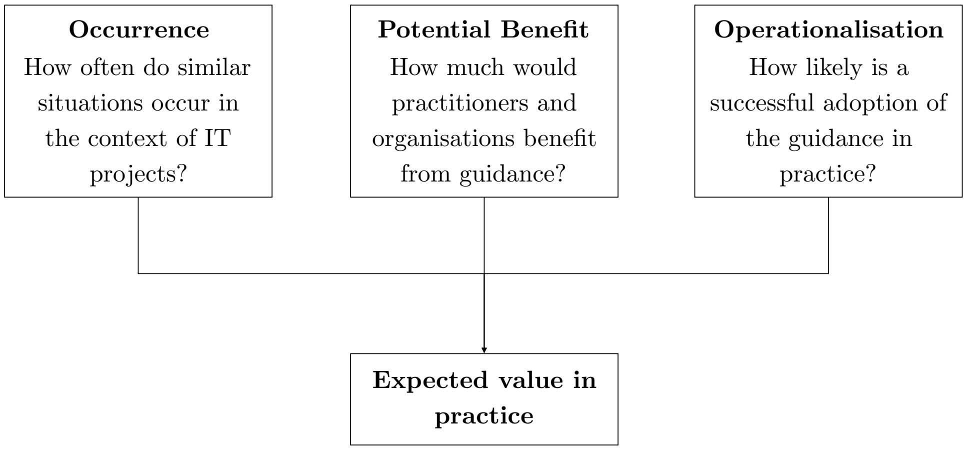


FIGURE 3.5: Conceptualisation of expected value in practice

the study design, the underpinned research philosophy, critical realism, and its influence on the study were covered. Furthermore, the research design has been presented in a structured form, consisting of different steps to collect and analyse data. At the core of the research, in-depth interviews were conducted with practitioners in IT projects to learn about their perceptions of complexity. In addition, the subsequent activities for data analysis have been divulged.

Based upon the research methodology which has been applied as described here, the subsequent chapter 4 will present the various findings which were derived from the research study.

Chapter 4

Findings

4.1 Introduction

In this chapter, the findings of the data collection and analysis process, as discussed in the previous chapter, will be presented. As the findings have been derived from the in-depth interviews with practitioners, this chapter contains various quotations from the study participants in order to illustrate the findings. In order to maintain confidentiality, the participant names used here are fictive (as displayed in table 3.3). The structure of this chapter follows the various data analysis subtasks *III-a* to *III-e*, as presented in the research design (see figure 3.2).

Since the different data analysis subtasks, and the research questions associated with them, vary in their scope, the corresponding sections in this chapter alter in length. For example, section 4.3 discusses the many findings related to the perception of complexity and is, due to the rather open exploration of perceived complexity, much longer than, for example section 4.2 which presents the results of the comparably narrow aspect of whether there is a common understanding of complexity among participants.

4.2 Common Understanding

As discussed in the literature review in chapter 2, the term *complexity* lacks a general definition, at least one that would be agreeable within various fields of study. Therefore, all the participants of this study were asked in the introductory section of the interview to provide their own definitions of complexity in IT projects. The question was asked very early, so that answers were unbiased and not influenced by other questions within the interview.

The results confirm the previous observation that indeed, there is a lack of common definition. All the participants gave different answers with regards to what the complexity of an IT project means to them. Some of the answers had overlapping aspects (e.g. the number of people involved in the project), but there were no identical answers. Many of the participants hesitated for a while before actually providing an answer, so it can be inferred from this that the answers did not come easily which, in turn, might mean that the participants are not fully aware of a proper definition. An interesting observation in this context was that participants in most cases did not try to provide a clear-cut definition but rather started listing complexity drivers, as for example in Jane's answer:

> *Jane:* "A project is definitely complex if you don't have the required knowledge. Also, if too many parties are involved that need to be managed or that are supposed to manage you, that is stakeholders. Same with long-running projects that often have a certain complexity, because of their sheer size."

These lists of complexity drivers given by the participants had varying degrees of structure and completeness. Some of the answers, for example the ones from Steven, Carol, and Paul, seemed to reflect their most recent project challenges, as became clear over the course of the interview. One participant, Anne, gave an almost textbook answer (distinction between technical and non-technical factors, as introduced by Baccarini, 1996), probably the result of a personal preparation for the interview. Meanwhile, another participant, Walter, responded with a structured list of eight different drivers. From all fifteen participants, only Frank actually provided a definition of complexity:

> *Frank:* "A project is complex if it cannot be grasped in its main dimensions, that is its target and the allocated time. And with 'cannot be grasped', I mean it cannot be handled with conventional project management methods. For example, it does not fit into typical schemes of how projects are planned or broken down into sub-projects."

Throughout the course of the interviews, participants rarely referred back to their own definitions again, despite talking about complexity most of the time. Occasionally, it was apparent from the participants' narratives that they were using "complexity" in a different, and sometimes contradictory, way than as they had defined it before. It appeared that none of the participants were aware of the distinction between descriptive and perceived complexity, and some participants even used "complexity" in both ways throughout their interview. Although not explicitly mentioned, the notion of perceived complexity was used in the majority of cases—this was not surprising, as the interview questions mainly addressed personal aspects and opinions. In rare cases, however, participants seemed insecure about their own perceptions which stood in contrast with what they called "real" or "actual" complexity.

Altogether, the interviews underlined that there is no common understanding of the term "complexity" in the context of IT projects and that, besides the lack of a common definition, there is a wide range of ways in which the participants used the word "complex".

4.3 Perceived Complexity

4.3.1 Experience As A Key Factor

Without exception, all participants of the study highlighted the importance of experience to contribute to the perception of complexity. When asked about the influence between the two, participants often used strong language to stress the significance, e.g. "huge influence" or "crucial factor". Sangeetha even considered it to be the most important factor:

> *Sangeetha:* "In my eyes, it [experience] is the most important aspect from an individual perspective. The complexity of a task is very different whether I am doing it for the first or for the tenth time."

Since the strong influence of experience was to be expected from the researcher's previous observations in the field, multiple questions were asked in the interviews to further explore the relationship between experience and complexity. The following findings were identified:

Experience is more important than education. While the participants in general, and graduates from STEM disciplines (science, technology, engineering and mathematics) in particular, mentioned that their education had been helpful for them when dealing with complexity, the majority of them also stated that experience is a far more important factor. Also, when asked the fictive question of whether they could think of an additional education or set of experiences that would prove helpful for dealing with complexity, all of them answered with a set of experiences (e.g. more experience from different cultures).

Experience has two positive effects. As indicated in Sangeetha's statement above, experience influences whether something is perceived as complex or not. This means that depending on an individual's (positive) experience, a situation or task may not even be perceived as complex. This is, for example, illustrated in Edward's statement:

> *Edward:* "I think there is a huge influence [from experience]. I think through experience, we can assess complexity a lot better."

In addition to this function, experience has a second means of influence: it helps in the handling of complex situations. Multiple participants reported how experience makes them behave more "relaxed", that is more analytical and factual, in complex situations, like for example indicated by Edith and Nathalie in the two statements below. As will be discussed in subsection 4.6.1, the collected data implies that an analytic and fact-driven response to complexity is more likely to succeed.

> *Interviewer:* "In what way do you think experience changes the perception of complexity in IT projects?"
>
> *Edith:* "I think it helps you to put things into context. And it makes you less afraid of failing. I guess if you know you survived a few other tricky situations before, you will not fall into some sort of panic mode when there is a complex problem in your project."

> *Nathalie:* “I am not sure whether it actually changes the perception. [pauses] With experience, people stay more relaxed and focused I guess. It is like some kind of protection against the stress that comes along with complexity.”

A few of the participants, for example Mark, even explicitly referred to the different experiences they had had on the day, and explained how they would have responded differently had the experience occurred earlier. They reflected on past situations:

> *Mark:* “Looking back with today’s experience, I would probably see things more relaxed and would probably put my focus on different things than I did back then.”

Experience is not everything. While all participants underlined experience as being one of the most important influencers on perceived complexity, it also became apparent that experience does not guarantee the successful handling of complex situations. For example, Paul described how he expected his more experienced co-workers to help him deal with a situation that he perceived to be complex, but his co-workers struggled to to be of assistance. Another interesting observation came from Frank who, despite his many years of experience, still worked in a team member role for most of his engagements. According to him, experience might also add to complexity, as it can lead a person to a *false routine*:

> *Frank:* “The danger is that an experienced person could use wrong or old methods which are based on his or her previous experience, even if they actually do not apply in the current situation or might be outdated.”

4.3.2 Expectations As A Critical Factor

More than half of the interviewees (9) mentioned that expectations from their environments influenced their negative perceptions of complexity. This theme was observable with more junior participants, or when participants referred back to the time when they were junior, like Nathalie:

> *Nathalie:* "I found it very hard in the beginning of my career to balance my own expectations with the ones from my environment. I often was not sure whether I am meeting other people's expectations. Sometimes I misinterpreted feedback and thought that I have to do more, which made things a lot more complex for me."

Similarly, Andrew described a situation in which he struggled with a rather simple task due to him overlooking the obvious solution as a result of the high expectations he felt during one of his first assignments as a consultant. Sangeetha, meanwhile, associates the high expectations, that made things appear more complex for her, with her gender and asserts:

> *Sangeetha:* "As a woman in IT, people are less likely to accept you and it always feels like the bar is a bit higher. At least I thought so... and these expectations made things a lot harder for me, because I had to do more than others to do a good job."

Another participant, Walter, offered an explanation about the mechanics that are triggered by exaggerated expectations, when asked about the effects of stress on the perception of complexity:

> *Walter:* "I think a big influence here is expectations. If expectations are too high, this produces stress and this might lead for people to overlook something important or not taking it as serious as it eventually will be."

Lastly, Steven indicates that the expectation building of stakeholders already starts in the pre-sales phase. In his opinion, his consultancy firm is occasionally too eager to win a project and hence oversells the benefits or sets unrealistic expectations in terms of time or project costs. Consequently, when the project is won, project managers end up facing high expectations from clients, and chasing after them distracts from their regular tasks, so creating additional complexity.

4.3.3 Attitudes Towards Complexity

> *Andrew:* "Personally, I love complexity. [laughs]"

Although one would expect practitioners to be rather averse to complexity, many of the study participants actually revealed that they try to embrace it and maintain a positive attitude towards it. Andrew's statement above illustrates this impressively. Often, the participants implied that higher complexity also meant a greater challenge to them.

> *Interviewer:* "Would you say complexity is value laden and, if so, would you see it rather as positive or negative?"

> *Jane:* "Actually, positive... Otherwise, it would also be boring. Why are large programs so challenging? Because they are complex. And it is much more challenging to execute a large program rather than a small project with only 3 or 4 people working on it."

Often, interviewees indicated that their positivity towards complexity is meant to rub off on others, encouraging them to see complexity as being manageable. One participant, Andrew, even described a cultural correlation in this context, as apparent in his statement below. Unfortunately, the study did not have the chance to interview enough persons with cultural roots in the US in order to confirm Andrew's suggestion.

> *Andrew:* "I have learnt many things from Americans. They agree to do things even without knowing what exactly needs to be done. They say 'Sure, we will do this' and they will wait for the project to become big enough until they involve themselves. I couldn't really understand this behaviour in the beginning. [...] I was often a sceptic who said "No, this is not going to work because we already tried it two times before.""

4.3.4 Emotions Related To Complexity

Although many study participants explained that they see (moderate) complexity in IT projects as being something positive (see subsection 4.3.3), many of them also described the shadow side of complexity in their various accounts regarding situations where complexity was too big to be handled, or where the people in charge misperceived it and responded in an inappropriate way. When analysing the emotions which were used by participants to describe how they felt in these situations, mainly two emotions recurred: helplessness and frustration.

The feeling of helplessness was typically associated with moments when the participant realised that they had been in a situation where they could not deal with complexity by themselves. It is this turning point—which seems to be located differently for each individual—whereby complexity is no longer a positive challenge but evolves instead into a negative burden. For example, Jane, a high potential employee at that time, described how she got assigned to lead a large program in an early stage of her career and how she felt overwhelmed with the complexity at times:

> *Jane:* "Because when you are young and you lead a large program, and this was among the top 10 projects of my company at that time, you often feel a bit helpless."

It is ostentatious that it is mainly project managers who describe the feeling of helplessness towards complexity. For example, Walter described that complexity is primarily influenced by external factors that are out of the control of a project manager:

> *Walter:* "I don't think project management has a lot of options to reduce it [complexity] though, because the complexity is there and is more or less given."

Likewise, Jane stated how she felt helpless in the project manager role, for example she mentioned that she had no real options for motivating her project team, because she was not their line manager. Another example was provided by Edith, who mentioned that one of her strategies to deal with external factors that cause complexity is to use her network to influence key persons in her favour. However, she had to admit that in a large corporation with many particular interests, this strategy was not always successful. She also shared how these situations often made her feel frustrated:

> *Edith:* "Earlier in my career, I could easily get hung up on things like this and feel very frustrated. I think I needed to learn to let these things go."

As indicated in Edith's statement, it seems as though project managers think that they eventually have to learn to live with a certain complexity they can neither influence nor change. However, depending on the personal management style, people might not be willing to accept this easily for certain reasons. For example, Jane seemed to be a project manager with a tendency to a very authoritative leadership style. Consequently, she mentioned many aspects that made her feel helpless due to a lack of control mechanisms, e.g. subcontractors. In contrast to this, project managers who displayed a less authoritative leadership style, like for example Walter, seemed to be more willing to accept the fact that they cannot control every aspect which influences complexity.

In a few situations that the participants shared, there was no immediate remedy found for complexity. This means that the participants felt stuck in complex situations without help over a long amount of time. In these cases, the interviewees described how the feeling of helplessness developed into frustration and eventually into indifference:

> *Jane:* "[...] there was no way to resolve the complexity in my own organisation, and I actually even stopped trying to after a while because it was too pointless to me. [...] If someone refuses to understand the complexity, you can explain and explain as much as you want, there is no point."

Similarly, Sophie explained how she would lose the fun in her job if she were in a situation which would overwhelm her with a high level of complexity:

> *Sophie:* "I think it would not be fun anymore if you feel overwhelmed by the complexity, or if nobody can help you or the time pressure is too much."

4.3.5 The Relationship Between Perceived Complexity And Stress

From his experience as a practitioner in IT projects, the researcher wanted to explore the relationship between complexity and stress in more detail. In particular, there were two different aspects that required further study. First is the question of whether stress is a driver for perceived complexity; that is, whether an individual who is under great stress is more likely to perceive situations or tasks as complex. Previous field observations by the researcher suggested this relationship. Secondly, the question emerged of whether the relationship also works in the opposite direction; that is, whether complexity promotes stress.

The findings from the data confirm both queries. In particular, the first question, the influence of stress on the perception of complexity, has been confirmed by almost all participants, often through very prompt and confident answers. Andrew and Nathalie provided almost identical explanations as to the mechanics that link the two aspects together:

> *Andrew:* "[...] if the stress level is high, people work less concentrated, and when people work less concentrated, the puzzle pieces will not fit together, and if the puzzle pieces do not fit together, complexity rises."

> *Nathalie:* "I think stress and complexity are tightly coupled to each other. A high stress level may lead to less focus, and less focus may lead to seeing more complexity in things than there actually is."

