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How to exploit the settings of inter-organisational collaboration

A context-sensitive approach to inter-organisational collaboration in high-technology innovation

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This work is dedicated to
Prof. Dr.-Ing. Bernhard Katzy,
a wholehearted scientist
whose time on earth was cut short far too soon.

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Abstract

In order to face the urgent societal and ecological – often wicked – problems of our time and to address the economic challenges that result from the increasingly complex, volatile, and uncertain environment in which (economic) organisations operate, nowadays inter-organisational relationships are a pivot for organisations' strategizing. The result is a highly interconnected world in which inter-organisational collaboration (IOC) plays a decisive role at the business management, economic, and societal levels. However, IOC projects still pose one of the most demanding – and unresolved – challenges for management and the attainment of a successful project outcome. This is due to the highly complex and heterogeneous nature of the phenomenon of IOC itself which ultimately is not just a business, but also a social activity. To better cope with IOC projects and their challenges in different business contexts, a better understanding and consideration of this complexity and heterogeneity in research and practice is requisite.

With this motivation, this research aims to take and promote an IOC-context-sensitive, holistic approach to IOC through consideration of its heterogeneity to provide an improved baseline for successful IOC, especially in frontier pushing high-technology innovation (FPHTI) projects. A tripartite, multi-scale design science research (DSR) approach is chosen in which a system theoretical perspective is taken to holistically model and approach specific IOC-contexts with a special focus on (inter-)relational aspects. In the first research step, the specific IOC-context for FPHTI projects as an application domain is theoretically explored by literature analysis. Empirical data on how IOC may be managed and conducted in practice is gathered and analysed in a qualitative case study at 3rd Generation Partnership Project (3GPP) in the second research step. On this basis, in the third research step, a method for the IOC-context-sensitive development of IOC-settings – the LD²M – is developed as a design artefact of the DSR, which is also used to fuse the research findings to draw conclusions concerning IOC in FPHTI projects.

This research project combines the highly interconnected streams of multi-actor innovation and IOC (management) research. A contribution to close the research gap concerning how IOC is concretely conducted in practice is bridged by the case study findings. With the LD²M, a prototype for the design of tailored IOC-settings, which are harmonized with the specifics of an IOC project, is introduced, which in addition provides innovative impulses for both IOC practice and research: It is encouraged to face – and not antagonize – the heterogeneity and uniqueness of IOC projects which is in this thesis primarily attributed to the social dynamics within IOC projects and thus its actors, their incentives, and interaction. Both the concept of context-sensitive analogy reasoning in the LD²M and the presentation and analysis of this research's empirical findings represent a new approach to exploit existing empirical findings, knowledge, and experience in the field of IOC, namely in an context-sensitive, reflected way as source of inspiration. With regard to research methodology, the LD²M expands the techniques in the field of IOC and at the same time the application domains of the adapted concepts of design thinking, the double diamond process, and lead user methodology.

Abstract (German)

Sowohl drängende gesellschaftliche und ökologische Probleme, die grundlegenden Innovationen bedürfen, als auch komplexe und unsichere Wirtschaftsbedingungen erfordern immer intensivere und umfangreichere Zusammenarbeit verschiedener Wirtschatssubjekte. Das Ergebnis ist eine stark vernetze Welt und Wirtschaft, in der organisationsübergreifende Zusammenarbeit (*inter-organisational collaboration*, IOC) einen wichtigen Schlüssel für betriebs- und volkswirtschaftliche Erfolge darstellt. Gleichzeitig verlaufen IOC-Projekte besonders häufig nicht erfolgreich. Das kann auf die hohe Komplexität und Heterogenität von IOC sowie die hohe soziale Interaktion und Dynamik, die IOC im Vergleich zu anderen Wirtschaftsaktivitäten auszeichnet, zurückgeführt werden. Um die Erfolgsrate von IOC-Projekten zu steigern, ist es erforderlich das Phänomen IOC und seine Komplexität besser zu verstehen und der Heterogenität von IOC-Projekten in Forschung und Praxis Rechnung zu tragen.

Hierzu trägt diese Arbeit mit einem ganzheitlichen Ansatz für die Analyse von IOC-Projekten bei, der die Einzigartigkeit jedes IOC-Projekts berücksichtigt und als IOC-Kontext modelliert. Dies ermöglicht die Gestaltung von genau abgestimmten Rahmenbedingungen in Form eines IOC-Settings und somit einer verbesserten Ausgangsposition für die erfolgreiche Durchführung von IOC-Projekten, insbesondere im Bereich von bahnbrechenden Hochtechnologie-Innovationen (*frontier pushing high-technology innovation*, FPHTI). In dem dreigeteilten Design Science Research Ansatz dieser Arbeit werden IOC-Projekte und ihre spezifischen IOC-Kontexte mit besonderem Fokus auf soziale und interpersonelle Aspekte ganzheitlich systemtheoretisch analysiert. Der erste Forschungsschritt dient der theoretischen Analyse des spezifische IOC-Kontexts von FPHTI-Projekten. Im zweiten Forschungsschritt wird eine qualitative Fallstudie über das 3rd Generation Partnership Project (3GPP) durchgeführt, um empirische Daten zur Durchführungspraxis von IOC zu gewinnen. Diese Erkenntnisse werden im dritten Forschungsschritt einbezogen, um eine Methode (*lead user-centred double diamond method*, LD²M) zur kontextsensitiven Gestaltung von IOC-Settings zu entwickeln. Durch die Zusammenführung der Ergebnisse aller drei Forschungsschritte im LD²M können Erkenntnisse für die Gestaltung von IOC-Settings in FPHTI-Projekten abgeleitet werden.

In dieser Arbeit wird die Relevanz von IOC (Forschung und Praxis) für Innovationsmanagement(-forschung) in Multi-Akteur-Szenarien aufgezeigt. Die Ergebnisse der Fallstudie tragen zur Schließung einer Forschungslücke im Bereich IOC bei, nämlich wie IOC in der Praxis umgesetzt und durchgeführt werden kann. Mit der LD²M wird ein Prototyp für die Gestaltung von IOC-Settings, die auf die Besonderheiten eines IOC-Projekts abgestimmt sind, vorgestellt. Darüber hinaus werden innovative Impulse für die IOC-Forschung und -Praxis liefert: Die Einzigartigkeit von IOC-Projekten, die unter anderem und wesentlich durch die Akteure und ihre Interkationen bestimmt wird, ist ein wichtiger Schlüssel für die Beantwortung von relevanten Fragestellungen der IOC-Forschung und -Praxis. Um der Heterogenität von IOC-Projekten Rechnung zu tragen, wird in dieser Arbeit ein neuer Ansatz zur (kontext-)reflektierten Verarbeitung empirischer Daten präsentiert und angewandt, der in der LD²M mit dem Konzept des kontextsensitiven Analogieschlussverfahrens umgesetzt ist: Bestehende IOC-Praktiken werden nicht auf Basis ihres bisherigen Nutzwerts, sondern auf Basis der zu erwartende Wirkung in einem konkreten zukünftigen IOC-Kontext bewertet. Die Arbeit führt außerdem das Design Thinking, den Double Diamond Prozess und die Lead User Methodik in die IOC Forschung ein und erweitert damit gleichzeitig die Anwendungsbereiche dieser Konzepte.

Table of contents

List of abbreviations

3/4/5G	3rd/4th/5th Generation of wireless mobile telecommunications technology
3GPP	3rd Generation Partnership Project
5G AA	5G Automotive Association
ARIB	Association of Radio Industries and Businesses (SDO Japan)
ATIS	Alliance for Telecommunications Industry Solutions (SDO USA)
BFGCM	Bona Fide Collaboration Group Model
CCSA	China Communications Standards Association (SDO China)
CEPT	European Conference of Postal and Telecommunications Administrations
DSR	Design Science Research
ECRT	Electronics Communications Related Turnover
ETSI	European Telecommunications Standards Institute (SDO Europe)
FPHTI	Frontier Pushing High-Technology Innovation
FRAND	Fair, Reasonable and Non-Discriminatory
GP	Guiding Principle (see Appendix D.3)
GSM	Global System for Mobile Communications
ICT	Information and Communications Technology
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IOC	Inter-Organisational Collaboration
IOCA	Inter-Organisational Collaborative Activity
IOCS	Inter-Organisational Collaborative System
IPR	Intellectual Property Rights
IS	Innovation System
ITU	International Telecommunication Union
LD^{2}M	Lead User-centred Double Diamond Method
LTE	Long Term Evolution
MRP	Market Representation Partner
NIS	National Innovation Systems

PCEI	Problem-Centred Expert Interview
PCG	Project Co-ordination Group
PCI	Problem-Centred Interview
proCoFA	Propagative Context Factor Approach
R&D	Research and Development
RIS	Regional Innovation System
SDO	Standard Development Organisation
SIS	Sectoral Innovation System
SMG	Special Mobile Group
STM	System Theory-based Model
TIS	Technological Innovation System
TSDSI	Telecommunications Standards Development Society (SDO India)
TSG	Technical Specification Group
TTA	Telecommunications Technology Association (SDO Korea)
TTC	Telecommunication Technology Committee (SDO Japan)
UN	United Nations
W3C	World Wide Web Consortium

List of figures

List of tables

1 Introduction

1.1 Motivation

> *'Technology has become so sophisticated, broad and expensive that even the largest companies cannot afford to do it all themselves.'*
>
> R.Z. Gussin, Corporate Vice President Science and Technology Johnson & Johnson, New Brunswick, NJ (1303, p. 241)

Inter-organisational collaboration (IOC) gains importance in the face of the urgent social, societal, and ecological challenges of our time – for example, climate change, environmental pollution, and the scarcity of resources (Kwibisa and Majzoub, 2018, p. 1). It is these problems which urgently demand solutions developed using fundamental innovations and changes in society and technology (Moulaert et al., 2013). Furthermore, it is the complexity, and the infrastructural and interoperability requirements – often accompanied by high economic risk and effort – of such epoch-making technological innovations in a globalised and knowledge-based world, which necessitates collaboration across entities, organisations, sectors, and national boundaries. As a consequence, a successful IOC is pivotal for technological innovations which have the potential to cause the required fundamental changes to solve the urgent problems in our world today. However, IOC and inter-organisational relationships are still strongly impacted by dysfunctions and failures (Kwibisa and Majzoub, 2018, p. 1; Oliveira and Lumineau, 2019, p. 232). This is largely because 'collaboration is not only a human activity but also a team and group dynamic' and is thus itself a very complex phenomenon (Gazley, 2016, p. 1), which in its entirety cannot solely be addressed by general management practices. However, this is also because complex innovations have resulted in the fact that 'traditional boundaries between the sectors have become blurred' (Kwibisa and Majzoub, 2018, p. 1), which leads to new (governance) roles of economic actors, politics, and society that affect IOC (Mangoyana et al., 2014). For this reason, further research is necessary to improve the theory and management practice of IOC to provide the best possible conditions and settings for epoch-making innovations to be exploited and transferred into marketable and successful solutions. This is of significant societal, economic, and scientific interest—especially because the timely appearance of innovations which have the potential to solve actual challenges, is a rare and highly valuable coincidence.

A topical example to illustrate the significance of IOC for the success of epoch-making technological innovations is emission-free electric mobility, which aims to reduce the emissions of carbon dioxide and other greenhouse gases that contribute to global warming. This example is interesting in the view of this research because it originates in the automotive sector, which has no relevant tradition of collaboration among competitors. This is why electric mobility development initially missed IOC for the development of a common standardised basis and charging infrastructure for electric vehicles. As a result of the solo project approach chosen at the beginning of the development of electric mobility, several parallel systems coexist today that lack interoperability at the hardware and software levels: plugs and outlets are as incompatible as the systems for identification, payment, and communication. These rather randomly distributed and incompatible charging stations result in expenses in terms of resources, time, money, and customer trust and convenience and have been identified as one reason for the poor market penetration from which electric mobility has long suffered (European Court of Auditors, 2021, p. 7). As a consequence, the call for inter-organisational, cross-sectoral, and international collaboration is becoming louder and the development of one interoperable, standardised charging network which meets the customer needs concerning quantity and quality has become the ultimate objective of many political (European Court of Auditors, 2021, p. 8) and economic actors in different industries, including the automotive sector:

> 'We know that electromobility only works as a complete system, with vehicles on sale and good charging infrastructure, as well as a legal framework and proper incentives.'
>
> Henning Kagermann, chair of the German platform for electromobility (Delhaes, 2017)

The EUROLECTRIC, which is the federation of the European electricity industry, has made a declaration for more IOC around electric mobility:

> …in order to ensure rapid market penetration and avoid any future incompatibility, it is vital to work out a cross-industry agreement on how to charge the vehicles and arrange for payment of the electricity. Standardising electric vehicle charging infrastructure will provide benefits to all stakeholders and developing standards is of the utmost importance to drive forward progress in European car and battery technology research, development and innovation.
>
> For all these reasons, we call upon all stakeholders, transport and energy policymakers, companies in the relevant sectors, and standards bodies to support the drive towards standardization in electric vehicle charging systems.

Given the relevance of IOC for technological progress and the solution to urgent challenges of our time, this research aims to contribute to the understanding and successful management of IOC, especially in the environment of epoch-making high-technology innovations.

1.2 Structure of the thesis

This thesis is structured into three main segments, to which its 10 chapters can be allocated: the development of a (theoretical) research foundation, the actual research study, and the presentation and discussion of the research results.

The research foundation is built in Chapters 1, 2, and 4. Chapter 1 depicts the practical motivation for this research based on real-world observations and gives an overview of the structure of this work. In Chapter 2, the theoretical motivation and justification for the research are described by means of an analysis of the state of the art in the field of IOC and related research in the field of innovation management which reveals existing research gaps. Finally, in Chapter 4, a theoretical framework for the research is developed. This includes a specification of the type of IOC under consideration to determine parallel research streams. In addition, the theoretical concepts that will be used to approach the research questions are defined. System theory is introduced as a paradigm to model the complex phenomenon of IOC and its context in a holistic way, while the concept of (perceived) relational risk is elaborated to describe the specifics of IOC.

Chapters 3 and 5 to 7 deal with the conduction of the research study. In Chapter 3, the course of research is presented including the chosen research approach, the definition of the research objectives and questions, and the investigation of the research limitations and the expected relevance. Chapters 5 to 7 are each dedicated to the three research sub-questions which are answered in separate research steps. In Chapter 5, sub-question 1 is answered by means of a complex literature review which results in a system theory-based modelling of inter-organisational collaborative systems[1] (IOCSs) of frontier pushing high-technology innovations[2] (FPHTI IOCSs). In Chapter 6, a case study on IOC at a 3GPP (3rd Generation Partnership Project) is conducted which primarily serves to answer sub-question 2, but also enhances the understanding of the nature and practice of the type of IOC considered in this research. In Chapter 7, the design artefact is developed and partially implemented which is designed to (1) answer sub-question 3, (2) merge the results of the three sub-questions, and (3) achieve the primary research objective.

The research results are finally discussed and evaluated in Chapters 8 to 10. Chapter 8 is dedicated to the validation of the research project by using a quality criteria framework for multi-method research which allows for the evaluation of the entire project and a particular assessment of its most important methodical research steps. In Chapter 9, the research results are discussed by considering both the value of the main research components (the case study and the design artefact) and the contribution of the entire research project for practitioners and the research community. A summary of the research including its course, findings, limitations, and an outlook on possible further research is provided in Chapter 10.

[1] See Chapter 4.2 for details

[2] See Chapter 5.2.1 for details

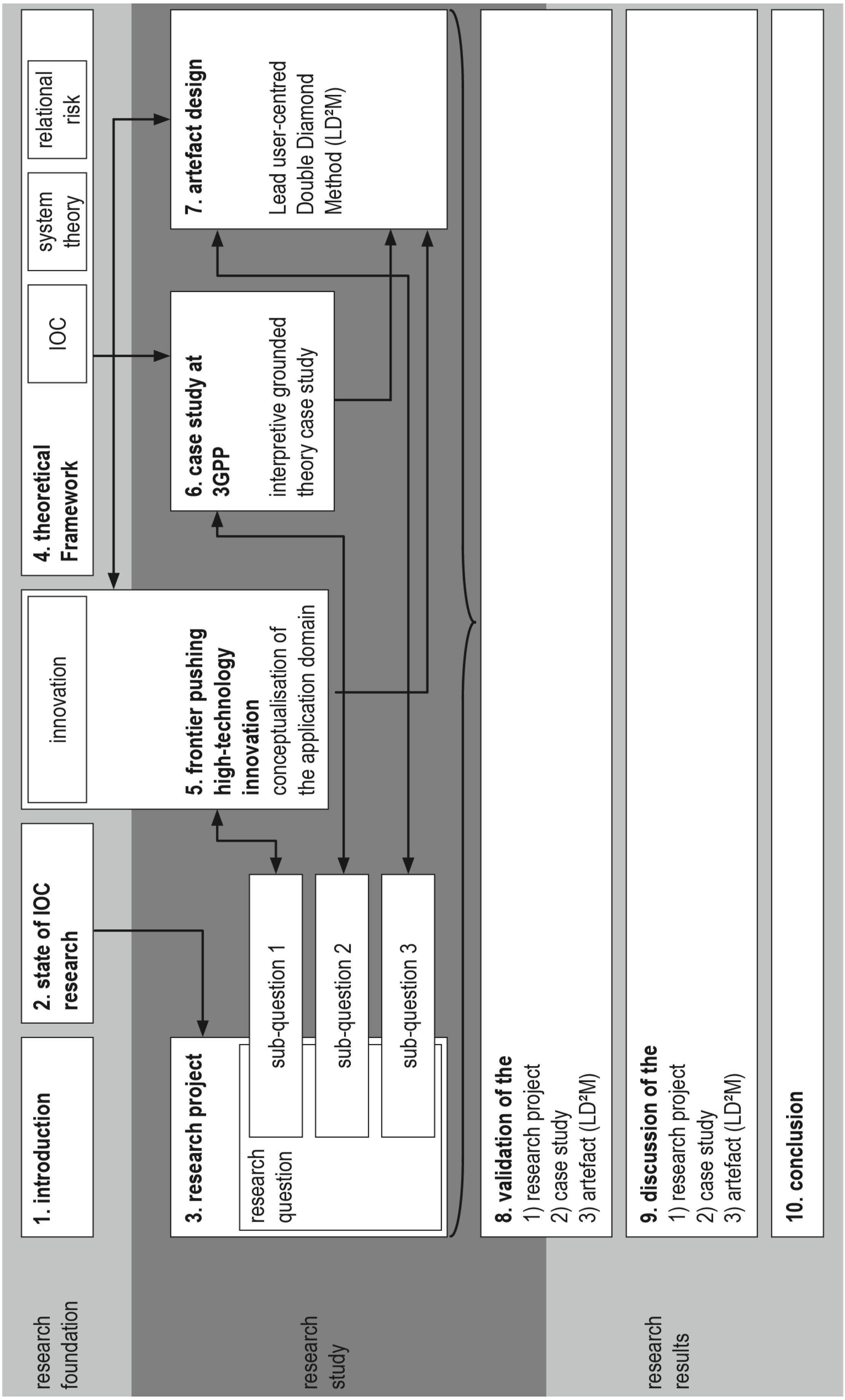

Figure 1: Structure of this work

2 State of research

In order to develop a thorough and substantiated theoretical understanding and foundation on the research topic, a comprehensive complex literature study on IOC and IOC-related innovation research is conducted. Its summary is provided in this chapter to place the current research into context and to disclose areas and aspects that need further investigation and research as a basis for the deduction of research objectives.

2.1 State of research in the field of IOC

> In the context of this research, **inter-organisational collaboration (IOC) in a broader sense** is perceived as the engagement of two or more organisations in an economic system for joint problem-solving and/or goal-attainment by sharing – amongst others – unique capabilities and resources.[3]

IOC is a highly researched topic which yields a wide variety of research outputs. IOC research is conducted in different disciplines (such as sociology, psychology, business and management, organisational behaviour, network theories, etc.) and by both academics and managers (the latter mainly after 1990). It focuses on different inter-organisational entities (business entities, public sector agencies, or non-governmental or non-profit organisations) and takes on different levels of investigation (such as a strategic or operational perspective) (Hibbert, Huxham and Ring, 2010, p. 1; Kwibisa and Majzoub, 2018, p. 1; Gazley, 2016) to produce various findings such as, for example, characteristics of IOC(Ss), (success or failure) elements, preconditions, and processes or outcomes of collaboration (Kwibisa and Majzoub, 2018, p. 5; Wood and Gray, 1991). A periodic review discloses that in the early stage of research on IOC from the 1970s, the focus was on the not-for-profit sector (Gazley, 2016, p. 1). Significant contributions in this time were – amongst others – made by Galaskiewicz (1985), Aldrich and Whetten (1981), Oliver (1990), Van de Ven (1976), and Wood and Gray (1991) (Kwibisa and Majzoub, 2018, p. 5). Starting with the increasing privatisation in the 1990s (Gazley, 2016, p. 1), the scholarly and managerial interest in IOC was steadily enhanced up to the present date and is accompanied by a strong shift of focus towards IOC in economic settings in the literature. Among others, significant contributions in this area were made by Barringer and Harrison (2000) and Huxham and Vangen (2000, 2003, 2005). For this study, a cross-disciplinary literature review of existing research is conducted. In the following, existing research is presented with a view on (1) the underlying theories, (2) the scale of investigation, (3) the exploratory focus, and (4) the presented research findings with their relevance for IOC practice and management.

(1) Analysis of IOC research concerning the underlying theories

Hibbert, Huxham and Ring (2010, p. 6) analysed research according to the underlying theories and found – amongst others – the following as relevant for research on the management of IOC: agency and exchange theory, institutional theory, political economy, and political science, resource dependence, theories of power, transaction cost economics,

[3] This definition is further specified for the scope of this study in Chapter 4. See Chapter 4.1 for the definition of IOC in a narrow sense, which is taken as a basis from Chapter 4 onwards.

and self-organisation theory. Each of these theories was originally developed to explain certain (economic) phenomena other than inter-organisational collaborative interaction. Unsurprisingly, the findings of IOC research each display their theoretical foundation. For example, transaction cost economy-based research uses transactions to approach and model IOC (Todeva and Knoke, 2005). In line with the basic assumption of transaction cost economy, actors aim to maximize their profit by means of transactions, whereby collaborative relationships are mainly characterised by competitive and opportunistic behaviour (Neumann, 2012, p. 336). On the other hand, supply chain management, which is concerned with the flow of goods, information, and knowledge, generally assumes actors to be cooperative (Neumann, 2012, p. 337). Thus, research on IOC which is based on supply chain management takes the cooperative behaviour and nature of actors as a basis to approach collaborative relationships (Neumann, 2012, p. 337). These examples show that the explanatory power of theories that do not originally focus on relationships might be limited for IOC because although they partially capture the phenomenon they do not do so in its entirety (Neumann, 2012). Nevertheless, the majority of research on IOC is based on such a theory, while little attention has been paid to theories which originally emphasise and aim to approach relational aspects.

With the introduction of ‘collaborative systems’, Neumann’s contributions are an exception in the field of IOC research (Neumann, 2012; Neumann, Santa-Eulalia, and Zahn, 2011). He uses social system theory as a basis for his work and describes a collaborative relationship as an indivisible unit of study which allows him to specify the social and organisational nature of IOC (Neumann, 2012, p. 368). With this approach, Neumann complements IOC research in the discipline of collaborative networks and provides a basis to integrate and adapt knowledge from organisational theory to research in this discipline (Neumann, 2012, p. 371). Although Neumann’s approach and the system theoretical perspective have not yet been established in IOC research, it nevertheless seems to be promising to close this research gap by intensifying IOC research based on theories that originally focus on relational aspects. Such research has the potential to grasp the phenomenon of IOC in its entirety and could thus enhance the understanding of the high failure rates of IOC that are observed in practice (Neumann, Santa-Eulalia, and Zahn, 2011, p. 307).

(2) Analysis of IOC research concerning the scales of investigation

With regard to the scale of investigation, research can be classified according to the unit of analysis in contributions at the macrosystem, (intra-)system, or subsystem levels. There is a rather comprehensive amount of research on IOC at the macrosystem level (Schneider, Wickert and Martin, 2017; Kozuch and Sienkiewcz-Malyjurek, 2016; 2016a) amongst others from the fields of economics political sciences, social networks theories, and institutional theory (see Huxham and Ring, 2010, p. 4 for details). This research regards IOC as a black box (Kwibisa and Majzoub, 2018, p. 5) and focuses on the structural embedding of an IOCS. It focuses on external factors, namely factors that cannot be influenced and controlled by the IOCS, its members, and management, but require the responses of the same (Pitsis, Kornberger and Clegg, 2004; Huxham and Vangen, 2000). The identified preconditions which have to be dealt with in IOC are for example (Hibbert, Huxham and Ring, 2010, p. 3) social, cultural, governmental, and economic influences (Golonka, 2012, p. 25). This research is sometimes also referred to as IOC research from a macro or strategic perspective (Hibbert, Huxham and Ring, 2010, p. 3; Golonka, 2012, p. 25).

Research at the (intra-)systemic level, also referred to as the meso or organisational level, takes a look in the black box: it focuses on the course of action within an IOCS. How is IOC organised and managed within and by the IOCS? Elements, processes, structures, and outcomes that are relevant to conducting IOC are the main aspects of research. The processes at the intra-systemic level describe interactive processes such as the course of action and procedure instructions for IOC and are not to be confused with research that takes on a processual exploratory focus (see the next section (3)) and regards IOC as a process in order to model dynamics and its timely dimension. Research at the intra-systemic level is very comprehensive[4] . However, existing research is mainly focused on factors (Krathu et al., 2015; Kozuch and Sienkiewicz-Malyjurek, 2016), preconditions and outcomes (Wood and Gray, 1991; Thomson and Perry, 2006; Thomson, Perry and Miller, 2007; Ring and Van de Ven, 1994), while there is a shortcoming in the research on internal processes of IOC and collaborative interaction and activity (Jonas and Leiponen, 2018, p. 7). For example, not much attention has yet been paid to the decision-making process in IOC, although this process has been identified as elementary for the outcome of IOC (Hibbert, Huxham and Ring, 2010, p. 17).

Research at the unit level of IOC is focused on actors that participate in and conduct the inter-organisational collaborative activity. Because research at the unit level is occupied with the smallest element of IOC, it is also referred to as micro-scale research. It is focused on behavioural and inter-relational issues and concrete practices to conduct and manage IOC. There is plenty of research on actors in IOCSs including their interrelations (Kozuch and Sienkiewcz-Malyjurek, 2016, p. 106), their behaviour (Bierhof and Müller, 2005; Salorio, Boddewyn, and Dahan, 2005) and their characteristics and competencies (Kozuch and Sienkiewcz-Malyjurek, 2016 and 2016a; Schruijer, 2020; Williams, 2002). However, the research on concrete practices to manage and conduct IOC is not satisfactory. This can be illustrated using the example of motivation in IOC: although much attention is given to motivation in IOC, it is rather investigated as a management task and not from a practice and process perspective (Hibbert, Huxham and Ring, 2010, p. 17). This finding on motivation can be generalised to research at the unit level. This is why the question of ‘how to achieve certain aspects of IOC in practice’ requires further investigation (Hibbert, Huxham and Ring, 2010, p. 17).

Summarizing the state of research concerning the scale of investigation, it can be stated that there is a good and rather comprehensive stream of research and literature on the ‘what’ and ‘why’ questions of IOC, while there are notable omissions concerning the ‘how’ of IOC, in other words in terms of research that contributes to a better understanding of the internal processes of IOC and focuses on how IOC is actually and effectively conducted, organised, and managed at a practical and an organisational level (Hibbert, Huxham and Ring, 2010, p. 16; Gazley, 2016, p. 4). In addition, in most cases, the existing research is limited to one scale of investigation although the interconnectedness of pre-existing factors, the organisational setup, and managerial practice is evident (Berends and Sydow, 2020, p. 3). This is why multi-scale research, meaning research which considers all three scales of investigation, should be intensified.

(3) Analysis of IOC research concerning the exploratory focus

By investigating the exploratory focus of IOC research, work that analyses IOC at the process, entity (also referred to as institutional), or performance level can be distinguished. Research with a processual exploratory approach focuses on the timely

[4] See Hibbert, Huxham and Ring, 2010, p. 4 for details, including literature and different research strands.

dimension of IOC to model the complexity and dynamics of IOC with the aim to theorize 'phenomena dynamically – in terms of movement, activity, events, change and temporal evolution' (Langley, 2007, p. 271). Process research on IOC has intensified steadily (Majchrzack, Jarvenpaa and Bagherzadeh, 2014) since it became popular under Ring and Van de Ven in the 1990s (Ring and Van de Ven, 1992, 1994) and especially in Organisation Science (1998). Early process research on IOC described IOC as a rational, linear sequence of stages which dominates the process view research up to date. Typically for many research approaches in this area, the sequential stages are used to develop linear life-cycle models that describe IOC from start-up onwards and terminate either in the operation phase or add a termination stage to show that IOC is not an indefinitely continuing state (Ring and Van de Ven 1994; Inkpen and Ross, 2001). The linearization of the IOC process makes the complexity and dynamics of IOC manageable and thereby helps to generate basic findings and a general understanding of the phenomenon of IOC. However, the linearized approach of IOC in process research disregards substantial aspects which are essential to thoroughly understanding a complex phenomenon. In addition, linearization hinders the original intention of this research focus: to grasp the dynamics and non-linear complexities of the phenomenon of IOC to date. The need for more consideration of dynamics is verified by Majchrzack, Jarvenpaa and Bagherzadeh (2014) who found that (1) IOC has an ever-evolving nature, (2) especially successful IOC projects show high dynamics and complexity, and (3) that the dynamics in IOC may be either detrimental or beneficial.

Research that considers IOC from an entity perspective aims to typologize and categorize IOC according to certain attributes that can be ascribed to IOCSs. Common attributes are the size of an IOCS, its legal and contractual constitution, duration, purpose, objectives, power, risk, and investment structures, actor composition (heterogenous or homogenous, entities and/or individuals), spatial and sectoral dimension, and governance structures (see for example Mortati 2013; Todeva and Knoke, 2005). As a result, subgroups are formed that share some common IOCS characteristics. But unfortunately, there is neither consistency in the items included in each category, nor is there consensus concerning the terminology that is used for different forms of IOCSs (Hibbert, Huxham and Ring, 2010, p. 8). This makes a comparison between and the application of findings from different contributions laborious and challenging. By forming subgroups that are homogeneous concerning some common IOCS attributes, entity research on IOC contributes significantly to structuring and mapping IOC according to its different forms of appearance. However, existing research does not yet sufficiently focus on forms of IOC with a comparably unstable and nonbinding constitution and an exceedingly heterogeneous and distributed set of partners (Berends and Sydow, 2020, p. 10). This kind of IOC is gaining importance in the light of the increasing complexity of business projects and innovations and the new possibilities for IOC – like digital platform- or crowd-based IOC – resulting from technological progress (Berends and Sydow, 2020, p. 10).

Performance-based research can be described as 'success factors research', which is based on the idea that management practice may be improved by a thorough understanding of the factors that influence the performance and outcome of IOC (Bijlsma-Frankema, 2004). The research findings of Kozuch and Sienkiewicz-Malyjurek (2016) for the public sector are presented in Appendix H as an example of a comprehensive set of success factors for IOC. Performance-based research is focused on both the performance of IOC (collaborative performance) and IOCSs and investigates a variety of different aspects in this context including the management and selection of partners, and the power distribution of the paradoxical coopetitive nature of IOC[5]. As a result of this research, there are various sets of success factors which differ in the number of factors they comprise according to the level of detail and focus of research but tend to represent rather complementary results with little context-specification in commercial settings (Hibbert, Huxham and Ring, 2010, p. 9; Golonka, 2012; Kim, 2019). Researchers often refrain from distinguishing external from internal factors but present a mix of uncontrollable (like environmental influences), directly controllable (like governance and coordination), and indirectly controllable factors (like trust and commitment). As a result, the relevance and implications for managerial practice (or governmental action) differ from factor to factor and have to be determined individually. Nevertheless, the density of research in this area is very high and many contributions are available for a broad variety of aspects. However, the presented results have to be used and assessed with some caution. The presentation of success factors often indicates that determinants of performance are presented although the findings are deduced from empirical and often qualitative research methods such as case studies and are not based on performance measures. In these cases, the presented findings portray what is perceived to influence IOC(S) performance. In the light of the difficulties to measure the performance of IOC(S) and the great importance of relational aspects for (the performance of) IOC, the value of research on perceptions and their significance is undeniable. Significantly, however, the perceptions and actual determinants of performance should not be confused as they are different aspects in terms of their practical and theoretical applicability and generalisability (Hibbert, Huxham and Ring, 2010, p. 11).

Summarizing the state of research concerning the exploratory focus, it can be stated that there is a broad variety of research on each of the three research objects mentioned. However, it becomes evident that IOC is too multifaceted to be modelled in its entirety by taking just one exploratory focus which is why the findings of such 'one-dimensional' research approaches contribute significantly to a better understanding of different aspects of IOC but have limited potential to draw generalised conclusions. This is not necessarily an omission in research but displays the multifaceted complexity of IOC and its heterogeneity and uniqueness (Greer, 2017, p. 4; Dekker, 2004, p. 29). While this does not diminish the significance of existing research, it shows that there is a need for additional multidimensional research and for research that considers the 'ambiguity and complexity as part of the solution rather than the problem' (Pitsis, Kornberger and Clegg, 2004, p. 51) like Schneider, Wickert and Martin (2017) suggest (see the last section of this chapter).

(4) Analysis of IOC research concerning its relevance for IOC practice and management

Due to the high practical relevance of IOC, much research does not only make theoretical contributions but provides concrete findings to assist the conduction and management of IOC. As a result, a rich potpourri of findings for collaborative practice is provided in existing research, which can be grouped into three categories, of which the third category requires closer analysis. Firstly, there are findings at the unit level, or more precisely concerning the actors and especially managers of IOC. These findings describe for example (Hibbert, Huxham and Ring, 2010, p. 12 und 13) the skills, competences, capabilities, behaviours, and attributes (Williams, 2002) of actors, which are conducive to conducting and managing IOC successfully. Often, but not exclusively, the focus is on managers. Secondly, some findings describe activities and tasks (Vangen and Huxham, 2003) which

[5] See Hibbert, Huxham and Ring, 2010, p. 9 for detailed information

have to be conducted in IOC or by the IOC management. These findings are frequently derived for specific IOCSs (Hibbert, Huxham and Ring, 2010, p. 12).