While the findings confirm the influence of stress on perceived complexity, indications for the opposite claim, the influence of complexity on stress, were also identified. Compared with the relatively strong evidence for the former, indications for the latter were not as strong. Many participants pointed out that they could imagine complexity being one influencing factor on stress, among many others. Occasionally, it was indicated that stress was caused instead by personal factors rather than by complexity—however, as this study advocates the notion of perceived complexity, that is the subjective interpretation of complexity, this actually does not pose a conflict; in fact, it is indeed a confirmation.

4.4 Practical Relevance

The analysis of the practical relevance of previously identified complexity drivers from two distinct directions of research, project complexity

Table 4.1: Mentions of drivers for complexity

Driver	Description	Number of mentions: driver	inhibitor	total
D1	Size	48	2	50
D2	Variety	4	1	5
D3	Interdependence	8	1	9
D4	Novelty	0	0	0
D5	Clarity	6	8	14
D6	Variability	3	0	3
D7	Temporal demand	5	0	5
D8	Incongruity	1	1	2
D9	Action complexity	1	1	2
D10	Experience	5	19	24
D11	Importance	0	0	0
D12	Stakeholder support	7	4	11
D13	Fit/convergence with	10	6	16
D14	Transparency	5	0	5
N/A	others (no match)	28	11	39

and task complexity, shows that in the eyes of practitioners, complexity drivers from both groups seem to be generally relevant. From the 14 drivers identified in the consolidated collection, 12 were mentioned during the interviews, as displayed in table 4.1.

The dominant drivers in the interviews were *Size (D1)* and *Experience (D10)*. Size was the complexity driver which had the most matching interview aspects, while experience was attributed the highest importance from many interviewees. Interestingly, there is another notable contrast in the way these two drivers were mentioned. Size was almost exclusively seen as a driver, while experience was mostly mentioned as being an inhibitor for complexity. Accordingly, size was almost never mentioned as an inhibitor and (lack of) experience was rarely described as a driver. One speculative interpretation of this finding would be that the size-related complexity is rather an *external* factor which is hard to change, hence no emphasis on it as inhibitor, while experience-related complexity is seen as *internal* factor and so primarily seen as a solution instead of a problem.

Further drivers which were over-proportionally discussed were *Clarity (D5)*, *Stakeholder support (D12)*, and *Fit/convergence with (D13)*. Clarity was mostly brought up in relation to communication and was mentioned in both roles, as a driver and inhibitor. Stakeholder support was more often mentioned as a driver for complexity and typically associated with the stakeholders' lack of know-how and hence inability to support adequately—a notion which has not previously been stressed in the literature. Lastly, the fit or convergence with the client environment has been mentioned both as driver and inhibitor and has been linked to various environmental factors within the host organisation.

When looking at the results from table 4.1, it seems notable that two drivers were not explicitly mentioned, *Novelty (D4)* and *Importance (D11)*. As novelty is related to experience, which was a driver of its own and as such discussed extensively, there were no further aspects which directly referred to novelty. Likewise, neither importance nor lack of importance were raised as influencing the complexity of IT projects. A possible explanation for this might be the nature of IT projects. Due to short innovation cycles within the IT industry and a rather high fluctuation among practitioners, novelty might be seen as a given and hence not seen as a driver for complexity. On the other hand, IT projects typically have a high priority since they are often connected to strategical goals. Therefore, importance does not seem to be a problematic factor adding to complexity within this context.

For both cases, concerning drivers and inhibitors of complexity, a few aspects were discussed which did not fit to any of the drivers within the consolidated collection. An analysis of these specific aspects revealed that they most often addressed a *lack of* something, e.g. know-how, quality, or resources. In particular, quality seems to be an interesting element, which surprisingly has not previously been mentioned in the context of complexity, and is related to certain themes, such as the downplaying of complexity by superiors (see 4.5.4) which often results in lower quality and then, in turn, leads to greater complexity.

Lastly, it seems noteworthy that hard factors, i.e. factors which relate to the product which is implemented, are more often mentioned as drivers for complexity, whereas soft factors, i.e. factors which relate to the persons who are implementing the product, are more often referenced as inhibitors. A few potential explanations for this phenomenon are possible but the data provides no evidence for any.

4.5 Role As An Influencer On Perception

Another theme that emerged from the interviews was the different perception of complexity, depending on the individual role. Two thirds of the participants mentioned that they had been in a situation where someone with a different role had had an alternative perception of complexity. The patterns described below could be observed.

4.5.1 Team Members And Project Managers

Another perception of complexity between project members, i.e. work-level employees, and project managers, was mentioned multiple times. Some of the participants offered an explanation: while hands-on roles are closer to the details and so can observe the full complexity, a project manager only gets to see a distilled version of these details and hence has a different perception of complexity. This pattern is best reflected in the answer from Mark:

> *Mark:* "I think the complexity which is seen on the management level is not the actual complexity. For me, their complexity is only a 'reduced' view on complexity which has been filtered by explanations, reporting and management-style descriptions."

Another very illustrative answer coming from the same direction was offered by Jane, who remembered her own personal progression from being a developer to being a project manager, and explained:

> *Jane:* "[...] When I was a developer, I thought complexity mainly comes from the requirements and their level of detail. As a project manager, however, you do not zoom in to such a level of detail anymore. Instead, you rather see things on a macro level and complexity mainly arises from inter-personal relationships. As a developer, inter-personal aspects were not that important to me and I could mainly focus on getting my development done."

4.5.2 Project Managers And Sponsors

Some of the project managers among the participants mentioned how their perception of complexity differed from the perception of the project sponsors. This applied to situations where both roles belonged to the same employer or the project manager was from a consulting firm which was contracted by the project sponsor's organisation. In the second case, financial interests interfered with the perception of complexity, and one of the most senior participants of the study, Richard, confirmed that the complexity is used as a means to drive one's business agenda:

> *Richard:* "I think everyone in the business context has their own agenda and acts on it. Having a different perception of aspects like complexity or difficulty is normal in this context."

4.5.3 Project Managers And Senior Management

The third pattern that emerged was a different perception of complexity between project managers and their senior management. This was typically related to milestones in waterfall projects, more specifically to the decision of whether or not a project should go into production. As with the first pattern, the role that is closer to the details, in this case the project manager, seems to have a more critical point of view about complexity than the role who is further away from details. The following quote from Nathalie provides an example of this pattern:

> *Nathalie:* "I had this situation a while ago where we were shortly before go-live and I personally thought we had big issues and should rather postpone the go-live and fix these issues. However, the program manager forced his will through and insisted on his opinion that these were all minor problems that could be dealt with."

Altogether, it can be concluded that perception of complexity seems to differ, depending on the role of the observer. This finding is also supported by another related theme, *downplaying of complexity by superiors* (see subsection 4.5.4). Two of the three patterns that emerged in this theme also suggest that the closer a role is to the details of the project, the more exposed this role is to complexity and hence the more critically these roles seem to perceive complexity.

4.5.4 Downplaying Of Complexity By Superiors

Another theme that became apparent in the interviews was that sometimes superiors forced through their perceptions of complexity against the opinion of their direct reports. In light of the separate observation described in section 4.5, whereby superiors have a more limited view on complexity compared to hands-on workers, this is surprising. For example, one situation in which the downplaying of complexity was described is during the pre-sales stage, when effort estimations need to be done in order to write a proposal during a tender. Accounts for this were given by Andrew and Steven. In this situation, it may be assumed that the motivation for downplaying complexity is to close a deal by keeping the price low. Both participants, who work for a consulting firm, stated that this sales strategy is used frequently within competitive markets.

Another downplaying situation was described by Sangeetha who, while acting as project manager in a critical situation, argued to her superior about a potential postponement of the go-live date, since the project deliverables did not have the expected quality, in her eyes. However, her manager was not willing to accept her arguments:

> *Sangeetha:* "When my management did not trust my assessment, I felt bad. I mean, it was a bad situation in general because of the financial impact. But for me personally, it was frustrating because I felt like my superiors were not listening to me and there seemed to be nothing that I could do about it."

When asked to speculate about the reasons why her management had a different perception of complexity and were not willing to listen to her, Sangeetha went on to assert:

> *Sangeetha:* "Well, there was a lot of money at stake. It was a fixed-price contract and pushbacks from the client were to be expected about the financial implication of postponing the go-live. So obviously, they tried to find a way to stick with the original plan."

An almost identical account was provided by Nathalie who also found herself being overruled by her superiors shortly before a go-live. Like before, the superior downplayed the complexity:

> *Nathalie:* "I had this situation a while ago where we were shortly before the go-live and I personally thought we had big issues and should rather postpone the go-live and fix these issues. However, the program manager forced his will through and insisted on his opinion that these were all minor problems that could be dealt with."

An explanation for the motivation behind downplaying complexity was offered by Richard, for whom complexity clearly is just another tool to force through one's business goals, e.g. in negotiations:

> *Richard:* "I think everyone in the business context has their own agenda and acts on it. Having a different perception of aspects like complexity or difficulty is normal in this context."

Nevertheless, it is important to note that in all the examples mentioned by the participants, downplaying was only a successful strategy in the short-term. Over a longer period of time, in all scenarios, the effects of a downplaying strategy were negative, sometimes even fatal for the project. Hence, it cannot be considered a sustainable strategy to effectively deal with complexity.

4.6 Responses to Complexity

4.6.1 The Importance Of Rational Responses To Complexity

In many of the answers to questions that addressed the best way to deal with complexity, the participants emphasised that they consider it crucial to analyse the situation thoroughly before taking any actions. Otherwise, there would be risk of misinterpreting certain aspects or overlooking important details, both of which may lead to deterioration. However, while the majority of them were aware of this being the best practice, many also admitted openly that they find it difficult to always respond in such a rational way to complex problems. For Frank, his response towards complexity was rather defined by personality:

> *Frank:* "It is a personal question, how somebody deals with problems. Some people might panic and some might see them as challenge. Personally, I think I'm in-between these two types of personalities."

In contrast, other participants, like for example Richard or Edith, rather attributed having a calm and rational response towards complexity to experience:

> *Richard:* "I think if you have experience in something, you are less likely going to overlook something. Instead, your previous learnings usually provide you a better judgement. If previous experiences were at least somewhat successful, you also gain some confidence from it."

> *Edith:* "I guess if you know you survived a few other tricky situations before, you will not fall into some sort of panic mode when there is a complex problem in your project. And this is important, to stay focused in a fact-orientated way and to consider the best options."

Similar accounts about the pivotal role of experience were made in other interviews, as already discussed in subsection 4.3.2. However, as mentioned there, experience neither guarantees a positive reaction to complexity, nor a well-considered response. For example, Frank mentions how, despite his almost 20 years of experience as practitioner, he still occasionally struggles not to panic in the face of a complex problem:

> *Frank:* "Sometimes I panic, even if I don't want to, but I think I can also pull myself together well."

Another interesting point was raised by Carol; she explained how she consciously encourages optimism in order to prevent others from panicking and so to trigger a rational response. This way, she thinks she can lead the team to better results.

> *Carol:* "When I say it is not so complex, they [her colleagues] usually calm down. So I look at the problem and I tell them: 'no panic, we will solve it'. And this often helps them to start the thinking process."

Another aspect which was mentioned by Walter, and is closely related to experience, is age. He saw younger colleagues as bringing in fresh ideas and new ways of approaching problems, while more seasoned colleagues had the advantage of greater experience. When asked a follow-up question about the reason why being "relaxed" was so important, Walter gave a comprehensible answer:

> *Walter:* "I think younger colleagues have a different way of approaching problems, without judging it. Sometimes, they bring fresh ideas that didn't even exist earlier. Whereas more senior colleagues who have seen a lot already, they have a tendency to be more relaxed and more factual when analysing a problem. "
>
> *Interviewer:* "And being relaxed is helpful for handling complexity?"
>
> *Walter:* "Yes, I think so. There is less risk to overlook things or to misinterpret them, if you are more relaxed when approaching the problem."

4.6.2 Active Handling Of Complexity

Two of the most senior participants in the study, Walter and Richard, both stressed the importance of actively addressing complexity. They both have experience as project sponsors and also have worked as program managers, so they were responsible for steering projects. They each saw it as the project manager's duty to properly analyse the complexity of a project, as indicated in Walter's statement below:

> *Walter:* "Overall, I think it helps to actively manage complexity."

When asked about ways in which a project manager can reduce the complexity in their project, Walter mentioned that he thinks transparency is important and that the development of complexity must be tracked closely:

> *Walter:* "[...] project management can track complexity very closely and, this way, it is possible to detect if complexity is developing in an unhealthy way."

Richard advocated a similar position and even further stressed the need for proper, that is proactive, risk management:

> *Richard:* "As a sponsor or project executive, I mainly see complexity as a risk and that is the way I expect my project manager to manage it. If something is complex, he should take the necessary precautions. [...] So I expect my project managers to be proactive about complexity in general."

He further explained that complexity often stemmed from sudden events that nobody expected to happen or prepared a response strategy for. It was clear to him that unexpected events could not be stopped from happening, but he saw it as being a duty of a proactive project manager to think about possible negative events that could occur within the project and how they could be contained:

> *Richard:* "Of course, there might always be things that weren't planned for, and then one has to contain the situation as good as possible. But preferably, there is already a plan for this situation that has been laid out upfront."

Similarly, Walter also recognised the need for risk management, and he identified an interesting relationship between risk exposure and complexity:

> *Walter:* "We are also looking at taking risk mitigation measures, because a reduced risk means reduced complexity as well."

4.6.3 Divide And Conquer As The Main Heuristic

When asked about a strategy for how best to deal with complexity, a frequent answer was to analyse the problem (see subsection 4.6.1) and then decompose it into smaller components that are less complex. This notion of complexity is tightly linked to the idea that small objects are naturally less complex—an idea that is very popular momentarily in the IT industry, for example: the microservice paradigm in the software engineering field advocates for smaller and less complex services, as opposed to the monolithic architecture paradigm which has been predominant for the past three decades. An example statement of this divide-and-conquer heuristic to approach complexity was provided by Edward, while Paul went even further to argue that it was the *only* way to deal with complexity:

> *Edward:* "You can reduce complexity by cutting the overall project into smaller pieces [...]. And cutting it into smaller chunks that are easier to manage helps to handle the overall complexity."

> *Paul:* "If it is complex, I try to break down the complexity of making it easier. I think this is the only way to deal with complexity."

In this context, participants saw the greatest benefits from their studies, especially participants who held an engineering degree. To them, the ability to decompose a problem into smaller units is one of the core skills of an engineer. For example, Richard, who has an engineering background, provided the following answer when asked about the importance of his studies:

> *Richard:* "I think it has been helpful. It taught me how to deal with complex problems in a structured way. Collect data about a problem and analyse it, then choose the best option. Break a big problem down into smaller components that might be easier to handle. These strategies have proven to be quite valuable in my career."

Another advantage of the divide-and-conquer heuristic which was mentioned multiple times is that decomposition also allows for the delegation of tasks. That way, team members can work independently and in parallel on different aspects which belong to the same problem. This is, for example, illustrated by Sangeetha's following statement:

> *Sangeetha:* "The most important thing for me is to get an overview about the issue. I need to understand what I am dealing with. In my experience, it helps to break down the

> complexity, so I would try to do that and break it into chunks that I can work on together with my team."

Finally, Andrew, who also holds an engineering degree, explained how he iteratively uses abstraction—he referred to it as "taking a step back"—until he arrives at a level of complexity which is manageable for him. This intriguing method seems very powerful, especially in combination with visualisation, as discussed in subsection 4.6.4.