In the third category, findings on how to facilitate and conduct the activities and tasks presented in group two can be allocated. These findings include tools and techniques (de Man 2005; Shaugnessy 1994; Winer and Ray 1994), which assist the conduction and/or management of IOC as well as guidelines and procedural instructions. A closer analysis of the findings of the third group reveals two interesting facts. First, there is a general trend to focus on 'what has to be done', but little research exists on 'how to do it', which is in line with the findings on the state of research at the unit and system level of investigation. Second, most findings in this group are clearly very prescriptive and the authors present their findings in the form of remedies or instructions that imply a strong imperative and assertive character. In the light of the heterogeneity, complexity, and dynamic of IOC this is unfavourable because as stated above, conclusions and recommendations of universal validity for all – or at least a given category of – IOCSs are hardly possible. Hence, findings should rather be presented as suggestions and sources for creativity and ideas, which experts for a specific IOCS may use to develop an individual course of action (Bardach, 1998).

It is the work of Huxham and Vangen (2005) that clearly stands in contrast to the research summarized above (Schruijer, 2020, p. 1; Pitsis, Kornberger and Clegg, 2004, p. 51). Huxham and Vangen's research is innovative because it addresses many of the omissions identified above: with the concept of 'collaborative advantage' they use a structurally different approach to deduce findings on practical managerial action. First, the theory of collaborative advantage is a multi-scale approach which takes all three scales of an investigation into consideration as it is rooted at the unit level of investigation but regards deductions at the system and macrosystem levels as an equally important source for parameters which influence (managerial) action and practice. Second, Huxham and Vangen do not try to 'overcome' the complexity and dynamics of IOC but consider these as inherent characteristics of IOC, which have to be dealt with by researchers and managers. For this reason, they introduce 'reflective handles of practice' (Huxham and Vangen, 2005) which emphasise that individual solutions and courses of action have to be developed which meet the uniqueness and individuality of each IOC (situation). Huxham and Vangen's theory of collaborative advantage has become a source of inspiration for new ways and foci of research in many disciplines.[6] However, broader adoption of their multi-scale approach and/or handling of the complexity and dynamics of IOC as part of the problem has not occurred up to date, and there are also few contributions with a similar approach to the complexity and heterogeneity of IOC (Crosby and Bryson, 2005; Imperial, 2005; Schneider, Wickert and Martin, 2017).

2.2 State of IOC-focused innovation research

Two domains in innovation research mainly address issues of IOC or at least inter-organisational cooperation and interaction in the light of inter-organisational innovation: open innovation research and research on innovation (eco)systems.

[6] See for example the research of Brattström and Faems (2019), Coghlan and Coughlan (2015), Merkus et al. (2016), Ospina and Saz-Carranza (2010), Solansky, Beck and Travis (2014), Swärd (2016)

(1) Analysis of the IOC-focused in open innovation research

In open innovation research, most business models contain some sort of cooperation to make knowledge flow between partnering entities as a central element (Kaplan, Norton and Rugelsjoen, 2010). The cooperation covers a broader set of forms to partner with other entities than merely through collaboration. However, although it includes less intense types of interaction than collaboration, cooperation often involves and requires at least some collaborative elements. Chesbrough and Bogers (Chesbrough, Bogers, 2014) conducted a literature review based on five levels of analysis, which had been introduced by West, Vanhaverbeke and Chesbrough (2006): the intra-organisational, organisational, extra-organisational, inter-organisational, and industrial innovation system levels. The literature review revealed that contributions at the organisation-level of analysis dominate open innovation research followed by inter-organisational approaches (Chesbrough, Bogers, 2014). Yet, the inter-organisational open innovation research mainly focuses on the business perspective, namely the impact of inter-organisational relations on a cooperating organisation and how it can deal with these influences than on the setting and management of inter-organisational cooperation (Kim, 2019, p. 14). This is why more research on IOCSs around open innovation projects should be conducted to improve the understanding and success rates of inter-organisational innovation projects.

(2) Analysis of the IOC focus in innovation systems research

Research on innovation systems (ISs) is based on system theory and emerged in economy studies in the 1990s (Granstrand, 2000, p. 8). It can be traced back to Freeman and his fellow researchers in Europe and the United States (Lundvall, 1988; Freeman, 1988; Nelson, 1988; Freeman and Lundvall, 1988), who – according to Lundvall (2003) – came up with the idea of national innovation systems (NIS) in an unpublished paper in 1982. While most early research on innovation systems focused on national innovation systems (Markard and Truffer, 2008, p. 598; Carlsson, 2004, p. 58), Lundvall already published a general approach to innovation systems in 1985 (Lundvall, 1985, pp. 30). Based on the theoretical concept of NIS, which still dominates the literature on innovation systems with about 50% of the total (Markard and Truffer, 2008, p. 598), complementary approaches have evolved that define IS on different levels. These include regional innovation systems (RIS) as suggested for example by Braczyk and Heidenreich (1998) or De la Mothe and Paquet (1996), sectoral innovation systems (SIS) (see for example Breschi and Malerba, 1997), and technological innovation systems (TIS) as proposed by Carlsson and Stankiewicz (1991). As the qualifiers ‘national’ and ‘regional’ indicate, these two types of ISs are defined by a set of prior spatial boundaries which limits their explanatory power to systems with a defined territorial expansion (which mostly does not cross legal systems) and is accompanied by a rather strong policy and institutional focus (Granstrand and Holgersson, 2020, p. 1). In contrast, TIS and SIS take a specific technology or industry as a starting point and define the boundary of an innovation process in a specific technological field with all its contributing actors, networks, and institutions. However, while it provides a concept that is thus not bound to territorial dimensions, existing TIS research is predominantly limited to spatial boundaries and/or models interaction across this territorial boundary in a simplified way by means of a ‘global technology opportunity set’ (Carlsson et al., 2002, p. 237). One attempt to meet the increasingly heterogeneous character of IOC projects which, in many cases, cross nations (and hence different policy areas), industries, and cultures, is the concept of corporate innovation systems, which has not gained much attention in research and literature up to date (Granstrand, 2000, p. 8).

The second strand of research is on innovation ecosystems. It emerged in the early 2000s as a holistic approach to describe dynamic collaborative networks around projects of innovative activity (Smorodinskaya et al., 2017), which increasingly evolve in knowledge economies and influence innovative capacity. The innovation ecosystem approach is based on Moore’s business ecosystem concept (Mercan and Göktas, 2011, p. 105), which is based on the idea of drawing analogies between the biological world and the economy (Mercan and Göktas, 2011, p. 103). Although the innovation ecosystem approach has received increasing attention worldwide (Xu, Wu, Minshall and Zhou, 2018; Granstrand and Holgersson, 2020, p. 1) from industry, academia, and governments (Oh et al., 2016), there is still no clear and unambiguous definition and/or sound theoretical backing for innovation ecosystems (Tsujimoto et al., 2018, p. 49; Granstrand and Holgersson, 2020) and there is an ongoing debate on its relation to innovation system research and its usefulness to extant IOC research which is based on innovation systems (Oh et al., 2016). Regardless of whether researchers see innovation ecosystems as a derivative of the concept of (N)ISs (Mercan and Göktas, 2011, p. 104), a merging of (N)IS theory and Moore’s of business ecosystems, a fusion of the two distinct ecosystems of knowledge and business (Xu, Wu, Minshall and Zhou, 2018), or a largely disconnected field of research that is based on the science of ecology, innovation ecosystem research is characterised by its strategy and business focus (Granstrand and Holgersson, 2020, p. 1). It has contributed significantly to enhancing the understanding of the complex social dynamics of innovative activity (networks) (Jucevicius and Grumadaite, 2014, p. 125): Innovation ecosystem research emphasises interactions and relations (instead of finding the ‘right’ delineation or composition of components as focused on in IS research) and the right ways to stimulate them in non-linear and non-hierarchical ways (Jucevicius and Grumadaite, 2014, p. 127) to enhance self-organisation. This is why both research concepts, IS and innovation ecosystmes, greatly contribute to approaching IOC in innovation settings.

3 Research project

3.1 Research gap

Chapter 2 discloses that existing research with few exceptions (like that of Huxham and Vangen, 2005; Crosby and Bryson, 2005; Imperial, 2005; Schneider, Wickert and Martin, 2017) approaches the complex, heterogeneous and dynamic nature of IOC rather as a problem which has to be solved than as a basis to approach IOC (Pitsis, Kornberger and Clegg, 2004, p. 51). This results in simplifications, generalisations, and prescriptive recommendations, which limit the ability to cope with and meet the uniqueness of each IOC(S), both in theory and practice. This can be exacerbated by research which emphasises the context-dependence of IOC and qualitative findings and may even promote Huxham and Vangen's (2005) approach of reflected handles in IOC practice, especially with regard to the utilization of qualitative research findings. At the content level, the literature review reveals that existing research does not yet sufficiently answer how-to questions, which help to understand which concrete action is necessary for IOCs to meet certain requirements, achieve objectives, and/or promote successful IOC. A particular deficit is detected in the internal measures and processes – such as the decision-making process – of IOC which enables and facilitates inter-organisational collaborative activity. More multi-scale approaches to IOC are necessary to account for the high mutual influence and interconnectedness of an IOCS's environment, setup, conducted IOC activities, and IOC outcome. With regard to the presentation and utilization of research findings, less imperative and generalising alternatives are required that meet the prescriptive character of most outputs. Concerning inter-organisational innovation research, there is a lack of focus on the micro-level, which is necessary to understand and affect the course of collaborative innovation projects among different organisations.

3.2 Research objective and goals

The research objective is motivated by the high failure rates of IOC in the light of the importance of successful IOCA for epoch-making high-technology innovation projects – which is specified as frontier pushing high-technology innovations (FPHTIs, see Chapter 5) in the following – and addresses the identified research omissions in multi-scale research. It also provides a deeper understanding of how IOC is conducted, and more appropriate handling and presentation of qualitative findings in IOC research. This thesis aims to provide a means for the design of an optimised baseline for effective and successful IOC by better harmonizing the setting which is constituted for an IOC project – and especially FPHTI projects – with the specific inherent context of this IOC project (see Figure 2). As such, the basic idea of this research is in line with Huxham and Vangen's (2005) concept of a need for more 'reflected handles of IOC practice'.

For the scope of this research, the IOC-context and IOC-setting of an IOC project are defined as follows:

The entirety of the conditions in which IOC is conducted is defined by the IOC-context and the IOC-setting of an IOC project:

The **IOC-context** of an IOC project describes inherent, project-specific conditions—including the human and socio-cultural aspects—which define the unique and individual nature of an IOC project.

The **IOC-setting** of an IOC project, on the other hand, refers to the man-made conditions which are constituted for an IOC project. The setting may be regarded as the designed (regulatory, organisational, processual, and structural) framework which is defined for conducting a given IOC project.

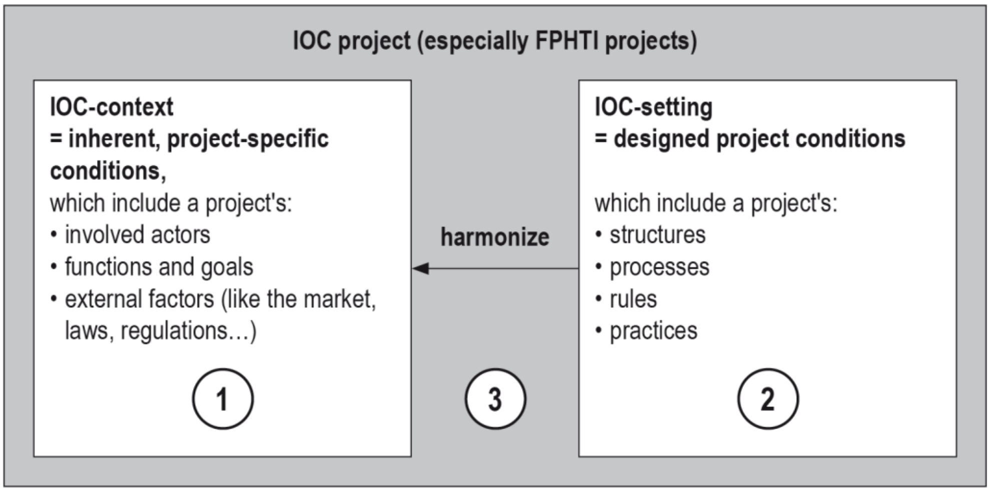

Figure 2: Overview of the research objective including the secondary research objectives 1 to 3

In order to achieve the primary research objective as shown in Figure 2, three secondary research goals as subordinated research objectives are derived (without prioritization):

Primary research objective

The **primary objective of this research** is to provide an improved baseline for IOC projects – and especially FPHTI projects – by harmonizing the designed IOC-setting with the specific context, namely the heterogeneous and unique inherent conditions of an IOC project.

Secondary research objectives (see Figure 2)

The **first research goal** is to explore and analyse the generic IOC-context of FPHTI projects in modern economies to enhance the understanding of the specifics of such innovation projects with regard to IOC (see point 1 in Figure 2).

The **second research goal** is to study the IOC-context and IOC-setting at 3GPP[7] to gain a better understanding and knowledge of (1) the concrete design of this successful IOC-setting and (2) the perceived influences of

[7] 3GPP (Third Generation Partnership Project) is an outstanding example of sustained (since 1998) global IOC in the information and communication technology (ICT) sector (see Appendix D.1)

this setting on inter-organisational collaborative activity (see point 2 in Figure 2).

The **third research goal** is to develop a method for the design of IOC-context-specific IOC-settings (see point 3 in Figure 2).

3.3 Research questions

In line with the defined research objectives, the following research questions are studied in this work:

Primary research question:

How can the harmonization of IOC-settings to their specific IOC-context provide an improved baseline for successful IOC?

This research question comprises different subtopics, which need to be elaborated separately in order to answer the research question. The research question is thus detailed in three secondary research questions, which each focus on one secondary research objective.

Secondary Research Questions:

- Sub-question 1

What characterises FPHTI projects in modern economies with regard to IOC? (corresponding to the first research objective)

- Sub-question 2

How – meaning in which concrete setting – is inter-organisational collaborative activity conducted and experienced in 3GPP? (corresponding to the second research objective)

- Sub-question 3

How can the IOC-settings of IOC projects be designed IOC-context-sensitively? (corresponding to the third research objective)

3.4 Research approach

3.4.1 Design science research (DSR) methodology

This research is founded on design science, which inherently is a problem-solving process (Hevner, March and Park, 2004, p. 82). While behavioural science aims to determine 'what is true', design science strives to create 'what is effective' (Hevner, March and Park, 2004, p. 98). Hevner, March and Park (2004, p. 80) argue that truth and utility are inseparable goals. They thus introduced a conceptual framework for design science research (DSR) which combines the paradigms of behavioural science and design science (Hevner, March and Park, 2004, p. 79) (see Figure 3).

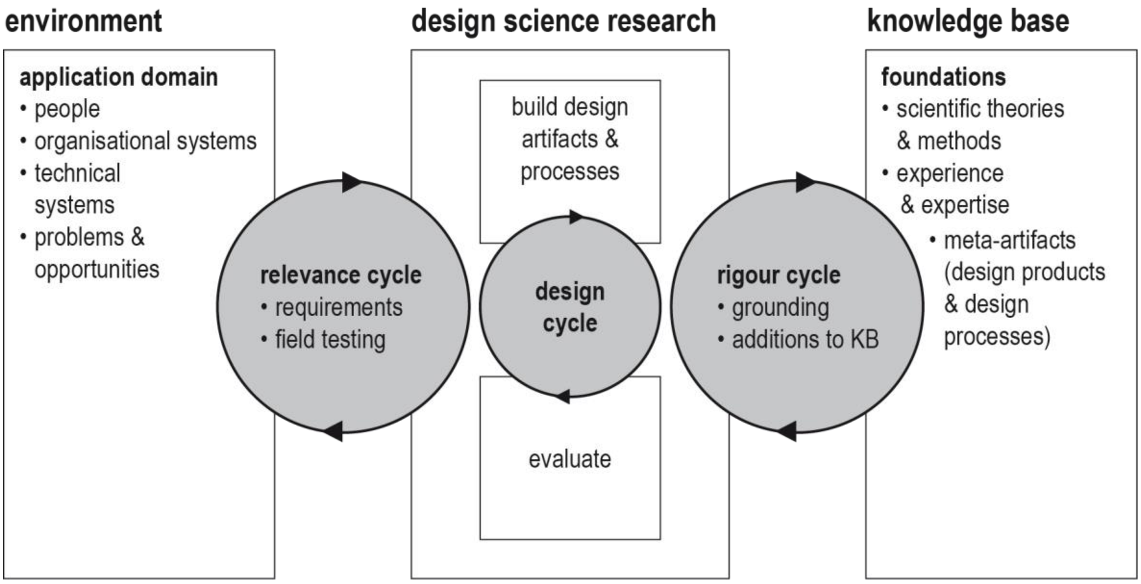

Figure 3: DSR framework of Hevner (2007, p. 88)

The framework consists of three cycles, namely the relevance, rigour, and design cycle which connect its three elements (the 'environment' as the application domain, the 'knowledge base' as the theoretical foundation, and the 'design science research' in which the artefact is designed and evaluated). It is the knowledge base and its interconnection with the other elements by means of the cycles that make DSR distinct from practice despite its highly pragmatic nature and its emphasis on inducing results with relevance to the application environment (Hevner, 2007, p. 91). Identified problems, needs, and opportunities in an environment, which subsequently become the application domain, often mark the start of a good design science research approach (Hevner, 2007, p. 89). This is why the relevance cycle which bridges the environment and the design science activities (Costa, Soares and Sousa, 2006, p. 533) is generally the initial cycle. In this cycle, the requirements for the intended artefacts are derived from the identified problem in the application domain and acceptance criteria for the evaluation of the artefact are defined as input for the DSR. The artefact that is developed in DSR, is finally returned to the application environment for evaluation (field testing), study, and application. The rigour cycle provides a thorough scientific foundation by connecting the design science activities to the knowledge base. In this way, existing knowledge in the form of theories, methods, and experience are used and applied by the researcher for the development of the artefact, while the knowledge and understanding of the design problem and its solution that is acquired in the building and application of the artefact, is added to the knowledge base in return. The design cycle finally describes the iterative conduction of the core activities of design science research: developing and evaluating the design artefact. It is important to ensure that both activities are in balance and convincingly based on both rigour and relevance (Costa, Soares and Sousa, 2006, p. 535).

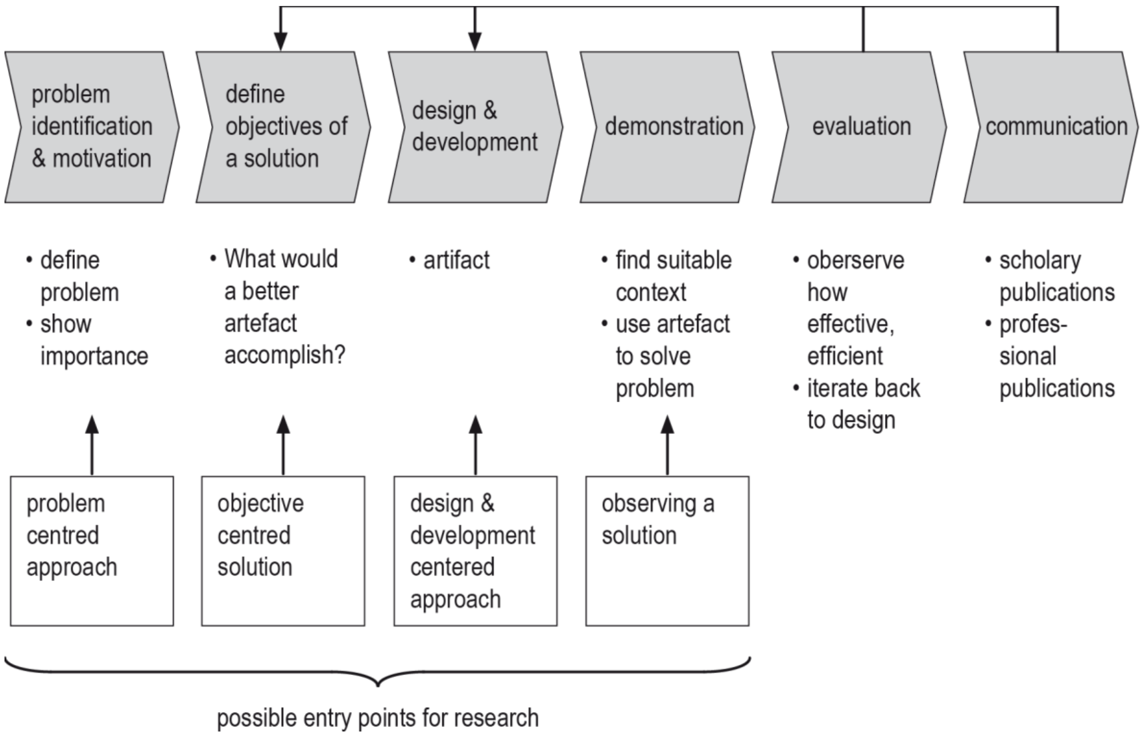

Figure 4: Peffers et al.'s (2006, p. 93) DSR process model

Based on Hevner, March and Park's (2004) rather abstract model, Peffers et al. (2006) developed a DSR process model as shown in Figure 4 that provides a framework for conducting and presenting DSR to enhance the understanding of DSR (Brenner-Wickner, Kneuper and Schlömer, 2020, p. 6; Peffers et al., 2007). Peffers at al.'s (2006) description of the six sequentially ordered but iterative activities are shown in Table 1.

Table 1: The six activities of DSR (citation of Peffers et al., 2006, pp. 89, 90 and 92)

Activity	Description
1. Problem identification and motivation	'Define the specific research problem and justify the value of a solution. Since the problem definition will be used to develop an effective artefactual solution, it may be useful to atomize the problem conceptually so that the solution can capture the problem's complexity. Justifying the value of a solution accomplishes two things: it motivates the researcher and the audience of the research to pursue the solution and to accept the results and it helps to understand the reasoning associated with the researcher's understanding of the problem. Resources required for this activity include knowledge of the state of the problem and the importance of its solution.'
2. Objectives of a solution.	'Infer the objectives of a solution from the problem definition. The objectives can be quantitative, e.g., terms in which a desirable solution would be better than current ones, or qualitative, e.g., where a new artifact is expected to support solutions to problems not hitherto addressed. The objectives should be inferred rationally from the problem specification. Resources required for this include knowledge of the state of problems and current solutions and their efficacy, if any.'
3. Design and development.	'Create the artefactual solution. Such artifacts are potentially, with each defined broadly, constructs, models, methods, or instantiations (Hevner et al. 2004). This activity includes determining the artifact's desired functionality and its architecture and then creating the actual artifact. Resources required moving from objectives to design and development include knowledge of theory that can be brought to bear as a solution.'

4. Demon-stration	'Demonstrate the efficacy of the artifact to solve the problem. This could involve its use in experimentation, simulation, a case study, proof, or other appropriate activity. Resources required for the demonstration include effective knowledge of how to use the artifact to solve the problem.'
5. Evaluation.	'Observe and measure how well the artifact supports a solution to the problem. This activity involves comparing the objectives of a solution to actual observed results from [the] use of the artifact in the demonstration. It requires knowledge of relevant metrics and analysis techniques. Depending on the nature of the problem venue and the artifact, evaluation could include such items as a comparison of the artifact's functionality with the solution objectives from activity 2 above, objective quantitative performance measures, such as budgets or items produced [by] satisfaction surveys, client feedback, or simulations. At the end of this activity the researchers can decide whether to iterate back to step 3 to try to improve the effectiveness of the artifact or to continue on to communication and leave further improvement to subsequent projects. The nature of the research venue may dictate whether such iteration is feasible or not.'
6. Communication.	'Communicate the problem and its importance, the artifact, its utility and novelty, the rigour of its design, and its effectiveness to researchers and other relevant audiences, such as practicing professionals, when appropriate. In scholarly research publications researchers might use the structure of this process to structure the paper, just as the nominal structure of an empirical research process (problem definition, literature review, hypothesis development, data collection, analysis, results, discussion, and conclusion) is a common structure for empirical research.'

3.4.2 Course of action

This research is conducted as multi-method research and applies Peffer et al.'s (2006) DSR process model according to Figure 4. The multi-method approach is chosen to best approach the research problem and each research element and to align to the pragmatic nature of DSR: multi-method research allows for using the method that best suits each research element in the actual research context and situation regardless of the methods applied in other iterations or process stages of the research (Schmidt, 2019, p. 51; Blessing and Chakrabarti, 2009). As a result, the researcher may creatively and flexibly combine empirical and theoretical research methods and use triangulation to maximize the significance of the research (outcome). Because each method is accompanied by its own perspective concerning the research problem, the understanding of the same is enhanced which contributes to the development of a substantiated solution (Goldkuhl, 2004).

The empirical research components in this study are mostly qualitative although there is one empirical core element, the 3GPP case study in Chapter 6, which is predominantly conducted to answer research sub-question 2. Furthermore, it also contributes to a better understanding of the application domain (FPHTI projects), which is the focus of sub-question 1 (see Chapter 5). In addition, the insights and enhanced understanding of IOC which results from this empirical research provide a basis and inspiration for the design of the artefact. Both qualitative and quantitative empirical research methods are used for artefact validation: the conducted expert interviews provide detailed in-depth feedback on the design artefact, while the quantitative face validity survey provides quantified data from a broader set of practitioners for statistical validation.

The complete research process as shown in Figure 5 is accompanied by theoretical research in the form of a comprehensive literature review. It contributes to all three DSR cycles by revealing relevance (relevance cycle, labelled '1' in Figure 5), by integrating and making use of the existing knowledge base in all research elements (rigour cycle, labelled ‘3’ in Figure 5), and by inspiring and substantiating the artefact (design cycle, labelled ‘2’ in Figure 5).

As shown in Figure 5, ten research activities are defined, and each is allocated to one chapter to describe the course of research. In fact, DSR is not a sequential but rather is a highly iterative research process. However, the iteratively developed research contents and outputs of each activity are used in other activities which allows one to describe the course of research based on the sequential order of contents and outputs. The research activities can be classified into three groups: Activities 1 to 4 provide the research foundation and framework, while the knowledge contribution of this research is generated in Chapters 5 to 7, which can thus be categorised as the research conduction. Finally, Chapters 8 to 10 are dedicated to the research analysis.

Activities of the research foundation

This research follows the problem centred DSR approach because it is initiated and motivated by the observation of a problem in the real world (Chapter 1), which is confirmed and specified by findings and research gaps in existing research (Chapter 2). The resulting precise definition of the research problem and existing research gaps provides the basis to develop a methodological, procedural (Chapter 3), and theoretical concept (Chapter 4) for this research. However, because of the multi-method approach and the methodologically independent study of the research sub-questions 1 to 3, Chapter 3 only defines the overall methodology of the research process. The introduction of individual methodological concepts of sub-questions 1 to 3 is allocated to the corresponding chapters, namely Chapters 5 to 7 respectively. Regardless of their methodological independence, the study of all three sub-questions is built on common theoretical ground, namely system theory as it is introduced in Chapter 4, and the shared relational-risk perspective on IOC-settings links the research on each sub-question and provides the basis to integrate, compare, and merge the findings. Besides the methodological and theoretical research framework, basic requirements and inspirations for the method of resolution are deduced from the activities that are conducted in Chapters 3 and 4.

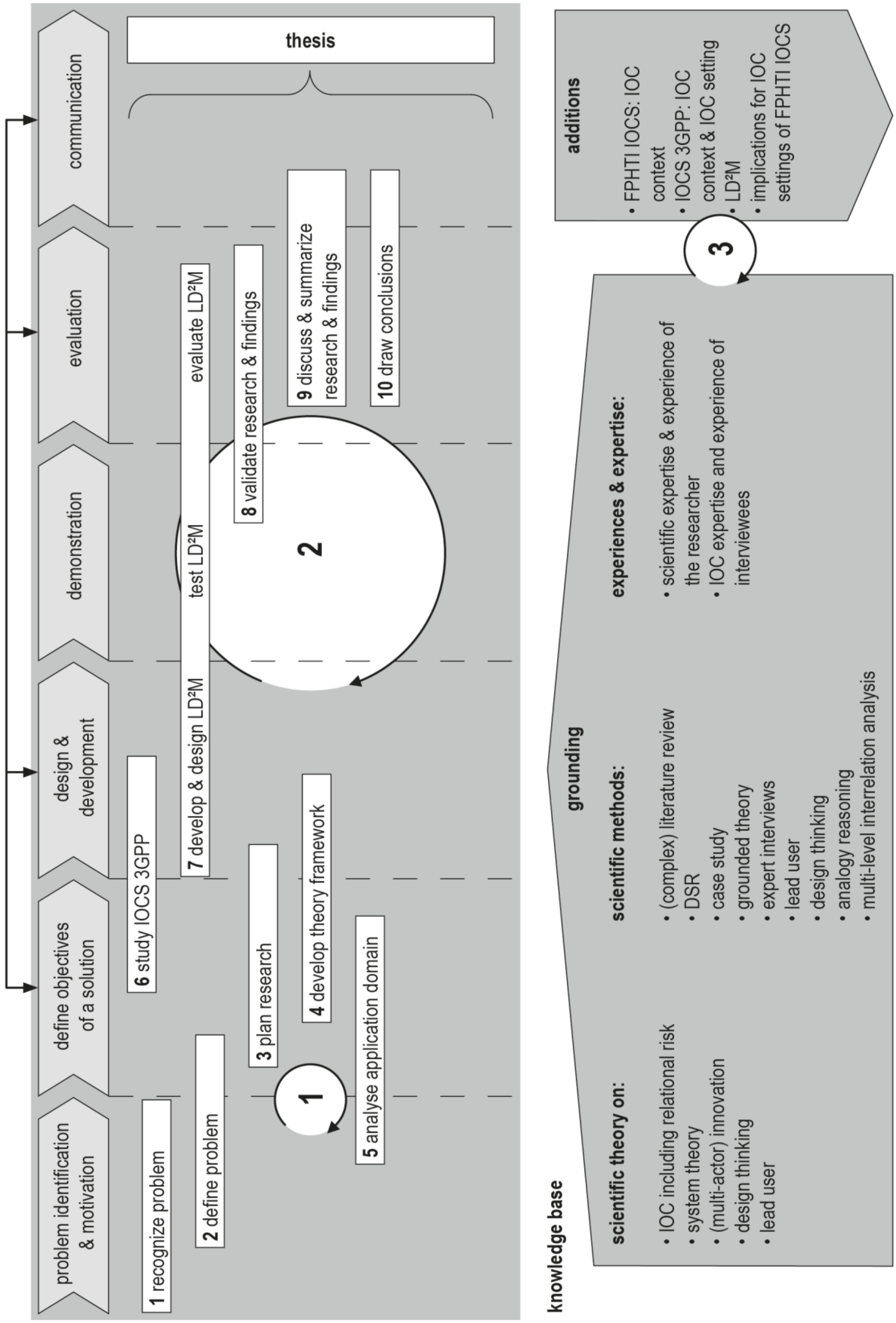

Figure 5: The course of action of this research project based on Peffer et al.'s (2006) DSR process

Activities of research conduction

The analyses of the application domain, which are allocated in Chapter 5, aim to answer the first research sub-question using a complex literature review. It provides insights into the nature of frontier pushing high-technology innovation (FPHTI) projects in globalised knowledge societies, whose IOC characteristics can be described from a system theoretical perspective. The study of the IOCS 3GPP in Chapter 6 is dedicated to the second research sub-question which is answered by means of qualitative analysis: an interpretive grounded theory case study design with problem-centred expert interviews is chosen, which adopts Schmidt's lead user method for sample detection (Schmidt, 2019, p. 57). The design of the artefact, which is the core activity of DSR, is finally conducted in Chapter 7 by fusing, adopting, and adapting existing concepts, methods, and techniques which are proven and tested in other domains and applications to generate a solution with a high solution-problem fit. The identification of suitable components requires a broad literature review in different domains, including psychology, organisation and economic science, management, and engineering. The overarching theoretical concept and perspective, system theory, is used as a means to model an IOCS. The resulting Impact Assessment Matrix (IAM)[8] is tested in a demonstrator which simultaneously allows one to make use of and combine the findings from all three research sub-questions.

Activities of research analysis

To evaluate the entire method, the design artefact, the lead user-centred double diamond method[9] (LD²M), is quantitatively and qualitatively evaluated by lead users through face validity. The actual validation not just of the LD²M, but also of the case study and the relevant research is described in Chapter 8. In Chapter 9, the findings are discussed individually and concerning each other, before a conclusion is drawn in Chapter 10.

The 10 activities each contribute to the different DSR cycles according to Hevner et al. (Hevner, March and Park, 2004). This is illustrated in Figure 5 where cycle 1 refers to the relevance cycle and the design and rigour cycle are labelled cycles 2 and 3 respectively. Chapters 1 and 5 refer to the relevance cycle, while Chapters 2 to 4 and 6 correspond to both the relevance and the rigour cycles. In the rigour cycle, they contribute to research grounding. In contrast, Chapters 9 and 10, which also predominantly refer to the rigour cycle, mainly contribute by enhancing the knowledge base by giving a condensed review of the research and its findings. The design cycle can directly be allocated to Chapter 7 in which the LD²M as the DSR artefact is built, tested, and evaluated by a peer group, and to Chapter 8, in which – amongst others – the DSR artefact is validated. As it is the most complex and important cycle for the output of DSR, the design cycle is shown in Figure 6 and expatiated in the next section.