> *Andrew:* "The longer you work as a professional, the more you have the skill to... [pauses] take a step back. [...] And the more experience you have, the more steps you can take back, until you reach the point where the problem does no longer look complex. And from there, if you take one step forward, it will become complex again. And being able to identify these frontiers, where things become complex. This allows you to work on the problem at a level where it is not complex by dividing it into sub-areas and by further analysing these sub-areas, until you finally understand them and therefore integrating them back is no longer complex as well."

4.6.4 The Power Of Visualisation

A picture says a thousand words—this was the final theme that emerged from the interviews. For many participants, visualisation was a crucial technique to deal with complexity. For example, Edith explained how visualisation is a very important method for them when facing complex problems:

> *Edith:* "Visualisation helps me a lot in my role as a moderator. It gives me the chance to grasp matters on a simplified level which otherwise are a lot more complicated."

Besides supporting the process of understanding and analysing a complex problem, Sangeetha asserts that visualisation also facilitates the discussion which is necessary to resolve complexity.

> *Sangeetha:* "I think communication is helpful in two ways, one is the analysis of a complex issue and the other is when communicating about it."

Similarly, Nathalie actively uses visualisation techniques when discussing complex issues with her team, and Carol even sees value in the drawing process itself:

> *Nathalie:* "It is much easier to discuss based on a drawing than just discussing verbally. I love to discuss with the whiteboard or flip chart as a tool because it is a really great way of expressing thoughts and testing ideas with others."

> *Carol:* "It helps me a lot to see how someone draws a complex problem. Somebody filmed me once while I was drawing something, because he wanted to follow my thought process that went into the drawing."

One participant, Andrew, made a unique comment that visualising a complex problem calms him down, so whenever he is under stress, he tries to visualise the problem:

> *Andrew:* "I am not sure whether this can be called a tactic but when under stress, I visualise with pictures. For example, I create system context diagrams, draw pictures, create an interface model. This really calms me down when I see for example that 'this is only an SAP system' or 'this is only a database connected to it' or 'this is only a middleware which we implement'."

However, both Edith and Mark (who each stated that they embrace visualisation as a technique to tackle complexity) make clear that visualising complex problems is a difficult problem itself and that this skill is hard to find:

> *Edith:* "I am always happy if one of my team members is able to visualise complex problems, which is definitely a great skill that you cannot find easily."

> *Mark:* "The visualisation of a complex problem is a complex problem in itself."

4.7 Conclusions

As shown in this chapter, the study produced numerous interesting findings which together provide a better understanding of the perception of complexity within IT projects. With regards to the five different data analysis subtasks which were part of the research design, all of them were able to produce relevant findings.

The upcoming chapter 5 is going to build upon the presented findings and will introduce two main contributions of this work: (1) a conceptual model of perceived complexity in IT projects, and (2) practice-orientated guidelines for handling complexity in IT projects. As will be shown, these contributions provide answers to the research questions and thus support the overall study aim.

Chapter 5

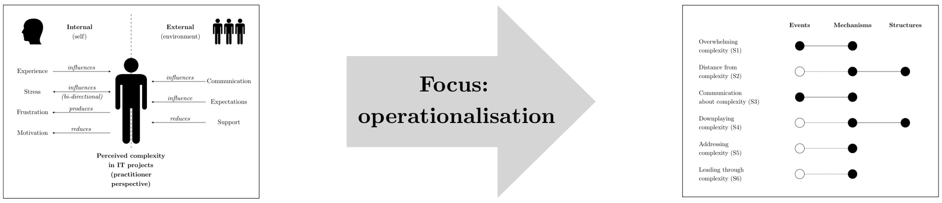
Discussion

5.1 Introduction

The purpose of this chapter is twofold, reflecting the ambition of this study to contribute to theory and practice. Therefore, at first, this chapter summarises the findings which were presented in the previous chapter and connects them with the initial research aim, existing literature, and the identified research questions. To facilitate the discussion, the structure of the corresponding section 5.5 follows the research questions. However, due to the relevance of the corresponding findings, the main focus will be on research question *Q2* (How do practitioners in IT projects perceive complexity?). The manifold findings which refer to this research question were consolidated into a conceptual model of perceived complexity in IT projects.

In an attempt to operationalise this conceptual model and thereby provide a valuable conclusion to practice, this study extracted reoccurring patterns and mechanisms from the collected data and built practice-orientated guidelines for handling complexity in IT projects. These guidelines are linked to the conceptual model, but in contrast to the model, which is descriptive, the focus of the guidelines is on concrete situational guidance for individuals and organisations, and thus rather has a normative role. Figure 5.1 displays the relationship between the two main contributions to theory and practice. The practice-oriented guidelines for handling complexity in IT projects are discussed in section 5.4.

The linking element between these two main contributions was critical realism. The model of a layered reality, which is emphasised by critical realism (Bhaskar, 1989; Sayer, 2010), was used to analyse the situational descriptions which had been collected in the interviews. By



Conceptual model of perceived complexity in IT projects
(section 5.2)

Practice-orientated guidelines for handling complexity in IT projects
(section 5.4)

FIGURE 5.1: Main contributions to theory and practice

mapping situational aspects to the different layers (events, mechanisms and structures), the conceptual model could be linked with the social context of IT projects. This is describe in section 5.3, which has, therefore, been injected between the discussions of the two main contributions of this study. Lastly, section 5.5 will close this chapter by reflecting on the study contributions to theory and practice.

5.2 Revisiting The Research Questions

5.2.1 Common Understanding (Q1)

> *Q1. Is there a common understanding regarding IT project complexity among practitioners?*

The study findings confirm the existence of various different definitions of IT project complexity. Therefore, they strongly indicate that there is no common understanding of complexity among practitioners in IT projects. For example, the word *complex* was used to label a wide variety of projects—ones with a big scope, with many interdependencies, with different client environments, or the narratives of situations in IT projects which were hard to solve. Only one participant of this study provided a scientific definition as suggested for example by Geraldi et al. (2011) for project complexity or by Liu and Li (2012) for task complexity. Thus, a certain distance between the scientific discourse and the realities of practitioners can be assumed. Furthermore, both the notions of descriptive and perceived complexity were found in the interviews, without one of them being dominant over the other.

While the lack of a common definition for complexity has been stressed by various authors in general (e.g. Vidal et al., 2011; Erdi, 2008; Rosen, 1977), the existence of a common definition within IT projects has not been studied before. The findings of this study indicate that no such common definition exists. To many practitioners within IT projects, this conclusion will not be a surprise. A possible explanation for the lack of a common definition might be the practice-driven nature of the project management discipline (Cunha et al., 2016; Smyth & Morris, 2007), which leads to a tendency to pragmatism rather than to academic debate. For example, it has been argued that pragmatism is a suitable method to generate a common understanding for abstract concepts within projects (Joham, Metcalfe, & Sastrowardoyo, 2009). Such pragmatism may have led to the many varied and fragmented understandings of complexity in IT projects.

5.2.2 Perceived Complexity (Q2)

> *Q2. How do practitioners in IT projects perceive complexity?*

This research question was formulated in a wide way, so that, consequently, many interesting aspects about perceived complexity were discovered. The various findings were consolidated into a conceptual model of perceived complexity in IT projects and are visualised in figure 5.2. This model was created using the themes which emerged from the data analysis process and which can be found in appendix E. The focus was thereby on the practitioner perspective, as the model represents a conceptualisation of how practitioners perceive complexity in IT projects. In consequence, themes which are directly related to practitioners, e.g. *Motivation and frustration* have been stronger emphasised in this model than themes which mainly focus on situational aspects, e.g. *Downplaying complexity.*

The model distinguishes between internal and external factors which influence perceived complexity or are influenced by it. This is consistent with the conceptual framework which has been used for this study (see section 1.4), where internal factors relate to the micro perspective, and external factors relate to the macro perspective. The identified variables which interact with perceived complexity will be discussed below.

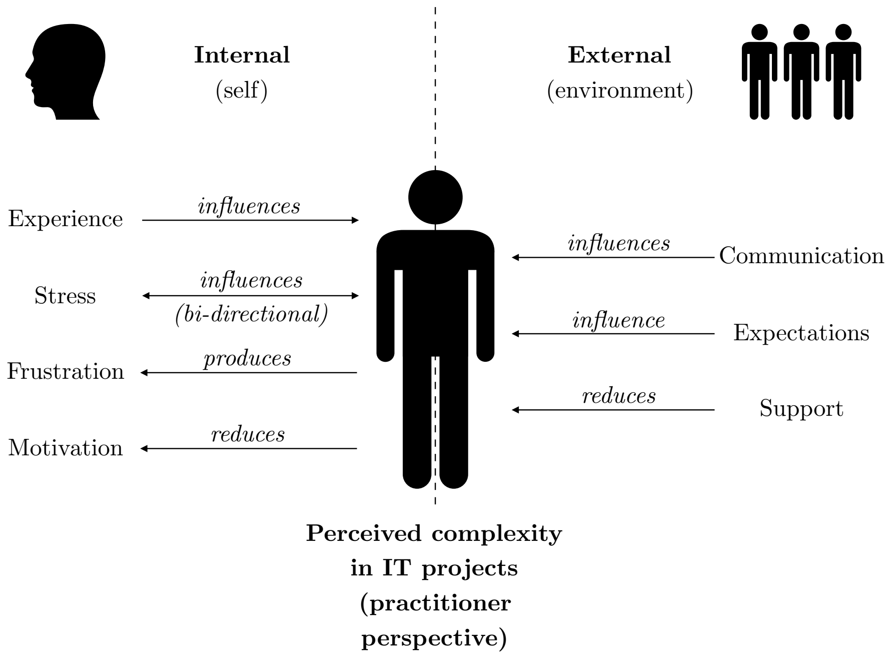


FIGURE 5.2: Conceptual model of perceived complexity in IT projects

Where the findings allowed it, the relationship between perceived complexity and the variable has been described in a detailed conceptual model, for example for the relationship between stress and perceived complexity. Furthermore, corresponding links into existing literature will be established. With reference to the conceptual framework, variables from the internal group will mainly draw on to literature from the fields of psychology and social sciences, while variables from the external group primarily link into project complexity research.

Experience

Experience is seen as being one of the most critical factors for the perception of complexity in IT projects. The importance of experience for the success of IT project work has been shown in earlier studies (Siau, Tan, & Sheng, 2010; Hunter, 1994). On a conceptual level, however, experience partially overlaps with knowledge (Staniewski, 2016; Kelly et al., 2011; K. Schneider, 2009), and knowledge management seems to receive more research attention (Behfar, Turkina, & Burger-Helmchen, 2018; Acar, Tarim, Zaim, Zaim, & Delen, 2017; Wasielewski, 2010). A clearer distinction between the two might be helpful to promote further insights regarding the role of experience within IT projects.

Furthermore, the findings of this study have shown that the value of experience is considered far higher than the value of formal education. This is consistent with earlier findings from different fields, e.g. forensics (Bonadiman, 2007) or law enforcement (Shernock, 1998). Therefore, the recruitment process for IT project workers should reflect this finding accordingly.

Stress-Complexity Relationship

The findings confirm that there is a bi-directional relationship between perceived complexity and stress. The first causal relation, that perceived complexity causes stress, was confirmed by many participants. Similar conclusions can be found in the literature (Wallace, Edwards, Arnold, Frazier, & Finch, 2009; Spector & Jex, 1998; Bowers, Weaver, & Morgan, 1996), although not directly linked to perceived complexity, but to specific drivers of perceived complexity, as identified in the consolidated collection of complexity drivers which was presented in this work (see subsection 3.3.2). For example, the identified complexity drivers *D7. Temporal demand* and *D12. Stakeholder support* can be mapped to the workplace stressors "workload" and "lack of control" identified in a previous study (Jex, 1998).

The opposite relation, that stress causes an increased perceived complexity, was indicated too, but with slightly weaker support. This appeared to be caused by the participants' tendencies to reject a subjective notion of IT project complexity in the context of this topic. While occupational stress and its negative effects have been relatively well researched (Schaufeli & Enzmann, 1998; Jex, 1998; Motowidlo, Packard, & Manning, 1986), only a few studies have focused on the stress-complexity relationship so far. Existing literature mainly stems from psychology: for example, it has been shown that speaking under pressure results in a lower linguistic complexity (Saslow et al., 2014) and that a high stress level can lead to reduced cognitive abilities, resulting in "narrow and rigid" ways of thinking (Fearon & Boyd-Macmillan, 2016). The results of this study therefore well connect to these previous findings, insofar as a stress-induced, narrow way of thinking may limit the ability to grasp the many aspects of complex problems within

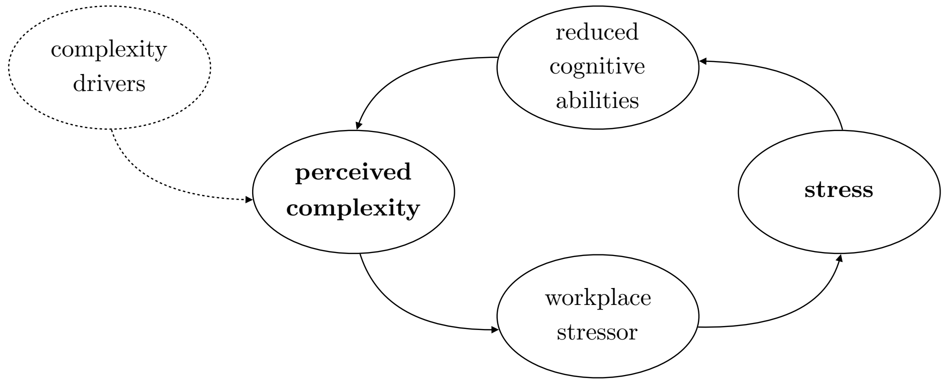


FIGURE 5.3: Conceptual model of the suggested stress–complexity relationship

IT projects. This hypothesis is supported by an experimental study among surgeons which discovered that experience seems to reduce the physiological effects of stress (Marrelli, Gentile, Palmieri, Paduano, & Tatullo, 2014)—a notion which has been expressed similarly by many study participants and so would explain why experience is seen as such a pivotal influencer on perceived complexity.

To summarise the findings, the suggested bi-directional relationship between stress and perceived complexity is presented as conceptual model in figure 5.3. The model integrates the different statements from participants of this study with the previous findings regarding occupational stress. By connecting these findings, it seems more likely to find a way to successfully break the vicious circle between perceived complexity and stress, as intended in previous studies (Fearon & Boyd-Macmillan, 2016). Meanwhile, organisations should consider introducing more systematic monitoring measures, as for example suggested for other industries (Marrelli et al., 2014), to detect complexity-related stress and prevent affected practitioners from developing a burnout.

Motivation And Frustration

Besides stress, perceived complexity has also been shown to influence work motivation in this study. Since job motivation is known to effect job satisfaction (Springer, 2011; Chen, 2008), the findings imply that perceived complexity indirectly influences the job satisfaction of professionals within IT projects. However, the findings of this study suggest that perceived complexity is not simply a moderator of job motivation and job performance. Instead, it seems that a balanced level of complexity is perceived positively, while a low or high level of complexity seems to reduce job motivation and performance:

1. If perceived complexity is below a certain threshold, it has a demotivating effect on individuals who will not see a challenge in the project.

2. If perceived complexity is on a moderate level, it has a motivating effect on individuals who will see the project as challenging for them.

3. If perceived complexity is beyond what an individual is able to handle, it has a devastating effect on performance.

Based on the study's findings, a three phase model as displayed in figure 5.4 has been constructed. According to this model, there is a corridor in which complexity is perceived as motivating. Below this corridor, practitioners feel under-challenged, while above, they feel overwhelmed with complexity. In particular the latter has been mentioned many times during the interviews. According to the participants, a longer exposure to elevated levels of complexity causes frustration and, if practitioners are left alone with complexity, the feeling of helplessness. These symptoms have been summarised as "emotional exhaustion" in the literature and their strong negative moderation effect on job motivation and performance has been proven in multiple studies (Halbesleben & Bowler, 2007; Wright & Cropanzano, 1998; Wright & Bonett, 1997).

Negative work satisfaction may further lead to fluctuation among the affected practitioners (Brawley & Pury, 2016; Tsai & Wu, 2010). Therefore, organisations should consider becoming more sensitive to the level of complexity as perceived by their IT project practitioners, for example by addressing this aspect in regular meetings between them and their managers.

Communications

Many practitioners stated how good communication reduces perceived complexity and how bad communication has the opposite effect. The

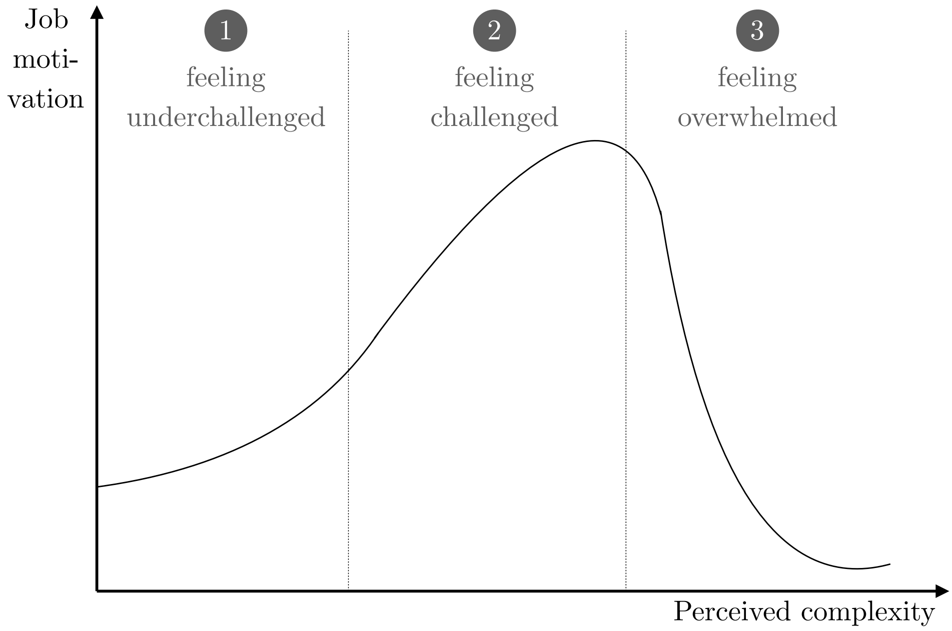


FIGURE 5.4: Suggested conceptual model for the relationship between perceived complexity and individual performance

general importance of good communication within the context of projects has been emphasised by various authors (Ziek & Anderson, 2015; Zulch, 2014; Emmitt, 2010). Within the specific context of IT projects, previous research has shown the importance of direct communication (Yin & Kuo, 2013). This aspect is particularly important as IT projects often are partially or fully delivered by offshore resources. With regards to offshoring, the study participants offered divergent opinions on its supposed impact on complexity. Some saw it as a driver for complexity, while others argued that offshoring would be neutral to complexity, when done properly—stressing the need for the local team to interact efficiently with remote team members. This notion has not been focused on in previous research (Jørgensen, 2014; Verner & Abdullah, 2012; Reed & Knight, 2010; Lee-Kelley & Sankey, 2008) and should be further explored.

When looking at project communications as a broader concept, it also includes the specification of the project requirements. As mentioned in the literature review in chapter 2, IT projects, in contrast to projects from other industries, typically accept very vague and ambiguous requirements as initial input (Rivera & Kashiwagi, 2016; Thakurta, 2011). This practice has been mentioned to contribute to complexity by many study participants. Furthermore, participants not only stated how (bad) communication contributes to complexity, but also how communication within the context of IT projects is often complex itself. This is consistent with the literature, where for example the difficulty of transferring natural language into a formal notation has been discussed (Hinchey & Coyle, 2012). The lack of a common definition for complexity within IT projects, as identified in this study, further increases this difficulty.

A further notion which was highlighted by the participants, was the importance of visualisation when communicating about complex aspects. Similar conclusions have been drawn before by Geraldi and Arlt (2015) in a study which focused on projects in general (no specific focus on IT projects).

Altogether, it can be concluded that the study results regarding communications are consistent with the literature and the participants of this study did not reveal any ground-braking insights. Yet, as a few authors note (Ziek & Anderson, 2015; Zulch, 2014), some well-known best practices regarding communication are frequently ignored in practice. Therefore, in order to minimise perceived complexity, it seems advisable for IT project organisations to adopt a holistic communication strategy (Kerzner, 2014).

Expectations

Expectations from a practitioner's environment seem to influence his or her perception of complexity. In situations, where participants felt great pressure from expectations within their environments, there was a tendency to perceive complexity as being relatively high. This was particularly so with more junior participants. In addition, one of the interviewees, Sangeetha, explained how she felt that as a woman, she had to fulfil higher standards than her male colleagues. Although Sangeetha lives in India, a society with different cultural values, her statement sounds alarming, as it describes a solidified double standard existing towards females in the IT industry. This complicates work for them, eventually leading to waste, as they need to spend more effort than necessary to solve problems.

The available project management literature has not focused specifically on this aspect. A previous study revealed how multiple (professional and private) roles can produce stress (Cooke & Rousseau, 1984). Since the theme emerged primarily in interviews with junior participants, it seems possible that the participants were still in the process of adopting a new role and therefore felt more stressed. This would be consistent with the previous discussions regarding the related findings on experience and stress above. In addition, a recent case study with nurse managers revealed that increased—and from the nurse managers' point of view, unrealistic—role expectations produce stress (Udod, Cummings, Care, & Jenkins, 2017). With reference to the suggested model in figure 5.4, it can be assumed that "unrealistic" role expectations relate to phase three of the model, where perceived complexity is overwhelming.

Support

Some interviews indicated that strong support from their environment in complex situations reduced perceived complexity and, in contrast, the lack of support produces a feeling of helplessness and led to an increased perception of complexity. While there are no findings in the literature on the relationship between perceived complexity and social support, a similar relationship has been identified between stress and social support (Ross, Altmaier, & Russell, 1989; Seers, McGee, Serey, & Graen, 1983; Blau, 1981). Given the bi-directional relationship between perceived complexity and stress which has been established above, it seems plausible to assume that stress has a moderating role on perceived complexity in this context and hence, there is an indirect relationship between social support and perceived complexity.

Another possible explanation might be that practitioners have stronger confidence in solving a complex problem as a team rather than as individuals. This notion is supported by occasional interviewee accounts of feeling helpless amidst a complex problem when there was lack of support. The importance of confidence for successful projects has been stressed by other authors before (Doloi, 2009; Chowdhury, Endres, & Lanis, 2002).

One of the participants (Jane) shared two situations related to social support, with divergent outcomes. In both of them, she was in complex and challenging roles. The difference was that in the first situation, her organisation provided her support in various ways, for example by assigning a senior executive as dedicated mentor to her. In contrast, in the second situation, her organisation did nothing to support her, but instead rather added further complexity by inconsistent top-down management. Unsurprisingly, the first situation was a success and resulted in a promotion for Jane, while the second ended with Jane leaving the company. Although anecdotal, this underlines the importance of social support for practitioners.

5.2.3 Practical Relevance (Q3)

> *Q3. Are the complexity drivers identified in the literature relevant for perceived complexity among IT project practitioners?*

The study findings confirm that perceived complexity of practitioners in IT projects is influenced by drivers from both streams which were identified in the conceptual framework (see section 1.4): project complexity and task complexity. As shown in table 4.1, the consolidated collection of complexity drivers from both streams, represented by the works of Geraldi et al. (2011) and Liu and Li (2012), matched well with the complexity drivers that were mentioned in the interviews.

When looking at the relevance of individual complexity drivers for the perceived complexity of IT projects, size and experience have been emphasised by many of the study participants. However, the findings also indicate that perceived complexity is highly situational and therefore it cannot be concluded that size or experience *always* have the greatest influence on perceived complexity. When further analysing the origins of complexity according to the individual study participants, with a distinction between technical and non-technical aspects, as displayed in table 5.1, the results show that the majority of participants considers non-technical aspects to be the main cause for complexity. Interestingly, none of the participants primarily attributed complexity to technical reasons. In this context, it seems noteworthy that none of the interviewees with a non-technical background blamed technology to be the driver for IT project complexity. Instead, the majority mentioned non-technical factors (e.g. lack of experience, socio-political difficulties

Table 5.1: Origins of complexity

Interviewee's background	Ratio between technical and non-technical complexity drivers: predominately technical	equally distributed	predominately non-technical
Business	0	3	2
Technical	0	2	8
Total	0	5	10

or unclear communication). Such a dominance of "soft" factors has not been addressed by existing project management complexity metrics.

The findings also show that the perception of complexity is influenced by personal factors, for example experience. In the context of task complexity, this challenges the notion of objective task complexity, as advocated by Campbell (1988), Wood (1986), Hackman (1969). If attributes of the task performer significantly moderate perceived complexity, the notion of subjective complexity seems far more relevant from a practitioner's point of view than objective task complexity, which does not become invalid through the findings of this study, but seems to be rather of theoretical importance than of practical. Likewise, this conclusion can be transferred from the micro to the macro level of the conceptual framework; providing grounds for the argument that perceived complexity should receive similar attention within the context of project management as the notion of descriptive complexity. Similar claims for more subjective conceptions of complexity have been articulated by other researchers (Cilliers & Preiser, 2010; Heylighen et al., 2006; Morin, 2006).

5.2.4 Role As An Influencer On Perceived Complexity (Q4)

> *Q4. Does the role of a practitioner in an IT project influence the way complexity is perceived?*

The findings have shown that alternative roles perceive complexity differently, and two key themes emerged in this context: To begin with, the findings show how the hierarchical distance from complex aspects changes the way complexity is perceived. Experts who work as project team members in IT projects typically are closer to complex aspects than their project managers, who in turn are closer than project sponsors. Through the reduced distance, project team members seem to have the clearest view on complexity, while sponsors have a condensed perspective which often lacks details. Secondly, the findings reveal that perceived complexity also varies with the situational goals of a role. The two situations that were described in multiple interviews were the presales phase of projects where the seller and buyer of IT projects tend to underestimate complexity, and before important project milestones, where project managers or sponsors tend to downplay complexity for opportunistic reasons.

Both aspects have previously not been discussed in the literature. The first aspect, the varied perception of complexity depending on the hierarchy level of an individual's role, falls into the micro level of the study's conceptual framework. With respect to subjective task complexity, the relevance of various personal factors has been studied (Maynard & Hakel, 1997), but role or power distance have not been among them. However, a study on executives' perception of their environment was able to show that the focus of executives declined, the more complex the environment was perceived to be (Boyd & Fulk, 1996). This would support the hypothesis that the hierarchy level influences perceived complexity.

The second aspect, in contrast, pertains to the macro level of the conceptual framework, as it is primarily caused by conflicting goals which are associated with an individual's role. While goal conflicts at the workplace have been relatively well studied (Wiese & Salmela-Aro, 2008; Pomaki, Maes, & ter Doest, 2004; Kehr, 2003), the effect on perceived complexity has previously not been investigated.

5.2.5 Responses To Complexity (Q5)

> *Q5. How do individual practitioners in IT projects respond to perceived complexity?*

The study data contains many examples of how practitioners deal with perceived complexity in IT projects, both successfully and unsuccessfully. Successful response strategies often shared a rational and analytic approach to complexity. Regardless of the individual role and its hierarchy level, most participants also mentioned that the divide-and-conquer approach was useful for them. On the other hand, the data also shows that irrational responses are not likely to succeed. This conclusion matches with earlier observations of Fearon and Boyd-Macmillan (2016), according to which human thinking becomes more narrow when under stress. While response strategies to complexity for individuals have not been studied in depth yet, the studies of Ashmos, Duchon, and McDaniel (2000), Greenwood, Raynard, Kodeih, Micelotta, and Lounsbury (2011) analysed response strategies on organisational level by applying systems thinking approaches. For example, it has been shown that complexity absorption is a more successful response strategy for organisations than complexity reduction (Ashmos et al., 2000). Transferred to the individual level, this would mean that it is preferable to analyse complex problems in depth, rather than acting upon a partial and simplified understanding. Although the findings of this study support such a conclusion, further verification is needed.

In addition, the findings of this study underline the need for an active approach by project managers towards *perceived* complexity. Similar findings have been identified for other aspects of project management, e.g. project planning (Sharon & Dori, 2015; Sudhakar, 2012) and risk management (Bannerman, 2008; Charrel & Galarreta, 2007). Yet, this is at odds with the current reality of project management for two reasons. On one hand, the discipline is dominated by a positivist ontology and epistemology (Smyth et al., 2006; Williams, 2004) which results in a stronger emphasis on descriptive complexity than on perceived complexity. On the other hand, project management is also known for its pragmatism, which often results in reactive problem-solving strategies, instead of actively pursuing known best practices (Maylor, Turner, & Murray-Webster, 2013; Müller et al., 2012). Therefore, it is hoped that the findings of this study further strengthen the notions of both, perceived complexity and active project management approaches towards it.

5.2.6 Practice-orientated guidance (Q6)

> *Q6. What practice-orientated guidance for handling complexity in IT projects can be provided to individuals and organisations?*

The purpose of the last research question *Q6* was to produce a contribution to practice, as advocated by Easterby-Smith, Thorpe, and Jackson (2012), Saunders et al. (2016) for management research. Therefore, practice-orientated guidelines for handling complexity in IT projects were identified, consisting of six critical situations which are typical within IT projects (see section 5.4).

These situations reflect the learnings regarding perceived complexity that seem to be relevant within IT projects. The philosophical underpinning of this study, critical realism, has been used to analyse events, mechanisms and structures (Sayer, 2010), as will be discussed in the next section 5.3. The guidelines therefore represents a practice-orientated collection of the causal relationships between these different layers. In addition, they do not only address project management aspects, but also traits of project team members, sponsors, and of organisational entities. From the collected data, possible solution approaches were presented for each situation as part of the guidelines. As such, they can be used by practitioners to improve upon how complexity is addressed in IT projects and so better the outcomes of these projects.

5.3 Applying A Critical Realist Perspective

As outlined in the research methodology (see chapter 3), a critical realist research philosophy has been adopted for this work. The purpose of this section is to interpret the conclusions from the previous section through the lens of critical realism. The interpretation will focus on three different aspects of critical realism:

1. The combination of ontological realism with epistemological relativism (Bhaskar, 1979, 1978).
2. The ontological notion of seeing the world as a layered construct (Sayer, 2010).
3. The epistemological emphasis on context-dependency, which is caused by relativism (Baghramian & Carter, 2017).