The following process step model in Figure 6 with the most important stages and iterations of the design cycle illustrates and structures the highly iterative design procedure of the LD²M:

[8] See Chapter 7.5 for details

[9] See Chapter 7 for details

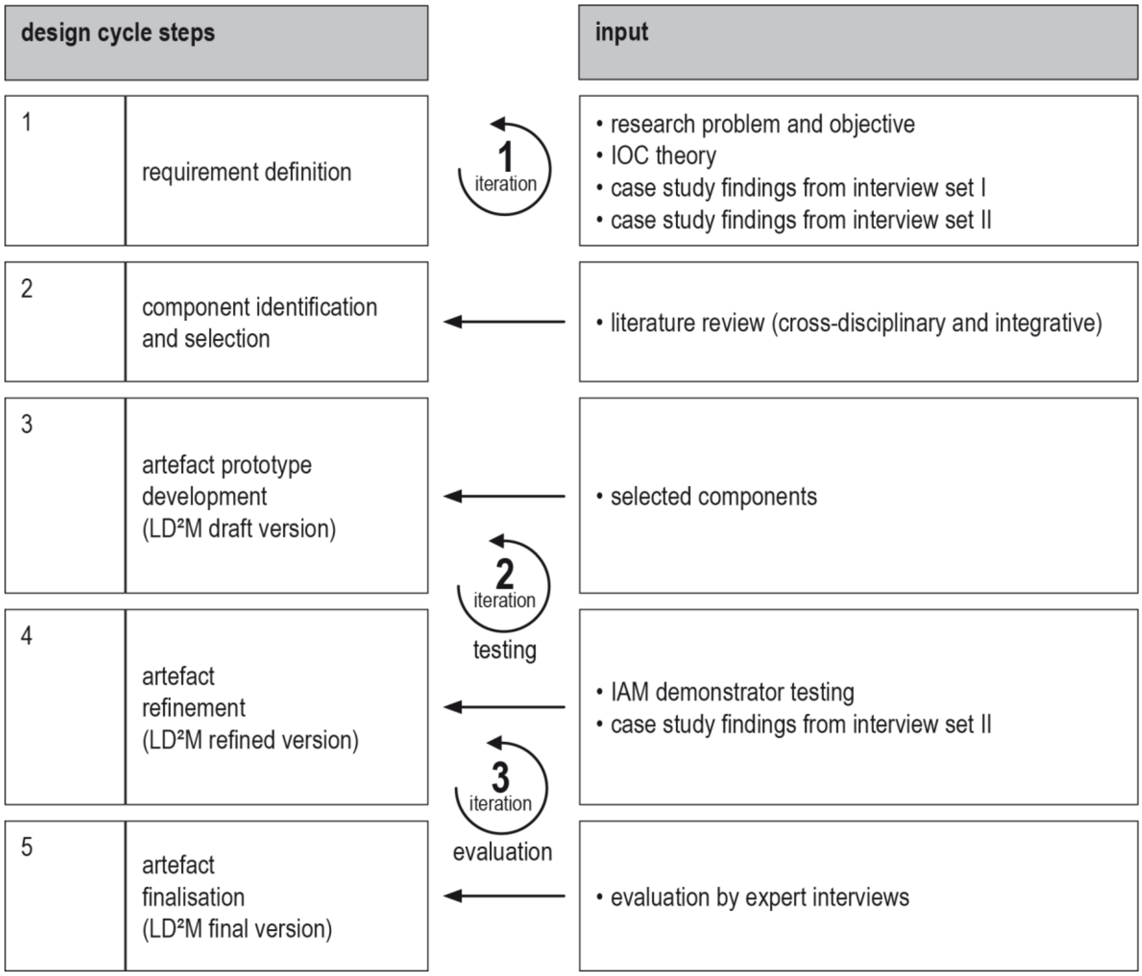

Figure 6: Design cycle of this research

In the first step, the requirements for the LD^{2}M are defined based on the findings from research activities 1 to 6, and therein mainly from Chapters 3, 4, and 6. Firstly, the rather generic requirements for the LD^{2}M are defined on the basis of the identified problem in the application domain and the research objectives. Systemic findings from the case study – mainly from the first interview set – help to develop more specific requirements, which facilitates the identification of concrete methods of resolution. These requirements are confirmed by findings from the second interview set, in which additional ‘control’ data on other IOCSs than 3GPP is gathered and analysed (requirement iteration). A cross-disciplinary integrative literature-based research is conducted to identify proven and tested theories, approaches, and concepts in other domains which are suitable for the current research problem. In addition, the researcher’s experience concerning the use of system theory for IOCS modelling and the matrix-based interrelation analysis is integrated into the selection and development process. After the set of components is chosen, they are each adapted and altered in such a way that they can be combined into one new method that solves the research problem: a prototype in the form of a draft version of the LD^{2}M is developed. The functionality of the newly created and thus not yet well-tried component, the Impact Assessment Matrix (IAM)[10], is tested in a demonstrator version with the findings of research sub-questions 1 and 2: FPHTI IOCSs are defined as the problem space, while the findings on 3GPP provide the data set of the solution space. In order to

[10] See Chapters 7.2.2.2 and 7.5

apply the IAM, which is part of the last step of the LD²M, the results of the previous steps are integrated and hence the findings on the IOC-context of FPHTI IOCSs in Chapter 5 and on the setting at 3GPP from Chapter 6 are transferred to the LD²M. In consequence, by applying the IAM demonstrator all steps of the LD²M process are executed once and thus tested across Chapters 5 to 7. As a result, the LD²M can be refined (LD²M iteration 1). The refined version is subsequently presented to lead users in order to conduct qualitative and quantitative face validity. Based on their evaluation and feedback, the final LD²M is defined (LD²M iteration 2). In addition to the three illustrated main iterations, the design process was steadily accompanied by numerous micro iterations within and across each design step.

3.5 Research relevance

The research's relevance for practice is based on the fact elaborated above that there is a growing number of settings in which economic and/or innovative achievement relies on and uses IOC and thus requires IOCA to be successfully conducted. The existing generalised recommendations for collaborative practice and activity do not meet the unique requirements and challenges of particular individual IOCSs. With the LD²M, this research provides a method that (1) as a practical means concretely assists (managerial) IOC practice, (2) facilitates the development of IOC-context-specific solutions, and (3) enables and encourages breaking new ground. The research introduces a rather creative practical approach to IOC, which facilitates and promotes stakeholders to leave the safe harbour of unity in order to *vive la différence* (Pitsis, Kornberger and Clegg, 2004, p. 54). As such, this research may both be a motivation and guideline for practitioners for IOC-context-specific adoption and adaption of findings and experiences from one IOCS to another.

This study also contributes to theory. Primarily, this research spotlights and models the complex, heterogeneous, and dynamic nature of IOC. As such, it might promote further research that does not try to overcome these attributes but uses them to approach and answer research questions on IOC. In addition, this research is based on system theory, which is not yet a popular theoretical approach in IOC research although it is promising because it aims to describe and understand complex systems and phenomena. By using different concepts of system theory (Neumann, Santa-Eulalia, Zahn, 2011, p. 76), this research provides a multi-scale approach to IOC. The emerging model for the design of individual courses of action identifies the expert of a specific IOCS and their knowledge as a primary source for the development of IOC-context-specific IOC processes and practices, which has not yet gained much attention as a knowledge source in IOC research. In addition, a new perspective on the handling of existing findings from qualitative research is introduced whereby findings are no longer regarded as a basis for implications and prescriptive recommendations but are repurposed as a 'pool of inspiration' and 'source for reflected handles' which assists the expert to develop creative and individual courses of action. The case study on 3GPP contributes to the relatively blank area of 'how-to' research by giving insights on internal IOC processes and practices of a pioneer of large-scale IOC which enhance the understanding of how inter-organisational IOCA may be conducted in practice. In addition, due to the heterogeneous and distributed set of partners in 3GPP and its non-binding membership policy, it might provide a good starting point for research into new forms of IOC. Finally, a bridge between IOC research and innovation research is built. Concerning innovation research, the study especially contributes to the system-theoretical analysis of FPHTI projects and the application of findings from IOC research to this context.

4 Theoretical framework for IOC

4.1 Conceptualisation of IOC

In this chapter, the theoretical IOC concept of this study is introduced. The development of a precise and narrow definition of the type and nature of IOC under consideration follows the appeal of Barley and Weickum (2017) to fellow researchers in the field to clearly operationalize their IOC phenomenon. This facilitates the classification of the broad variance of IOC research and provides a basis for the identification and integration of parallel streams of research. The type of IOC under consideration in this research is based on Pitsis, Kornberger and Clegg's (2004, p. 48) project-based approach:

> **Inter-organisational collaboration (IOC)** in this thesis refers to the discretionary [2] engagement of organisations and their delegates [5] at eye-level [7] with the aim to jointly solve a problem [3] by sharing unique capabilities and resources [4] in a coopetitive [1] alliance which relies on neither market nor hierarchical mechanisms of control [6].
>
> An **IOC project** in this regard is defined as the joint solving of one specific, clearly defined problem by IOC as defined above/according to the above definition.
>
> **Inter-organisational collaborative activity (IOCA)** describes the operational part of IOC, meaning the actual practical conduction of the collaborative problem-solving process, and thus refers to all activity and (inter-) action that is performed in this regard.

In the following sections, all attributes [1] to [7] of the IOC concept are analysed to understand the phenomenon of this type of IOC and to create awareness of its specific nature.

[1] IOC is coopetitive

Like much research in this field (see for example Dekker, 2004, p. 29; Rousseau et al., 1998; Lui and Ngo, 2004; Zaheer and Harris, 2006, p. 186)[11], this study approaches the nature of IOC participants from a transaction cost theory perspective. This theoretical foundation is chosen because this study refrains from regarding collaboration as pure cooperation, where entities prefer fairness to an unfair outcome even if it requires them to abdicate their own economic interests (Bachmann and Zaheer, 2008, p. 549). It is rather argued that collaboration among market actors is always a deliberate composition of competition and cooperation, which is also referred to as 'coopetition' (Reiss and Neumann, 2015, p. 10). Therefore, although it is assumed that collaborating entities are willing to lower their economic self-interests in favour of collaborative outcomes, they never lose sight of their individual agenda. Consequently, collaborating actors are still regarded as classical, economic, rational individuals, who might even act opportunistically and calculatedly to some degree (Bachmann and Zaheer, 2008, 549). This results in the paradoxical situation (Das and Teng, 1998) of concurrent competition and cooperation among

[11] For a detailed justification, see for example Bardach and Ecclers (1989) or Bromiley and Cummings (1995)

partners in IOC-settings. The competitive component does not generally imply opportunistic behaviour on the part of collaborating entities but rather suggests that each organisation naturally strives to benefit from the IOC and to protect its own agenda, which includes influencing other participants, the IOC itself, and its agendas (Vangen and Huxham, 2003, p. 18). Although the existence of competitive behaviour might stoke distrust, it is not only conducive to the economic health of the organisation itself, but also to the IOC and its success (Sharfman and Gray, 1991, p. 184). The cooperative component describes the willingness of a collaborating organisation to pursue common compatible objectives (Das and Teng, 1998, p. 492) even if it requires a certain degree of compromise concerning the individual interests. As each collaborating organisation has its individual 'coopetitive comfort zone', a key element for a successful IOC is to balance competition and cooperation (Das and Teng, 1998, p. 492).

[2] IOC is discretionary

This distinguishes the type of IOC with regard to two relevant aspects. First, IOC is not mandated by any third party (Rodríguez et al., 2007, p. 152) – for example, governments which may publicly enforce IOC through regulations or laws – but voluntary in the sense of being up to the discretionary, active decision of each entity to participate in IOC. In consequence, individual objectives are the pivotal element and driver for participating in IOC. For actors, IOC is just one alternative to pursue their individual objectives, as other alternatives exist—even if the alternatives may not appear realistic at a certain point in time. Each entity voluntarily decides on the alternative IOC and will continue the collaboration as long as it has an individual benefit. As soon as there is a more beneficial alternative, it will quit pursuing the less attractive alternative IOC. In consequence, IOC has to be attractive to be sustainable. Second, IOC in this study refers to IOC which is 'discretionarily accessible' which means that IOC-settings are regarded as more open than selective systems with regard to their accessibility (Ménard, 2004, p. 7). This does not mean that there are no entry barriers, but rather that anyone who accepts and fulfils these uniform barriers is allowed to participate without the further agreement of other participants. In consequence, actors cannot directly influence or choose their partners of collaboration, which results in an increased relational uncertainty. Despite this severe disadvantage of open settings, the neutrality of open IOCSs is gaining importance for several reasons. First, it avoids antitrust issues, especially in vertical IOC-settings among competitors. Second, the integration of all parties of interest is the best strategy to prevent the development of competing solutions to one problem. Third, open systems do not exclude potential resources and capabilities and thus provide the most comprehensive knowledge base for high-quality outcomes. Furthermore, in complex and big IOC projects, it is not manageable to conduct a vote for every new participant.

[3] IOC evolves around a specific problem

Woo (2019) specifies an important characteristic of IOC, which is adopted for this study: he describes IOC as an 'alliance to address a shared problem' (Woo, 2019, p. 845) which means that IOC is bound to and founded on (the solution of) a certain problem. This indicates two important attributes. Firstly, IOC is limited to the scope of problem solution and besides this common project, the organisations involved also conduct other activities (Woo, 2019, p. 346). As a result, constraints, relationships (to other participants as well as to third parties) and activities outside of the IOC-setting influence the participants' objectives, incentives, and behaviour. This complex, dynamic, and maybe sometimes even contrary set of incentives and motives of participants, makes actor behaviour difficult to anticipate and IOC less predictable. For this reason, the Bona Fide Collaboration

Group Model (BFGCM) suggests that IOC can only be understood concomitantly with the happenings outside of the IOCS (Woo, 2019, p. 847; Stohl and Walker, 2002). Secondly, IOC is generally a temporary construct which starts to evolve around the problem-solving process as more and more entities get involved and terminates with the solution of the problem. As a result, such IOC generally takes place in an institutional framework and environment, which is not already well established and elaborated, but rather characterised by few formal mechanisms of control (Woo, 2019, p. 846). Also, the actors' behaviours and attitudes are influenced by their awareness of the temporary nature of the collaboration (Woo, 2019, p. 848; Stohl and Walker, 2002), which is noted without judgement but has to be taken into consideration. The creeping process of increasing IOC which often precedes the conscious organisation and management of IOC and an IOCS bears the risk of delayed IOC-directing action. As a result, golden opportunities (like the development of one solution or at least a common standard instead of a tapestry of competing solutions) may be left out and/or IOC habits and customs are already established which can hardly be changed even if they turn out to be of little benefit, efficiency, or effectiveness for IOC.

[4] IOC includes knowledge-exchange

Subramani and Henderson describe IOC in the context of hybrid governance as 'firms working together closely, each providing unique capabilities and resources and jointly deriving advantages that neither party could derive on their own' (Subramani and Henderson, 1999, p. 4). Unique capabilities and resources in knowledge-intensive environments like knowledge societies are predominantly intangible assets without physical substance including skills, competencies, experience, knowledge and/or standard operating processes (Subramani and Henderson, 1999, p. 8). These assets have in common that their exchange requires knowledge transfer. However, the exchange of knowledge is not comparable to the exchange of other 'traditional' (physical) resources. Instead, the unique attributes of knowledge as a resource greatly affect knowledge exchange processes: the transfer of knowledge is always bound to a transfer from one knowledge base to another.

As a result, knowledge transfer

- is *irreversible*: once knowledge is disclosed and transferred, it cannot be returned or taken back.
- is *limited*: a transfer of 100% of knowledge is not possible, because knowledge always has some ineffable component.
- is always *defective* to some extent: due to the different knowledge bases of the sender and receiver, the received knowledge will never be completely congruent with the transmitted knowledge.
- is always accompanied by a certain *alteration of knowledge*: as a result of the different knowledge bases, the received knowledge is always processed.
- requires *learning processes*.
- is *inter-personal*: as knowledge is rooted in and bound to individuals, there are always at least two persons involved who each add a subjective component to the transfer process.
- is an *analogue* process, that is best conducted face-to-face and can generally not be fully automated and digitalised.

- requires *confidence* (in the similarity of the knowledge bases) between the sender and receiver: transmitted knowledge can only be well understood if the knowledge bases of sender and receiver possess a certain degree of congruence.

Additionally, the exchange of knowledge between different economic entities is challenging because the valuation of knowledge is not universal but depends on the knowledge base and application.

As a result, the value of knowledge:

- is not objectively measurable
- is not universal
- unfolds with the application
- varies with regard to the individuum or organisation, the time of valuation, and the context
- requires disclosure as knowledge needs to be disclosed to be evaluated (information paradox or disclosure dilemma (Bogers, 2011, p. 96).

In consequence, IOC which relies on knowledge as a unique capability and resource is highly interactive and interpersonal and the quality of social interaction and the degree of trust among the knowledge exchange partners directly influence the quality, usability, and value of transferred assets and thus the outcome of IOC.

[5] IOC is interpersonal

In line with the resource-based implication for high social interaction in IOC derived under [4], in his definition Woo highlights another indicator for strong interpersonal relationships. He states, that – although collaboration is between different organisations – it is people, more precisely the representatives of the different organisations, who come together and collaborate (Woo, 2019, pp. 845). Although this might appear trivial, it is an important aspect of IOC as it is the organisation which becomes a member of an IOCS if participation is expected to be beneficial for the achievement of the organisation's individual objectives (see [2] in this section). Thus, at a strategic level, the organisation plays a decisive role in IOC. However, at the operational level, it is the delegates who represent each organisation that actively 'play the game' and determine and form the process of IOC. Because the process of IOC is bound to individuals with their own emotions and incentives, the conduction of IOC turns out to be a highly social activity, although it is based on the merits of organisations which are per se rather rationally acting unemotional entities. In consequence, the management and guidance of social interaction is a decisive factor for the successful outcome of IOC. The differentiation between organisations and their delegates also emphasises that the predictability of a delegate as a physical actor is limited because delegates are both driven by their own individual incentives, motives, and beliefs, and are also committed to the objectives and directives of their organisation which might be conflicting and thus cause divided loyalties.

[6] IOC is 'hybrid'

According to Phillip, IOC is further characterised as a relationship that 'relies on neither market nor hierarchical mechanisms of control' (Phillips, Lawrence and Hardy, 2000, p. 2). This attribute is decisive for the governance mechanisms in IOC as the governance of IOC cannot be allocated to one of the traditional, extreme governance structures of market or hierarchy (Dekker, 2004, p. 28), but is some sort of hybrid in between (Ménard, 2004;

Sauvée, 2001; 2013; Subramani and Henderson, 1999). Because IOC takes place outside of capitalistic price mechanisms or the authority of one partner, a very wide and fundamental range of issues like the role of partners or the collaborative structures and objectives (Phillips, Lawrence and Hardy, 2000; Dekker, 2004) has to be addressed to build a substantial basis for successful IOC. In combination with bounded rationality, potential opportunism, and the uncertainty of future contingencies, the resulting contractual or negotiated framework will always be incomplete (Bogers, 2011, p. 96; Dekker, 2004, p. 29) which is why additional governance mechanisms are necessary that promote successful IOC by absorbing and managing existing loopholes of negotiation and upcoming uncertainties (Bogers, 2011, p. 96; Dekker, 2004, p. 29). These governance mechanisms also support the actors to supervise and cope with the special dynamics of economic but neither market- nor authority-based inter-organisational relationships (Phillips, Lawrence and Hardy, 2000, p. 3).

[7] IOC is at eye level

Advancing the view of Phillips, Lawrence and Hardy (2000) on IOC as a hybrid between hierarchal and market mechanisms of control, this thesis focuses on IOC in which organisations collaborate at eye level like it is also introduced by Stohl and Walker in their IOC model 'BFGCM' (Stohl and Walker, 2002). This means that all actors in the IOC-setting have the same rights and duties and that there are no hierarchies or authorities among the IOC participants which result from different preassigned[12] roles in the IOC. However, this equality is limited to the formal status within the IOC-setting, which means that, firstly, outside of the IOC-setting, organisations may be connected by other relationships including any formal or informal dependencies like market, hierarchal, and/or contractual interrelations (see [6]). For example, in complex IOC-settings not just competitors, but also buyers and suppliers may participate. However, with regard to their role in the IOC-setting, actors have little or no status difference[13]. Secondly, the participants' equality is limited to formal equality as informal hierarchies and relationships will develop over time through interaction primarily within but also outside of the IOC-setting (Woo, 2019; Stohl and Walker, 2002). That has consequences both for the IOC management and for the actors: IOCSs at eye level will most likely be managed by consensus-based orchestration (Reypens, Lievens and Blazevic, 2019) and IOC management has to consider external interdependencies among actors which might influence IOC (Leiponen, 2006, p. 28). Within the IOCS, networking and political capital become the most relevant sources of power and influence for actors.

4.2 System theory approach to IOC (projects)

As defined in the primary research objective, this research aims to take a holistic approach to IOC which considers its complex and heterogeneous nature. As such, a theoretical paradigm is required which allows the researcher (1) to model the complexity of IOC and (2) to conduct multi-scale investigations for a holistic approach. System theory is identified as an appropriate paradigm concerning the two requirements. Firstly, system theory

[12] Nevertheless, some actors are elected to perform certain IOCS-inherent roles with additional rights and duties which they conduct in addition to their delegate role.

[13] If there are different types of membership, there might be differences between the status of each membership category, but not within the same category.

particularly aims to describe and model complex phenomena (Rophol, 2009; Neumann, Santa-Eulalia, Zahn, 2011). Secondly, there are different system concepts in system theory which can be used in a complementary fashion to allow and facilitate conducting multi-scale investigations.

Because system theory is an interdisciplinary paradigm which is appropriate for the description of systems of all kinds in nature, society, and technology, it is established in various disciplines reaching from social science to technical fields such as cybernetics or engineering to management applications (Rophol, 2009; Neumann, Santa-Eulalia, Zahn, 2011; Mele, Pels and Polese, 2010; Sillito et al., 2017). It is based on the core idea that modelling and understanding a system's behaviour is fundamentally dependent on the determination and interpretation of its overall context and all existing interrelations because a system is more than the sum of its subsystems or components. In this thesis, a system's engineering approach to system theory in line with Neumann et al. (Rophol, 2009; Neumann, Santa-Eulalia, Zahn, 2011) is chosen[14]. In ISO/IEC/IEEE 15288, a system definition is provided which takes the various perspectives that influence the interdisciplinary system approach of systems engineering into account:

> A **system** is defined as a combination of interacting elements organised to achieve one or more stated purposes (ISO/IEC/IEEE 15288). It consists of components, relationships and attributes, serves a certain function, and is delineated by the system boundary.

Depending on the system concept and the research objective, models focus on one or several of the system's elements, which are further described below (Carlsson et al., 2002).

Components

In systems engineering, components are defined as the operating part of a system. For the purpose of IOCSs, the systems engineering primary meaning of 'operating' as 'acting, performing, or executing tasks' can be defined as all elements within a system that directly or indirectly contribute to the common objective, and which are interconnected. Active – meaning directly contributing – components, are mandatory for the existence of a system, while passively contributing components are optional supplements to augment (the explanatory power of) systems of innovation. The primary actively participating components are called *actors* and include all physical entities. The optional or secondary components may include all elements that extrinsically or intrinsically stimulate the actors' behaviour (Edquist, 2002, p. 8). Which (if any) secondary components are considered depends on the system model. While the most established secondary components are institutions, in the latest research there is a tendency to also consider cultural and/or social conditioning, assets, or even infrastructural and architectural components[15] (Rabelo and Bernus, 2015, p. 2252).

- *Actors:* as the 'physical' main components, these comprise all economic, non-economic, and social players such as individuals, business firms, research institutes and universities, private foundations, and public policy or government agencies (Edquist, 2002, p. 8; Carlsson et al., 2002, p. 234). They are the only component which is mandatory for the existence of a system.

[14] See Kwibisa and Majzoub (2018) for an overview of the various system theory perspectives which have developed in different research streams.

[15] For more details on the latter components, see Rabelo and Bernus, 2015, p. 2252.

- *Institutions*[16]*:* are the 'rules of the game' which means that they define the institutional context in which the actors operate by constituting (extrinsic and/or intrinsic) incentives and/or constraints. Depending on the system model, institutions follow a wide or narrow definition. The narrow view just includes 'hard' institutions, which refers to all extrinsically stimulating components, while the wider definition also includes 'soft' institutions, which refer to intrinsic stimulants.
  - *'Hard' institutions* are the 'regulatory rules of the game' (Edquist, 2002, p. 8; Rabelo and Bernus, 2015), for example, laws, norms, rules, policies, and (technical) standards. They may evolve spontaneously over time (market standards) or are intentionally designed, often as a (political) instrument of governance (Edquist, 2002, p. 8).
  - *'Soft' institutions* are the 'social rules of the game' and are also referred to as the cultural and/or social context. They concern the intrinsic incentives and constraints that influence an actor's behaviour in the system and towards other actors. It is a very recent component of a system of innovation, which is often used in the context of innovation ecosystems and includes social rules and conditioning, routines, habits, cultural norms, etc.

Attributes

Attributes are defined in systems engineering as the properties of components and the system. Transferred to IOCSs, attributes are the features of components, relationships, and the whole system that characterises the components, their relationships, and the whole system (Carlsson et al., 2002, p. 234). The attributes or *features of components* vary according to the level of analysis and can thus not be defined in general (Carlsson et al., 2002).

Relationships

Relationships are defined as the links between components by systems engineering. Transferred to IOCSs, relationships describe interdependencies and influences of different components caused by their properties and behaviour (Carlsson et al., 2002, p. 234). Relationships are a crucial element because they embody the basic idea of the approach of systems of innovation that a system can only be modelled and understood as a whole if not just elements but also relations are considered. Relationships generally include both market and non-market linkages (Carlsson et al., 2002, p. 2). There are different types of relationships, which have distinctive consequences for and impacts on a system and its characteristics:

- *Unidirectional linkages*: They are the simplest relationship between components. The directed character of these linkages does not consider (or allow) feedback loops and thus interaction between the components. As a result, a system that is solely described by unidirectional linkages is always *static* concerning the relational perspective. It might be questioned whether a construct without interaction might be regarded as a system at all in the context and objective of systems of innovation.

[16] Unfortunately, there is ambiguity in IS literature on how to use and define the term 'institutions'. This study follows Lundvall's (1992) definition of 'institutions' (for example as used in Mercan and Göktas, 2011). Other authors like Nelson and Rosenberg (1993) refer to institutions as a certain kind of organisation.

- *Bidirectional linkages:* They can be defined as the relationship of interaction between components because feedback loops are integrated into a system by bidirectional linkages and feedback provides the basis for interaction among the components. Consequentially, bidirectional relationships are essential for creating and modelling relationally dynamic systems (Carlsson et al., 2002, p. 234). For example, changes in a system's configuration can be explained by the shift and growth of capabilities over time, which are caused by interaction (and thus by feedback through bidirectional linkages).

Assets

Assets are the tangible and intangible goods and resources which actors provide and exchange within the system. Because assets flow between the actors and the system, they can be regarded as one type of relation between the components. IOCSs unanimously focus on the asset 'knowledge', although 'traditional' assets like production factors or capital might also have to be regarded as influencing assets in certain systems. The knowledge asset is formally or informally exchanged and includes implicit and explicit knowledge (Rabelo and Bernus, 2015, p. 2252).

Boundary

A system's boundary defines the 'ingredients' or content of a system, i.e. the set of components that form the system (Markard and Truffer, 2008, p. 598). It thus distinguishes the system from its environment (-al influences). In dynamic systems, the boundary of a system changes over time and might be porous. Although the definition of a system's boundary is decisive for the findings of a study, there are no right or wrong boundaries or a set way to define an appropriate one. For example, descriptive delineation suggests defining system boundaries concerning the research question, while conceptual delineation determines the boundary based on the relatively higher interaction intensity of components within the system compared to interaction with the environment (Markard and Truffer, 2008, p. 601). Another approach is operational delineation which defines the boundary with regard to the system's functions (Markard and Truffer, 2008, p. 601; Edquist, 2005; Johnson and Jacobsson, 2001). In this approach, all components which influence – i.e. promote or hinder – the development and achievement of system functions are regarded as part of the system (Markard and Truffer, 2008, p. 601; Johnson and Jacobsson, 2001).

Functions and activities

The function of a system describes a system's purpose and objective and thus what it performs or achieves (Markard and Truffer, 2008, p. 599; Edquist, 2005, p. 182). Functions consider the *activities* that take place in systems of innovation (with the function) to contribute to the goal of the system (Hekkert et al., 2007, p. 415): functions are served by components and can be defined as the contributions to a system's goal (Johnson, 1998, p. 3). Apart from structural considerations, which focus on how a system is structured and composed, research on functions of systems of innovation also analyses what the system does or how it works (Markard and Truffer, 2008, p. 601). Naturally, the structure of a system and its functions are interrelated and cannot be separated since they influence each other (Markard and Truffer, 2008, p. 601). Nevertheless, structural and functional approaches need to be clearly differentiated due to the incoherence of their relationship as systems which are similar from a functional point of view might have completely different structures and vice versa.

This system theoretical approach allows for the description of IOC projects as inter-organisational collaborative systems (IOCS):

> An **IOCS** is a system (in the sense of ISO/IEC/IEEE 15288, see p. 29) which evolves around an IOC project and is thus defined by the set of all elements which interact to attain the IOC project's joint objective.

Based on this definition of an IOCS, the definition of the IOC-context and IOC-setting (see Chapter 3.2) can be specified and refined:

> System theoretically, the **setting** as 'man-made, modifiable conditions of an IOC project' is defined by the soft and hard institutions of an IOCS, while the other elements of an IOCS and the external influences build the IOCS **context**.

For the development of holistic IOCS models, three system concepts are provided, namely the functional, structural, and hierarchical system concepts. Although these concepts are often regarded as parallel or even conflicting concepts (Ropohl, 2009, p. 75), this research follows the opinion of Ropohl who emphasises their complementary nature (Rophol, 2009, p. 77) as it is their combination which allows for a system to be described in its entirety. The functional concept helps to elaborate what a system does, while the structural concept reveals its inner composition including its elements and their interrelations, which may cause different system characteristics. The hierarchical concept finally helps to put the system into a broader context to understand its significance as well as to determine its supra-systemic embedding and external influences. In the following, the three system concepts according to Ropohl (2009, p. 75–77) are introduced as a basis for the multi-scale research in this study.

The functional system concept

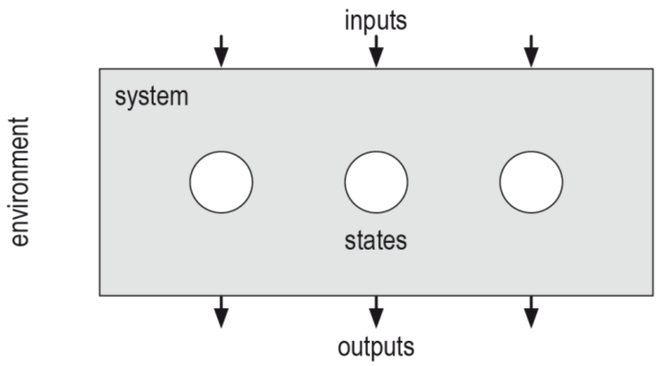

Figure 7: The functional system concept according to Rophol (2009, p. 76)

The functional system concept can best be described as a 'black box approach', which describes the system according to the features which can be observed and/or measured from the outside in the form of one or more functionalities and states. It describes 'what a system does' in order to reveal the performance (pattern) of a system and is not concerned with 'what a system is' (like the structural system concept). The functional system concept thus analyses a system according to its states and correlating inputs and outputs. In line with the technical origin of Ropohl's considerations, his functional system concept is limited to a descriptive function analysis and does not cover normative aspects. However, Ropohl himself points to the importance of objectives in the context of 'systems of action (Rophol, 2009, p. 97) as especially (socio-)economic 'systems of actions' are often rather arbitrary, man-made constructs, which can only be clearly defined by considering their purpose and thus require a normative description (Rophol, 2009, p. 97). For example, without knowing the purpose of using the technical system 'car' can be defined – at its minimum – by the components that are necessary for the technical system to fulfil the function 'to drive'. In order to do so, it will always contain the same basic parts such as an engine, wheels, etc. which allow it to conduct this descriptive function. On the other hand, a (socio-)economic group may just be a conglomerate of actors and institutions, until they collaboratively follow a common purpose: the purpose or objective of such a system of action is then constitutive. This is why the description of social or economic systems in their entirety often requires the inclusion of normative aspects. Furthermore, the description of both the current state and the target state, and a target-performance comparison can be conducted. Despite this difference, (socio-)economic systems also have different inputs and outputs than technical systems which is why the technical input, output, and state description need to be specified and reinterpreted for this context. Figure 8 provides an example of possible inputs, outputs, and states that may occur in (socio-) economic systems:

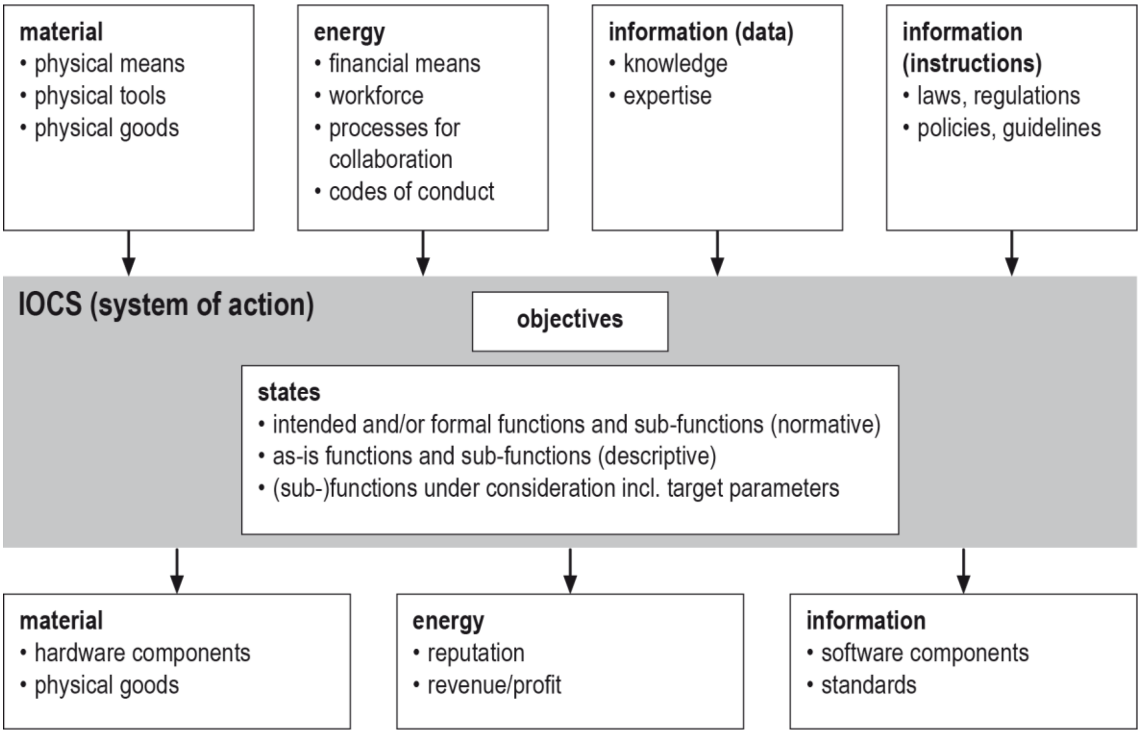

Figure 8: Ropohl's (2009, p. 97) block diagram of systems of action exemplified for IOCSs

The hierarchical system concept

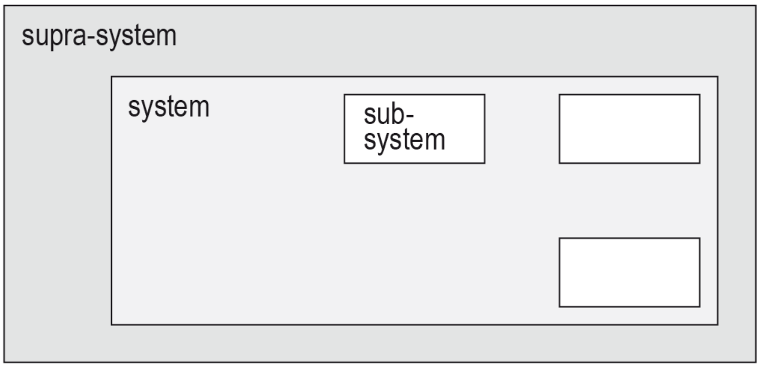

Figure 9: The hierarchical system concept according to Rophol (2009, p. 76)

The basic idea of the hierarchical system concept is that systems can be defined at different levels of hierarchy. Depending on the chosen scale of analysis, the system of one level is the sub-system of a superior level and the supra-system of a subordinate hierarchy level. The hierarchical system concept thus aims to complete the understanding of a system by analysing the exerted influences of and interrelations to supra- and sub-systems. By moving to a subordinate level of analysis, the understanding of its elements (which are sub-systems) and their effects on the system is enhanced, while the analysis at a superior hierarchical level discloses a deeper synthesis of (supra-systemic) interrelations. Besides the determination of external influences, the elaboration of a system embedding including an understanding of the functions that it performs in the supra-system is the main aim of the hierarchical system concept. In line with the author's definition of external context factors in earlier research (see Theissen, 2018), the term 'external' in the system theoretical context is defined as follows in this thesis:

> **External** are all elements (including conditions) which belong to and originate from a system of a different hierarchy level, and which are thus beyond a system's direct influence. They are commonly predetermined and can be regarded as IOC-context elements.
>
> **Internal** are all elements which belong to the IOCS. They thus fall under the direct influence of the IOCS and can principally be affected by its components and/or its institutions. However, there are certain internal elements (like the product as an outcome of an IOCS) which in fact cannot be changed and may thus be considered as pre-set factors and not as controllable elements.