TABLE 5.2: Mapping conceptual model variables to critical realist layers

Variable	Layers: Events	Mechanisms	Structures
Experience		yes	
Stress	yes	yes	
Frustration	yes		
Motivation	yes		
Communication		yes	yes
Expectations		yes	yes
Support		yes	yes

Revisiting the first aspect serves the purpose to validate whether the earlier assumption of critical realism (and its combination of ontological realism with epistemological relativism) was a sound choice for this study. In fact, two findings support the decision. Firstly, multiple interviewees found themselves switching between a notion of descriptive and perceived complexity (see section 4.2), often with a critical undertone towards their own perception, as opposed to “the real” complexity. Thus, it can be concluded that practitioners apply both, realism and relativism, to the concept of complexity. Secondly, the lack of a common definition for complexity within IT projects (see subsection 5.2.1) further highlights the relativistic nature of complexity. Therefore, it can be concluded that critical realism fits well with perceived complexity in IT projects.

With regards to the critical realist notion of seeing the world as a layered construct, the seven variables which have been identified to interact with perceived complexity (see subsection 5.2.2) relate to different levels of such a layered reality, as mentioned by Sayer (2010): events, mechanisms, and structures. Table 5.2 displays the results of mapping the variables to these layers. It can be noticed that the identified variables cover all the three layers. The table therefore demonstrates that various causal relationships between the different layers have been found. Thus, when comparing the study findings regarding perceived complexity with the ambition of this study to combine generalisation and intensive research (Dobson, 2002), the variables seem to be a valid result.

Lastly, critical realism emphasises the context-dependency of research. The main context, IT projects, has been implicitly provided to this study by the research aim. Furthermore, a context-dependency to cultural identity was observable; but since culture had not been a variable for the sampling of this study, the findings were not substantial enough to discover relationships between events, mechanisms and structures.

Altogether, it can be concluded that critical realism was a suitable choice of research philosophy for this study. It supported the descriptive-perceived complexity dualism well, without requiring the researcher or the interviewees to choose a particular side. In addition, the ontological model of viewing the reality as layered construct proved as helpful. The mappings in table 5.2 show that the study findings span across all the three layers and the identified causal relationships between the layers further informed the contribution to practice, which are practice-orientated guidelines for handling complexity in IT projects (see next section 5.4).

5.4 Practice-Orientated Guidelines

5.4.1 Overview

In order to provide a contribution to practice, the research design included the creation of practice-orientated guidelines for handling complexity in IT projects. The guidelines were derived from the conceptual model presented in subsection 5.2.2. However, they represent a slightly different view on the findings, as they focus on concrete situational guidance for individuals and organisations.

The situations were identified from the collected data and the themes which emerged from the data analysis (see appendix E). All the situations which were shared by the study participants in the interviews and relate to complexity in IT projects were filtered and assessed as described in subsection 3.3.5, considering their likeliness to occur, their potential benefits and their suitability to operationalise them.

The resulting six situations mapped to the three different layers (events, mechanisms, and structures) of a constructed reality, as advocated by critical realism (see previous section 5.3). The goal of this activity was to gain transparency about hidden mechanisms and causal relationships between the different layers (Sayer, 2010) and thus to provide a better understanding into these situations. Figure 5.5 displays the six different situations which have been identified and selected, and how they can be mapped to the different layers of a layered reality.

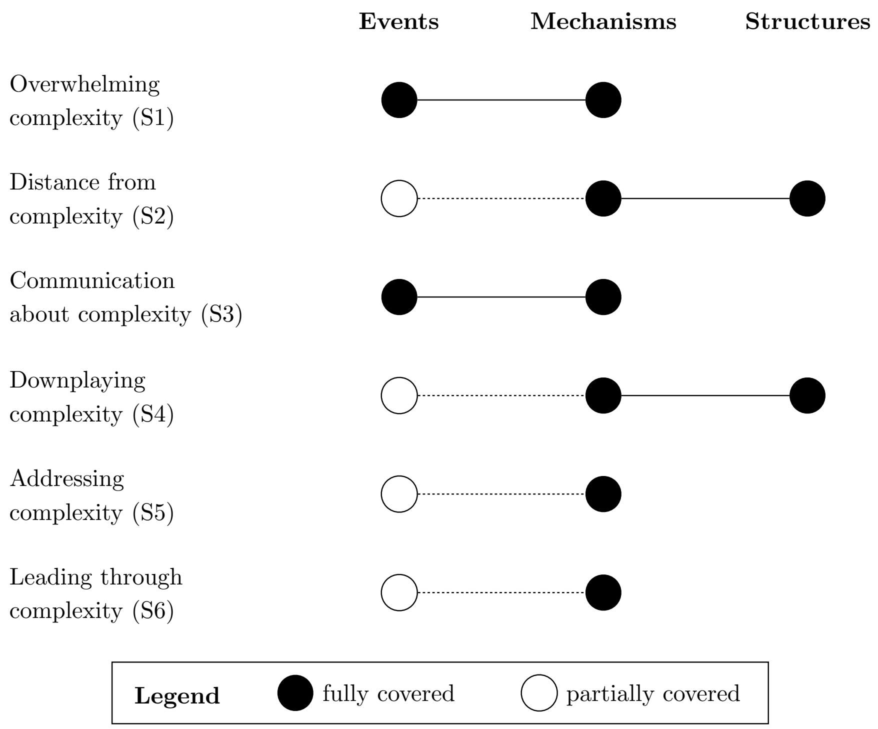


FIGURE 5.5: Practice-orientated guidelines for handling complexity in IT projects

The different situations will be discussed in the following subsections. For each of the identified situations, there is an accompanying description of the situation and suggested solution approaches which could be found from the interviews.

5.4.2 Overwhelming Complexity (S1)

Situation Description

While most participants of the study mentioned that they saw complexity in their work as being something generally positive, many of them also acknowledged that there are limits to the amount of complexity that an individual can cope with. When they recalled previous complex situations in their careers, they often described how, at first, they did not notice the complexity to be a problem, but then at a certain point found themselves faced with situations which seemed impossible to handle due to their complexity. The reasons for the sudden increase of perceived complexity were manifold but a common theme in many narratives was the occurrence of unforeseen events. Another commonality in the narratives was that the participants described feeling overwhelmed by complexity and noted that it significantly lowered their work performance. Some narratives further indicated that practitioners mentally check out of projects as a response to being overwhelmed by complexity; this seems to be particularly relevant when they feel that the complexity is caused by socio-political factors. The effect was often worsened by the fact that practitioners had to dedicate most of their attention to solving the complex problem and had no option but to neglect other tasks, hence producing a domino effect in terms of overall productivity.

With reference to the suggested relationship between perceived complexity and job motivation (see figure 5.4), this scenario addresses situations whereby practitioners are transitioning from phase 2 to 3, i.e. when starting to feel overwhelmed by complexity. By recognising such scenarios and by properly addressing them, the corresponding practitioner can be protected from the negative effects of overwhelming complexity.

Possible Solution Approaches

As mentioned above, the feeling of being overwhelmed by complexity typically arrived abruptly, often when practitioners discovered a new dimension of complexity which they had not seen before and that they had not enough time or resources to solve properly. Consequently, in order to address these situations, it is crucial to detect them quickly. The ideal person to help project team members would be the project manager, but peers can also be of assistance. In case the project manager is affected themselves, the line manager is a good candidate to help and, depending on the relationship, the project sponsor. In all cases, sensitivity to the problem and empathy are required.

Throughout all accounts which addressed this aspect, one notion was similar: the feeling of being helpless and left alone. Therefore, to prevent practitioners from being overwhelmed by complexity, it seems necessary to break these perceptions. This can be achieved, for example, by actively addressing the situation and by discussing potential solutions to the problem. Many interviewees described the positive effects of solving complex problems together as a team. However, when overwhelmed by complexity, practitioners seem to have a tendency to discard the help of others. For example, Mark described how he was stuck for weeks on a problem which he perceived as being complex and which he felt obliged to solve alone, hence ignoring the expertise of people in his environment. When he finally gave up and involved others, the problem was solved within hours. Conversely, it would be an anti-pattern for leaders to leave their subordinates alone with problems of an enormous complexity.

Since there is a strong relationship between experience and perceived complexity, it seems reasonable to support more inexperienced persons on the project by providing them an experienced mentor, especially when they are assigned to relatively complex parts of a project. One participant, Jane, explicitly stated how such a mentoring programme had helped her to succeed in her first leadership role in an IT project which she perceived as being enormously complex.

5.4.3 Distance From Complexity (S2)

Situation Description

When comparing statements about complex situations across different levels, i.e. from project members over project managers to project sponsors, it was noticeable that each role implied that other roles view complexity in a different way. A reoccurring pattern in this context was the notion that project members typically had the clearest understanding of the root causes of complex problems, while the further up the chain of command, the more insensitive to complex details these persons became.

To a certain extent, this is no surprise since senior management is often more concerned with strategy than with tactical issues. Interviewees on a subordinate level did not think of it as a problem per se, as long as there is an awareness about this *detail blindness* when it comes to complex problems. If, however, superiors simply ignored complexity because it was not tangible for them, the participants described significant problems emerging as a consequence of this underestimation, e.g. additional complexity from inadequate planning of milestones and budgets, as well as a lack of required resources. In addition, the corresponding subordinates mentioned in the interviews that they found it demotivating and frustrating if their concerns and expert judgement were not heard. Hence, in order to prevent IT projects from ending in similar situations, it seems imperative for superiors to be aware that their "distance" is often responsible for complexity, if not addressed properly.

Possible Solution Approaches

Superiors should reflect upon their positions within organisations and the distance they have from possibly complex problems. In addition, if the organisation is driven in a hierarchical way, upstream communication typically goes from hierarchy level to hierarchy level, which means that complex details will be filtered out multiple times. In case superiors find themselves in a situation where they receive information from downstream about complex problems which they cannot grasp, it seems advisable to engage in a direct conversation with the corresponding experts who are the closest to the complex problem in order to receive an unfiltered explanation. These *skip-level meetings* are more frequent in less hierarchical organisations so as to gather a better understanding for senior managers. If a direct dialogue does not resolve the conflicting perspectives, a third person should be involved as a mediator: potentially an external consultant who can provide an outside view.

Another critical element to avoid in this scenario is for superiors to ignore the temptations of micro management when dealing with complex situations. Many interviewees described the ideal role of a project manager as *moderator* for the resolution of complex problems, and not as an expert who resolves the details all by themselves. Some mentioned that a micro management leadership style was hard to avoid for leaders whose personal background matched the domain of a complex problem. Yet, they acknowledged the need for someone to steer through the resolution of complex problems from a higher level and to maintain an overview about the different components of this complexity.

5.4.4 Communication About Complexity (S3)

Situation Description

This scenario is closely related to the previous one and focuses on another aspect which emerged in multiple interviews: the difficulties practitioners encounter when communicating about complexity. The problems mentioned in the interviews included both vertical communication with superiors and subordinates, as well as horizontal communication with peers. As established in section 4.2, a critical issue within this context is the existence of the various definitions of complexity that are adopted by practitioners. While this aspect does not seem to be significant *after* a complex problem has occurred, as the focus will at this point be on the resolution of the concrete problem, it seems to hinder the process of addressing complexity *before* it manifests itself in the form of a concrete problem. Yet, different cultural and professional backgrounds may well complicate the communication concerning complexity.

In upstream communication, socio-political aspects often overlay the mere communication of facts. In addition, as mentioned in the interviews and discussed in the previous scenario, upstream communication requires a certain consolidation and filtering of details. Both aspects provide grounds for communication to be misperceived. Lastly, raising a complex problem to the upstream management is particularly challenging as it requires the recipients of the information to understand the complexity—which is naturally not easy. Even if this obstacle were overcome, there may still be tactical reasons evident on a socio-political level which lead others to challenge the described complexity. Due to the nature of complex problems, they typically also provide ample opportunities for selective challenges on a detailed level—a strategy which can often be found in reality.

As mentioned by a few participants, escalating a complex problem typically means bad news for the superiors, in that either the timeline or budget planning will be affected. Therefore, a certain resistance is to be expected (see also the next scenario *S4*). This may lead to hesitation in terms of communicating complex problems, in the hope that one can successfully sit the problem out. While occasionally successful, this approach typically leads to an accumulation of further complexity. In order to inform all relevant stakeholders about complex aspects of an IT project, it is crucial for the project team, and in particular the project manager, to communicate efficiently and to overcome the aforementioned challenges.

Possible Solution Approaches

When communicating about complexity, practitioners should always be reflective about their own definition of complexity and the fact that, most likely, others do not share their definition. At the core of the problem with different definitions lies the distinction between descriptive complexity and perceived complexity. In addition, complex is a term frequently used to indicate tough and challenging situations in narratives, regardless of the descriptive-perceived complexity distinction. As it seems impossible to align the complexity definition of all stakeholders of an IT project, a practical recommendation would be to raise awareness of this problem by encouraging practitioners to define their positions on complexity and share it with others in the team.

Many participants mentioned how they value visual over textual communication when it comes to complex aspects. Especially in combination with a divide-and-conquer problem solving strategy, visual communication seems helpful, as it allows for the decomposition of complex problems in a comprehensible way. However, as one of the interviewees, Mark, noted: “The visualisation of a complex problem is a complex problem in itself.” Consequently, corresponding skills are not always easy to find. For larger projects, it therefore seems advisable to establish team members who can facilitate the project communication by providing good visualisation skills.

For the socio-political component of this scenario, no clear approach of resolution appeared from the interviews, and there is no (known) way to overcome socio-political resistance when communicating about complex issues. Yet, from the interviewees’ accounts, it seems strongly advisable not to delay informing stakeholders about complex problems merely for this reason.

5.4.5 Downplaying Complexity (S4)

Situation Description

Aspects of this scenario have already shone through in the descriptions of the previous scenarios *S2* and *S3*, but since this particular theme was brought up in multiple interviews, it has been chosen as a separate scenario for consideration. It describes a situation where someone *willingly* ignores the complexity of a specific aspect. The distinct element here is the intentional motive in the superior's action, which was not assumed in *S2* or *S3*. According to the collected data, this situation comes in two different variants: firstly, during the pre-sales phase of a project and secondly, during the project execution, when forced to deliver results.

The first variant applies to IT projects which are sold to a contractor, i.e. an external IT consultancy firm. Two of the participants who had been working for IT consultancies mentioned that they had worked in IT projects which were oversold by downplaying the complexity of the project scope. As the market for IT services has become highly competitive, with low-cost service providers from Asia entering the market aggressively since the 2000s, sellers are under pressure to make competitive prices. On the other hand, buyers are aware of the market situation and so demand low prices from their IT suppliers. In the pre-sales phase of a project, this may lead to the situation depicted in figure 5.6, whereby seller and buyer both have an advantage when downplaying the complexity of an IT project, at the expense of the later project manager who has to deliver the project under inappropriate conditions and in the face of inflated expectations.

This effect seems to be even stronger when the seller in the consultancy firm is not responsible for delivering the project themselves and when the project is sold for a fixed price. From a systemic perspective, there is no incentive for the seller to consider complexity in detail in this situation. On the other hand, the buyer has no incentive either, as they buy a service for a fixed price and hence, the commercial risk is entirely with the service provider. As a consequence, the project manager who gets assigned to this project will find themselves in a difficult situation from the start, as the project setup in terms of budget, resource and milestone planning most likely is inadequate.