The structural system

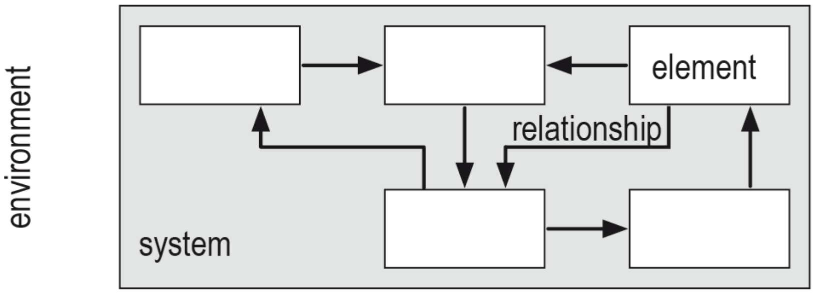

Figure 10: The structural system concept according to Rophol (2009, p. 76)

The structural system concept deals with the inner structure and composition and thus all internal elements of a system. It is the most common system concept in system theory because, just like system theory itself, it is led by Aristoteles' idea that 'the whole is greater than the sum of its parts'[17]. As a consequence, sub-systems and components cannot be analysed in isolation, but only in the context of the system, which itself is regarded as the entirety of its interconnected components. It is these relations between the elements which account for the 'more' of the system and hence the analyses of the interrelations between the system's components and their diversity is a central part of the structural system concept. To understand the interrelations, the composition, characteristics, and activities of each component have to be determined in the first step. This allows for a network of interrelations of all system components to be modelled to determine, understand, and/or influence certain system characteristics and/or states.

4.3 Relational risk perspective on IOC

In this section, the question of if and why the management of IOC requires special attention and specific solutions – including an especially IOC-context-sensitive setting – are investigated from a risk perspective. Furthermore, the role of control and trust as main antagonists of relational risk are also investigated (Das and Teng, 2001, p. 258; Lui and Ngo, 2004, p. 471; Zaheer and Harris, 2006, p. 169).

4.3.1 Risk in IOC

Risk – and more precisely relational risk – has been identified as a key element to understand and explain the specifics and high failure rates of IOC (Das and Teng, 2001, p. 253). For this thesis, the framework of Das and Teng is applied. The researchers developed a bipartite risk concept for IOC, which defines two primary risk types: performance and relational risk. Following a downside risk perspective, both risk types are concerned with uncertainties in IOC, more precisely in IOC performance and in partner cooperation, respectively. Based on this concept, Das and Teng developed a framework which interrelates risk, control, and trust and proposes trust and control as antagonists of risk (Das and Teng, 2001, pp. 251) (see Figure 11).

[17] See (translations of) Aristoteles' Metaphysik VII 17, 1041b for details.

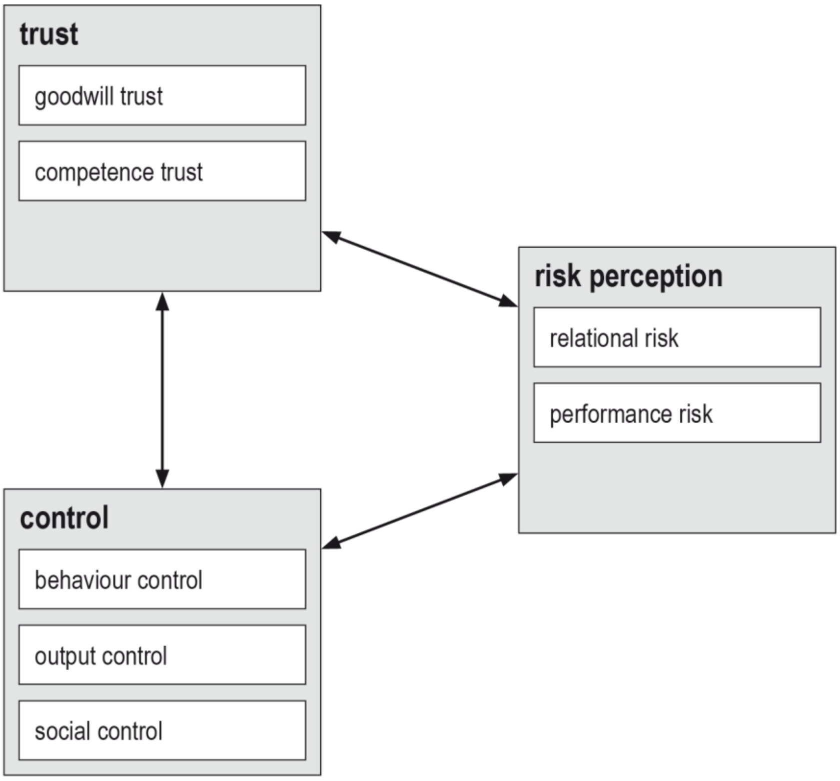

Figure 11: Das and Teng's integrated framework of trust, control, and risk in IOC (Das and Teng, 2001, p. 257)

This concept is chosen for the scope of this study because the type of IOC under consideration requires collaboration with various unselected actors including entities with competing and/or conflicting objectives. The resulting uncertainty is perfectly described by the concept of relational risk:

> **Relational risk** is defined as the probability and consequences of not having satisfactory cooperation, meaning a partner not collaborating in good faith in IOC (Das and Teng, 1996; 2001, p. 253).

Relational risk is to be clearly differentiated from 'general' performance risk. While the sharing of performance risk in IOC – and thus a performance risk reduction for the single actor – might even be a reason for IOC, relational risk is a unique phenomenon in IOC, which only arises therein (Das and Teng, 1996, p. 253). Performance risk may be described as the risk of unsatisfactory business performance (Das and Teng, 1996, p. 253), which is inherent to all strategies and business activities:

> **Performance risk in IOC** is defined as the probability and consequences that alliance objectives are not achieved because of unsatisfactory business performance (Das and Teng, 1996).

The concept of risk always requires differentiating objective from subjective risk (Das and Teng, 1996, p. 254):

> **(Objective) risk** is 'factual or calculatable risk' which results from the probability of alternatives and their consequences or of the known possible outcomes (for example a lottery) (Das and Teng, 1996, p. 254).

With regard to IOC management, objective risk reduction describes a reduction of the actual risk in the collaboration by 'narrowing the domain and severity of risk' which is accompanied by a factual higher probability to achieve objectives (reduction of performance risk) and/or to have satisfactory cooperation (reduction of relational risk) (Dekker, 2004, p. 34).

> **Subjective or perceived risk**, on the other hand, is the individual situational estimation of objective risk by a decider (Das and Teng, 1996, p. 254).

As a result, the total risk in IOC can be defined as follows:

$$\text{(perceived) risk in IOC} \\ = \Sigma(\text{(perceived) relational risk} + \text{(perceived) performance risk})$$

This entails relevant consequences as perceived risk is dependent on the individual and their unique experiences and knowledge base, as well as on the situation at the time of estimation. Thus, perceived risk may differ significantly from objective risk over time and between deciders. This personal and situational character makes it difficult to handle and measure perceived risk for research purposes. However, the focus on perceived risk reduction may be advantageous, especially if behaviour should be influenced as a governance mechanism that reduces the objective (but not subjective) risk that may impose the adherence to a certain rule or agreement. However, only the reduction of perceived risk will be able to induce a sustainable change in the collaborative attitude and decision-making of the collaborating entities which is why institutions that aim to positively affect the IOC process and thus the behaviour of their actors have to reduce perceived relational risk, while the reduction of objective risk is more closely related to a reduction in the performance risk.

The main function of institutions from a risk perspective is to reduce the (perceived) risk of IOC. The definition of the IOC-setting can thus be specified with regard to its function of risk reduction.

> Integrating the risk perspective, **the IOC-setting** can be specified as the set of all institutions[18] which are directed towards the attainment of an IOCS's goals by enhancing:
>
> (1) the efficiency and effectiveness of IOC through planning, organising, leading, and controlling organisational resources and/or
>
> (2) the (perceived) probability of satisfactory IOC performance by reducing the (perceived) or performance risk IOC and/or
>
> (3) the (perceived) probability of satisfactory cooperation by reducing the (perceived) relational risk in IOC.

This definition shows that the function of institutions in IOCSs exceeds the function of 'general' management measures whose scope is limited to (1) and (2). In consequence, the development of institutions which aim to enhance the efficiency and effectiveness of IOC or to reduce performance risk may be inspired by 'general' management techniques. However, suggestions for how to reduce relational risk are lacking because the relational risk is a unique attribute of IOC which does not occur in single-actor business activities. This is why special institutions are necessary to develop a complete set of institutions that cover all functions. The fact that relational risk is regarded as the main challenge of IOC and the key hazard for IOC failure makes the need even more urgent. As a result, the

[18] Institutions are again understood in a broad sense, including soft institutions (see Chapter 4.2)

reduction of (perceived) relational risk is often defined as the primary objective of institutions and thus defines their main focus.

In order to develop a better understanding of institutions with regard to (relational) risk reduction, the main mechanisms to reduce risk, namely trust and control, are examined more closely.

> **Trust and control (mechanisms)** are the main antagonists of risk in IOC (Dekker, 2004, p. 34; Tomkins 2001).

While trust and control as the 'principal antecedents' are undisputedly linked to risk (Das and Teng, 2001, p. 251; Dekker, 2004) in IOC research (Das and Teng, 2001, p. 258; Kwibisa and Majzoub, 2018, p. 8) there is an ongoing and unresolved debate on the link between trust and control (mechanisms) whereby some authors regard trust as a kind of informal control mechanism (Das and Teng, 1998, p. 495). However, this thesis does not regard trust as an instrument to exercise control over others, but regards trust and control as parallel – although interdependent – concepts (Das and Teng, 1998, p. 491):

$$\text{trust} + \text{control} \sim 1/((\text{perceived})\ \text{risk in IOC})$$

In the following section, the concepts of control and trust are introduced before their interrelation is analysed in order to draw conclusions for institutions.

4.3.2 Control as a risk reduction mechanism in IOC

Control mechanisms are installed to enhance the (perceived) probability of a satisfactory outcome of the collaboration. As antagonists of risk, they pursue this objective by (perceived) risk reduction to diminish the likelihood of collaborative failure. The following definition of control by Leifer and Mills is also adopted by Das and Teng (2001, p. 258; Leifer and Mills, 1996):

> **Control** is a regulatory process by which the elements of a system are made more predictable through the establishment of standards in the pursuit of some desired objective or state.

Research generally distinguishes between formal and informal control mechanisms. Informal control mechanisms—also referred to as social or relational control mechanisms—are associated with internal value-based control (Eisenhardt, 1985) and comprise informal institutional systems, norms, values, and culture to induce self-regulation toward a desirable behaviour and outcome (Das and Teng, 2001; Dekker, 2004). On the other hand, formal mechanisms refer to external measure-based control (Eisenhardt, 1985) and include contractual obligations and formal institutional mechanisms such as rules, procedures, and policies to monitor and reward desirable performance (Das and Teng, 2001, p. 259; Dekker, 2004, p. 31). Formal control mechanisms are subdivided into outcome or behavioural control mechanisms. Behavioural control mechanisms pursue the objective to monitor, impact, standardise and guide collaborative behaviour, while outcome control mechanisms are installed to affect, specify, and control the outcome of this behaviour (Das and Teng, 2001, p. 259). In other words, behavioural control is concerned with an appropriate IOC process (Das and Teng, 2001, p. 259), while output control focuses on goals and output by means of performance targets (Dekker, 2004, p. 31). Eisenhardt (1985) developed a matrix based on the two task characteristics (1) outcome measurability and (2) knowledge of the transformation process to identify the appropriate type of control mechanism.

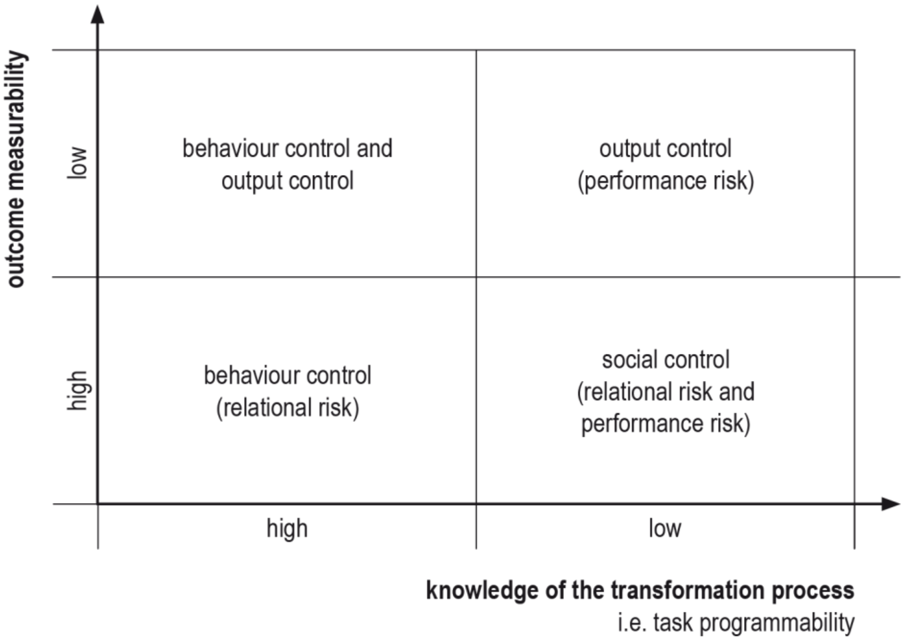

Figure 12: Eisenhardt's (1985) matrix for control modes and incidences of relational and performance risk

Eisenhardt's matrix (Figure 12) highlights two aspects. Firstly, the importance of behavioural control mechanisms for IOCs and relational risk reduction is pinpointed. This is due to the fact that several researchers have concluded that IOCs are often characterised by 'goal incongruence and performance ambiguity' (Dekker, 2004, p. 32). The consequences and outcomes of relational risk are generally hardly measurable because it is concerned with relational problems such as malicious or opportunistic behaviour (Das and Teng, 2001, p. 260). As a result, the outcome measurability of IOCs is generally regarded as being low. Secondly, it becomes obvious that control mechanisms are generally not equally suitable to counteract relational risk and performance risk which is why control mechanisms always have to be developed concerning the type of risk that should be reduced.

4.3.3 Trust as a risk reduction mechanism in IOC

The importance of trust for economic collaboration has long been studied, since trust is regarded as a major element of social capital (Dekker, 2004, p. 182; Smith and Lohrke, 2008, p. 315). Apart from its direct economic effects like lowered costs of negotiation, which refers to the costs related to finding common agreements with partners (Zaheer, McEvily and Perrone, 1998, p. 144), and transactions (Dyer and Chu, 2003) as well as enhanced economic performance outcomes (Zaheer and Harris, 2006, p. 190), several intermediate relational effects have been identified, which include a reduced perception of relational trust (Nooteboom, Berger and Noorderhaven, 1997). Trust is also strongly linked to vulnerability (Vangen and Huxham, 2003, p. 10) which is why risk – together with partner-interdependence – is regarded as a mandatory presupposition of trust. This leads to a general interdependence of trust and risk: risk 'constitutes' the development of trust and trust may decrease perceived risk (Das and Teng, 2001, p. 256; Ring and Van de Ven, 1992).

For the purposes of this research, **trust** is defined as the expectation in the probability that an actor:

(1) can be relied on to fulfil obligations (competence performance – capability)[19],

(2) will act and negotiate fairly when the possibility for opportunism is present (social performance – fairness)[20], and

(3) will behave in a predictable manner (processual performance – reliability).

The following analysis of trust is strictly tailored to the purpose of a better understanding of institutions. For a comprehensive and detailed description of the multidimensional and complex phenomenon of trust, for which a plethora of research approaches and definitions exist, see for example Vangen and Huxham (2003) or Zaheer and Harris (2006).

The definition of trust as an expectation emphasises that trust is the uncertain anticipation of future behaviour, which can be abused by opportunistic behaviour (Zaheer, McEvily and Perrone, 1998, p. 143). In addition, the sole source of trust lies in an individual (Zaheer, McEvily and Perrone, 1998, p. 143) and hence trust always has a subjective and personal component and is variable over time (and thus dynamic) (Rousseau et al., 1998, pp. 395), and cannot be created but has to develop over time (Sabel, 1993, p. 1134; Dekker, 2004, p. 33). For the purpose of this study, the expectation is limited to positive expectations (compared to distrust as negative expectation (Rousseau et al., 1998, p. 398)) which is the prevalent link between trust and expectation and facilitates discussions on the effect and influences of trust.

The chosen definition of trust provides a future-oriented economic approach to trust, which is to be clearly distinguished from the backwards-oriented sociological perspective of trust as a result of past relations (Zaheer and Harris, 2006, p. 181)[21]: economic trust research always regards future behaviour and performance as the focal object. Depending on which attribute of the trustee a trustor bases his trust on, there are three focal dimensions, namely cognitive, behavioural, and emotional (referring to [1] to [3] in the above definition respectively) that can be used to classify future behaviour.

(1) Trust based on cognitive attributes is called *competence trust*. Competence trust can be described as ‘the expectation in a technically competent role performance’ (Barber, 1983, p. 14), which means that someone has the ability and expertise to perform a task satisfactorily and according to agreements (Dekker, 2004, p. 33).

(2) *Goodwill trust* results from an emotional dimension and is ‘the expectation that a trustee will perform in the interests of the relationship, even if it is not in his or her own interest to do so’ (Dekker, 2004, p. 32). Thus, this form of trust is about a good intention which refers to the intention to not behave opportunistically or about social performance.

(3) While most authors make do with these two types of trust, some researchers that focus on IOCs introduce *reliability trust* as a third type (Liu, 2015, p. 2). Reliability trust is introduced to describe trust which refers to the processual performance of the

[19] See for example Anderson and Weitz 1989

[20] See for example Anderson and Narus 1990; Bromiley and Cummings, 1995

[21] Of course, the role of past relations is also studied by economic researchers, see for example Gulati and Singh, 1998; Lui and Ngo, 2004; Young-Ybarra and Wiersema, 1999.

trustee. It is based on the behavioural attributes of a trustee during the process of interaction whereby it can be concluded that the trustworthiness of a trustee is measured by expectations concerning their future performance. This is derived from capability, as a trustee's ability and competence, and their future predicted behaviour are predicted based on their reliability which is determined from the consistency of intended behaviour during the process of interaction and fairness that indicates a good intention and integrity.

The development of trust can be differentiated according to the source of trust, i.e. the entity in which an individual places their trust, which may be a personal relationship (interpersonal trust), rational arguments (cognitive/knowledge-based trust), and/or organisational routines and structures for IOC (institutional/institutions-based trust). The three sources of trust are elaborated in the following:

(1) Most intuitively, another individuum may be the source of trust. In this case, trust is based on a personal relationship, which includes emotional involvement and develops over time through repeated interaction between the trustor and the trustee (Rousseau et al., 1998, p. 399). This type of trust is referred to as *relational or interpersonal trust.*

(2) Repeated interaction may also provide rational evidence concerning the trustworthiness of a partner and may thus lead to the development of cognitive trust (Smith and Lohrke, 2008, p. 317). Because this type of trust is based on a conscious decision and rational arguments and calculations, it is also referred to as *cognitive* (Lewis and Weigert, 1985), '*competence*' (Mayer, Davis and Schoorman, 1995), 'knowledge-based' (Lewicki and Bunker, 1996), or '*calculus-based*' (Rousseau et al., 1998, p. 399) *trust*. Other sources of evidence for the development of calculative trust may be external data such as credible information (e.g. certification or rating), reputation due to the affiliation to certain networks, or independent ratings (Rousseau et al., 1998, p. 399), or Axelrod's (1984) forward-looking, game-theoretical view. Axelrod links trust and future prospects in gains and losses and concludes that an economic entity will choose cooperation and thus the risk to trust instead of opportunistic behaviour if the prospected future benefits from cooperation are expected to exceed the gains from opportunism. As a result, trustees with a long-time horizon are judged as being more trustworthy – and will more likely be trusted – than partners with a high rate of time discount (Zaheer and Harris, 2006, p. 181).

(3) The third kind of trust, namely the 'trustee-entity' can be described from a process-based perspective as the phenomenon whereby a person trusts institutionalized patterns of dealing (Zaheer, McEvily and Perrone, 1998) which results in trust towards an organisation or institution (Zaheer, McEvily and Perrone, 1998, p. 143). This type of trust is 'built upon impersonal processes and routines that create a stable context for exchange' (Dyer and Chu, 2000, p. 263) and can best be described as the trust of an individual in a 'set of institutionalized processes and routines' (Dyer and Chu, 2000, p. 263). This is why this thesis prefers the term '*institutions-based trust*' (Rousseau et al., 1998, p. 400) which is in line with the system theory approach of this study (see Chapter 4.2) for this trust type although most research refers to this trust type as 'inter-organisational trust' (Zaheer, McEvily and Perrone, 1998; Dyer and Chu, 2000). According to Zaheer et al. (Zaheer, McEvily and Perrone, 1998, p. 144) this trust may also emanate from the interpersonal trust as although individuals in an organisation may change, the roles are enduring and remain stable (Zaheer, McEvily and Perrone, 1998, p. 144). In this case, the informal commitment of individuals, which founds interpersonal trust, is codified by the institutionalized process

and is eventually regarded as natural organisational routines and structures (Zucker, 1997).

Rousseau et al. (1998) developed a trust model (see Figure 13) which displays the interrelation between these three source-based trust types as well as the development and composition of trust over time.

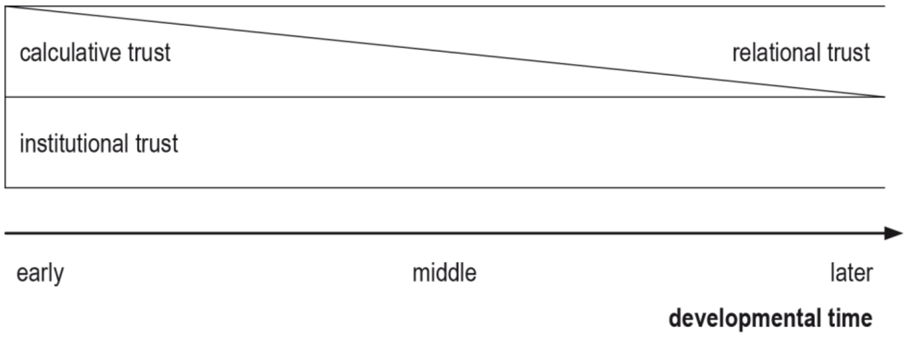

Figure 13: Rousseau et al.'s (1998) model of trust

According to this model, the institutions-based trust may facilitate the development of both calculative and relational trust (Rousseau et al., 1998, p. 400).

In summarizing, it can be concluded that the phenomenon of trust and its mechanisms and effects varies under different boundary conditions (Child and Mollering, 2003; Dyer and Chu, 2003) and that the level of trust is generally higher and more easily built among partners with similar backgrounds, which results in the installation of fewer safeguards in economic relationships (Gulati, 1995).

4.3.4 The interrelation between control and trust

It is generally undisputed (Das and Teng, 1998; 2001) that there is an interdependence between trust and control. For example, Das and Teng (1998, p. 496) base their definition on their supplementary contribution to the reduction of relational risk. By conflating empirical evidence from existing research, they identify a joint and an interdependent contribution of control and trust to the reduction of relational risk although, unfortunately, there is no agreement on the specification of this dependence. Especially the question of whether control and trust are substitutes or complements is highly disputed and the literature provides a great deal of empirical evidence and argumentation to support either view[22]. A detailed analysis reveals a simple explanation for these inconsistent results and arguments: 'It depends'. More precisely, it depends on the level of trust. According to findings from the literature, it can be assumed that the substitutional or complementary

[22] For further literature see a) view of substitutes: Dyer and Chu (2003); Van de Ven and Walker (1984); b) view of complements: Luo (2002); c) damaging effect: Das and Teng, (1998); d) enhancing effect: Poppo and Zenger (2002); e) cause-effect analysis: Rousseau et al. (1998).

relationship between trust and control varies with the level of trust[23]. As each IOC is unique, there is not 'the' level of trust, but an individual level of trust for each collaborative project (Das and Teng, 1998, p. 496). This level of trust might even change over time in a project (Zaheer and Harris, 2006, p. 188).

Based on these findings, this thesis combines transactional cost economics and the equation introduced above for the reduction of relational risk to advance the findings. Transaction cost economics assigns costs to every economic action and assumes that economic individuals act on the maxim of cost minimization. The partners of each IOC find their individual point of cost minimization at a certain threshold of risk reduction by outweighing the cost for further risk reduction and the potential costs of the remaining risk. High perceived risk is concomitant with a high threshold. The resulting threshold defines two zones as displayed in Figure 14:

- Zone A, in which the sum of trust and control lies below the threshold and zone B at and above this threshold. According to the given definition, this threshold in both zones is reached by a sum of trust and control. Zone A is generally characterised by a lower level of trust relative to the level of trust in zone B. The aim in zone A is to approach the threshold in the best possible way to reduce the IOC-threatening relational risk: the level of trust and the level of control are added, thereby resulting in a complementary relationship. Better control mechanisms may even result in an enhanced level of trust by 'narrowing the domain and severity of risk' (Poppo and Zenger, 2002).
- In zone B, trust and governance mechanisms have an inverse substitutive relationship, because trust is approved to be the low-cost risk reduction mechanism in IOC (Dekker, 2004, p. 34). Thus, if the level of trust increases in zone B, the partner will not unnecessarily adhere to more expensive control mechanisms but rather reduce them (Dekker, 2004, p. 34). Moreover, an extension of control mechanisms in the environment of relatively high trust in zone B may imply a lack of trust in the partners, thereby resulting in an overall decrease in the level of trust (Das and Teng, 1998).

[23] Some researchers only indirectly refer to the level of trust. They take the dynamic development of relationships into account and identify the stage of the relationship as the determining factor, which itself is defined depending on the development of trust between the partners (see Zaheer and Harris, 2006, p. 188). For further literature see a) view of substitutes: Dyer and Chu (2003); Van de Ven and Walker (1984); b) view of complements: Luo (2002); c) damaging effect: Das and Teng, (1998); d) enhancing effect: Poppo and Zenger (2002); e) cause-effect analysis: Rousseau et al. (1998).

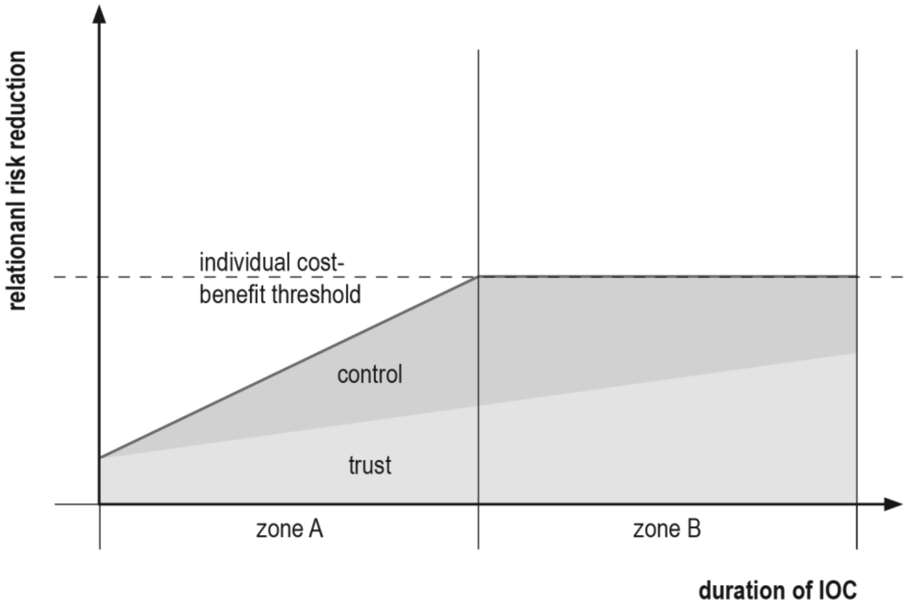

Figure 14: A transaction cost-based model of the interrelation between trust and governance mechanisms in IOC

4.3.5 Implications for institutions in this study

To derive implications and characteristics for the institutions in this study, the above considerations can be analysed in light of the specific IOC concept of this research.

Estimating the risk level in the considered type of IOC

IOC as it is defined in this study (see Chapter 4.1) involves a large number of diverse actors that enter and leave the IOCS in a discretionary fashion. As such, IOC is accompanied by high actor dynamics which substantiates the considerations concerning the relevance of relational risk in IOC in Chapter 4.3.1 and determines the (perceived) relational risk as being the dominant and decisive risk type for the IOC outcome. Consequently, although the conceptualisation of IOC does not allow for a general estimation of performance risk, the total risk is also assumed to be relatively high.

Estimating the trust level in the IOC under consideration

At the same time, trust as the sum of institutions-based, calculative, and relational trust, is considered to be low because repeated interaction as a basis for the development of relational trust cannot be assumed in a highly dynamic actor composition. The same can be assumed for calculative trust in an IOCS with a large number of arbitrary actors. While evidence for rational calculations may be gathered for each partner as a basis for the development of calculative trust in an IOC with a manageable number of partners who can best be selected by the trustee, this becomes unrealistic in the type of IOCS under consideration. According to Rousseau et al.'s model of trust, institutions-based trust is the only trust type which can be presumed in the IOCS under consideration. However, the institutions-based trust may not compensate for the lack of calculative and relational trust but merely provides a trust basis that facilitates the development of the other forms of trust.

It has to be concluded that the estimation of trust and risk takes place at a system level and determines ordinary values. Of course, analysis at the component level would disclose that – especially in large IOCSs – some actors share a common history and are thus more familiar with each other and these specific relationships are naturally characterised by lower perceived risk and a higher level of trust.

Implications for the institutions in this study

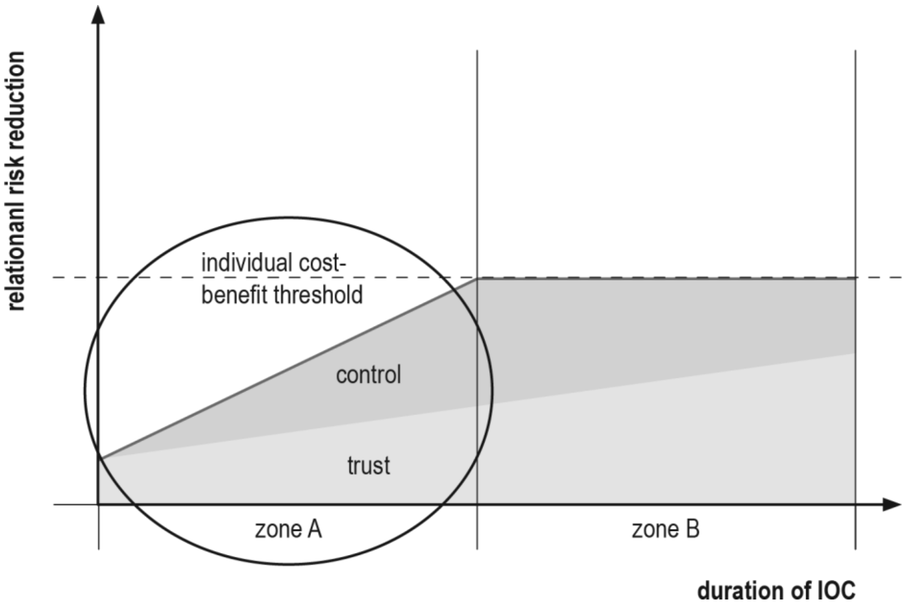

Figure 15: Zone of trust-control interrelation for the type of IOC in this research

(1) Because the total trust in the IOCSs under consideration is estimated to be low while the (relational) risk is considered to be high, the IOC lies in zone A (see Figure 15). Accordingly, there is a complementary relationship between trust and institutions and, as a result, institutions can be installed without further consideration of a potentially trust-reducing effect.

(2) The individual threshold of risk reduction is expected to be high. This means that actors have a considerable desire for risk-reducing institutions and will thus accept to bear costs in the form of investments and/or constraints/restrictions, which they would not accept in an IOCS with a lower threshold.

(3) In line with the research problem, institutions will positively influence IOCA and consequently have to induce a change in the actors' behaviour. This implies that relational risk-reducing institutions (see [3] in the definition of IOC-settings on p. 37):

   – which aim to reduce the *perceived* relational risk (in line with Chapter 4.3.1) and

   – which can be ascribed to the group of 'behavioural institutions' (as a pendant to behavioural control mechanisms, see Chapter 4.3.2) and thus affect the IOC process

   are best suited to achieve this objective.

(4) In order to facilitate the development of a higher trust level in the IOCS, an important function of institutions is to create a stable framework for exchange by

means of IOC-context-specific robust routines and procedures (see Chapter 4.3.3), which can best be achieved by definition of institutions' (p. 37) stated general (project) management institutions specified under (1).

In summarizing, the following specifications for institutions in the IOCSs under consideration and within the scope of this thesis can be made:

- institutions are a complement of trust (and thus have no potential to substitute the cheaper mechanism of trust)
- institutions that reduce perceived relational risk are the most relevant type of institutions for enhancing IOCA
- general institutions support the development of institutions-based trust
- institutions are generally appreciated by the actors as they reduce risk in IOC, which is why institutions may be accepted even if they are accompanied by costs.

5 FPHTI – a case for IOC?

This chapter is dedicated to the analysis of frontier pushing high-technology innovation (FPHTI) projects in modern economies with a special focus on the pre-estimation of the need for IOC. FPHTI describes a certain type of high-technology innovation, which is strongly associated with advanced economic settings. However, this is not mandatory which is why this thesis specifically focuses on FPHTI projects that take place in modern economic settings. It could rightly be questioned if there is a need for yet another innovation concept for innovations with a high technical degree of innovation. However, the elaboration in Chapter 5.1 reveals a high inconsistency in the existing concepts related to the degree of innovation and it subsequently has to be assumed that most readers will automatically have certain individual associations with already established terms, which will likely not correspond to the interpretation used in this study. As such, the clear an unambiguous definition of the type of innovation under consideration and thus the scope of research and application is regarded as a mandatory basis for well-founded research.

5.1 Schumpeter’s concept of innovation

Originally, innovation is derived from the Latin words *novus* (meaning ‘new’ or ‘novel’) and *innovatio* (meaning ‘something newly created’) which leads to the linguistic meaning of ‘something novel’. The ‘father’ and founder of the economic perspective on innovation is the Austrian economist Joseph A. Schumpeter (Fichter and Hintermann, 2015, p. 13), whose idea of technological change processes was described in 1912 in *Theorie der wirtschaftlichen Entwicklung* (The Theory of Economic Development, Schumpeter, 1912) and is still the foundation for many current innovation approaches (Borbély, 2008). With this fundamental theory, he caused innovation to be recognized as an economic and organisational and not only a technological aspect (Hutterer, 2012, p. 57; Chang and Chen, 2004, p. 11). In 1939, Schumpeter introduced the term ‘innovation’ based on his work of 1912 as the ‘carrying out’ of ‘new combinations’ that ‘appear discontinuously’ (Schumpeter, 1912, pp. 100–101) and defined five different types of innovation, namely new products new production methods, exploitation of new markets, new ways to offer products on the market, and new ways of business organisation (Diaconu, 2011, p. 133). His clear distinction between *invention* as the creative process of generating ideas, developing concepts and prototyping before commercialisation, and *innovation* as the commercialisation of an invention or a tradeable application of an invention (Borbély, 2008; Mahdjoubi, 1997) is still valid and established in technological-economic approaches. According to Herzog and Leker (2010, p. 9), innovation can be defined as follows:

innovation = invention + commercial exploitation

In line with Schumpeter’s approach to innovation as a new combination of production means, Hauschild and Gemünden (2005) developed a widely established classification of innovation by five dimensions. First, the processual dimension refers to the differentiation of the perspective by which innovation is approached: as a process, or as an outcome. The normative dimension deals with a question that can only be answered retrospectively and is thus of little relevance for innovation management. It investigates if ‘new is also successful’ on an economic and/or ethical level (Hutterer, 2012). The subject dimension considers to whom innovation is new and may distinguish for example between individuals, systems, or mankind as a whole (Hutterer, 2012, p. 60). The fourth and fifth dimensions are introduced in more detail below because they serve as a basis to characterise and distinguish frontier pushing high-technology innovation.

Content dimension of innovation

The content dimension deals with the question 'What is new?' The fundamental distinction is based on a technological and 'industrial' perspective and distinguishes between product and process innovation. Product innovation describes the new combination of factors in a way that the resulting product enhances its effectiveness for the user. Thus, product innovation deals not only with the factor combination but also with the exploitation in the market. Process innovation, on the other hand, aims to enhance (the efficiency of) the production process of a certain product or good and is thus internally exploited within an organisation. Zahn and Weidler (1995) extend innovation beyond the industrial interpretation and classify the content of innovation from an economic perspective according to functionality into (1) technical innovations, including products, processes, and technical knowledge (corresponds to the technological perspective), (2) organisational innovations, and (3) business innovations. This classification may be enhanced by societal innovations (Hauschild and Gemünden, 2005, p. 5). Defining innovation from the content dimension provides some general indications for the corresponding innovation process:

> **Technical innovations**, which are the focus of this study,
>
> - are accompanied by a high R&D (research and development) effort[24] compared to the other types of innovation, and
> - are predominantly driven by innovators with a technical – natural sciences, computer science, or engineering – background and mindset, who can consequently be regarded as the dominant and primary group of actors (and thus of FPHTI IOCS's actors).

Intensity dimension

The content dimension deals with the question 'How new is an innovation?' and thus describes the degree of innovation. The degree of innovation is a highly researched issue which becomes visible in a large amount of literature and the number of concepts around this topic. However, the degree of innovation always has to be determined with regard to a certain aspect or characteristic of the innovation and/or its effect which is why different dimensions for the evaluation of the degree of innovation have been introduced in research. Such dimensions help to develop concepts and classifications of innovations according to their degree of innovation in one or more specific dimensions.

> This study focuses on innovations with a very **high technical degree of innovation**.

[24] For example, illustrated in the technological innovation process of Diaconu (2011, p. 131).

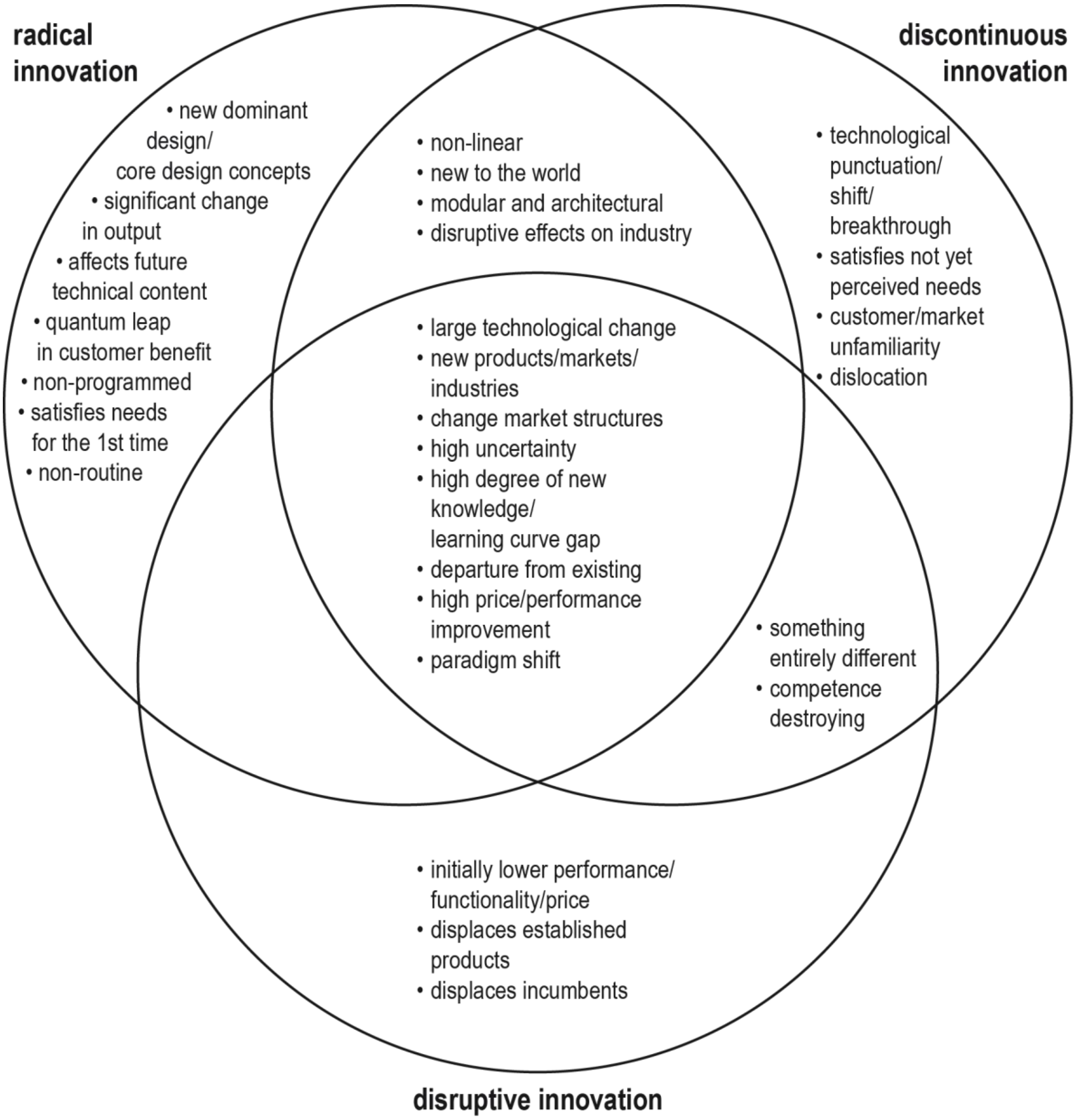

Figure 16: Augsdorfer’s et al. (2013, p. 16) overview of the ambiguous attribute intersection to different innovation concepts

The most established concepts around innovations with a high degree of innovation in one or more dimensions are discontinuous, disruptive, and rapid innovation and they are examined in more detail because they are closely related to the scope of this research. While discontinuous innovations and disruptive innovations are often referred to if existing products, markets, and value networks are displaced by yielding a new concept of product values, radical innovations tend to focus more on the change of core technical concepts and their linkages (Rahman, Abdul Hamid and Chin, 2017, p. 112). However, the concepts are also used differently and/or (partially) synonymously by other researchers. Augsdorfer et al. (2013, pp. 16) addressed the problem of ambiguity and provided a detailed overview of a large number of highly inconsistent and – partially conflicting – definitions and understandings of each of the three terms as shown in Figure 16. The summary illustrates the immense lack of clarity which is concomitant with each term as there is a large number of characteristics that are neither consistent in respect of the dimensions of the degree of innovation considered nor concerning the attributes themselves or their relative demarcation to each other. As a consequence of this ambiguity, the use of such terms should be deliberate and accompanied by a clear definition. Since the use of these terms in this field is challenging and bears the risk of fundamental misunderstandings and confusion, this research refrains from the use of either of the examined concepts but prefers to introduce a new concept for reasons of unambiguous communication in the following Chapter 5.2.1.

5.2 FPHTI projects

5.2.1 The concept of FPHTI

This study focuses on a certain type of high-technology innovation which stands out due to its severe impact on technological, economic, and/or societal frontiers and is thus referred to as FPHTI. According to the Cambridge English dictionary, high-technology is defined as the most advanced and developed machines and methods. However, a common definition of the term in the scientific, economic, and statistical contexts does not exist (Zakrzewska-Bielawska, 2010, p. 93). Many approaches make use of input-based criteria (Kask and Sieber, 2002, p. 18) and/or economic parameters to define high-technology (sectors, companies, and products). These approaches aim to conduct a relative classification based on the quantitative determinants over a period (Zakrzewska-Bielawska, 2010, p. 2). Although the most common determinant is the intensity of R&D expenses (Zakrzewska-Bielawska, 2010, p. 2), other parameters such as the employment index of highly qualified scientific and technical personnel or patenting and licensing activity are also established to separate high-technology (products, industries, or companies) from other 'regular' technologies (OECD, 2009). This study focuses on output-based criteria and approaches high-technology from a technical perspective in line with Zeleny (2012, p. 3) whose definition allows for the derivation of specific characteristics of high-technology (innovation). He bases the approach on his fundamental view of technology as a tool to perform the task of transforming inputs into products.

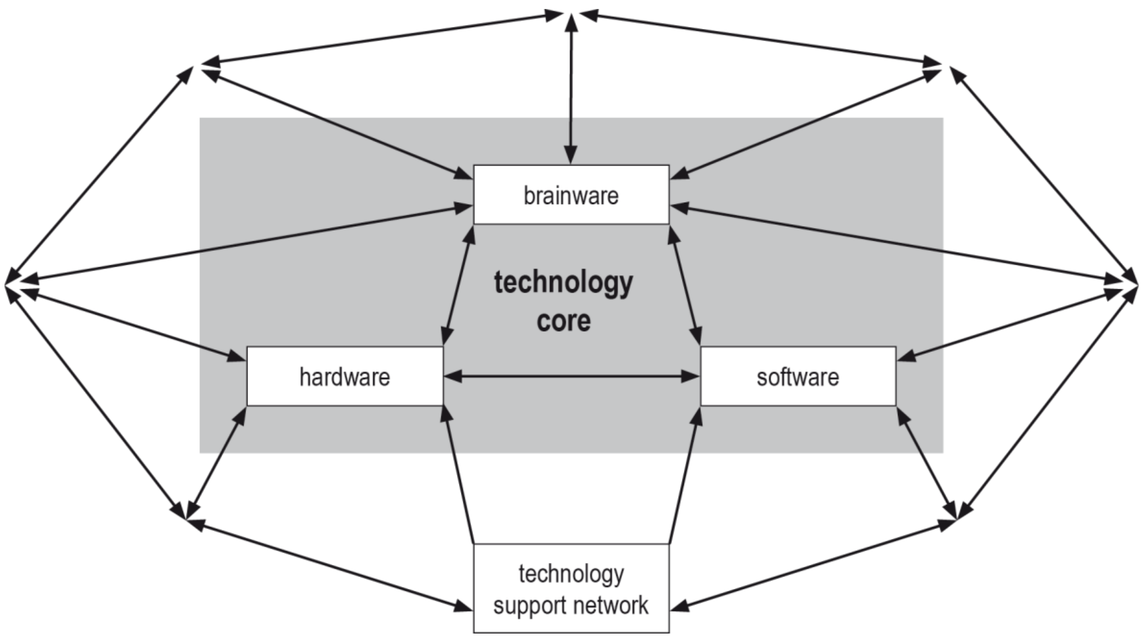

Figure 17: Zeleny's (2012, p. 3) concept of technology

> **Technology** is defined as a set of four components – hardware, software, brainware, and a technology support network – which transform inputs towards achieving certain purposes (see Figure 17).

Hardware refers to the means by which the transformation process of a given technology is conducted and includes the physical structure as well as the logical layout. While hardware used to be the decisive component for innovative advantage in an industrial economy, it has progressively taken a back seat in knowledge-intensive environments. Software is the know-how and consists of algorithms, rules (of usage) and other guidelines that constitute how the transformation process is carried out. The third equally important element is brainware, which can be described as the know-what and know-why of a technology. It provides the purpose and justification for why the hard- and software are used in a particular way. The technology support net is the pivotal component for the functionality of a technology core as a technology: it describes the flow of materials, information, energies, skills, laws, and rules of conduct which are necessary for, through, and from each technology-specific support network to support and enable proper use and functioning. As the flows can be assigned to actors of the supportive setting, a technology support network can be defined as the physical, informational, and socioeconomic relations in which the technology core is embedded.

As such, Zeleny’s approach perfectly matches the system theory perspective of this research. He further specifies the technology support network as being the essential physical, organisational, administrative, and cultural structures such as work rules, required skills, or standards of organisational patterns (Zeleny, 2012, p. 3). Based on this theoretical framework, Zeleny distinguishes high-technology from ‘regular’ technology by classifying the kind of change to the technology support network relative to the superseded parent technology caused by changes in a technology core: high-technology not only allows (and often requires) doing things differently or more efficiently than ‘regular’ technology but even to do different things altogether. ‘Regular’ technology innovation on the other hand describes changes in a technology core that cause quantitative modifications of a qualitatively identical architecture. This leads to the following definition of high-technology innovation:

> **High-technology innovation** is defined as a change of a technology core that alters the very architecture, e.g. the qualitative nature of (the components, relations and flows of) a technology support network in order to do different things.

Based on this output-based definition of high-technology innovation, FPHTIs can be described as a sub-type of high-technology innovation, which alters the components, relations, and flows in a technology support network. FPHTIs affect the skills, roles, and styles of management and coordination and even the organisational and/or economic culture itself (Zeleny, 2012, p. 3). FPHTIs also introduce new technological solutions which change and/or create markets and economies as well as social and behavioural habits and needs:

> **Frontier pushing high-technology innovations (FPHTIs)** as a subgroup of high-technology innovations are defined as ground-breaking high-technology innovations, with ground-breaking being defined as the alteration of the technology core and/or the architecture of a technology

support network to such an extensive degree that technological, economic and/or societal frontiers are shifted or at least pushed.

From this definition, the following main characteristics of FPHTIs can be deduced, which determine the nature of FPHTI projects as shown in Figure 18:

- *High inventiveness*: In order to break new grounds, FPHTI projects are occupied with innovations of high technological complexity, novelty, and inventiveness. As a consequence, FPHTIs require exceedingly high research and development activity and investment, which is associated with high costs, high risk, and highly skilled personnel. This often results in the necessity to share costs, pool risks, and extensively exchange knowledge.
- *Multidimensionality of technological change*: This feature refers to the fact that FPHTIs ‘require many’. FPHTIs include significant infrastructural interface changes and complementary innovations, which generally require cross-sectoral input and cannot be solved internally by any given company or sector.
- *High range of impact:* This feature refers to the fact that FPHTIs ‘affect many’ as the impact of FPHTIs is not limited to actors in the adjacent economic and technological surroundings, but also spreads into very distant markets. As a result, a broad diversity of actors with various economic and technological backgrounds participates in the innovation project.
- *High intensity of impact:* This feature refers to the fact that FPHTIs ‘attract many’. FPHTIs are likely to cause the obsolescence of leading technologies, which fundamentally changes existing market structures as well as the technological, economic, and even cultural state of the art. Both the danger to be put out of business and the chance to be a winner in the FPHTI-initiated market changes is a strong motivation to participate in FPHTI projects from the very beginning. As a result, FPHTI projects are highly competitive and attractive arenas in which time to market is increasingly decisive.

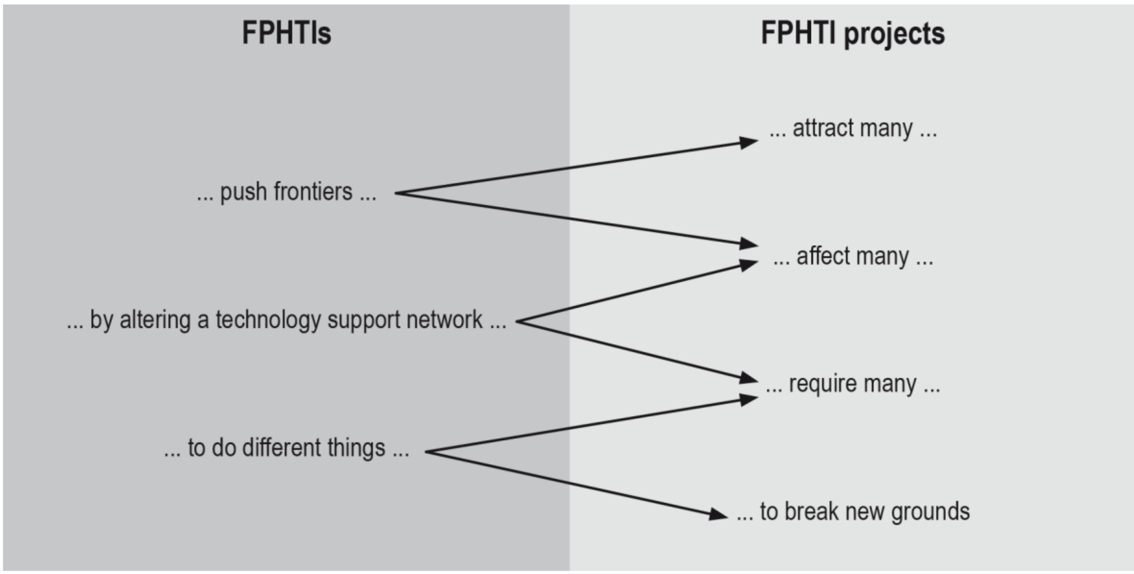

Figure 18: Implications for the nature of FPHTI projects

5.2.2 The setting: Modern economy

Projects do not exist in a vacuum. For example, Valiev et al. (Neumann, 2012, p. 644) who research open-source projects highlighted the importance of the ecosystem as the project-surrounding supra-system despite project internal factors being used for the description and evaluation of a project. Although FPHTIs are by definition not bound to modern economic settings, the required means and infrastructure make major economies the predominant and most relevant setting for these innovations. In major economies, significant economic changes have occurred lately, which are mainly attributed to the increasing globalisation and knowledge-intensity of economic activity (Houghton and Sheehan, 2000, p. 2; Powell and Snellmann, 2004, p. 199). The resulting economic structures differ fundamentally from conventional resource-based concepts (Houghton and Sheehan, 2000, p. 9). Amongst others, ‘traditional’ sectoral ecosystems increasingly take a back seat in many economic projects. Nevertheless, Smith (2002, p. 6) found that there is no coherent concept or theory to describe this ‘product of globalisation and technological revolutions’ (Hadad, 2017, p. 203). A term that is widely used to describe the new economic system is the ‘knowledge economy’ (KE)[25] (Hadad, 2017, p. 204) The metaphor of a knowledge economy hits the mark because there is consensus that the pivot for the latest changes in economic structures is the increased importance of knowledge for economic processes and development (Hadad, 2017, p. 204; Davenport and Prusak, 2000; Mehmood and Rehman, 2015; Nonaka and Takeuchi, 1995; Viedma and Cabrita, 2012). Unfortunately, no clear concept is assigned to this potent term (Smith, 2002, p. 6; Powell and Snellmann, 2004, p. 199)[26]. In addition, the concept of the knowledge economy predominantly focuses on the effects that are induced by knowledge as the main resource, but not equally on globalisation and its impact. For this reason, this study defines the term ‘modern economy’ (which is widely used, but rarely defined) as an economic setting that is mainly formed and affected by both globalisation and the knowledge-intensity of economic activities.

> **Modern economy** – as used in this thesis – refers to the economic setting which results from the two driving forces of the latest economic changes in major economies: (1) knowledge-intensity and (2) globalisation.

(1) Knowledge-intensity

Knowledge-intensity refers to the increasing importance and value of knowledge as a driver of economic development (Hadad, 2017, p. 204) as knowledge has evolved into the key resource of major economies (Houghton and Sheehan, 2000, p. 1). Although economic success without knowledge has never existed, there is a new dominance of knowledge for economic success which is unprecedented. Firstly, knowledge increasingly dominates all economic elements in all economic sectors (Davenport and Prusak, 2000; Mehmood and Rehman, 2015; Nonaka and Takeuchi, 1995; Viedma and Cabrita, 2012) across the entire business and value-added chain (Houghton and Sheehan, 2000, p.

---

[25] The ‘knowledge’ economy is synonymously known as the ‘knowledge-based’, ‘new’, or ‘modern’ economy (Hadad, 2017, p. 204).

[26] The most popular views underlying the concept of knowledge economies are (Smith, 2002, p. 8; Powell and Snellmann, 2004, p. 200): (1) knowledge is gaining importance as an input factor, (2) knowledge has gained importance as a product, (3) the importance of codified knowledge in knowledge bases increases, (4) technological changes in the ICT sector gave rise to the knowledge economy, and (5) theoretical knowledge is gaining importance as a source of innovation.

2). Secondly, the relevance of and demand for knowledge-intensive solutions in the economy is growing (Houghton and Sheehan, 2000, p. 6).

> **Knowledge-intensity** describes (1) the increasing dependence of the entire value-added process on knowledge as the main source of competitive advantage and (2) the growing importance of knowledge-intensive solutions in the economy (based on Andreeva and Kianto, 2011, p. 1020 and Houghton and Sheehan, 2000, p. 2).

The trend towards knowledge as a key resource has a drastic impact on the entire economic structure, economic activities, strategies, and processes. This is largely due to the unique attributes of knowledge as a resource, that were highlighted in Chapter 4.1.

(2) Globalisation

Globalisation is a multidimensional concept that epitomizes the set of forces, effects, and phenomena which are related to the process of increasing cross-national interaction and interdependency among individuals, companies, societies, institutions, and states. Globalisation has been recognized and studied – amongst others – at the economic, cultural, societal, political, and technological levels. This chapter is concerned with the economic dimension of globalisation, which can be described as the trend towards one global, international economy and marketplace. The following definition of economic globalisation is in line with that of the Organisation for Economic Cooperation and Development (OECD) because it highlights the influence of globalisation on the patterns and structures of competition and thus of interaction and power among market participants:

> **Economic globalisation** is an increasing internationalisation and interdependency of markets for goods and services, the means of production, financial systems, competition, corporations, technology, and industries, which results from the increased cross-border movement of people, tangible goods – like products and capital – and intangible goods like ideas, information, knowledge and/or services (according to OECD, 2013).

Naturally, the transfer of technologies and knowledge between cultures and nations is not new at all but can be traced back to aboriginal tribes. What makes it significant and formative for the modern economy is the intensity and speed with which it progresses (Archibugi and Iammarino, 2002, p. 99). The fundamentally increased mobility of information, capital, people, and goods has and is strongly fostered and facilitated by technological revolutions (especially in and caused by the ICT sector (Sleuwaegen, De Voldere and Pennings, 2001, p. 16)) and economic deregulation. This is why technological change is inextricably interrelated to globalisation. This thesis does not intensify the 'chicken vs egg' discussion concerning technological changes and globalisation, which is of little additional value for the long-term perspective of this study. Instead, it makes do with the indisputable fact that globalisation, technological revolutions, and free trade mutually enforce and facilitate each other (Archibugi and Iammarino, 2002, pp. 99). The result is a unique rate of diffusion and transfer of knowledge and technologies, which severely affects both the geographical dimensions and the dynamics – meaning the competitive processes – of markets (Sleuwaegen, De Voldere and Pennings, 2001, p. 7).

Based on Narula and Zanfei (2003, p. 4) and Sleuwaegen, De Voldere and Pennings (2001, p. 19), the following effects of modern economies concerning innovation are identified as the most important:

- *Size of markets grow*: More actors, information, volume and scale together with the geographical expansion of markets results in a higher diversity in the market, a larger number of competitors, and increased competitive pressure.
- *Heterogeneity of markets:* An increased heterogeneity within markets concomitant to decreased heterogeneity between markets resulting in a high
  - diversity of needs and capabilities of actors, accessible information, services, and products,
  - uniformity among national markets, and
  - internationalisation of flows,
  - global rationalisation of value chains results in
  - ‘fracturing’ of value chains (Houghton and Sheehan, 2000, p. 12).

  As a result, large scales have to be rolled out very quickly in all major markets which afford high financial, infrastructural, and manufacturing means.
- *High dynamics:* The high non-linearity of economic processes, faster distribution of goods, capital, people and ideas, and faster propagation and diffusion of innovations and technologies result in shorter life cycles of products, production means, and processes and thus increase the importance of timing for competitive advantage.
- *High interconnectedness*: The high interaction and interconnectedness of actors, capital, goods, products and their applications, results in an increased necessity to network in order to stay competitive. In addition, one cannot limit collaboration in complex projects to a set of selected partners but has to accept rather unrestricted accessibility of those IOC-settings.
- *Low predictability*: An increasing instability of markets, disruptive effects of new actors and innovations, lock-in effects, and new business models and opportunities results in lower predictability of market developments and thus increased risk, which needs to be pooled.
- *High knowledge-intensity*: Knowledge is the primary resource for economic progress, advantage, and innovation. Due to the above-mentioned characteristics of knowledge, it requires new ways of trading (compared to traditional resources) which are accompanied by more interaction, higher risk, and an increased need for trust among business partners.

5.2.3 Characteristics of FPHTI projects in modern economic settings

In order to derive characteristics of FPHTI projects in modern economic settings, it is necessary to understand the impact of the modern economy setting on FPHTI projects and their interrelation. As stated in Chapter 5.2.2, projects do not take place in isolation but are embedded in an economic, cultural, and technological environment. Of course, not all environmental aspects and influences are equally decisive in this context because both the sphere of the impact of the innovation and the sphere of environmental influence varies for each innovation project. The relevant environmental factors thus depend on the project and on the time of the investigation. For example, resource availability might only become a relevant environmental factor if raw materials are scarce. This is why the effects of the modern economy cannot be regarded as a fixed set of relevant environmental influences for all innovation projects. However, as FPHTI projects are ground-breaking and affect societal, technological and/or economic frontiers, they do not take place in and/or limit their sphere of influence to enclosed systems but rather claim a dynamic, open, and highly diverse setting, which is strongly affected by the modern economy, to be their stage. This claim can be justified by the need for a broad knowledge base from various domains as a basis for FPHTIs, which can only be found and developed by making use of the knowledge-intensity in modern economies. The knowledge-intensity in modern economies can thus best be described as source and promoter of FPHTIs, while globalisation has the effect of a booster for FPHTI projects. For example, if FPHTI is characterised by the interaction of many actors or high risk, FPHTI in the globalised environment of the modern economy faces even more actors and higher risks. Figure 19 illustrates the interrelation of a modern economic setting and its main factors of knowledge and globalisation and FPHTI projects.

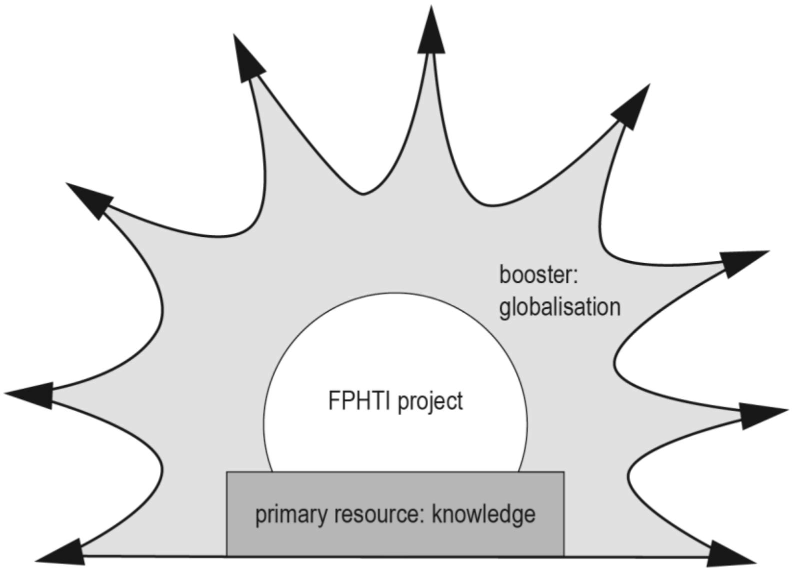

Figure 19: Schematic illustration of the embedding of FPHTI projects into the modern economy

With this understanding, an advanced set of characteristics of an FPHTI project which takes place in modern economies can be derived based on the features of FPHTI projects and modern economies identified above as shown in Figure 20.

features of FPHTI				characteristics of FPHTI projects in modern economies	features of modern economy					
high inventiveness	multidim. change	high range of impact	high intensity of impact		high market size	high market heterogeinity	high dynamics	high inter-connectedness	low predictability	high knowledge-intensity
■				high knowledge-intensity						■
■				broad knowledge base	■					■
■				high technological complexity						
■				high product complexity						
■				high R&D investment		■				
■				high R&D intensity						
■				high risk					■	
■	■	■	■	multidisciplinary						
■	■	■	■	multisectoral	■					
	■	■	■	high number of actors	■					
	■	■	■	large actor diversity		■				
		■	■	dynamic actor composition			■			
			■	highly competitive	■					
			■	global expansion	■					
				large scale	■	■				
				short product life cycles			■			
				high innovation rates			■			
				criticality of time to market			■			
				tangled network of interdependecies				■		

Figure 20: Project characteristics of FHT innovation projects in modern economies

This set of characteristics is then structured into first- and second-order characteristics. First-order characteristics are regarded as obligatory core attributes of an FPHTI project, while second-order characteristics describe common traits of an FPHTI project and its core attributes. Figure 21 helps to display the classification by means of a comb structure.

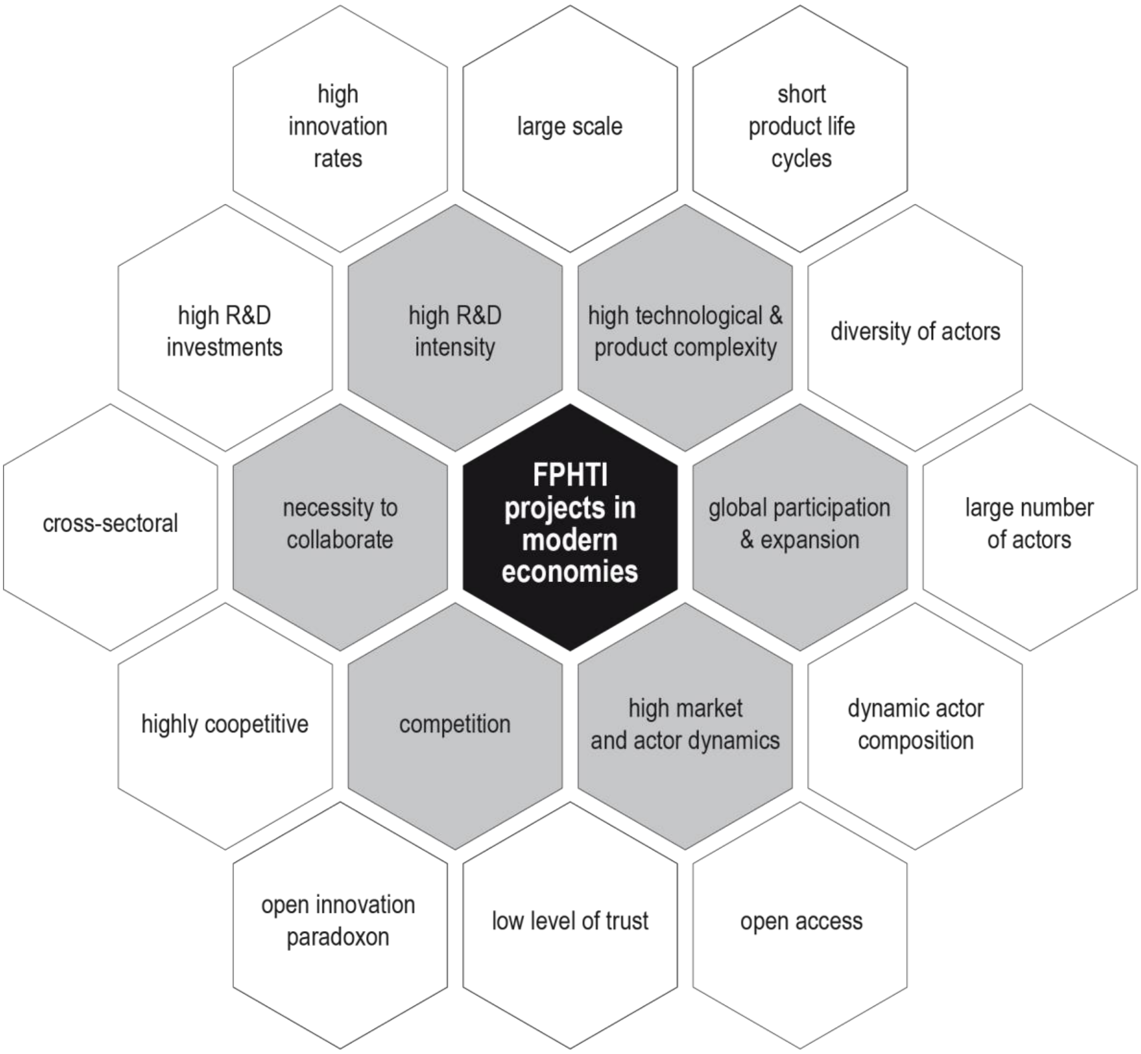

Figure 21: First (medium grey) and second (light grey) order characteristics of FPHTI projects in modern economies.