This leads to the second variant of this scenario: when complexity is downplayed in order to deliver results. According to the findings, IT project leadership roles, i.e. project managers and sponsors, downplay complexity before important project milestones for their personal advantage or, more specifically, to avoid personal disadvantage and negative impact to their careers by being perceived as weak leaders who failed to deliver as expected. In such situations, these roles have a tendency to downplay complexity against their subordinates and ignore their judgement in terms of complexity. However, as established in scenario *S2*, expert roles typically are closer to the problem and so have a clearer view on complexity, meaning that dismissing their judgement is dangerous. Yet, there is a fine line between career opportunism and being a *pragmatic* leader, as became evident from Nathalie's interview: she described how her complexity assessment was downplayed by her superior, a program manager, in order to push through with the planned go live, but she leaves it open whether delaying the go live would have been the better alternative in hindsight.

> *Nathalie:* "We went live and there were issues, the stakeholders were pretty unsatisfied with it. But in the end, he

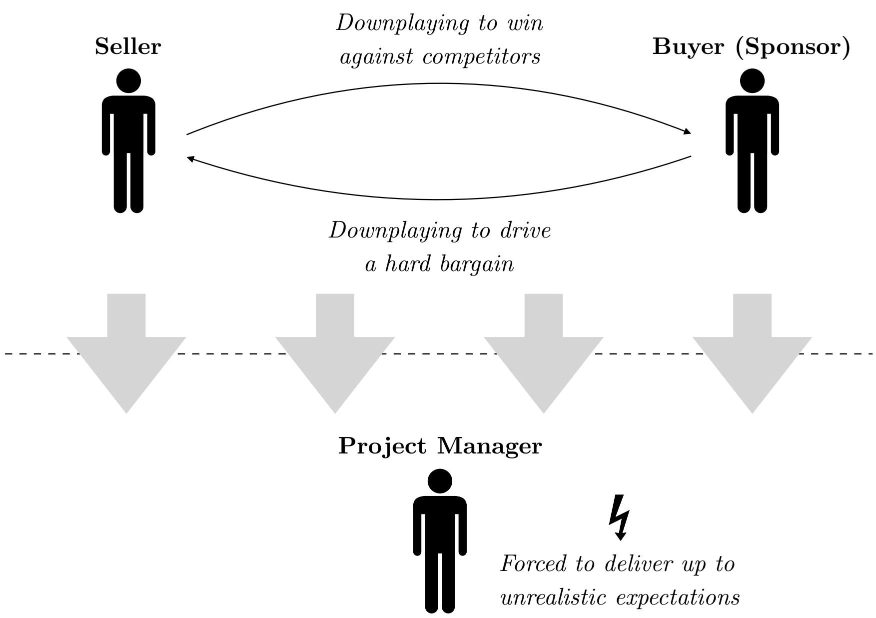


FIGURE 5.6: Conceptual model of downplaying complexity as a sales strategy

> [the program manager] was also right, the problems were manageable. Whether it was the better decision, I am not sure."

In either case, participants described feelings of frustration and demotivation when their superiors downplayed complexity against their judgement.

Possible Solution Approaches

The risks of the first variant, downplaying complexity during the presales phase, can likely be reduced by avoiding two factors. Firstly, engaging with an external service provider which does not have distinct *hunter* and *farmer* roles, i.e. where the seller is responsible for delivering the project. If the seller is responsible for the project delivery, there is an incentive for considering complexity in detail and for not overselling the project. Secondly, the buyer should not strive for fixed price agreements for complex IT projects. Even though buyers may think the commercial risk that is associated with complexity is fully on the contractor's side, the study's findings suggest that this setup may lead to a no-win situation, as the contractor will try to compensate for their financial damage by delivering results of questionable quality.

For the second variant, downplaying complexity in order to deliver results, there are no clear indications as to solution approaches within the study. For the project's host organisation, it might be advantageous to create transparency about occurrences of this variant. In order to achieve this, they would need to provide means for practitioners to anonymously state their concerns about potential downplaying which undermines long-term goals. If not protected from possible sanctions through anonymity, it seems unlikely that subordinates would raise their concerns against the will of their superiors publicly. When organisations learned about a potential downplaying of complexity in IT projects, the concerns could then be reviewed through an independent review board.

5.4.6 Addressing Complexity (S5)

Situation Description

This scenario focuses on project managers and the way they handle complexity. From the study's findings, it has been identified that project managers tend to manage complexity passively, i.e. complexity is only addressed when problems have manifested themselves but there is seldom an active management that strives to avoid complexity-related problems from appearing.

For example, the findings show that experience is one of the most crucial factors in terms of perceived complexity. However, few project managers systematically know about the experience levels of their project team, especially not with larger teams that are divided into sub-project teams. Some organisations may consider the overall mix of seniority, trying to keep the balance between junior and senior professionals, but experience is not equal to seniority, especially in a fast-moving environment like the IT industry.

Many of the study participants suggested that, in their eyes, an active project management style towards complexity would be advantageous. One participant from the group of executive managers, Richard, posited that he expects his project managers to deal actively with complexity by treating it like any other risk which is handled through a structured risk management process.

Possible Solution Approaches

It seems that project managers should deal with complexity more actively. This does not only include the descriptive notion of complexity, but also the notion of perceived complexity. For example, all project stakeholders can be asked to share their opinions on complexity drivers at the beginning of a project, and how they would address them. As a framework, the complexity drivers identified in this work (see subsection 3.3.2) could be used, if helpful. As the project is being executed, the list of complexity drivers could be reviewed and updated regularly.

In a similar way as with risk management, complexity drivers need to be identified and evaluated, according to their possibility for impact. Based on this evaluation, they can be prioritised and corresponding measures can thus be initiated. Strategies may vary from preventing the complexity driver from becoming an issue by actively resolving it, to preparing for possible remedies which will be applied when issues have manifested.

5.4.7 Leading Through Complexity (S6)

Situation Description

The final scenario focuses on ways to lead through complex situations within IT projects. The interviews for this study contained many different cases of complex situations and how they have been dealt with. Hence, this last scenario summarises the *best practices* which were identified across these interviews. Their focus is primarily on project managers, who are most likely responsible for dealing with complex situations in their IT projects. However, they also apply to team members who may be in charge of solving a complex problem without the involvement of the project manager.

Possible Solution Approaches

The study's findings suggest that a rational approach to resolving complexity is beneficial. Many interviewees mentioned how deconstructing a complex problem into less complex sub-components is the preferred choice for approaching complexity. This method has been contrasted with irrational approaches which were described as "panic" in response to complexity and, according to the interviews, never lead to positive outcomes. Many participants indicated that they appreciate a leader who stays calm in spite of complexity and responds in a structured way. While not explicitly said, it can be speculated that such an approach fosters confidence among the project team that the complex issue will be successfully resolved, while a panic reaction rather achieves the opposite.

The supporting role of visuals when resolving complex problems has been brought up many times as well. Therefore, it can be deduced that project teams should be employed with the required tools and should be trained in visualisation techniques. The most dominant type of visualisation seem to be structured Microsoft PowerPoint™diagrams. In addition, the use of *doodles*, i.e. hand-drawn sketches, has become a recent trend to help with visualising complex aspects, since they appear more intuitive to people without IT backgrounds.

Another critical aspect was the role which leaders are expected to take in the process of resolving issues of a complex nature. Most interviewees suggested that project managers and other senior managers should get involved with issues of a certain significance. However, many did not expect managers to resolve the issue themselves but rather expected them to take over a moderating role, while empowering the experts to solve the issue. Yet, this finding may be dependent on the organisation's leadership culture.

5.5 Conclusions

The purpose of this chapter was to demonstrate how the findings of this study can be utilised to draw conclusions which contribute to both, theory and practice. A summary of the contributions of this work, and how they relate to research questions and literature gaps, is displayed in table 5.3. In terms of contributions to theory, it was laid out that the different research questions *Q1* to *Q5* were successfully addressed by the study and corresponding findings could be drawn upon to provide conclusions. The main goal of this study was to complement the existing body of knowledge by improving the understanding of complexity within IT projects. The agenda behind this goal was, as discussed in chapter 1, to strengthen a subjective notion of complexity within IT projects, as has been advocated by various complexity researchers in general (Cilliers & Preiser, 2010; Heylighen et al., 2006; Morin, 2006). Consequently, it has been chosen to study the complexity of IT projects through the eyes of the people who face it on a daily basis. By introducing this alternative perspective, the conclusions drawn in this chapter are seen as a viable contribution to the existing body of knowledge. In order to bridge the gap between theory and practice, the critical realist research philosophy and its model of a layered reality has proven useful. By mapping the findings to these layers, the underlying relationships between them became transparent. Thereby, this study was able to identify six different situations which stem from complexity within IT projects, and to provide guidance for addressing complexity in these situations in response to research question *Q6*. This contribution to practice has been consolidated into practice-orientated guidelines for handling complexity in IT projects and aims to help practitioners and organisations.

Due to the exploratory nature of this research study and the chosen research design, the conclusions are not to be interpreted as universal facts—a notion which would be rejected from a critical realist's perspective. Moreover, the conclusions discussed in this work provide an understanding and an attempt to explain the hidden mechanisms behind the visible aspects of the studied phenomenon: the complexity of IT projects.

TABLE 5.3: Summary of contributions to theory and practice and their relation to research questions and literature gaps

Contribution	Addressed research question	Addressed literature gap(s)
Contributions to theory		
No common understanding regarding complexity within IT projects	*Q1*	*G1, G2*
Conceptual model of perceived complexity within IT projects	*Q2*	*G4*
Complexity drivers size and experience most relevant for IT projects	*Q3*	*G2, G3*
An individual's role has an influence on how complexity is perceived	*Q4*	*G4*
Divide-and-conquer strategies seem most successful for managing complexity in IT projects	*Q5*	*G4*
Contributions to practice		
Guidelines for six different situations was provided in order to improve the handling of complexity in IT projects	*Q6*	*G4*

The main findings of this study have been presented in the form of the conceptual model of perceived complexity in IT projects. This model explains the seven different variables which interact with perceived complexity. As shown in this chapter, the findings of this model are original, but integrate well with existing literature. While many detail findings around the seven variables of the model seem interesting, one stands out: the bi-directional relationship between perceived complexity and stress. As shown, the relationship seems to be a vicious circle: perceived complexity causes stress and stress in turn causes an increased perception of complexity. Since stress can have enormous negative effects on the health of practitioners, this finding underlines the need for an increased awareness about the complexity of IT projects in practice.

Another key conclusions of this work is that perceived complexity within IT projects seems to be a combination of project complexity and task complexity aspects. This reflects the idea that in the lived experiences of practitioners, aspects from an organisational (macro) perspective, i.e. the project, and aspects from an individual (micro) perspective, i.e. the specific tasks that are assigned to a practitioner, merge together, as presented in figure 1.1 and as formulated in the conceptual framework in section 1.4. This means that from the perspective of practitioners, complexity consists of two components: the micro level component which is caused by concrete task assignments, and the macro level component which is caused by the interdependence of own task assignments with those of other co-workers, and the political complexity which results from the fact that most IT projects are a transformative project for the project host organisation.

Therefore, and in order to also provide a contribution to practice, the findings have been assembled in practice-orientated guidelines for handling complexity in IT projects. Based on the analysed data, six reoccurring situational patterns have been discussed. Furthermore, for each of the situations, practical guidance for IT project professionals and organisations has been added.

Given the versatile nature of the contributions to theory and the relevance of the contribution for practice, it can be concluded that the study goals have been achieved. Next, chapter 6 reflects upon the study and its limitations, as well as suggested further research.

Chapter 6

Conclusions

6.1 Introduction

This chapter summarises and concludes the study. Firstly, section 6.2 is going to reflect on the overall study and its aims. Then, the relevance of the study conclusions will be demonstrated by discussing contributions to knowledge in section 6.3 and contributions to practice in section 6.4. Afterwards, section 6.5 is going to discuss limitations to the study, followed by suggested further research in section 6.6. The chapter will be closed by a final conclusion and an outlook in section 6.7.

6.2 Reflections On The Study

At this point, it seems important to reflect upon the study and how the findings and conclusions fit to the study aims. As stated in section 1.3, the motivation for this work was to help practitioners in IT projects to better cope with complexity, which appears to be one of the greatest challenges within the modern IT industry. The first step in helping is understanding—and this was the purpose of the study at hand.

The literature review has shown that the study of complexity is highly complex in itself. Much has already been found out about complexity, from researchers in various disciplines. One of these disciplines is project management, in which complexity seems to play an important role. Yet, this study has identified gaps in the current literature: project complexity has been mainly studied through the lens of descriptive complexity, greatly driven by the Cartesian-Newtonian paradigm. However, as pointed out by Schlindwein and Ison (2004), the notion of perceived complexity should not be overlooked in the studies of complexity. Therefore, this research has applied the concept of perceived complexity to IT projects, where subjective aspects about complexity have not been researched for the most part so far. Due to the lack of substantial findings in the literature about perceived complexity, there was no basis on which to formulate hypotheses and validate them, so the nature of this study was driven by the aim to explore and to develop such hypotheses, rather than to test or even prove them.

Accordingly, a critical realist research philosophy has underpinned this study, which seemed to fit well to the descriptive-perceived complexity distinction. It advocates for an ontological view that assumes reality to be independent of the observer—descriptive complexity—while emphasising the need for an interpretivist epistemology, as we can only interpret this reality through subjective schemas—perceived complexity. As a consequence of this, a qualitative research design has been chosen, with a series of semi-structured interviews at the core of it. Due to the interactive character of semi-structured interviews, this type of data collection method seemed to provide the best basis for an exploratory study. To integrate the study into the existing body of knowledge, the data analysis was framed with complexity drivers which had been previously identified in the literature. Two distinct research streams were identified here, project complexity and task complexity. Meanwhile, complexity drivers from Geraldi et al. (2011) and Liu and Li (2012), both systematic literature reviews in their corresponding stream, were used to build a combined collection of complexity drivers. These drivers were used to initially structure and analyse the collected data, hence validating existing complexity drivers from the literature.

The data which was collected from 15 in-depth interviews with practitioners in IT projects provided rich and varied insights into the perception of complexity. The participants shared many interesting situations from their lived experiences about complexity and described manifold contextual aspects that they considered important. Many of them also welcomed the research aims, thus underlining the need for such a study from a practical point of view. Consequently, the collected data contained insightful findings for all of the formulated research questions, particularly the exploratory question concerning the perception of complexity (*Q2*). The findings were presented in chapter 4 and illustrated with respective quotations from the participants.

Afterwards, the individual findings were restructured, integrated with each other, and linked back to the existing literature in chapter 5. This was done in two ways which served different purposes. Firstly, the findings were discussed in the context of the research questions. The discussion included linking the findings back to the existing literature in order to underline original findings of this work. As shown, the study was able to uncover many interesting aspects about perceived complexity which feed back to the research questions, most notably the conceptual model of perceived complexity in IT projects. Next, the findings were mapped against the three layers which are defined in a critical realist model of the social world—events, mechanisms and structures. Through the mappings, relationships between the layers became transparent. These relationships were used to extract typical situations regarding project complexity in IT projects and consolidate them into practice-orientated guidelines which aim to inform practitioners about the most important study results.

Hence, it can be concluded that the answers have been provided to all research questions and, consequently, that the study goals were achieved. The corresponding contributions to knowledge and practice will be reflected upon in detail in the further sections 6.3 and 6.4. As stated above, the purpose of this study was to create a better understanding about perceived complexity. This understanding is indispensable when it comes to influencing or even managing complexity in a controlled way, with the motivation to improve the outcomes of IT projects. The study has provided many insights into the mechanisms behind perceived complexity and hence serves as a good basis for further studies in this direction.

6.3 Contribution To Knowledge

As shown in table 5.3, five main contributions to knowledge can be highlighted from this study. Among them, the conceptual model of perceived complexity in IT project stands out. This model conceptualises how individuals perceive complexity in IT projects. The model contains seven variables which were identified to interact with perceived complexity, and the corresponding variables were analysed in depth, including more detailed conceptual models, as for example with the variable "stress". While all seven variables provide interesting insights into perceived complexity, the bi-directional relationship between perceived complexity and stress stands out. This finding may not only inform further research regarding (IT) project complexity, but also studies on stress at the workplace.

All the five main contributions to theory have previously not been studied and hence are original findings of this research. While many aspects of the conceptual model of perceived complexity in IT projects qualify for further in-depth studies, the relationship between complexity and stress should receive particular attention, given the importance for the well being of practitioners.

As displayed in the conceptual model (see figure 5.2), the seven variables which influence perceived complexity can be grouped into internal and external variables. This distinction fits well with the another main contribution to knowledge: the study has shown that perceived complexity in IT projects consists of two components:

- The *micro level component* which represents the complexity of tasks that are assigned to an individual.
- The *macro level component* which represents the organisational complexity caused by interdependencies of the individual's tasks with the ones of co-workers and the political complexity dimension which is thus entailed in the nature of projects, being a catalyst for organisational changes.

The data contains strong evidence for these two components and therefore confirms the assumption which has been made in the conceptual framework for this study (see section 1.4). This composite nature of perceived complexity in IT projects is new and original discovery. It may inform further research that brings together these previously unconnected research streams. Since task complexity research has a longer history, further findings with relevance for project complexity might possibly be integrated within this stream in the future.

Lastly, since the study drew upon existing findings regarding project and task complexity and tested them in the field, it contributed to the body of knowledge by increasing the validity of previous findings. Particularly, the existing works of Geraldi et al. (2011) and Liu and Li (2012) (which both were compiled from systematic literature reviews), have been validated with lived experiences of practitioners in the concrete context of IT projects, as was suggested by the respective authors. By applying a critical realist research philosophy, the study was able to shed some light on the hidden mechanisms of perceived complexity and the relationship between different variables which influence it.

In sum, the study has embarked upon a journey of extending the existing body of knowledge regarding perceived IT project complexity, a phenomenon that without doubt is complex in itself. This research focused on perceived complexity and has, therefore, put individuals and their subjective narratives into the centre of the study. In order to gather data in the required width and depth, a case study research design with in-depth interviews was chosen. While the presented results seem substantial, the study can be criticised as “anecdotal”, especially from positivist researchers. From a critical realist perspective, such criticism would be rejected with a reference to epistemic relativism, which is embedded into critical realism. However, critical realists are also open for mixed-methods research. Therefore, it is hoped that the findings of this study will be used as basis for further research which will test and validate them using alternative methods.

6.4 Contribution To Practice

Since the study explored the complexity of IT projects through the lived experiences of practitioners, it was inherently practice-orientated. The goal of the study was to explore the hidden mechanisms which drive perceived complexity in order to understand and improve the outcomes of IT projects within the field. By leveraging the ontological model of critical realism, which assumes the social world consists of three layers (events, mechanisms and structures), the study was able to reveal some of the hidden causal relationships between these layers. Among the discoveries were two of elevated significance for practitioners: the relationship between perceived complexity and stress, and the negative impact on practitioner motivation in a prolonged phase of exposure to high complexity. Furthermore, the study has highlighted the relevance of perceived complexity in the context of IT projects, which has traditionally been strongly dominated by the notion of descriptive complexity and, therefore, widely ignored subjective notions of complexity so far.

In order to improve the way in which individuals and organisations deal with complexity, the study has produced a set of practice-orientated guidelines for handling complexity in IT projects. These guidelines, consisting of six typical situations in which complexity is of relevance for IT projects, have been presented in this document and aims to inform practitioners about potential risks related to complexity. The guidelines also offer practical suggestions on how to approach complexity in the described situations to improve the results.

It is hoped that the provided guidance is considered by practitioners and organisations in the field. This way, further feedback could be collected which might lead to revised and improved versions of the guidelines in the future. Concretely, the researcher will be using the guidelines in his own projects and is evaluating options to anchor them within his current employer, which is a global IT consulting firm.

6.5 Study Limitations

The research study was designed with the specific scope of researching perceived complexity in the context of IT projects. The different IT projects which were analysed in the case studies were varied in their size and scope, and included projects that were carried out by internal IT as well as external IT consultancy firms, and hence they seem to represent a wide range of IT projects. With regards to the study results, the following limitations need to be mentioned:

- *Lack of cultural diversity.* Even though the sampling strategy focused on heterogeneity and considered the variation criteria of age, gender, and experience, it does not contain enough variability in terms of cultural background. This limitation is particularly important, as the findings indicated cultural differences as being prevalent in the perception of complexity and responses to it, e.g. participants who grew up in India or South America put less emphasis on a structured divide-and-conquer approach to complex problems but instead stressed the need for efficient communication concerning complex issues.

- *Practical validation.* The introduction to this work criticised existing research on project complexity as having a tendency to produce theoretical results which often lack practical validation. Yet, it must still be acknowledged that this criticism exists in this study. The researcher remains aware of this shortcoming and hopes to close the gap in future with further research that is based upon the findings of this study.

Even though the study was focused on IT projects, it seems likely that many, but not all, findings are applicable to projects in other industries too, e.g. engineering or construction projects.

6.6 Suggested Further Research

As this study aimed to explore the hidden mechanisms of perceived complexity in IT projects, further research on the findings is suggested. Due to the significance for practitioners' well-being, the relationship between perceived complexity and stress seems to be a finding that particularly deserves follow-up research. Other interesting findings which offer themselves for further examination are, for example:

- The influence of experience on perceived complexity from a cognitive perspective. While this research was able to show that experience helps practitioners to remain calm and factual in the face of complex problems, there is no explanation for this phenomenon, yet.

- The dependency of perceived complexity to the corresponding role of an individual. As this study was able to show, different roles influence the perception of complexity and, in certain situations, may even lead to wilful ignorance of complexity. This motive deserves further attention, for example in terms of the long-term success of such a strategy from both the individual and organisational perspective.

- The possible response strategies to complexity for individuals. Similar research has been conducted for organisational responses to complexity (Ashmos et al., 2000; Greenwood et al., 2011), and the distinction made between the strategies “complexity absorption” and “complexity simplification” seem applicable to individuals, too.

In addition, as advocated by critical realism, further research with an alternative research design would be welcomed. For example, the findings of this study could be used to build hypotheses and validate them with quantitative methods (e.g. surveys). Lastly, since there were indications in the data for cultural influence on perceived complexity, an in-depth study of the relationship between the two seems valuable, given the rising intercultural notion of IT projects in a globalised environment.

6.7 Final Conclusions And Outlook

In a world of growing complexity, it remains crucial to understand how we as humans perceive complexity and how we respond to it. Driven through the practical context of IT projects, which are particularly exposed to this growth in complexity, this study has aimed to provide a better understanding of perceived complexity. At the core were essential questions such as “What do we perceive to be complex?” and “What are the consequences of perceiving something as complex?”. Although it is doubtful whether these questions may ever be fully answered, this study has opened the door to possible answers, and has also brought up various new questions. The proverbial saying “The most still remains to be done” certainly applies to perceived complexity. Yet, this study has already revealed important and previously undiscovered aspects which inform both theory and practice.

As has been acknowledged, the researcher works as technology consultant in the IT industry. Therefore, it was hoped that the study’s findings may be especially helpful to practitioners. A great deal would be gained already if practitioners within IT projects were more aware of complexity and if an increased sensitivity would exist towards subjective perceptions of complexity. Since professional work environments have already come a long way, for example by accepting subjective views on similar concepts such as motivation, it can be hoped that perceived complexity will also be accepted as a subjective, yet relevant aspect in the future, and the researcher would be proud if this work may make a small but humble contribution to this path.

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Appendix A

Consolidated Collection Of Complexity Drivers

As described in subsection 3.3.2, complexity drivers which had previously been identified in literature from the two streams, project complexity (PC) and task complexity (TC), were consolidated into a single collection of complexity drivers. Table A.1 displays the results.

Table A.1: Consolidated complexity drivers

Driver	Id.	Origin	Interpretation
Size	*D1*	both	Size of the project or of a task
Variety	*D2*	both	Different tasks types within a project or sub-components of a task
Interdependence	*D3*	both	Interdependence of tasks
Novelty	*D4*	both	Novelty of a project (based on its scope) or of a task (based on its goal)
Clarity	*D5*	both	Clarity of goals, requirements, etc.
Variability	*D6*	both	Changes or unstable characteristics of a project or a task
Temporal demand	*D7*	both	Pace of the project, challenge from deadlines
Incongruity	*D8*	TC	How well do tasks or task-components fit to each other?
Action complexity	*D9*	TC	How difficult is it actually to perform the task (physically and cognitive level)?
Experience	*D10*	PC	Personal or group experience with similar tasks or projects (including the task/project context, e.g. the environment)
Importance	*D11*	PC	How important is the task or project for the individual/organisation?
Stakeholder support	*D12*	PC	Extent to which all affected stakeholders support the task/project
Fit/convergence with	*D13*	PC	Are the opinions, interests and requirements aligned or contradicting – and/or ill-defined to allow more divergence?
Transparency (of hidden agendas)	D14	PC	Extent to which goals of individual stakeholders are known and transparent

Appendix B

Interview Questions

This appendix presents all interview questions which have been a part of the framework for conducting semi-structured interviews for this study. As described in chapter 3, a slightly different combination of questions was asked in the three different interview series. After each question below, an indication is provided in brackets regarding the usage of the question in the different parts of the study. The meanings of the abbreviations are:

- *P* – Pilot study
- *M1* – Main study I
- *M2* – Main study II

B.1 Introduction

1. What is your current age cluster? *(P/M1/M2)*
2. What is your gender? *(P/M1/M2)*
3. How would you describe your cultural background? *(P/M1/M2)*
4. What is your current job title? *(P/M1/M2)*
5. What is your current employer? *(P/M1/M2)*
6. How many years of work experience in IT projects do you have and in which different roles? *(P/M1/M2)*
7. What do you like about the project-based work style? *(P/M1)*
8. What do you *not* like about the project-based work style? *(P/M1)*

9. How would you define the term “complexity” of IT projects? *(P/M1/M2)*

10. Do you think of IT project complexity as something positive, neutral or negative? *(P/M1/M2)*

11. How would you describe your personal attitude towards complexity? *(M2)*

12. Which factors seem to increase or decrease the complexity of IT projects in your opinion? *(P/M1/M2)*

13. How do you typically respond to complexity in IT projects? *(M2)*

14. How helpful is visualisation in this context for you? *(M2)*

15. How would you compare the complexity of IT projects against the complexity of previous job roles you had before (*if applicable*) or with the complexity in other sectors, e.g. engineering? *(P/M1)*

B.2 Complex Situations in IT Projects

In this section, the interviewee will be asked whether he or she remembers a specific situation they experienced in the past where an IT projects or certain parts of it where perceived complex. For every situation the interviewee mentions, the following questions will be asked.

1. Do you remember a specific situation when you thought about complexity in your past (or current) IT projects? If so, please elaborate. *(P/M1/M2)*

2. Please specify the project environment (e.g. organisation, year). *Each project should be specified detailed enough so that the interviewer recognizes when separate interviewees refer to the same project. (P/M1/M2)*

3. What made the specific situation complex for you? *(P/M1/M2)*

4. How did others perceive this situation? *(P/M1/M2)*

5. Did you expect the situation to be this complex before? *(P/M1/M2)*

6. What was your reaction to this complexity? *(P/M1/M2)*

7. Did the complexity change over time? *(P/M1/M2)*

8. Looking back—do you still think the situation was as complex as you thought it was at the moment it occurred? *(P/M1/M2)*

B.3 Education and Experience

1. What is your educational background? *(P/M1/M2)*

2. What influence has your education on the way you perceive complexity in your job role? *(P/M1/M2)*

3. What influence has your experience on the way you perceive complexity in your job role? *(P/M1/M2)*

4. Can you imagine how having a different educational background or experiences might improve the way you percieve complexity in your job role? *(P/M1)*

5. In what way do you think experience changes the perception of complexity in IT projects? *(M2)*

B.4 Stress Handling

1. What is your attitude towards stress in the workplace? *(P/M1)*

2. How would you describe your ability to handle stress? *(P/M1)*

3. Do you think a high stress level makes you perceive IT projects more complex than usual? If so, please elaborate. *(M1/M2)*

4. Do you think very complex IT projects lead to an increased stress level for you? If so, please elaborate. *(M1/M2)*

B.5 Project Management and Methodology

1. In your opinion, are there certain project management techniques which have an influence on a project's complexity (positive or negative)? *(P/M1/M2)*

2. Do you think the project methodology—traditional waterfall versus agile approaches—has an influence on the complexity of IT projects? *(P/M1/M2)*

B.6 Project Life Cycle And Contracting

1. Would you say the complexity of a project changes during its lifespan? If so, how? *(P/M1)*

2. Do you think the complexity of fixed-price IT projects is different from cost plus IT projects? *(P/M1/M2)*

B.7 Group Dynamics

1. Did others ever ask you to assess the complexity of an IT project? If so, how did you do it? *(P/M1)*

2. When you assess the complexity of an IT project, do you factor in other people's opinions? *(P/M1)*

3. Do you think your assessment had an influence, e.g. on how the project was executed? *(P/M1)*

4. Are you aware of how your complexity assessment influences others (e.g. project management, sponsors, customers, etc.)? *(P/M1)*

5. Were you ever in a situation where your management had a different opinion on the complexity of an IT project than you? *(M1/M2)*

6. Were you ever in a situation where expectations from your environment made a task of an IT project more complex? *(M2)*

7. Were you ever in a situation where anybody underestimated complexity significantly, probably for tactical reasons? *(M2)*

8. *If applicable.* Some of the drivers for the complexity of IT projects you mentioned before are not in your hands—how do you cater for this? *(M2)*

B.8 Power and Control

1. Do you think the complexity of IT projects would be different if the project manager or team leader had direct control over their teams, i.e. if all project team members were his or her direct reports? *(P/M1/M2)*

2. Have you every done a (potentially complex) project task yourself, even though this task was not part of your project role? *(M1)*

3. Do you think multiple subcontractors on an IT project affect its complexity? If so, how? *(P/M1/M2)*

4. Do you think the use of near-shoring or off-shoring has an impact on the complexity of IT projects? *(P/M1/M2)*

B.9 Closing

1. What else is important regarding the complexity of IT projects which has not been discussed in the interview yet? *(P/M1/M2)*

2. After this interview, do you think differently of complexity in the context of IT projects? *(P/M1/M2)*

Appendix C

Interview Handout

C.1 Introduction

Dear interviewee, many thanks for participating in this research study. Your help and your willingness to share your expertise and experience is highly appreciated! This Q&A aims to provide you an overview about this study and addresses some important questions about it. The researcher will walk you through this document before the interview is conducted. Please feel free to ask for clarification if needed. Also, please openly raise your concerns about the study if there should be any. Participation in this study is absolutely voluntary and should be consensual.