5.3 IOC in FPHTI projects

5.3.1 Outline and scope of the assessment

In line with Valiev et al.'s introduced view (see Chapter 5.2.2), this research also considers the project and its 'ecosystem context' (Neumann, 2012, p. 644) as the main determinants for a project's need for IOC. However, the project type is introduced as an independent third element that is not part of the project-based characteristics. This allows researchers to conduct a more accurate and precise pre-estimation of a project's need for IOC without consideration of a specific project (which is not within the scope of this study).

A **project's need for IOC** is determined by

- the project type,
- the project specifics, and
- the influencing environment, which is referred to as the ecosystem context,

as shown in the illustration on the left in Figure 22.

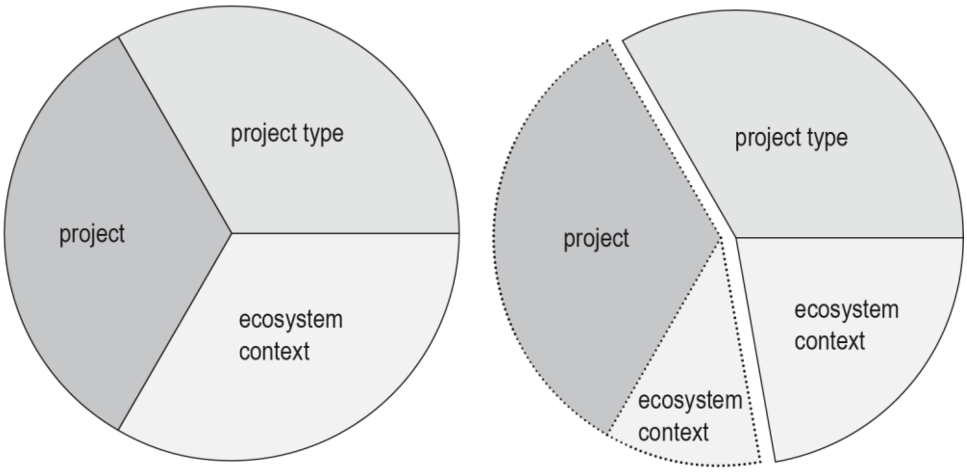

Figure 22: Determinants of a project's need for IOC (left) and a qualitative illustration of the analysis inside (bold) and outside (transparent) of the scope of this study (right)

The ecosystem context is a generic determinant and describes the environment in which a project takes place. It can be defined as the economic embedding in a broad sense as it covers both 'primary' economic aspects and also 'secondary' economic aspects which are caused by the political, regulatory, cultural and/or social space in which a project is embedded. Depending on the project, the ecosystem context may align with traditional industries or require a broader cross-sectoral perspective. The project type – for example research or innovation projects – allows for an analysis of the generic project characteristics that are common to all projects of this type. The more detailed a project type is defined the fewer projects are covered by this project type, but the more tailored findings can be generated. Finally, an analysis of the concrete project provides information on the specifics and the individual setup which may be decisive for the need for IOC in a project. As a matter of fact, a final statement about a project's need for IOC requires that all three sources which the following examples show be considered. The automotive sector is an ecosystem in which horizontal IOC is neither common nor likely, among others in projects which belong to the project type 'innovation projects'. However, the specific project 'e-mobility' has caused the need for horizontal IOC which now takes place. Another example is the 'project Apple' which mostly refrains from IOC in the very IOC-friendly ecosystem of the telecommunication sector. However, despite some exceptions, the need for IOC which arises from one determinant is, in most cases, not eliminated or compensated for by another element. Hence, the analysis of the generic determinants of 'ecosystem context' and 'project type' is suitable for the pre-estimation of the need for IOC in the majority of projects within the investigated project type.

This study focuses on generic characteristics of FPHTI IOC projects and does not consider specific projects which is why only a partial and not a complete analysis and evaluation concerning the need for IOC can be conducted (see illustration on the right in Figure 22). However, the focus on FPHTI projects as a clearly defined and precisely determined project sub-type in combination with the detailed analysis in Chapter 5.2 allows for conducting a sound analysis of the generic aspects which provides a substantiated subset of data as a basis for the analysis of specific projects of this subtype. In a project-specific examination, the generic conclusions generated here concerning IOC in this project sub-type can be complemented and/or refined to finally assess the need for IOC in a specific FPHTI project. The sound in-depth analysis of both FPHTI projects and the relevant effects of the modern economy imply that findings from the project-specific analysis may be expected to be complementary and have a rather adjusting than revising effect on the conclusions that are provided by the generic examination of the need for IOC in FPHTI projects.

5.3.2 The need for IOC in FPHTI projects

To qualitatively estimate the need for IOC in innovation projects, three IOC-related perspectives on innovation have been studied in detail in Appendix A.1 which allows for the disclosure of IOC indicators. It is found that the product complexity, the knowledge base, and the process complexity can be used to assess the need for IOC in an innovation project. By combining these indicators, an IOC cube (Figure 46) is developed in Appendix A.2, which is used in the following to qualitatively assess the need for IOC in FPHTI projects.

In order to apply the IOC cube, the three indicators of product complexity, knowledge base, and process complexity have to be evaluated for FPHTI innovation projects.

The product complexity of FPHTIs:

FPHTIs as ‘change of a technology core…[including] the nature of the technology support network’ (Chapter 5.2.1) inherently feature a high technological complexity. As such, high product complexity and systemic nature can generally be attributed to FPHTIs.

The knowledge base of FPHTI projects:

FPHTIs are defined as causing ‘alteration […] in such a severity that technological, economic and/or societal frontiers are shifted or at least pushed’ (Chapter 5.2.1). This indicates very fundamental changes, which require completely new intellectual and technical approaches and perspectives to problems and needs in the market. Expressed in other words, FPHTIs require the exploitation and combination of diverse, often unconventional, knowledge bases in a new way. This also becomes evident in the second-order attributes of cross-sectoral collaboration and a high sectoral actor diversity. As such, the use of a very broad knowledge base accompanies FPHTI projects.

The process complexity of FPHTI projects:

FPHTI is defined as innovation that ‘alters the very architecture, e.g. the qualitative nature of (the components, relations and flows of) a technology support network’ (Chapter 5.2.1). Changes in the technology support network are required to integrate the entirety of affected and contributing actors and components, which equates to the harmonization of a complex, highly interlocked gear cluster. In addition, FPHTI projects in the ecosystem context of modern economies per definition feature a high knowledge-intensity (see Chapter 5.2.2). High knowledge-intensity is strongly bound to complex, non-linear innovation processes. Additionally, FPHTI projects are also expected to be highly non-linear due to high market dynamics and the global setting and collaboration between globally distributed partners is generally accompanied by various communication barriers which include ‘physical barriers’ concerning communication tools and different time zones as well as language and/or cultural differences, which may result in misunderstandings or a delay of knowledge disclosure. The necessity to collaborate and the high level of competition in FPHTI projects further enhance non-linearity in the innovation process: knowledge has become the most relevant economic and strategic resource (Cricelli and Grimaldi, 2010, p. 3). This is why knowledge disclosure is part of a business strategy that is not oriented toward the needs of the innovation process. If knowledge transfer is not in line with the innovation process, non-linearity is caused. This is especially valid for settings with a low level of trust, different interests, and highly competitive nature.

Application to the IOC cube according to Appendix A.2 reveals the finding shown in Figure 23.

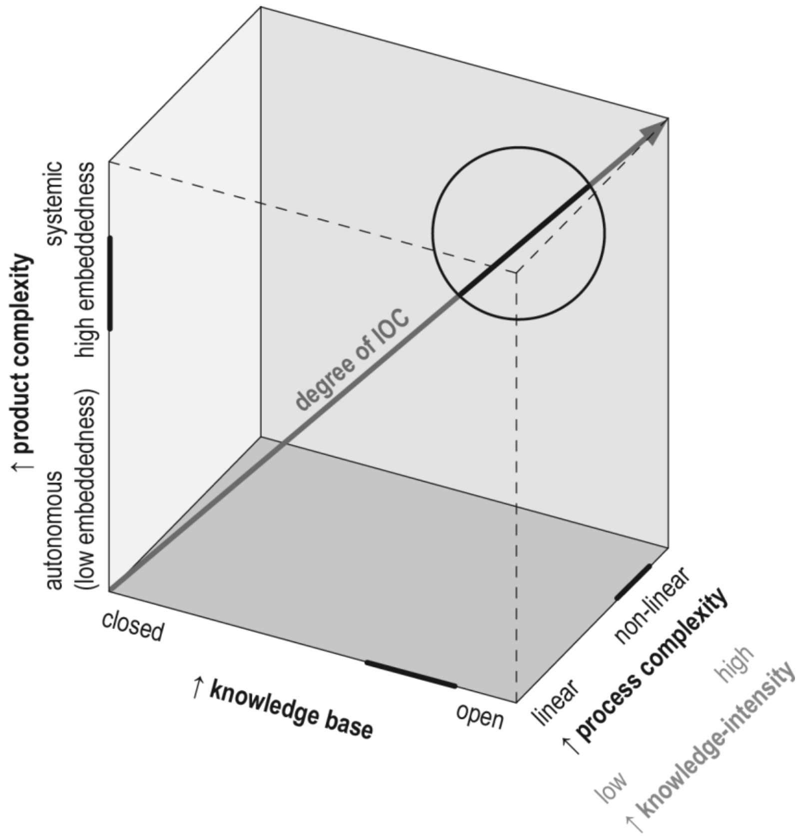

Figure 23: Qualitative assessment of the need for IOC in FPHTI projects by means of the IOC-cube (according to Appendix A.2)

The figure shows a clear result because all three indicators are evaluated as ‘high’. The product and process complexity of FPHTI projects are also assessed to be high. In combination with the broad knowledge base, all indicators show the same trend: they unambiguously indicate a great need for IOC.

5.4 FPHTI IOCSs

In this section, the findings from this chapter are transferred to system theory. The three system theory concepts are used to define common characteristics of FPHTI IOCSs.

Functional system concept analysis

The function of an FPHTI IOCS can generally be described in accordance with the IOC conceptualisation in the theoretical framework (see Chapter 4.1) as ‘the joint solution of a problem by means of an FPHTI’. Depending on the specific IOCS this may be limited to knowledge exchange only or include mutual R&D activity and/or the sharing of production means. However, two general sub-functions which have to be conducted by FPHTI IOCSs as a basis to achieve the main function can be defined:

- First, the IOCS will have a to provide a setting for efficient and effective collaboration (sub-function 1).
- Second, a trustful and yielding atmosphere for knowledge exchange and its additional functions has to be created (sub-function 2).

Structural system concept analysis

Based on the preceding analysis, the following conclusions for the structure and characteristics of FPHTI IOCSs can be drawn. There is a high economic pressure to innovate or at least to be part of innovative developments. In combination with the high level of technological complexity and R&D investment, a (nearly compulsory) incentive to collaborate and participate in IOCSs of FPHTI projects is created among a large number of entities from across sectoral and national borders. As a result, in IOCSs of FPHTI projects, actors have to collaborate, who have no common cultural and behavioural grounds, no common experiences, and no comprehensive mutual information on which to base trustful cooperation. Furthermore, to create the highest quality (which requires access to the broadest knowledge base possible) and avoid competing products and antitrust issues, IOCSs around FPHTI projects are most likely characterised by a rather open boundary which allows relatively free – meaning discretionary – access and exit to all interested actors. Generally, no entity of authority is defined for FPHTI projects although FPHTI projects could naturally be statutory if they are enforced by public authorities. However, this is a special case which would require individual consideration. Also, IOC can be initiated by one ‘leading entity’ that might be in power at the beginning. However, its factual authority is ultimately restricted because it has to convince other entities to voluntarily join in the collaboration. Second, as more and more actors participate, its factual power will degrade and finally vanish.

Because of the function of an FPHTI IOCS to solve a concrete problem by means of FPHTI, FPHTI IOCSs are not built around a perpetual task but around a nonrecurring – also often protracted – mission. They evolve rather ‘spontaneously’ around the problem to be solved and ‘start from scratch’ but do not have a long tradition or history. Of course, this is valid for any IOCSs when they are first launched. However, in IOCSs that evolve around permanent, perpetual tasks the formation process is often a phase that is conducted and completed once, which dwarfs in light of the ideally long-lasting phase of continuous or perpetual IOC. However, in IOCSs with nonrecurring missions, the formation phase makes up a notable share of the whole IOCS life cycle and thus more directly influences its characteristics, which leads to the attributes outlined below of FPHTI IOCSs in which nonrecurring missions are accomplished.

- FPHTI IOCSs have no reputation: FPHTI IOCSs have not yet developed a good reputation (in the beginning) which they can use to attract members and/or to create institutional trust which is why they have to invest much more in promoting and attracting participants by means of both marketing and the design and choice of institutions
- FPHTI IOCSs have no 'common (back)ground'. Instead, they have to form from scratch concerning all aspects of the IOC including the structural, organisational, power, and collaboration issues. As such, FPHTI IOCSs do not have to bother with existing but little beneficial traditions and habits in an IOCS but can freely create a setting which best serves their objectives and specifics. In return, the 'creators' of an IOCS carry the burden of the lasting impact and direction that they give to the IOCS due to the comparably high effort that is necessary to change the installed institutions compared to the effort of the first implementation. In any case, the FPHTI IOCS cannot build on a common culture, or a role model group whose members exemplify a common interpretation of the FPHTI IOCS's institutions and customs in order to stabilize and direct the interaction and way of collaboration in an FPHTI IOCS.
- FPHTI IOCSs have a highly dynamic actor composition: This is because an FPHTI IOCS starts from scratch – or has started from scratch only some years ago – and is in the process of formation which is accompanied by a proliferation of both the number and diversity of participating actors.
- FPHTI IOCSs feature high relational risk and low relational trust which is especially indicated by the preceding two points. Consequently, the installation of institutions, which generate institutional trust as a basis for further trust development and as a means to reduce relational risk is highly expedient.

All these characteristics may change over time because FPHTI projects are indeed non-recurring, however, in most cases very protracting, taking at least several years but may also exceed a decennium. During this time, reputation is built, and common codes of conduct are developed, which may be promoted and exemplified by long-established members. However, because of the relative timely dominance and duration of the formation phase of a highly dynamic, non-recurring IOCS, these characteristics remain decisive for the designing of FPHT IOCS settings.

Hierarchal system concept analysis

Concerning external influences from the FPHTI IOCSs supra system, the frontier pushing nature of the aspired-to product may serve as an indicator. It can be assumed that there is a high level of political interest in technological innovations that address the urgent challenges of our time and/or are likely to have a significant impact on the economy and/or society. As such, it can be stated that political influence will very likely affect FPHTI IOCSs. However, this intervention may take various forms which cannot be predicted in general, reaching from public funding programs over regulations to governmental mandates. As the FPHTI solution becomes more mature, the frontier pushing nature of this solution will cause disturbances and/or changes in the core market, which will affect the composition of the FPHTI IOCS and thus impact IOC.

Based on this tripartite system theoretical analysis, FPHTI IOCSs can be characterised as follows:

> In **FPHTI IOCSs**, generally, a large number of diverse and partially competing actors form a rather loose, voluntary partnership of convenience with the aim to jointly solve a problem by means of an FPHTI.

The corresponding FPHTI IOCS model is illustrated in Figure 24.

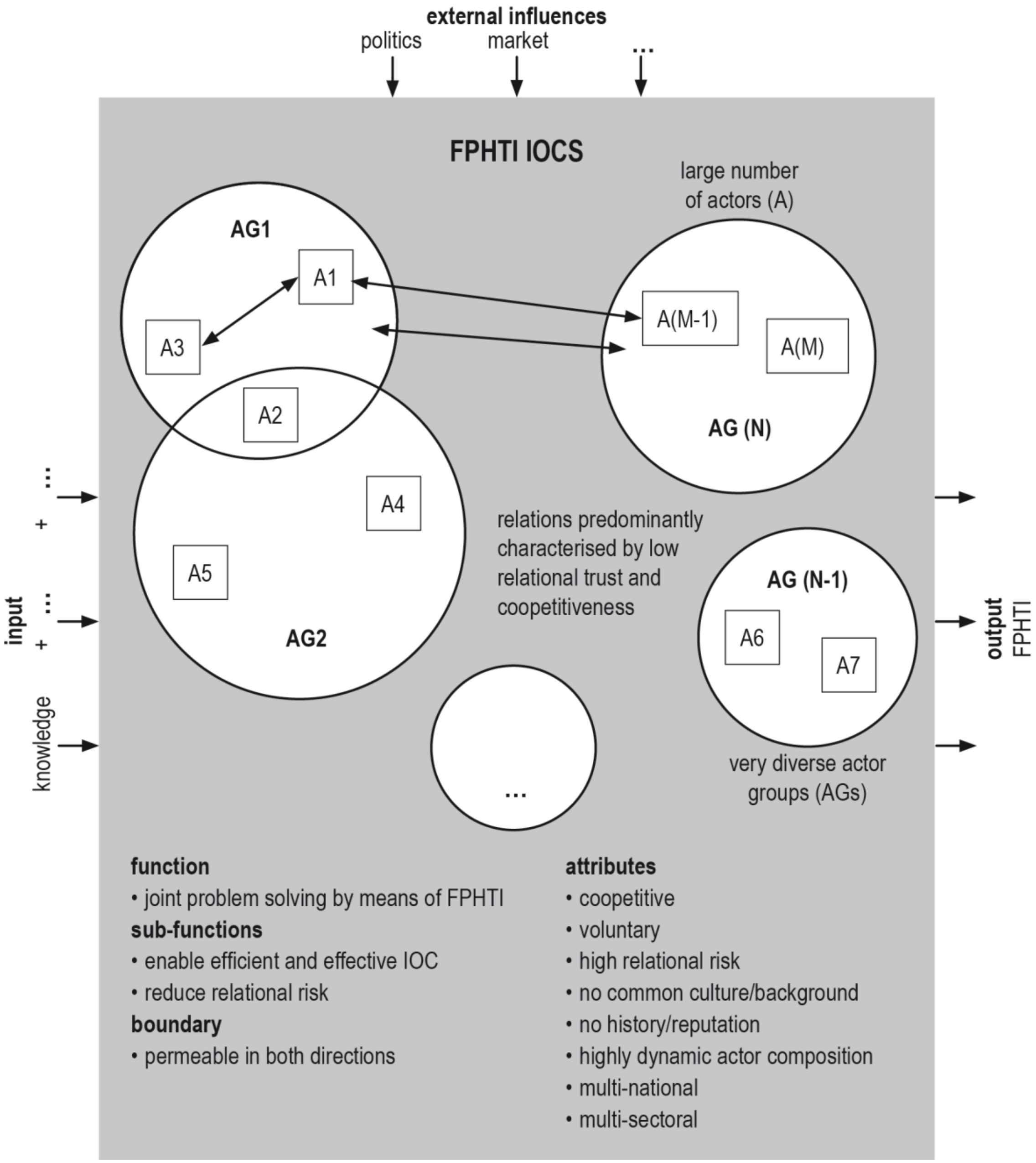

Figure 24: FPHTI IOCS model displaying the generic IOC-context of an FPHTI project

Comparing the model of FPHTI IOCSs to the type of IOC under consideration defined in Chapter 4.1, it is found that FPHTI projects provide an application domain for this research and its findings.

6 Case Study: IOC(A) at 3GPP

The case study in this research serves two purposes. Firstly, it is conducted to answer the second research sub-question. As such, it will explore the IOC-context and setting of 3GPP with a special focus on how IOCA is (1) concretely conducted and (2) experienced in a 3GPP. Secondly, the case study will enhance the general understanding of IOC around high-technology as inspiration for the artefact design and the basis for the definition of its requirements. With the Third Partnership Project (3GPP) a pioneer of global IOC is studied, which has successfully been developing specifications for mobile telecommunication technologies since 1998.

In order to best meet the requirements of this explorative study, an interpretive grounded-theory case study is conducted, which uses problem-centred expert interviews as an inquiry method. This research design is found to best meet the requirements that arise from the research question, the research project, and the complex object 'IOC', which touches engineering, economic, and sociological aspects alike. The detailed elaboration and justification of the research design to meet the challenge of multidisciplinary research at the intersection between engineering, business, and management sciences with their different standards concerning methodological depth and transparency are presented in Appendix B. In Appendix B.1, the interpretive case study research model is introduced. Appendix B.2 explicates the concept of grounded theory including its methods and suitability for this research. The research method of problem-centred expert interviews is provided in Appendix B.3. The research design is complemented with Appendix B.4 by the introduction of the quality criteria which are applied to validate the case study.

6.1 Empirical inquiry

6.1.1 Case selection

Three aspects were most decisive for the case selection. First, to contribute to the overall research question, the case is supposed to be related to the application domain (see Chapter 5). The second aspect focuses on the second research-sub-question. To disclose information on 'how-to' and not 'how-not-to' conduct IOC, the chosen case has to have proven to be successful in the sense that (1) IOC objectives were already demonstrably reached in the past, (2) its attractiveness for the relevant actor (groups) could be maintained and enhanced, and (3) its IOC practices were proven to be sustainable. Third, to ensure the integrity of the researcher, there are no previous, current, or contemplated interrelations between the researcher and the case.

Selection criteria for the case:

(1) The IOCS shall be related to the application domain concerning:

- the technical scope/field of activity (high-technology), and
- the global, multi-national and -cultural dimension of IOC.

(2) The IOCS shall have been proven to be successful.

(3) The IOCS shall provide for relational transparency.

In order to meet these criteria, only IOCSs in technical and preferably high-technology sectors are regarded and their IOC activity shall be spread across at least three continents. To assess sustainability and success, the IOCS must have existed for at least 10 years. During this time, it should have released at least two products and have an overall positive accession rate/rate of increase.

When studying IOC in (high-)technology sectors, one will inevitably come across the ICT sector because this sector has a long tradition of IOC due to the early recognized need for transnational standardization as a basis for enhanced transmission telecommunication systems. Although many successful IOCSs have evolved in and from this high-technology sector (for example ETSI, IEEE, IETF, ITU[27]), 3GPP is the IOCS which stands out due to its truly global orientation (Bar and Leiponen, 2014, p. 5) in combination with strong international recognition and reputation (Jonas and Leiponen, 2018, p. 6). As a result, 3GPP has roughly doubled its number of members from 338 members in the year 2000 (Bar and Leiponen, 2014, p. 5) to over 700 members in 2020 (TelecomTV, 2020). Their global distribution is shown in Figure 25.

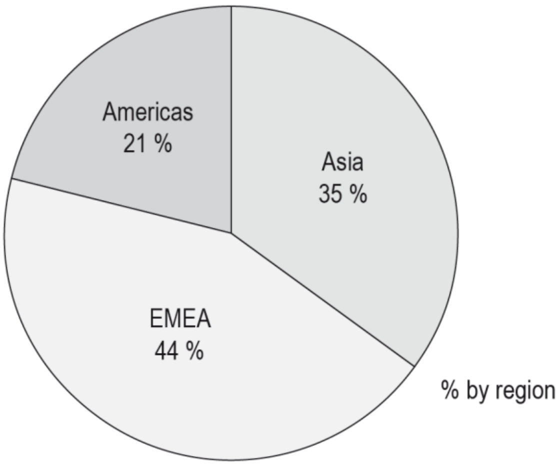

Figure 25: Distribution of 3GPP delegates by regions (TelecomTV, 2020)

Since their foundation in 1998, they have launched nearly 20 products in the form of releases (release 1999, releases 4 to 18), which initiated, defined, and enabled the mobile telecommunication standards 3G, 4G, and 5G each of which was revolutionary despite their backward compatibility. Each generation stands for a fundamental alteration of both the technology core and its support network which results in significant societal and

[27] European Telecommunications Standards Institute (ETSI), Institute of Electrical and Electronics Engineers (IEEE), Internet Engineering Task Force (IETF), International Telecommunication Union (ITU)

economic changes. For example, smartphones and internet-based (social) media networks resulted in completely new behaviour, user needs, and societal action, but also new markets, business models, and opportunities. Concerning the success of 3GPP, its existence for over 30 years, its numerous successful products and its sustained high reputation and attractiveness are self-explanatory.

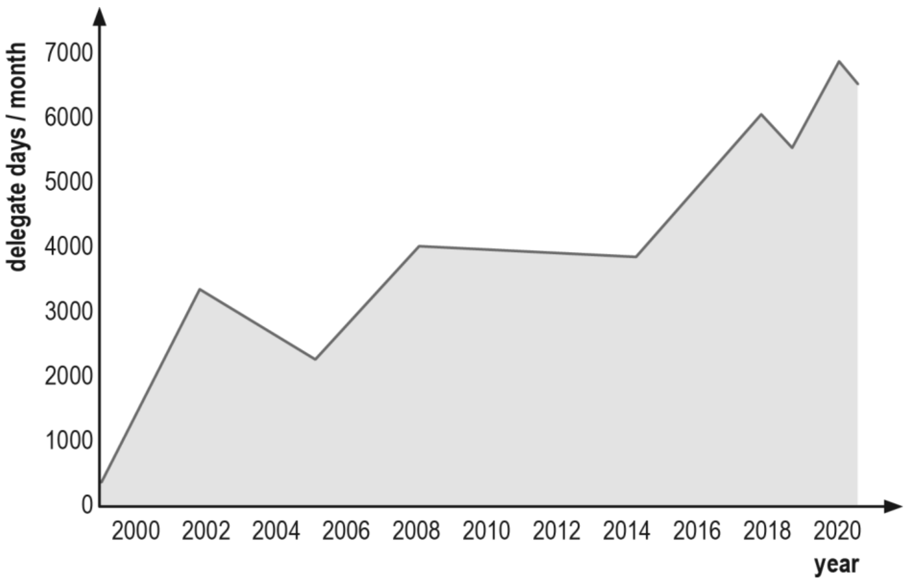

Figure 26: Development of the meeting attendance at 3GPP (TelecomTV, 2020)

Analysing the meeting attendance per delegate at 3GPP which is shown in Figure 26 reveals that the high level of commitment is not just formal, but concomitant with the increasing contribution and participation of delegates in the collaborative activities.

In accordance with the above-defined criteria, the researcher does not have any previous, current, or contemplated interrelations with 3GPP. In addition, 3GPP is characterised by high actor dynamics and a highly diverse actor composition (TelecomTV, 2020; also see Appendix D.1). This is why 3GPP is regarded as more than fulfilling the case requirements and, consequently, it is selected as the case for this study.

6.1.2 Sample selection

In order to conduct theoretical sampling, this study adopts the 'pyramiding' sample identification technique which is known and proven by lead user theory and method (Schmidt, 2019, p. 58; Hippel, Franke and Prügl, 2009). Based on the idea 'that people with a strong interest in a topic or field tend to know people more expert than themselves' (Hippel, Franke and Prügl, 2008, p. 1), the recommendations from interviewees are used in pyramiding to identify – and recruit – other suitable experts on a topic as potential samples. For more details on pyramiding, see Appendix F.1.2, in which the theory of lead users including pyramiding is introduced as a basis for its integration in the design artefact, the lead user-centred double diamond method (LD^{2}M).

The choice and relevance of pyramiding for this study have several reasons. Firstly, pyramiding is a very efficient way to identify relevant actors for a certain problem. This is especially favourable if samples are not easily accessible, and the acquisition is relatively difficult and time-consuming. This is true for this study because (1) a case is selected to which the researcher has no personal connection in favour of relational transparency, and (2) samples are located in the top management of international organisations and have to be individually located and contacted. Secondly, the dedication of an interviewee to the research topic is essential for both an actor's participation in a study and the efficient and effective generation of high-quality data. However, an actor's dedication to IOC cannot be externally evaluated by formal criteria (like the status of an actor in a company or similar aspects) (also see Andrade, 2009, pp. 50) which is why recommendations of fellow actors enhance the probability of identifying relevant samples who are interested in the scope of this study and provide significant experience and (explicated) knowledge. Thirdly, not just the identification but also the acquisition of interviewees is a prerequisite for successfully conducting a case study (Neumann, 1997), which is perfectly described by Morse's (1994, p. 228) definition of a good participant as 'one who has the knowledge and experience the researcher requires, has the ability to reflect, is articulate, has the time to be interviewed, and is willing to participate in the study.' By contacting potential interviewees upon recommendation of fellow 3GPP actors, the motivation of very busy interview candidates to spend time on an additional duty like an interview was considerably enhanced.

In line with the above considerations, the acquisition of the first sample was very challenging. Finally, the attempt to directly contact a chairman who was listed on the homepage of 3GPP was not just successful but hit the mark concerning the quality and quantity of interview data and served as a driving force for successful interviewee acquisition. As a result, 10 top managers with long experience in 3GPP and/or other IOCSs could be selected and gained as interview partners. Without exception, all interviewees provided outstanding valuable and significant data for the scope of this research. Because of the high consistency of findings in the Interviews 1–9, one complementing interviewee was selected who is not a delegate at 3GPP but has observed and examined the IOC activity at 3GPP (and in other IOCSs in the ICT sector) over decades as a founding member of the closely related global IOCS World Wide Web Consortium (W3C). Among the nine interviewees from 3GPP, the sample could be composed in such a way that views from different sectors and cultures with regard to both the interviewees and the organisation's origin are represented: five manufacturers, one operator and three verticals participated in the interviews. Concerning their background, one interviewee had an Asian, one a North American, and seven a European background. They represented organisations from Asia (one interviewee), North America (two interviewees), and Europe (six interviewees). However, the data show that an equal distribution could not be reached because of the significantly higher response rate of the European interview candidates. The interviewee from W3C also comes from Europe. Concerning academic education, only one interviewee has a legal as opposed to a technical background. This is in line with the assumption in Chapter 5.1 that actor with a technical and/or scientific background are the dominant actor group in technical (innovation) projects.

With the exception of one interview partner who had only joined 3GPP 4 years ago, all interviewees had participated in 3GPP and/or related IOCSs for at least 5 years, but often much longer. However, as an ab initio-delegate of a highly successful new vertical at 3GPP, the comparably inexperienced interviewee in terms of his participation at 3GPP was nonetheless deliberately selected because he promised (and proved) to provide very interesting insights. As the consistency of data within 3GPP became obvious during the course of interviewing, additional experience in related IOCSs is established as an additional criterion for further sample selection. As a result, the interviews can be divided into two sets for evaluation:

Interview set 1: contains seven (7) interviews on 3GPP, which provide in-depth information on 3GPP from different regional and sectoral perspectives

Interview set 2: contains three (3) interviews which, in addition to 3GPP, consider the interviewees' experience in other related – namely IETF, IEEE and W3G – IOCSs as a basis for comparative studies.

6.1.3 Data generation

Secondary data generation

As a basis for the case study, an in-depth literature review – partially inspired by informal discussions with experienced insiders of the ICT sector and 3GPP – was conducted. A thorough understanding and analysis of 3GPP and the ICT sector in which 3GPP is embedded are essential to (1) develop the necessary understanding of and familiarity with the case, (2) obviate misinterpretations and identify data for corroboration, and (3) provide a detailed analysis of the case and its surrounding. This is a prerequisite for the contextualization of results in order to both present qualitative findings IOC-context-sensitively and to enable reflected transferability of research findings to other IOCSs.

Primary data generation

Primary data is gathered by the problem-centred expert interviews described in the appendix. In order to make the interviewee feel as comfortable as possible and to facilitate free and nuanced communication, it was up to the interviewees to choose between German and English as the interview language. In addition, the interview guideline with the main topics of interest was provided prior to the interview to reassure candidates concerning the innocuousness of the interview course. The interviewer's neutrality in the field of IOC and 3GPP helped to generate a trustful atmosphere in which the interviewees could talk rather freely. The interview conduction is supported by four techniques as recommended for PCIs (Witzel, 2000, p. 3): a short questionnaire in the form of an introductory question, an interview guideline (both provided in Appendix C.2), audio recordings of the discussion including transcripts (see Appendix C.1), and a postscript. The introductory question at the beginning of the interview is posed to efficiently gather the required objective data using structured question-answer interviewing. In addition, a good introductory open-end question initiated the actual conversation. The guideline is rather used as a supportive device to steer the course of communication in the background and as an orientation and checklist to ensure that the relevant aspects and elements are covered during the discussion. It helps the interviewer to stay focused and thereby enhances the comparability of the interviews. In line with Witzel (2000), the guideline is not used to actively dictate the course of discussion and remains unnoticeable to the interviewee. Audio recording, which is highly recommended by Witzel (2000), is used in the interviews to allow the interviewer to fully concentrate on the discussion and all nonverbal impressions during the interview. Based on the authentic and precise recording, a detailed subsequent analysis from many perspectives is possible, including the compilation of interview transcripts. In addition to tape recording, postscripts are written immediately after an interview to edit notes, summarize and comment on the interview impressions of the interviewer, and capture spontaneous ideas on the topic or for further interpretation and analysis.