C.2 General Questions

Q: What is the purpose of this study?
A: The current study aims to explore the complexity of IT projects.

Q: Is this a new field of research?
A: Project complexity has been explored by numerous studies before. However, most of these studies focused on “the project”. In contrast, the current study’s main focus is the individual and how individuals *perceive* complexity.

Q: How is this study helpful?
A: The researcher aims to increase our understanding of perceived complexity in IT projects. This also includes to learn about potential influencing factors, i.e. aspects which make us perceive IT projects more

or less complex. These insights may inform the discipline of IT project management and might be the basis for further research in this area.

Q: What exactly is done as part of this research?
A: The research includes interviews with multiple persons who have been working or worked in IT projects. The interview answers will be analysed and where possible, corresponding findings will be highlighted and conclusions will be drawn.

Q: How are interviewees for the research project identified?
A: The researcher has identified potential interviewees from his personal network of business contacts. In order to keep the interviewee population diverse, recommendations from interviewees about further potential interview candidates are highly appreciated.

Q: How many interviews will be held?
A: The number of interviews is not fixed; interviews will be held until the collected data is large enough so that potential conclusions are justified. This is expected to be the case after approximately 15 to 20 interviews.

Q: Are interviews held face-to-face or remotely, e.g. via Skype?
A: If possible, interviews are held face-to-face. If this seems inadequate or cannot be arranged due to scheduling conflicts, remote interviews will be used in exceptionally.

Q: Is there any incentive for participation in the study?
A: No, except for free beverages during the interview.

Q: Who conducts the study?
A: The study is conducted by David Klotz, a research student at the Business School of the Edinburgh Napier University.

Q: What is the researcher's motivation for this study?
A: The study is executed as part of the researcher's aspiration of achieving a doctoral degree (Doctor of Business Administration, DBA).

Q: Is there a potential conflict of interest, e.g. with a sponsor?
A: There is no direct sponsor for the research project. However, IBM has sponsored the researcher's participation in the Edinburgh Napier

University's DBA programme. Regardless of the sponsorship, IBM does not influence the study and does not interfere with its findings. The researcher is committed to conducting high-quality research and therefore guarantees that there is no conflict of interest, neither from the side of the sponsor nor from a third party.

C.3 Interview Process

Q: Is there a given set of questions (like a questionnaire)?
A: The interviewer has prepared some questions which he deems important in order to explore IT project complexity. However, the main intention is to have an insightful conversation about this topic rather than checking off question after question. Therefore, the interview process, the questions asked and their order may vary and is not predetermined.

Q: Is there a given time frame for the interview?
A: No. As mentioned above, interviews should ideally be "insightful conversations" which are not limited by a given time frame. The expected length of a typical interview is approximately 60 minutes.

Q: In which language are the interviews conducted?
A: Interviews can be conducted either in English or German, whichever fits better to the interviewee. German interview data will be translated into English as part of the data analysis process which needs to be done on a unified basis.

Q: Am I being assessed with any of these questions?
A: No, none of the questions aims to assess the interviewee. In fact, there are no "right" or "wrong" answers in this study! Instead, all questions in the interview are asking for *subjective* answers. The interviewee is considered to holds valuable knowledge and experience which he or she hopefully shares with the interviewer.

Q: Can I reject to answer a specific question?
A: Yes, you can do this at any time during the interview, without

justification. In fact, a rejected answer is preferable to an answer which is not entirely true.

Q: Is there a chance to review my answers before they will be used within the study?
A: Yes, you will receive a written transcript of the full interview via e-mail. You will be asked to confirm your answers or provide corrections, if case of misunderstandings. Your statements will not be used unless you provide a confirmation.

C.4 Confidentiality and Data Privacy

Q: Is anyone informed about my participation in this study?
A: No, the researcher will keep this strictly confidential. Neither interviewee names nor indirect information which would allow others to identify individuals (e.g. "CEO of organisation *XYZ*"), will be included in the research results.

Q: Are interviews being recorded?
A: Yes, interviews are being audio-recorded. For face-to-face interviews, the recording is done via an audio recording device. For Skype interviews, the recording is done with a specific recording software which is installed on the interviewer's computer. The interviewer will point out when the recording is started and at any point during the interview, the interviewee can request the recording device to be paused.

Q: Why is this necessary?
A: In order for the interview data to be analysed according to scientific standards, it is necessary to transcribe them. Transcription is most easily done based on an audio recording of what has been said. Otherwise, the interviewer would be constantly forced to make notes which is considered to impair the natural flow of the conversation.

Q: How is data confidentiality ensured in this process?
A: All interview recordings and transcripts are stored anonymously. The interviewer does not maintain a file or document about the names of interviewed persons. Unless the interviewee explicitly mentions his

or her name during the interview for the recording—which is not advisable—there is no direct link between interview data (recordings and transcript) and interviewee. Furthermore, all digital documents are either encrypted or protected with a password against unauthorised access.

Q: Who has access to the interview transcript and recordings?
A: Access to the anonymous interview transcripts and recordings is normally limited to the interviewer only. In case the researcher hires subcontractors for specific tasks of the data analysis process (e.g. for transcription or translation), the anonymous material will also be accessible for these subcontractors. In this case, subcontractors need to guarantee data privacy and confidentiality during this process, that the data is absolutely not shared with others and that all the data is thoroughly deleted after their service is completed. In case the interviewee is interested to receive a copy of the interview transcript or recording, the interviewer is happy to provide one.

Q: For what purposes is the interview data used?
A: The interview data is exclusively used for research purposes, with absolutely no exceptions.

Q: How long will my interview data be stored?
A: To allow for future research, e.g. as a follow-up of the current study, the researcher plans to keep digital records of the interview data.

Q: Will I be quoted later in the study results?
A: Individual statements may be quoted anonymously in the study results or study-related publications. However, the researcher guarantees that it will not be possible to identify individual persons based on their statements.

C.5 Study Results

Q: Is it certain that my answers will be included in the study results?
A: It is likely that the answers or insights drawn from these answers are going to be included in the study results. However, there is no guarantee

that individual accounts will make it into the study results as this also depends on data gathered from other interviews and the data analysis process.

Q: When are the study results available?
A: According to the current planning, the research project should be completed by the end of 2017.

Q: Where will the results be published?
A: Primarily, the results will become part of the researcher's doctoral thesis. Whether the thesis, as a whole or partially, or any other findings from this study will be published, e.g. in scientific journals, depends on the researcher. As stated above, confidentiality will be guaranteed in any case and the researcher ensures that single statements, if included in the doctoral thesis or other publications, will not allow to identify the individual who made the statement.

Q: Will I receive a copy of the study results?
A: If interviewees express their interest, the researcher is happy to provide a digital copy of his study results.

C.6 Research Contact Details

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Appendix D

Excerpts From The Interviews

D.1 Interview With Jane

Interviewer: “How would you define the term ”complexity of IT projects”?”

Jane: “On one hand, there is the complexity in terms of what the project actually has to deliver, for example the processes and the solutions you want to design with the software. This can be complex because you may have new software components or the scope of the project is too big. But complexity also arises from heterogeneous aspects like contractor and customer. Sometimes customers are not really prepared for programs of a certain complexity. Complexity also arises from inter-personal relations. Or from environmental constraints that the project cannot really adhere to. Like if there is a front line between two enemy camps and you are the one who has to deliver a project with the two, that is also complex.”

Interviewer: “Would you say complexity is value laden and, if so, would you see it rather as positive or negative?”

Jane: “Actually, positive... Otherwise, it would also be boring. Why are large programs so challenging? Because they are complex. And it is much more challenging to execute a large program rather than a small project with only 3 or 4 people working on it."

Interviewer: "Are there any drivers or inhibitors to complexity of IT projects?"

Jane: "What increases complexity for sure is when politics produce too much pressure on customer and contractor. Often, this even happens for questionable reasons. For example, if you have a project which is already not doing so well and then, due to legal reasons and external pressure, you are forced to take certain measure which are not optimal, instead of just working with the client to solve the issue. This unnecessarily increases complexity. The reasons for this are influenced from outside the project and are out of control from you as a project manager or project sponsor, because someone in the organization might have a different agenda. And you are expected to execute."

Interviewer: "Are there also things that potentially reduce the complexity of IT projects?"

Jane: "When you have as much budget as you want! [laughs] Well, it definitely helps when both parties, customer and contractor, have the same goals and want to achieve the same things. That way, everyone is much more focused and you can reach your goals much faster than if the two parties are rather blocking each other for political reasons."

Interviewer: "When you compare the complexity of IT projects to the complexity of projects from other industries, such as engineering or construction, do you think there are differences?"

Jane: "No, I rather see commonalities. These projects also have many dependencies that needs to be managed. Take for example building a space telescope... There is a very complex production process and different activities rely on each other. And an important way to manage the complexity is to look at these dependencies and to sequence activities in an optimal way. That is exactly the same in IT projects. I think you have this kind of challenge in any kind of project, that you need to define the optional way of how to execute the individuals tasks within a project."

Interviewer: "As you mentioned you worked in IT projects with different roles before, do you think the perception of complexity differs, depending on the role?"

Jane: "Certainly. When I was a developer, I thought complexity mainly comes from the requirements and their level of detail. As a project manager, however, you do not zoom in to such a level of detail anymore. Instead, you rather see things on a macro level and complexity mainly arises from inter-personal relationships. As a developer, inter-personal aspects were not that important to me and I could mainly focus on getting my development done."

D.2 Interview With Sangeetha

Interviewer: "Do you think of IT project complexity as something positive, neutral or negative?"

Sangeetha: "I think it is neutral. I guess complexity can be a good challenge when at the right level. If it is too much, it becomes very negative, of course."

Interviewer: "How would you describe your personal attitude towards complexity?"

Sangeetha: "When I have something complex in my project, I focus on this aspect very much and make it my priority.

This would mean that I would try to allocate the best resources I can get to help me solve the issue. Personally, I would work extra hours, if necessary, to fix it."

Interviewer: "So you would see it as your task to resolve complexity?"

Sangeetha: "Yes, I think so. I mean my team would support me, but they would expect me to guide them and stay on top of things."

Interviewer: "Which factors seem to increase or decrease the complexity of IT projects in your opinion?"

Sangeetha: "In many cases, communication is very critical. If the client is able to express their needs in a clear and concise way, it helps a lot... if not, things might become a lot more difficult. Another important aspect is the knowledge of the team. If there are many skilled colleagues on the project, it helps to resolve complex tasks. Also, it helps if the people on the team know each other and have been working together in other projects already."

Interviewer: "How do you typically respond to complexity in IT projects?"

Sangeetha: "The most important thing for me is to get an overview about the issue. I need to understand what I am dealing with. In my experience, it helps to break down the complexity, so I would try to do that and break it into chunks that I can work on together with my team."

Interviewer: "How helpful is visualisation in this context for you?"

Sangeetha: "It helps, definitely. I think it is helpful in two ways, one is the analysis of a complex issue and the other is when communicating about it."

D.3 Interview With Richard

Interviewer: "Do you think the project methodology – traditional waterfall versus agile approaches – has an influence on the complexity of IT projects?"

Richard: "Our organisation is very interested in agile approaches but we have not yet applied it on a wide scale, so I have no real experience here. The idea looks promising though and we are excited about first results for our projects."

Interviewer: "Do you think the complexity of fixed-price IT projects is different from cost plus IT projects? If so, could you please explain?"

Richard: "Fixed-price projects have become popular in the IT sector to manage the complexity of cost overruns, which occurred often before. So while they resolve this problem, they produce another complexity, and that is many change requests. The reason is simple: when writing a contract, the scope is somewhat vague, at best. During the project, new details are discovered that one party does not consider as included in the contract and then new negotiations start. And this happens on a regular basis. With long-running projects, you might easily end up with 500 or more change requests, and waterfall methodology is not really good in handling changes. So overall I think it is a different complexity, but not necessarily higher or lower."

Interviewer: "Were you ever in a situation where your management had a different opinion on the complexity of an IT project than you?"

Richard: "[hesitates] I am sure I was but I don't recall a specific situation right now."

Interviewer: "Were you ever in a situation where expectations from your environment made a task of an IT project more complex?"

Richard: "Well, it depends how you define 'environment' here. But yes, I think I was in that kind of situation. For example, I managed a project once where the sponsors pushed really hard for a go-live as early as possible in order to demonstrate the value of the project. We had to rush many things and built functions with questionable quality, which made the project more complex altogether."

Appendix E

Data Saturation Details

The following table E.1 shows the details regarding the data saturation during the data collection process. The interviews are listed in chronological sequence in the table rows and the themes which have been identified during the data collection are displayed in the table columns. When a theme appeared in an interview, the corresponding cell shows a “yes”. Boldface indicates that this was the third appearance (in chronological order), and thus the respective theme is considered to be saturated, assuming that three appearances qualify for data saturation, as described in subsection 3.3.3.

TABLE E.1: Data saturation details

No.	Interviewee	Common understanding	General drivers and inhibitors	Experience as influencer	Complexity and stress	Motivation and frustration	Role as influencer	Expectations as influencer	Down-playing complexity	Active handling of complexity	Divide and conquer	Power of visualisations	Optimistic approach	Feeling helpless	Relaxed with age and experience
1	Andrew	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
2	Mark	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes			yes
3	Steven	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**					
4	Carol	yes	yes	yes	yes	yes	yes		yes		**yes**	**yes**	yes		
5	Sophie	yes	yes	yes	yes	yes	yes				yes		**yes**	yes	yes
6	Paul	yes	yes	yes	yes	yes				yes	yes	yes		**yes**	
7	Frank	yes	yes	yes	yes	yes	yes			yes			yes		**yes**
8	Anne	yes	yes	yes	yes	yes		yes			yes			yes	yes
9	Jane	yes	yes	yes	yes	yes	yes	yes	yes	yes				yes	yes
10	Walter	yes	yes	yes	yes	yes		yes		yes				yes	yes
11	Edward	yes	yes	yes	yes	yes		yes		yes	yes			yes	
12	Edith	yes	yes	yes	yes	yes			yes	yes		yes		yes	yes
13	Sangeetha	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		yes	
14	Richard	yes	yes	yes	yes	yes	yes			yes	yes	yes		yes	yes
15	Nathalie	yes	yes	yes	yes	yes		yes	yes	yes	yes	yes	yes	yes	

Legend	yes - theme was covered in the interview (blank) - theme was not covered in the interview bold font - saturation reached for theme (after third appearance)

Appendix F

Data Collection And Analysis Statistics

TABLE F.1: Data collection and analysis statistics

Metric	Value
Interviews	
Face-to-face	6
Via telephone	9
Total	15
Interview recordings	
Total length of all interviews	14h 37’ 46”
Length of shortest interview	0h 42’ 30”
Length of longest interview	1h 50’ 35”
Avg. length of interviews	0h 58’ 31”
Questions	
Total number of questions asked	785
Avg. number of questions per interview	52.33
Transcripts	
Total number of transcribed words	62,469
Avg. number of words per interview	4,165
Data analysis	
Main category codes	37
Sub category codes	110
Total number of main category codes applied	502
Complexity drivers and inhibitors	
Total number of mentioned complexity drivers	140
Total number of mentioned complexity inhibitors	45
Total number of mentioned complexity factors	185