6.1.4 Data analysis – the process of coding

In this chapter, the emphasis lies on the process of data analysis with the means of coding according to the grounded theory coding paradigm (see Appendix B.2.2)[28]. In line with the iterative data analysis and theory development of grounded theory, the results of analysis and coding are successively developed during several loops of evaluation and analysis. To balance the requirement of readability of the thesis on the one hand and the quality criterion of reliability, on the other hand, the documentation of the coding process describes all three coding steps but limits the presentation to the final results of selective and axial coding.

Open coding

Each sample is first approached using a word-by-word analysis of the transcript. All potentially relevant aspects are extracted without interpretation to avoid the loss of any relevant information due to a directed interpretative review. To handle the mass of information, three data groups are defined:

- *influencing factors*: all data that represents or contains facts that influence IOC(A) in 3GPP, is tagged as an influencing factor. This includes internal, influenceable or uncontrollable as well as external, non-influenceable factors.
- *descriptors*: all information that describes and characterises an influencing factor, its effects on collaboration, or its value for the success of 3GPP.
- *recommendations*: all data that contains information on how to solve or improve certain situations and conditions in 3GPP or how to advance institutions or success.

Data tagging proves to be very helpful to maintain an overview of the data and structuring the mass of data for further processing in coding procedures. Based on the tags, codes can be generated from data in group (1) (influencing factors), while data from group (2) (descriptors) are used to describe the codes and to identify relevant effects and influences for collaboration in 3GPP. Data from group (3) (recommendations) is each assigned to one or more codes.

Axial coding

The process of IOCA at 3GPP, by which delegates develop specifications for standard setting is the central point of this study, data collection, and discussions. This is why 'delegates' IOCA for specification development' is chosen as a phenomenon for the axial coding procedure. Interviewees consistently state that political influence and (rare) individual malpractices are the main disruptive factors and threats to collaboration. The rather uninfluenceable basis for the collaborative work in 3GPP is defined by the specifications of the product and outcome of the IOCA, and by the 'formation heritage' which refers to the well-established and thus hardly changeable routines, processes, and structures in an 'old' IOCS like 3GPP. The most determining context factor is the actor composition, which refers to the number and type of actors in the form of both the organisations and their delegates. Another contextual influence is the market (or markets), in which the collectively developed products need to stand the test. Seven main strategies which are regarded as being especially supportive to make the collaboration in 3GPP an example of success for so many decades are identified at this point of coding. The creation of a common mindset as a foundation for concerted collaborative action and consensus-based

[28] All findings are presented in detail in Appendix D

decision-making is a pivotal mechanism of IOCA. Moreover, the no-loser policy, which is actively practised, agreement on a common IPR policy, a high continuity of delegates, the appointment of chairmen with good mediating and leadership competence, and informal exchanges are found to be perceived as being highly influential. This leads to the clustered version of codes and categories as presented in Figure 27.

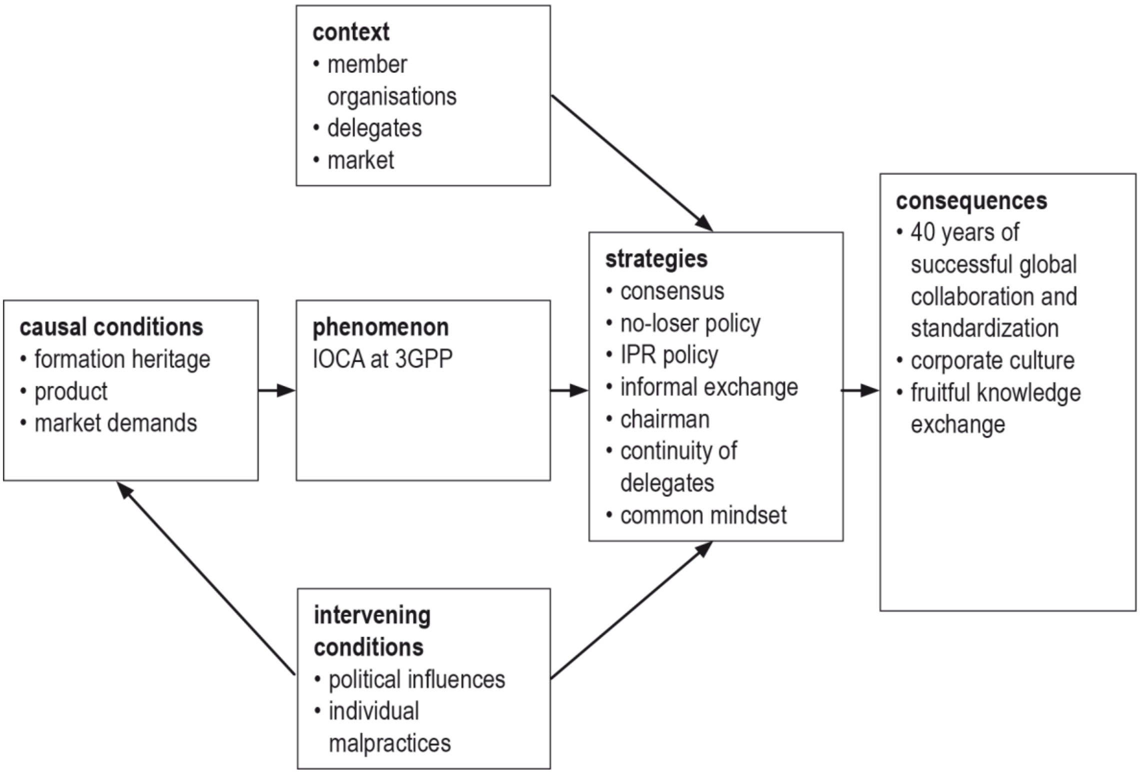

Figure 27: Result of axial coding

Selective coding

In the stage of selective coding, four main concepts are elaborated, which support theory development by restructuring the data and categories as shown in Figure 28. Each concept implies certain general attributes for the associated categories which facilitate the transfer of the case study results into theory and the deduction of recommendations for implementation. The central element is defined as 'IOCA at 3GPP' in order to emphasise the case study's focus on IOCA. The first concept is dedicated to the actors that form and participate in 3GPP. The second concept is the guiding principles. In this domain, data categories are allocated that describe the underlying guidelines for both the actors' behaviour and organisational configurations. In simple words, categories in this domain refer to the mindset and maxim of action on which collaboration is built. The third concept is organisational setup which refers to the internal setting for collaboration. It is chosen to allocate all categories that describe the organisational set-up and the working procedures which influence and determine the collaborative process. The concrete mechanisms of collaboration are allocated in the corresponding fourth concept. In this domain, all institutions are categorised that are implemented or established at 3GPP for successful long-term collaboration. These are both primary and secondary mechanisms. While primary mechanisms are actively implemented to foster collaboration, secondary mechanisms are not explicitly implemented instruments but rather are established 'habits of high impact' as a consequence of guiding principles, structures, and/or primary mechanisms. In the fifth concept, pre-set parameters are considered. In this domain, categories are allocated that describe the most important factors for the collaborative work which cannot directly be influenced, changed, or controlled by the organisation and its participants.

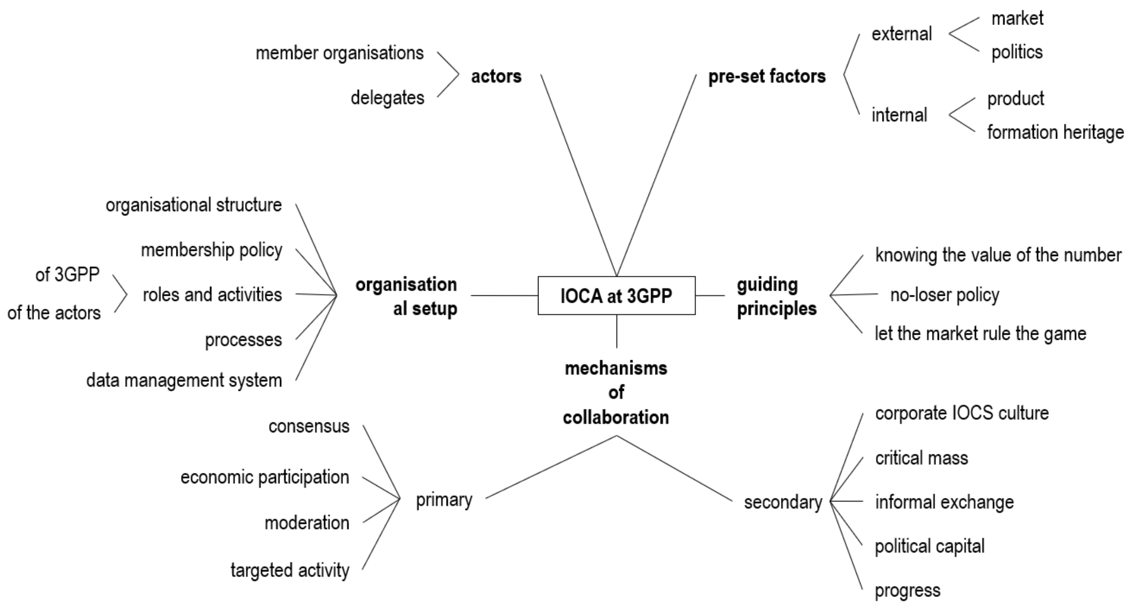

Figure 28: Result of selective coding

6.2 Interpretation

All case study findings (including findings derived from secondary data by literature analysis) are elaborated in Appendix D. The results – both from the primary and secondary data – are presented according to the result of selective coding as shown in Figure 28. The detailed presentation of the findings in Appendix D makes the conclusions that are arrived at here traceable and transparent. In addition, it makes the results of the case study accessible to fellow researchers for further use as secondary data in related research.

Based on the detailed description of the results in Appendix D, this chapter focuses on the interpretation of these case study results. First, the second sub-question, namely how IOCA is conducted and experienced at 3GPP, is answered in Chapter 6.2.1. This includes an analysis of the nature of IOCA and a determination of the concrete institutions that are implemented at 3GPP to foster IOCA. As such, the first Chapter 6.2.1 is dedicated to the setting of 3GPP. Second, in Chapter 6.2.2 the institutions are contextualised by means of a tripartite system concept analysis, which results in the development of an IOCS model for 3GPP. The contextualisation of the findings on how IOCA is conducted at 3GPP provides the basis for (1) the integration and use of the case study findings as a data set for analogy reasoning in the LD²M, which is designed in Chapter 7, and (2) a reflected further use and processing of these qualitative findings. The result of selective coding can be subdivided according to the two different foci of interpretation on the IOC-setting and IOC-context for IOCA at 3GPP in Chapters 6.2.1 and 6.2.2 respectively as shown in Figure 29.

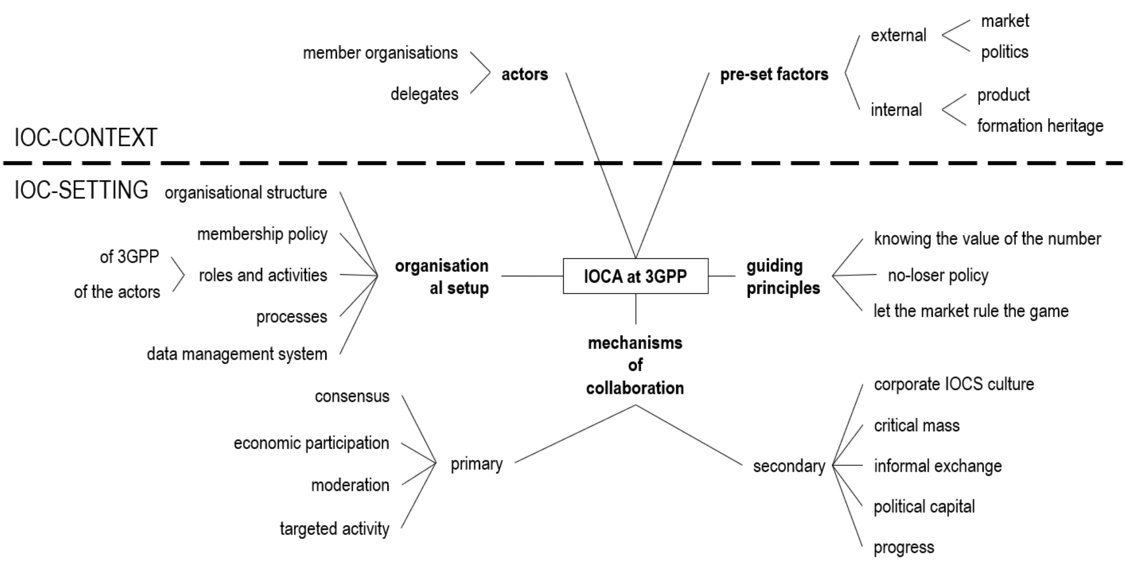

Figure 29: Allocation of the selective coding concepts (Figure 28) to the IOC-context and the IOC-setting of IOC(A) at 3GPP

6.2.1 IOCA at 3GPP

In this section, the setting of IOCA at 3GPP is analysed to answer sub-question 2. As such, this chapter focuses on the following three concepts of selective coding: guiding principles (GP), mechanisms of collaboration, and organisational setup (see Figure 29). However, before the three concepts are each analysed, findings on the nature of IOCA are synthesised using the model of the bipartite path of IOCA.

6.2.1.1 The bipartite path of IOCA

According to the definition in Chapter 4.1, IOCA is defined as the operational problem-solving process of IOC. As such, it describes how the idea for a joint solution is practically transferred into a product which solves a given problem. During the course of coding and data analysis, one prevalent attribute of IOCA for the specific challenges of problem-solving by IOC clearly crystallizes, which is perfectly embodied in the following statement:

> *'[...]in 3GPP, it's just as important to be able to get [...] social as it is to be technical' (Interview 8, p. 4)*

Although this statement refers to the competences of delegates and describes what distinguishes a delegate from an expert, it depicts IOCA around technical solutions as a highly social and not just technical process. This allegory is in accordance with this research's underlying basic understanding of IOC and with existing theoretical findings on IOC (see for example Chapter 4.3). Hence, it can be stated that it is the social constituent that makes both IOC and IOCA special and different from (problem-solving in) single-actor projects, and which may explain and account for the high failure rates in IOC projects.

The 'bipartite path of IOCA' as shown in Figure 30 helps to model this tenor on the nature of IOCA and allows the distinguishing and challenging feature of IOC(A) to be pointed out.

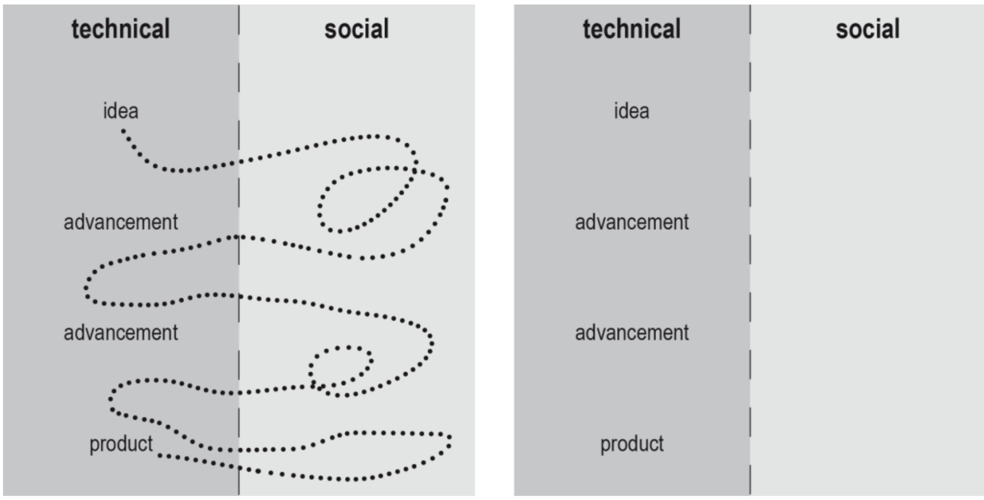

Figure 30: The bipartite path of IOCA (left), as overstatedly contrasted to problem-solving in single-actor projects (right)

The bipartite path of IOCA illustrates how knowledge transfer and problem-solving in IOC occurs at the operational level and, at a more abstract level, how the achievement of objectives and the outcome generation in IOC is accomplished by IOCA. Of course, single-actor projects are generally not free of social intercourse. However, it is far less dominant compared to the technical pathway because of defined roles and hierarchies. The model pinpoints that in IOCA, technical advancement in the solution process mandatorily requires passing through social terrain. The loops along the path of IOC in the social terrain indicate that it is the social part of the path, which is particularly challenging, risky, and unpredictable. In contrast, technical progress in the operational IOC process at 3GPP is experienced by the interviewees as rather 'natural', which evolves as a matter of course and with little complications as a product of expert pooling in IOC. That is why in IOCA, technological aspects which tend to take centre stage in single-actor projects and problem-solving processes are often eclipsed in the face of the challenges along the social path. Technical progress can thus often take a back seat and is left to the expertise of the participants, while the focus of actors, management, and measures in IOCA lies in steering the course along the social path. Figure 31 illustrates the guiding function of an IOC-setting and management activities on the IOC path, which is defined by the actors.

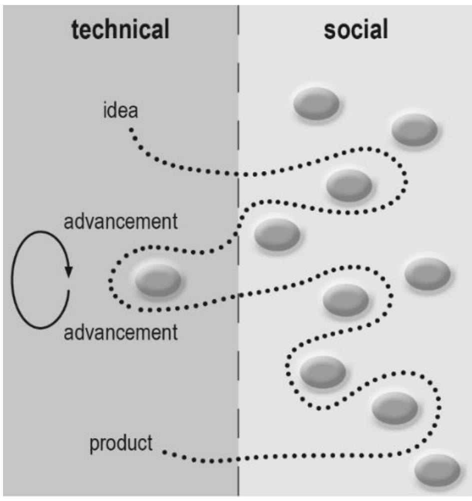

Figure 31: Illustration of the guiding function of the IOC-setting (spherical grey sections) in IOCA

As such, the 'bipartite path of IOCA' makes important points for the special challenges for IOC practice and management:

> The **'bipartite path of IOCA'** describes how in IOCA as the operational process of problem-solving in IOC projects, the technical attainment of an objective is intrinsically tied to and determined by the art of the social intercourse between people.
>
> As a result:
>
> - The *only* way to success and the technical progress in IOC is to tread the social path.
> - The – often dominant – challenges along the social path constitute and require the need for specific institutions and (management) practices.
> - Each IOC project is unique and evolving because of its dynamic social IOCA path.

6.2.1.2 3GPP's setting for IOCA

After delineating the essence of IOCA as a basis to approach how IOCA is conducted at 3GPP, the setting for IOCA, which is defined by the three concepts GPs, mechanisms of collaboration, and organisational setup (see Figure 29) is analysed. This section specifies the concrete institutions at 3GPP which are identified as being decisive for the successful conduction of IOCA at 3GPP. In line with the theoretical framework of this research, a system theoretical perspective is taken for the interpretation wherefore the findings of selective coding which are allocated to the IOC-setting of 3GPP are sub-divided into hard and soft institutions (see Chapter 4.2) as shown in Figure 32:

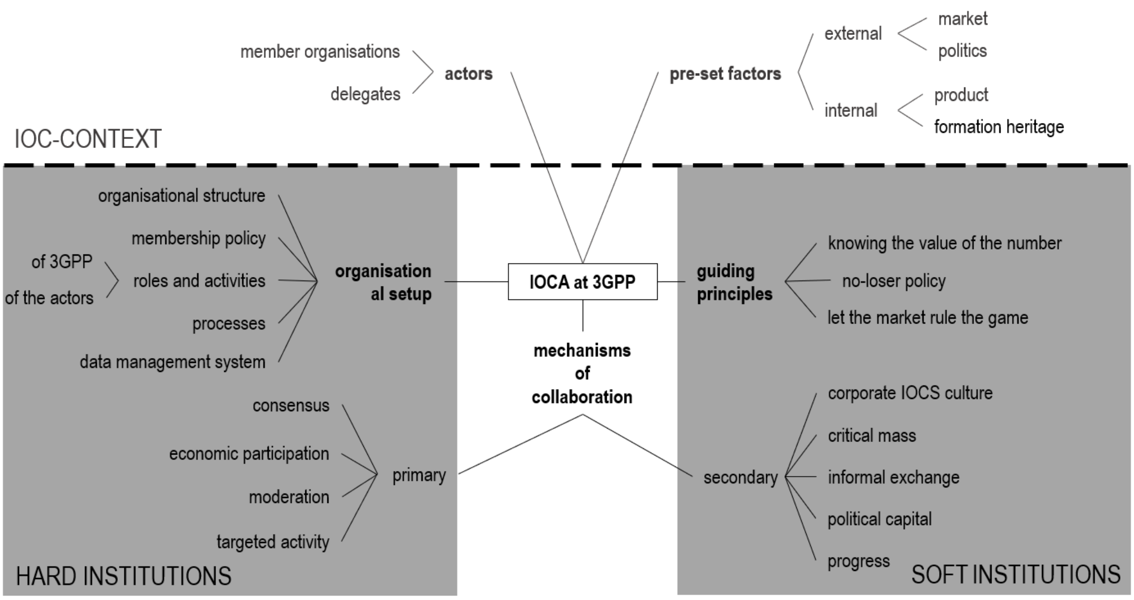

Figure 32: Overview of hard and soft institutions at 3GPP based on the selective coding concepts (see Figure 28)

The hard institutions describe the regulatory and structural framework of IOCA at 3GPP. As such, they reveal how the organisational setup at 3GPP is formed and which primary mechanisms of collaborations are installed to affect and guide how IOCA is conducted at

3GPP. The soft institutions at 3GPP include the GPs which exist at 3GPP for the conduction at 3GPP and the secondary mechanisms of collaboration, which are not explicitly installed but rather evolve as 'social rules of the game'. It is this particular ensemble of institutions which defines how IOCA is conducted at 3GPP. The analysis of the mutual effects of institutions on each other is provided in Chapter 6.2.3, in which the interrelation analysis for all elements of the IOCS 3GPP is presented.

6.2.1.2.1 Hard institutions

For the 'regulatory rules of the game', which refers to the way IOC(A) is organised and managed at the IOCS 3GPP, one overarching basic principle crystallized, which is based on and displays the role identity (Appendix D) and thus the nature and conception of 3GPP:

> The hard institutions at 3GPP, which define the man-made, determinable structural, organisational, and processual framework for IOC(A), are based on and informed by the **principle of 'temperate intervention'** which is best described by the motto 'as much intervention as necessary, as little as possible'.

Organisational setup

For the scope of this thesis, elements of the organisational setup are regarded as hard institutions. The organisational setup is more than the hard institutions discussed in this section because it also includes soft- and hardware aspects such as communication tools or channels. However, this analysis focuses on the institutional aspects of the organisational setup, which most influence IOCA, which are instructions, rules, processes, and structures in the organisational setup. It can be regarded as the institutional setup or 'playing field' on which IOC occurs and which thus defines the framework which is designed for the game IOC(A) at 3GPP.

a. Membership policy

At 3GPP, the membership policy strongly aligns with its objective to define globally accepted and implemented specifications. Its main aim is to attract all relevant players at a global level and not to exclude actors who would then have to develop a rival solution. As such, the membership policy at 3GPP distances itself from any mechanisms of punishment or coercive power. The membership policy is very open and allows all members of one of the partnering standard development organisations to join, while only the agreement in the FRAND-based (meaning fair, reasonable, and non-discriminatory licensing) mechanism of economic participation and a moderate financial mandatory contribution, which is graded according to an organisation's annual ECRT band (Electronics Communications Related Turnover), is required. This allows 3GPP to provide one and the same membership for all participants regardless of their economic and/or human resources. As a result, at 3GPP IOC(A) is conducted at eye level, which is highly appreciated by the interviewees and regarded as one factor for the sustained success of 3GPP.

b. Organisational structure

The organisational structure defines the hierarchy and organisation of the IOCS with corresponding competences and responsibilities for example the management embodiment and the structural solution at the operational level. It thus provides and determines hard institutions which can be more or less conducive to cooperation with regard to the conflict potential resulting from the chosen structure, the degree of efficiency and effectiveness, and its contribution to actor commitment. At 3GPP, a management body of periodically elected volunteering actors is installed, which is not consciously noticed by the interviewees compared to full-time officer management boards in other IOCSs which are partially perceived as negative and hindering for IOC by the interviewees. The management body of periodically elected volunteering actors at 3GPP is highly associated with the strong *Wir-Gefühl* (feeling of unity) at 3GPP, which describes the strong sense of unity and a common spirit at 3GPP. At the operational level, 3GPP chose the typical divisional structuring, which means that it is organised in working groups around certain sub-topics of the overall solution. This organisational structure – and especially the type of management body that was chosen – positively affects the institutional trust, efficiency, and effectiveness of IOC and positively contributes to the mechanisms of progress and targeted activity.

c. Roles and activities

The role identity of 3GPP can best be described as a platform as 3GPP aims to provide and be a place where IOC(A) can be conducted. As a neutral IOCS without any self-interests, it aspires to enable IOC(A) but does pursue any particular outcome. This determines the (self-)conception of 3GPP which is best described by the principle of temperate intervention introduced above. Especially the fact that 3GPP itself is neither a legal entity nor does it represent one or is founded by one is the basis for a neutral, level playing field and the development of the strong *Wir-Gefühl* (feeling of unity) at 3GPP.

With regard to the actor roles, 3GPP aims to foster equality and balanced powers within the potpourri of diverse actors, who have very different means to contribute to and participate in IOC. With the definition of the entity role, the voting power of each organisation is decoupled from the human resources that an organisation delegate which prevents the dominance of organisations through an excessive input of manpower. Second, by allowing for external representation, both the representation of interests and voting is decoupled from personal physical attendance which is a prerequisite for small players with limited (human) means to participate. As such, the actor roles at 3GPP highly contribute to the level playing field at 3GPP and to the chance for every organisation to effectively participate in IOC(A) according to its means.

At 3GPP, the possibility to counteract imbalances and misuse by the definition of subcategories for certain roles and/or maxima per roles and organisation (see Appendix D.4.3.2) is not yet used. However, it is regarded as a promising and effective means by many interviewees if the need for intervention arises.

d. Processes

Processes define the routines and procedures of IOCA and thus represent a fundamental element of the daily practice of IOCA. In particular, they greatly determine the effectiveness and efficiency of IOCA, which is decisive for the satisfaction of the delegates, and in the long run also for the participating organisations and thus their continued membership and investment in 3GPP. A specific contribution of processes to IOCA is their outstanding potential to steer the course of IOCA without showing anyone up or using a means of penalty which is in accordance with the GPs of 3GPP. For example, if there is a process that defines eliminating work items for which results have not been presented on schedule on three occasions, this processual habit allows the work to proceed while saving the face of, and not exposing, the unreliable actor. Finally, it is processes – or more precisely effective processes – which are the primary source of institutional trust.

e. Data management system

The data management system is included in this interpretation because it is the only IOCA-assisting hard- and software tool that is repeatedly mentioned by the interviewees. It is found that the data management system may support IOCA (1) by making work and contributions traceable and (2) by providing a clear terminology with unambiguous definitions which minimize discussions on the meaning of specific words. In addition, a data management and documentation system which – other than that at 3GPP – aligns with established international customs of documentation and traceability coding can make it a lot easier for newcomers to become familiar with the work. In fact, the data management system at 3GPP is mainly emphasised as an example of negative formation heritage as it shows how inconsistent coding hinders traceability and thus efficient and effective work and – for newcomers – familiarization, which is described as demotivating and tedious.

Primary mechanisms of collaboration

f. Mechanism of consensus

The mechanism of consensus is the core mechanism of collaboration at 3GPP that is formative for the entire concept of IOCA as it is realized at 3GPP. For this reason, all other mechanisms of collaboration are aligned to and support the mechanism of consensus. Concretely, the mechanism of consensus defines how decisions are taken. At 3GPP, 100% consensus, which means a 'lack of (sustained) objection' is aspired to. The 100% consensus contributes to a level-playing field at 3GPP and most importantly ensures that all actors are committed to and invest in the final solution that is requisite for the development of one uniform standard.

g. Mechanism of economic participation

The mechanism of economic participation defines how the 'pieces of the IOC action' are distributed among the actors of 3GPP to reach a fair profit-sharing among the actors with regard to their own investment and contribution to the development of the joint solution. It is thus the foundation to share and exchange knowledge, the main incentive to contribute to joint problem-solving, and a decisive factor for the attractiveness of 3GPP for different actor groups. At 3GPP, economic participation is based on IPR (intellectual property rights) and thus every member has to agree to make the intellectual property available at FRAND conditions if it is integrated into a technical solution and specification of 3GPP. However, the specification of concrete FRAND conditions is up to individual negotiations between each licensor and licensee.

h. Mechanism of moderation

The mechanism of moderation, which is primarily conducted by the chairmen of each working group at 3GPP, describes the mechanism of understanding, guiding, and influencing group dynamics during IOCA in order to, on the one hand, support and enable consensus-finding and thus progress and mission-attainment. On the other hand, it is the task of the moderator to ensure that interaction and conflict resolution in IOCA stays civilised, constructive, and factual and does not jeopardise sustainable collaboration by personal, out-of-control disputes.

i. Mechanism of targeted activity

The mechanism of targeted activity describes the focused course of IOCA[29] at 3GPP in line with the principle of 'temperate intervention'. More precisely, at 3GPP IOCA is focused and limited to exactly those activities and issues which are essential to attain the common objective within the available working hours, while all additional topics are left to individual considerations and solutions. As such, the mechanism of targeted activity significantly contributes to efficient and effective problem-solving which is important for the satisfaction of delegates and organisations but may also be at the cost of sustainability by attaching less importance to long-term, cross-project inputs. In addition, this mechanism circumvents the treading of additional, avoidable social paths with the concomitant potential to open up new conflicts.

6.2.1.2.2 Soft institutions

The soft institutions as social rules of the game of IOCA at 3GPP determine the way how actors (should) interact and behave within the IOCS when conducting IOCA. More precisely they describe how the vast majority of actors act and the behaviour pattern that is expected of fellow actors. As such, they define the expected and established codes of conduct and ethics at 3GPP. It turns out that it is the value of the number for the success of 3GPP (and its outcome) and/or for individual success at 3GPP which can be traced throughout all soft institutions. This is why the GP of 'knowing the value of the number' (see next section) crystallizes as the overarching basic principle that informs and affects the entirety of social institutions.

Guiding principles

a. Knowing the value of the number

The GP 'knowing the value of the number' describes the awareness of the actors that the success of (and in) 3GPP depends on and results from the maximization of 'quantity' as a mandatory complement to technological quality. First of all, IOC only develops where additional value is expected from 'the number', which in this case refers to the actors who contribute to the solution of a problem and is compared to single actor solutions. However, at 3GPP the GP is in particular backed and promoted by two factors. Firstly, the large network effects of the end products that are developed based on the outcome – meaning the technical specifications – of 3GPP enhance the 'value of the number' as more users are concomitant with an enhanced user value of the products. Secondly, the mechanism of consensus defines 'the number' of supporters for the own solution as the decisive factor for success within 3GPP which is manifested in the mechanism of the critical mass. As a result, at 3GPP both the IOCS's success and the individual success mandatorily require a large number of fellow actors which is why the tenor of appreciation for fellow actors characterises and dominates the mindset of the actors as well as the atmosphere at 3GPP despite existing disagreements, conflicts, and competition on concrete technical solutions.

b. Let the market rule the game

The credo 'let the market rule the game' is not just a GP, but also puts the self-conception of 3GPP into a nutshell: *'Induce as little influence and changes to the existing superior market economic system as possible'*. For IOCA at 3GPP, this means that joint activity and problem-solving are limited to those issues that require IOC to satisfy demands and

[29] The same is valid for IOC, but this is not in the focus of the case study

markets which cannot be served by one single actor but to refrain from unnecessary additional intervention. In addition, the main incentive and objective at 3GPP – not just at the IOC but also at the IOCA level – remains the market economic principle to 'make the pie bigger'. As a result, there is a high level of aspiration at the IOCA level to develop solutions which meet market needs wherefore much attention is given to the use-cases and the fulfilment of corresponding user requirements with profitable sales volumes. The high level of importance of 'market (economic) facts' which are regarded as undebatable and objective, results in the fact that the use cases and user requirements which are provided by verticals ease the competing atmosphere between rivals by providing indisputable arguments for or against certain rivalling alternatives.

c. No-loser policy

The no-loser policy is a derivative of the GP 'knowing the value of the number'. In order to not decrease 'the number' by losing actors, it is of priority to not annoy and/or alienate anyone. As a result, for IOCA, there is a strong emphasis on saving everybody's face at all times and *'rotate the ones who are unhappy'(Interview 1*, p. 8*)* which involves ensuring '*nobody losing big and nobody winning big'* (*Interview 1*, p. 20) in the long run. While there is a strong aspiration among (at least the vast majority) of actors to behave according to this GP by respectful interaction at eye level, this attempt might be forgotten in the heat of the moment during discussions and thus (the realization of) this GP is especially related to and dependent on the mechanism of moderation that is used by chairmen at 3GPP. The realization of the 'no-loser policy' is the chairman's primary responsibility, and involves ensuring interaction, communication, and the building of consensus in accordance/compliance with this GP. As such, they will guide and lead official discussions in such a way that no one is shown up or offended in disputes and that especially less successful parties have the chance to speak up and catch some concessions. In addition, the chairman will present decisions in a positive way in which especially the less successful parties' wins are highlighted.

Secondary mechanisms of collaboration

d. Mechanism of corporate IOCS culture

The mechanism of corporate IOCS culture defines common behavioural and interactional patterns and standards and is thus strongly interrelated to the GPs. Behavioural patterns are essential as an orientation guide for individual behaviour and (inter-)action but also, and in particular, for the interpretation, prediction, and predictability of fellow actors' behaviour. Because (un-)predictability is the main criterion for relational risk in IOC, the mechanism of corporate IOCS culture is a primary means for the reduction of relational risk. By enhancing the predictability of the actions of fellow actors, the mechanism of corporate IOCS culture essentially contributes to the foundation of a basis and common ground to conduct IOCA at all. In daily IOCA, the mechanism of corporate IOCS culture facilitates all (processes of) IOCA and in a particular interaction. The concerted framework (inter-)action pattern allows for conducting IOCA effectively and efficiently, because behaviour in accordance with the corporate culture may be taken for granted. The mechanism of corporate IOCS culture is also the source for the development of a *Wir-Gefühl* (feeling of unity) which is pivotal in a voluntary IOCS like 3GPP to generate commitment and dedication to IOC(A) and thus an intrinsic motivation among the delegates to contribute and actively participate in IOCA. With special regard to the highly established and deep-seated corporate IOCS culture at 3GPP, interviewees emphasise their resulting trust in the resilience and robustness of 3GPP to deal with singular actor deviances and malpractices without a lasting negative impact on the IOCS.

e. Mechanism of informal exchange

The mechanism of informal exchange describes the entirety of exchange around IOCA which takes place outside of official meetings. It thus refers to typical socialising while 'taking a beer or coffee' during breaks or evenings but also to all *'necessary conversations, discussions and problem-solving processes which take place outside of the official meeting of a working group'* (free translation of *Interview 4*, p. 10). An interviewee's metaphor for the mechanism of informal exchange as oil which makes rusty interaction and IOCA smooth depicts that this mechanism affects IOCA in its entirety (*Interview 2*, p. 13). However, most importantly, it facilitates and promotes IOCA by contributing to and enabling the development of (1) personal relationships, (2) mutual understanding, and (3) creative solutions which are primarily developed in or based on informal exchange and discussions. In addition, by providing short, unofficial channels for action, discussions, and problem solving, the mechanism of informal exchange makes IOCA much more efficient.

f. Mechanism of the critical mass

The mechanism of the critical mass refers to the fact that IOCA at 3GPP is all about playing the numbers game, which is de rigour for an actor's individual success at 3GPP, but also for the success of the 3GPP itself, because it determines IOCA progress and provides the basis for the development of a concerted, roundly accepted, and supported IOC(a) outcome. Practically, playing the numbers game means coalescing in order to build momentum in the form of a majority for a proposed solution. In consequence, allying is the only way for actors at 3GPP to achieve success and for the progress of IOCA, which requires convincing fellow players of the excellence and advantages of their own solution, but also revealing true objectives and motives through an informal exchange to make concessions and find compromises. Because the vote of each actor in the numbers game has the same weight for the development of the critical mass regardless of the actor's (economic) means of market power, the mechanism of the critical mass is largely responsible for the development of a level playing field at 3GPP. In addition, compromising is conducive to the attainment of objectives for small players who are often just interested in one aspect of a technological solution and can in consequence easily make concessions on and give support to issues beyond their interest. Another significant contribution of the mechanism of the critical mass to IOCA is the resulting robustness and resilience which is generated by the mechanism of the critical mass in big IOCSs like 3GPP. This is because the abuse of the mechanism of the critical – meaning the manipulation of the required number of actors to build critical mass – becomes increasingly difficult and eventually impossible as the number of actors increases. Finally, the necessity to convince others of the technological excellence of a solution and/or the joint development of technological compromises, guarantees and provides for the peer review and expert discussions which are requisite – although time-consuming – for the exploitation of the potential of expert pooling in IOC and resulting in superior creativity and out of the box thinking.

g. Mechanism of political capital

The mechanism of political capital is directly deduced from the fact that allying is the only way to success at 3GPP. In consequence, the most valuable – and in fact, even the only – asset which an actor at 3GPP may possess with regard to success and power at 3GPP is political capital. Political capital is thus an actor's key to success in IOC. It can best be described as the reputation of an actor within the IOCS which is achieved—besides active contribution to IOC(A) in the form of technical expertise and/or user requirements—by behaving and acting in accordance with the corporate IOCS culture and concomitant codes of ethics and conduct. This reputation is built by repeated conform (inter-)action and can be jeopardized and/or impaired by a single incidence of deviant behaviour. That makes an actor's win at 3GPP that is achieved by malpractice disadvantageous below the line, regardless of the size of this win. As a result, the mechanism of political capital at 3GPP makes actors behave predictably, namely in accordance with the codes of conduct and ethics at 3GPP and its concomitant behavioural pattern. It describes the self-discipline and motivation of actors concerning their conforming behaviour and (inter-)action, which replaces means of penalty or coercive power in IOCA at 3GPP. The mechanism of political capital thus mainly contributes to IOCA as a primary means to reduce the relational risk at 3GPP and as a definite self-disciplinary measure to never prioritize today's win at the cost of a burned reputation in the long run, which will in any case be disadvantageous

h. Mechanism of progress

The mechanism of progress refers to the mindset, aspiration, and (intrinsic) motivation of the vast majority of actors at 3GPP to meet deadlines and deliver results on time. It is an attitude which greatly affects and determines the cooperative and constructive behaviour of all actors because the mechanism of progress is concomitant with high expectations for fellow actors to support progress at 3GPP with their behaviour. As a result, at 3GPP progress-stopping actions both at relational and group levels are highly condemned and rigorously disfavoured by fellow actors.

6.2.2 3GPP's IOC-context for IOCA

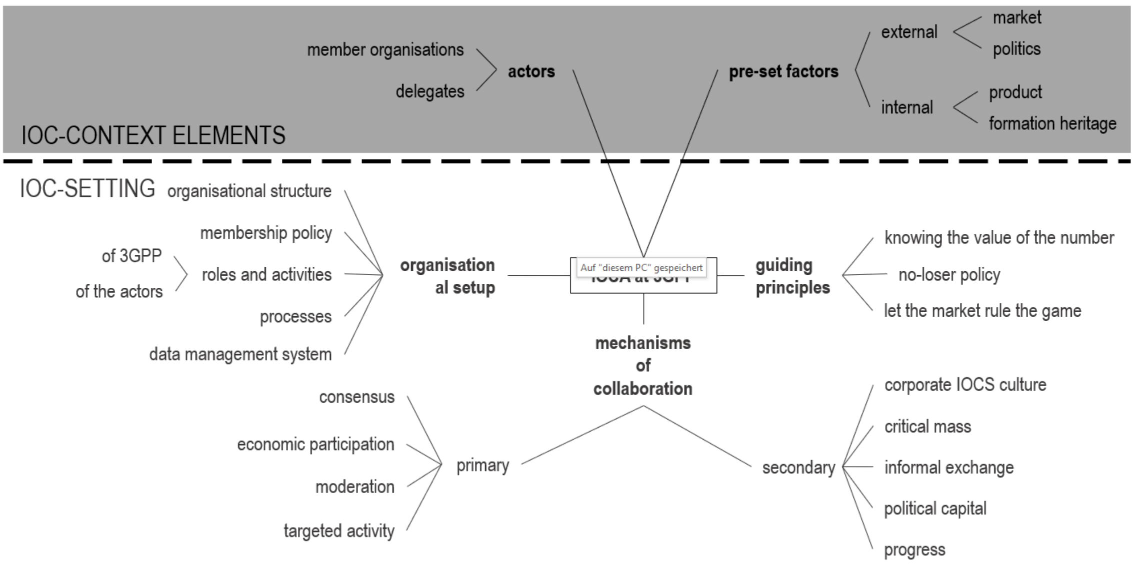

Figure 33: Overview of IOC-context elements based on the selective coding concepts (Figure 28)

Based on the IOC-context parameters found in selective coding (see Figure 33) and the secondary data on 3GPP (see Appendix D.1.1), 3GPP's IOC-context for IOCA can be described. The actors at 3GPP are the most pivotal IOC-context elements because they predominantly determine the relations, interactions, and sociocultural dynamics of and within the IOCS 3GPP. In addition, there are pre-set elements on both the internal and external levels. While both cannot be influenced, external influences originate from the IOCS's environment, while internal factors are system inherent and thus determine rather unchangeable IOCS attributes and/or assets. In the following, the three system concepts introduced in Chapter 4.2 are used to synthesize these contextual findings to depict the IOC-context for IOCA at 3GPP.

6.2.2.1 Functional system analysis

When using the functional system concept for interpreting the findings, a 'black box' perspective is taken to reveal what the ICOS 3GPP does, or more concretely, to define its function and the main inputs and outputs. As shown in Appendix D.1.1, the function of 3GPP is defined by 3GPP as 'the maintenance and development of the Technical Specifications and Technical Reports for evolved 3GPP technologies, beyond 3G' (3GPP, no date). More concretely, the function of the IOCS 3GPP can be specified as the development of concerted – and thus consensus-based – specifications for global standards for wireless mobile communication (main function). Using the perspective on IOC provided by the theoretical framework of this research (see Chapters 4.1 and 4.3) for closer analysis of the findings, the following subfunctions can be deduced: to achieve the main function, the IOCS 3GPP aims to attract all relevant actors (sub-function 1), to provide the basis for IOC by reducing perceived relational risk (sub-function 2), to generate institutional trust (sub-function 3), and to provide a setting for efficient and effective collaboration and achievement of objectives (sub-function 4). According to the findings presented in Appendix D, the main inputs can be defined both with regard to the actors and the system. The IOCS 3GPP provides (1) a framework of processes, working routines, and corporate habits and culture, which allows it to conduct its defined function, and (2) the reputation which is necessary to recruit and retain all actors who are required to conduct the function on a global scale. The actors (see Appendix D.2) generally contribute with their cooperativeness and engagement to develop and find a concerted solution. Additionally, depending on their industrial background, the representatives of traditional ICT organisations provide their knowledge and expertise for the development of technical solutions, while vertical delegates mainly contribute user demands and perspectives for the requirement definition.

In accordance with the main function of IOCS 3GPP, its primary output, the product, are specifications, which de facto are standards, for wireless mobile communication in the physical form of protocols. This discloses that IOC at 3GPP is not about the physical and factual production and realization of products, which remains the responsibility of organisations within and outside of the IOCS. Instead, it is about content and the definition of a framework for concerted technological action and trends in the market of wireless mobile communication. Since the product of 3GPP is specifications but not yet profitable products, a strong profit-investment gradient arises among the actors which means that while some actors carry the burden and investment of developing a technological framework, it is other actors who make a profit in the market by selling end products.

According to the findings in Appendix D.6.2.1, the IOCS 3GPP is affected by the following characteristics of the end products that are based on 3GPP's specifications:

a. wide range of applications and users,

b. strong network effects,

c. high technological complexity,

d. high R&D effort,

e. systemic (I) and cumulative (II) nature, especially with regard to innovations.

Because of the characteristics (a.), (c.), (d.), and (e.), both standard and product development require the interaction, support, and expertise of diverse actors from different domains. Furthermore, a large number of players are attracted to the development of such products to participate in economic advantages (characteristic (a.), (b.), and (e.I)). Because of characteristics (b.) and (d.), horizontal collaboration is common, which includes cooperation among competing entities.

6.2.2.2 Structural system analysis

With the structural system analysis, the inner structure of the IOCS 3GPP and its composition is examined. The focus of this section is on the disclosure of the main attributes and the characterisation of the boundary of 3GPP as well as the definition of main actor groups and their relations. Because the institutions define the setting and not the IOC-context for IOCA at 3GPP and have already been revealed and discussed in detail in Chapter 6.2.1.2, institutions are not considered in this structural system analysis. The detailed interrelation analysis is provided in the subsequent Chapter 6.2.3.

Characteristics of the IOCS 3GPP

In this section, the IOCS 3GPP's boundary and most distinguishing characteristics are elaborated.

- Boundary

According to Appendix D.1.1, the boundary of the IOCS 3GPP is characterised by its openness which allows free access and exit for all members of one of the 3GPP Organisational Partners and can thus best be described as being permeable in both ways.

- Attributes

The IOC-context element 'formation heritage' can be regarded as an attribute of the IOCS 3GPP. The 'formation heritage' describes the persistence of once established habits or procedures to change. It refers to the 'power of the first hour' which means that it is relatively easy to first implement institutions in an IOCS but requires a great deal of effort to change them. At 3GPP, the document management system is a good example of a less efficient yet established element, while the patent- and FRAND-based system of economic participation at 3GPP is an effective and successful heritage, which is not likely to be eliminated although increasing numbers of actors of less patent-affine sectors join the IOCS 3GPP. These examples show that the formation heritage may positively and negatively affect how IOCA is conducted but, in either case, can hardly be changed.

In addition, the following main attributes of the IOCS 3GPP can be derived from the case study findings, which are each discussed in more detail below. The IOCS 3GPP is a highly competitive yet voluntary IOCS, in which the 'social pathway' strongly determines IOCA and the IOC outcome. It is a large, highly diverse, and dynamic IOCS with regard to actor composition. The high continuity of delegates and the strong patent affinity which becomes visible in the chosen concept of IPR-based economic participation are found to be distinguishing factors for the IOCS 3GPP.

  – *Dynamic actor composition*

In line with the expansion of mobile communication into nearly all areas of life, society, and technology (see Appendices D.6.1.1 and D.6.2.1), 3GPP has experienced a tremendous development of its actor composition concerning both the size and diversity of backgrounds, incentives, and demands which is accompanied by altering informal power distribution. As a result, in 2021 the IOCS 3GPP counts over 770 actors. Newcomers both come from the ICT sector and application domains. The latter are referred to as verticals which represent the market and user demands of various fields of application reaching from public health services to satellite industries. By entering 3GPP, all newcomers directly affect the power distribution, because the critical mass both grows in size and diversity. As a result, the relative power of a single vote decreases, and the number of possible alliances increases, especially due to the higher diversity of demands and motives. In addition, the high diversity and dynamics of the actor composition cause the relational risk to be high while the relational trust is expected to be low at the beginning.

– *Openness*

Openness refers to the rather unrestricted access and exit policy of 3GPP: all members of one of the seven Organisational Partners of 3GPP[30], namely regional standardization bodies from Asia, Europe, and North America, are allowed to join 3GPP and there are no mechanisms installed to exclude actors (see Appendix D.1.1). As a result, the boundary of the IOCS 3GPP can be described as rather permeable in both directions. Such a boundary does not provide a basis for coercive power. Instead, the IOCS has to ensure its attractiveness to encourage actors with unique resources and capabilities to join and has no grounds to exert coercive power. Actors have no influence on the partners with whom they have to collaborate at 3GPP, which generally implies high relational risk. The attractiveness of joining 3GPP is primarily the result of the network effects of end products in mobile communication and the economic incentives to participate in and benefit from a highly profitable, growing market like mobile communication both directly and indirectly (meaning by intellectual property and licensing agreements which especially in cumulative innovation paradigms eventually pay off). However, apart from the economic advantages, what encourages actors to stay at 3GPP is the constructive and efficient way of conducting IOCA and the outcome-oriented respectful atmosphere at 3GPP which eventually leads to sustained successful outcomes.

– *Voluntariness*

Voluntariness at 3GPP both refers to the organisations' voluntariness to enter 3GPP (see the previous point 'openness' and Appendix D.2.1) and to the member organisations and delegates' voluntariness to actively participate in the IOC process and to contribute to the development of a solution (see Appendices D.2.1 and D.2.2). This is why the IOCS has to motivate its actors, meaning both organisations and their delegates) for participation by extrinsic and intrinsic means of motivation. Extrinsic motivation at 3GPP is caused by efficient working procedures and activities which are strongly focused on the common goal and problem solution to provide a setting in which actors may pursue their individual objectives. The intrinsic commitment of delegates to 3GPP is supported for example by providing opportunities to socialise, creating a positive atmosphere of IOC at eye level, and by emphasising fair codes of conduct and practice.

– *Coopetition*

At 3GPP, coopetition refers to two aspects. First, there are entities in the IOC that are competitors in the market but collaborate at 3GPP. This is in line with the general definition of coopetition. As a result, such IOC is generally defined by a high (perceived) relational risk and low relational trust. But coopetition also exists in the IOCS with regard to the different – partially conflicting, partially compatible – objectives and demands, that

[30] See 3GPP, no date

are the basis for allying and the development of a critical mass. Actors with compatible objectives cooperate, while actors with competing objectives and demands compete with regard to a certain decision or solution. In this way, alliances are predominantly built on arguments and common objectives but not directed by personal relationships, which makes it easier for less networked actors to pursue their objectives.

– *'Social pathway'*

As described in the preceding sub-chapter (Chapter 6.2.1.1) on the bipartite path of IOCA, the 'social pathway' describes the significance of social processes for IOCA. As such, a social pathway is not a specific characteristic of IOCA at 3GPP, but a general attribute of IOC or at least voluntary IOC as it is considered in this thesis (see Chapter 4.1). In the case study, it becomes obvious that it is perceived by the interviewees as a critical element of the IOCA's outcome and success and that its handling and governance are the primary focus of IOC management and institutions.

– *Continuity of delegates*

The continuity of delegates is a specific attribute of 3GPP and the main countermeasure for relational risk and the stability and robustness of the IOCS 3GPP. There is a core of delegates who have repeatedly interacted for years or even decades in 3GPP, while delegates have sometimes even represented different organisations over time which has several effects on the IOCS. Firstly, they have developed a common interpretation of all institutions, procedures, guidelines, and codes of conduct and practice at 3GPP, which they defend and exemplify through their behaviour and action. By doing so, they provide a valuable orientation for newcomers and direct their behaviour. They can be regarded as the 'compass of conduct', which provides stability and robustness. Additionally, they share a high level of relational and institutional trust based on the repeated interaction and experience in the IOCS. The (perceived) relational risk among these actors is very low. This is a unique feature which greatly influences the effects of institutions at 3GPP.

(Groups of) actors at 3GPP

Actor (groups) may refer both to organisations and delegates as individual persons that share similar characteristics. As shown in Appendix D.2.2, it is the delegates who conduct IOCA. However, a closer look at the actor composition on the organisation level is also required to reveal and elaborate on the relationships and dynamics within 3GPP. As a matter of fact, the number of actor (groups) at 3GPP is large and each actor (group) contributes to and influences the IOC process. Thus, in the following, only the most relevant and distinguishing actors with regard to IOCA and its IOC-context are considered.

– *Compass delegates*

This actor group describes the group of delegates (individuals, not organisations) who share a long common history of IOCA and thus repeated interaction at 3GPP and have, as a result, developed a common interpretation of 3GPP's codes of conduct and practice. They have a high level of institutional trust and high relational trust concerning their interrelation. Furthermore, they are also an example and compass for the right interpretation of codes of conduct and practice for newcomers or malefactors. As they are a major group, they ensure the stability and robustness of 3GPP but may at the same time inhibit changes.

– *Verticals*

Verticals in the IOCS 3GPP are a type of organisational actor that is characterised by (1) representing[31] a group of technology appliers from other markets than the ICT sector, (2) representing niche markets and their demands, and (3) being relatively new to the IOCS 3GPP. They generally have little common history and are not in economic competition with other actors in the IOCS. As ICT users, they do not provide or develop technological solutions for a problem but provide business cases and requirements that enrich and complement the development and consensus processes. In this way, they may contribute to the development of a less competitive atmosphere and the objective evaluation of competing solutions. In an IOCS with many and diverse actors, objectives, and possibilities to ally, their vote may be decisive for the development of the critical mass, which is how verticals can obtain concessions to pursue their objectives although they generally possess rather little means of influence due to the small scales in niche markets.

– *ICT market competitors*

At the other end of the organisations' actor groups with regard to coopetition, there is the group of actors that has the same target market and core business: their economic and market success directly depends on the implementation of their promoted solution which requires them to outrival their competitors' solution. As a result, their relationship is generally highly competitive due to rivalry with regard to both IOC objectives (IOCS internal) and market share (IOCS external).

– *Actors under national political influence*

Organisations and their delegates whose activity is influenced by political directives always have to be considered separately. Regardless of whether a whole group of organisations, a single organisation or certain delegates are influenced this actor (group) will not be able to behave in line with the codes of conduct and practice and thus severely enhance the relational risk. This may cause annoyance, imbalances (if a whole actor group is affected), and a shift away from the objective, demand-driven allying towards emotion-driven or politically enforced block building which is a threat to the IOC process and (the quality of) the outcome.

Relationships at 3GPP

To accommodate for the complexity of interrelations at 3GPP, Chapter 6.2.3 is dedicated to the detailed interrelation analysis of the IOCS 3GPP including both elements of the IOC-context and the setting.

6.2.2.3 Hierarchical system concept

By means of the hierarchical system concept, the influences of sub- and supra-systems can be identified and described. At 3GPP, only supra-system influences were perceived as critical for the IOC processes and outcomes by the interviewees, while sub-system influences (like for example the effect of an organisation's strategy) were not discussed. Politics and market development appear to be the most influential factors for the IOC

[31] Frequently, players of one application domain or with equal demands concerning wireless mobile communication technology unite as an MRP which fulfils the requirements to join one of the 3GPP Organisational Partners and by which the common objectives, demands, and requirements are conjointly (re)presented and pursued. An example is the European Broadcasting Union (EBU), which represents organisations from public service media worldwide.

processes at 3GPP. With regard to political influences, the delegates feel little affected by regulatory interference at a system level, which potentially is a significant political means of influence at the system level. An explanation could be the high level of societal, economic, and consequently political interest in ICT solutions which may be accompanied by mutual harmonization of legislative and IOCS action. On the other hand, most interviewees evaluate political interference which is directed at single actor (groups) as affecting and in some cases as the biggest – and existential – threat for 3GPP at the time of interviewing. At 3GPP, mainly two types of political influence at an actor (group) level are found. First, there is the exertion of power by political regimes to influence and direct the economic and IOC action of their economic entities. This directly influences both the behaviour of actors and the functionality of the mechanism of the critical mass. By political enforcement of a certain behaviour or result, political influences may cause the actors of an IOCS to behave against the corporate culture and customs of the IOCS. This negatively influences the atmosphere of collaboration and causes annoyance. As a result, both the relational risk in the IOCS and the political capital of the 'malefactor' is reduced. However, as the example of 3GPP shows, such happenings affect IOCA but do not cause a sustainable negative effect on the IOC process of a well-functioning IOCS if they occur at rare intervals. In contrast, the direct or indirect political exclusion of single (groups of) players from markets which are relevant target markets for the product of 3GPP is assessed as an existential threat for 3GPP. In the long run, IOC will most likely not be able to serve the individual objectives of the excluded actors anymore. Thus, politics can significantly influence the actor composition and the environment of an IOCS as eventually, the political exclusion will result – at least – in the departure of the excluded actors with their expertise, but much more likely in the division of the IOCS and/or the development of competing products. It can be concluded that the robustness of an IOCS may help to overcome political power exertion, while the biggest threat to IOCSs, namely political exclusion, cannot be compensated for by any institutions in the long run.

Besides politics, it is the core market and market changes which perceivably affect IOCA at 3GPP. First, the determining characteristics of the core market, the ICT sector, affect IOCA. As elaborated in Appendix D.5.1.1, the following market characteristics of the ICT sector are most relevant:

a. high patent affinity
b. high structural and technological dynamics
c. significant diversity of actors from different domains and nations
d. very globalised
e. short product life cycles with high innovation rates
f. large economies of scale

With regard to the actors in the IOCS 3GPP, this indicates that actors are likely to have very diverse sectoral and cultural backgrounds with very different incentives for IOC and demands for an 'optimal' solution (characteristics (c) and (d)). There is a high dynamic concerning both the actors that are in the lead and the composition of the actors (characteristic (b)). Because of (e) and (f), IOC is likely to be attractive or even necessary for market participants to stay competitive and successful. Since patents have a long tradition in the ICT sector, they are still a deep-seated element to protect intellectual property in the core market despite its dynamic development and expansion.

The influence of market changes was often not directly pinpointed by interviewees but indicated by their statements concerning the changing actor composition that affects IOCA. It is the numerous new market actors that entered the core ICT market as new business models evolved based on technological progress which caused a shift of power at 3GPP to the disadvantage of the actor group of operators (see Appendix D.5.1). As such, the market development caused a change in the IOC fabric at 3GPP. In addition, it is the rapid and extensive accrual of new business markets in which ICTs are applied that brings a completely new actor group, the verticals, into 3GPP. This development required solutions at the structural level because the new actors significantly varied from mature ICT organisations with regard to their size, economic means, and sales volumes. At 3GPP, this challenge is met by the concept of 'Market Representation Partners (MRPs)'[32] that may join 3GPP. By means of MRPs, verticals with similar demands concerning ICT technology may share the effort of participating in IOC and present concerted requirements. Second, the new actor group of verticals which are not in a market competitive relation to ICT actors and present actual market needs, affect the group dynamics significantly by reducing the competitive atmosphere and presenting facts that may make a given solution preferable or unfeasible.

6.2.2.4 An IOCS model of 3GPP's IOC-context

Combining the findings of the functional, structural, and hierarchical system analysis allows for modelling the IOC-context of IOCA at 3GPP using an IOCS model as shown in Figure 34.

[32] MRPs are 'official' organisations that apply to become participants at 3GPP to provide a consensus view of market requirements for a certain market, industry, or actor group. A prominent example of 3GPP is the '5G Automotive Association' (5G AA), which defines and presents the relevant future needs of the automotive sector at 3GPP.

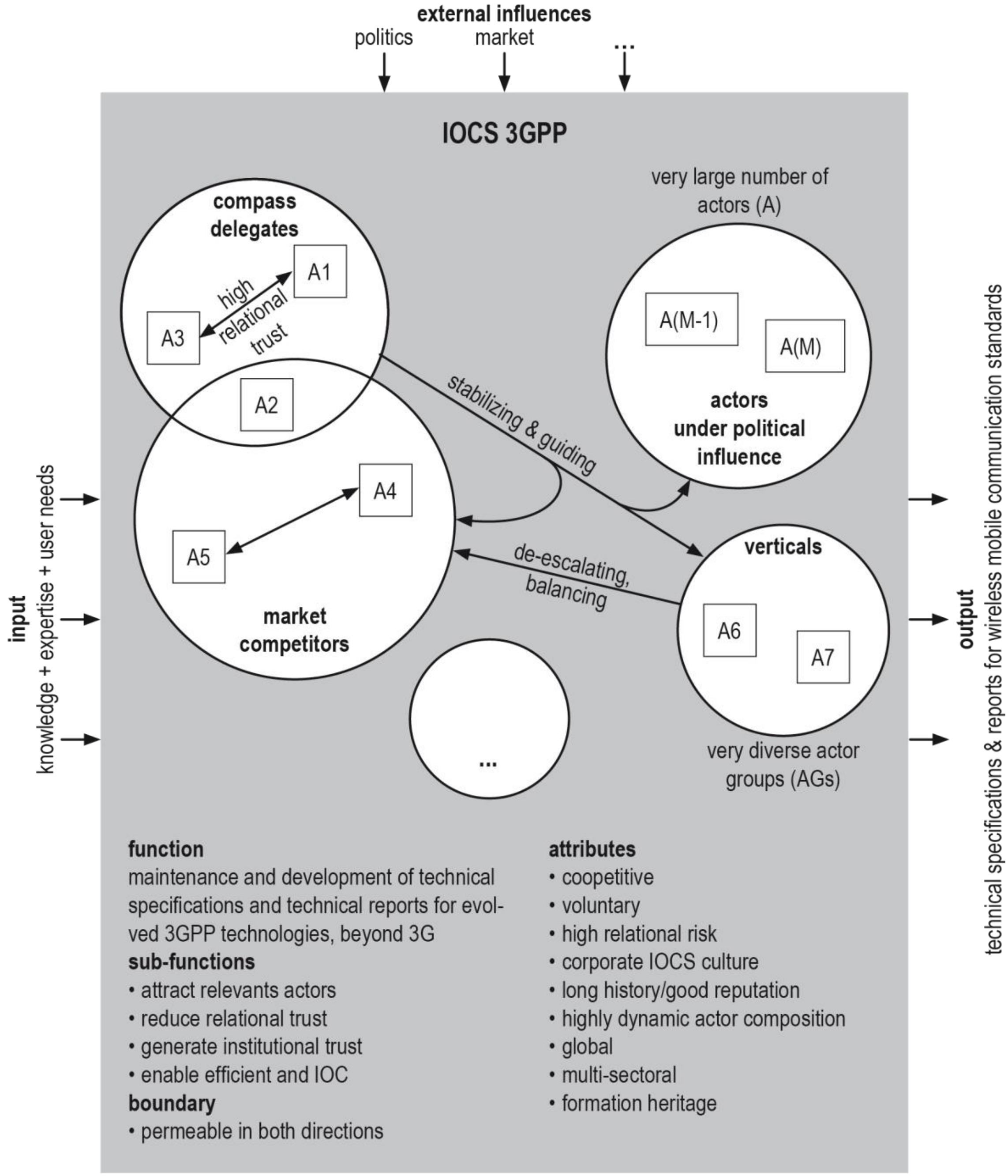

Figure 34: IOCS model of 3GPP's IOC-context for IOCA

6.2.3 The IOCS 3GPP – an interrelation analysis

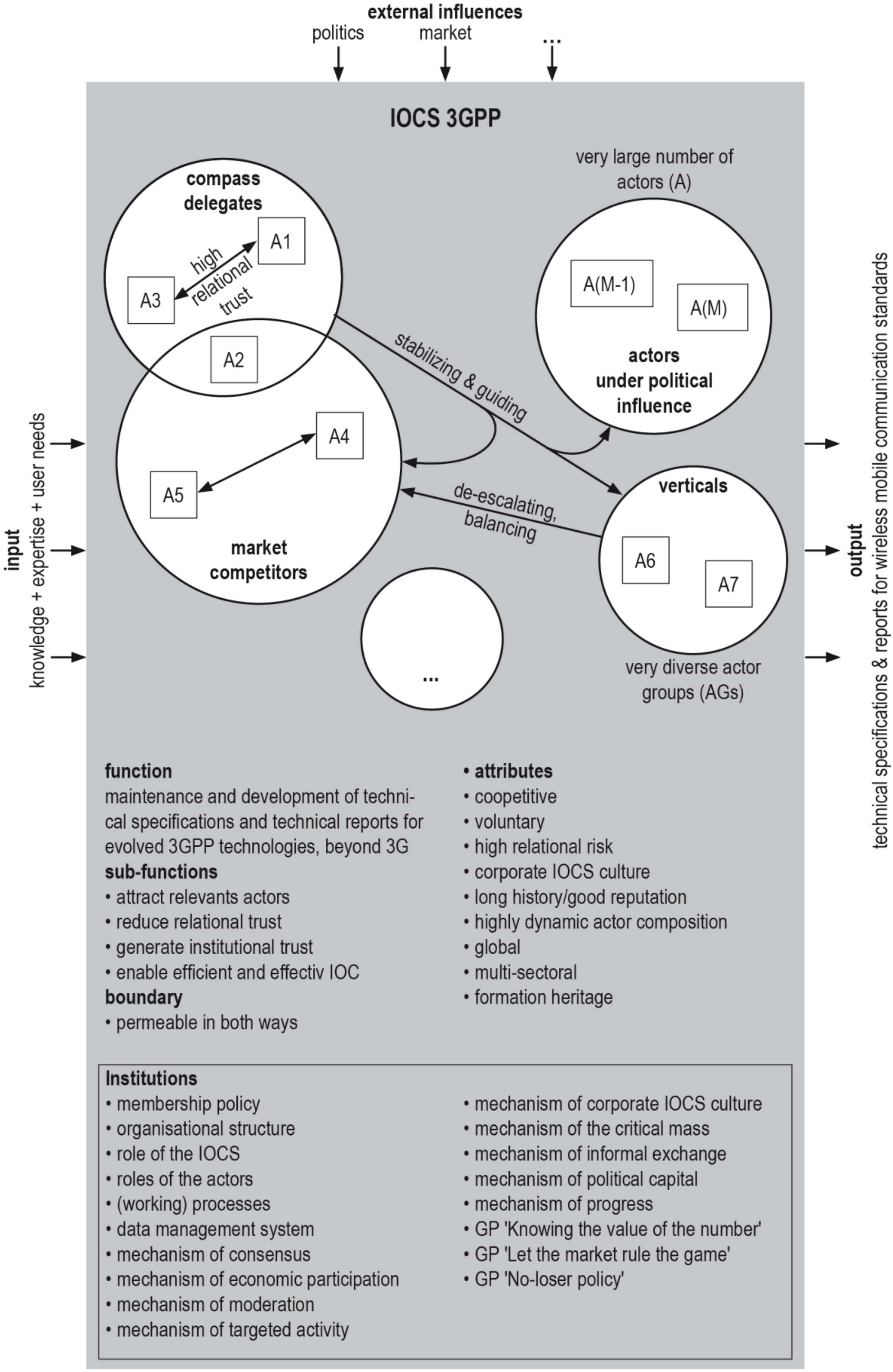

Figure 35: Holistic model of the IOCS 3GPP

By integrating 3GPP’s institutions as a setting for IOCA according to Chapter 6.2.1 into the IOCS IOC-context model in Figure 34 (Chapter 6.2.2.4), the above shown holistic model for the IOCS 3GPP is generated. Based on this model, the perceived interrelations and interdependencies between the characteristics, attributes, components, and external influences of the IOCS 3GPP that were disclosed in the case study analysis, are synthesized. To emphasise that the presented interrelations are based on the findings of the case study and thus on interviewees’ perceptions, and not on objectively measured interrelations, the terminology ‘perceived interrelations’ is used in the following. A symmetric matrix form is chosen for the evaluation, which contains the items presented in Table 2.

Table 2: Matrix items for the symmetric interrelation analysis matrix for the IOCS 3GPP

IOC-context	IOCS elements without institutions	profile	• objective (develop specifications) • function (develop global 'standards') • sub-function 1 (enhance global attractivity) • sub-function 2 (reduce relational risk) • sub-function 3 (cause institutional trust) • sub-function 4 (cause effectiveness and efficiency) • boundary that is permeable in both ways
		attributes	• coopetitive • voluntary • social pathway • large number of actors • high diversity of actors • highly dynamic actor composition • continuity of delegates • patent affinity
		actors	• compass delegates • verticals • market competitors • actors under political influence
	preset influences	internal	• product • formation heritage
		external	• market • politics (here: manipulation)
IOC-setting	institutions	hard institutions	• membership policy • organizational structure • role of the IOCS • roles of the actors • (working) processes • data management system • mechanism of consensus • mechanism of economic participation • mechanism of moderation
		soft institutions	• mechanism of corporate IOCS culture • mechanism of the critical mass • mechanism of informal exchange • mechanism of political capital • mechanism of progress • GP 'Knowing the value of the number' • GP 'Let the market rule the game' • GP 'No-loser policy'

With the holistic model in which both IOC-context and setting elements are integrated, the inter- and intra-group interrelation analysis of the IOCS with regard to the IOC-context and setting 3GPP is rolled into one. As a consequence, in the matrix which is created by plotting the matrix items against each other, four segments can be distinguished as shown in Figure 36. In field A2, the perceived mutual interdependencies of all IOC-context elements and characteristics of the IOCS 3GPP, including the pre-set factors that affect the IOCS 3GPP are analysed. Accordingly, in segment A1, the perceived mutual interdependencies between setting elements, namely the institutions of the IOCS 3GPP, are traced to reveal possible indirect effects. In field B2, the perceived effects of the contextual IOCS elements and characteristics on the IOCS's institutions as IOC-settings are analysed, while in field B1 the perceived influences of the setting elements on the IOC-context elements of the IOCS 3GPP are examined.

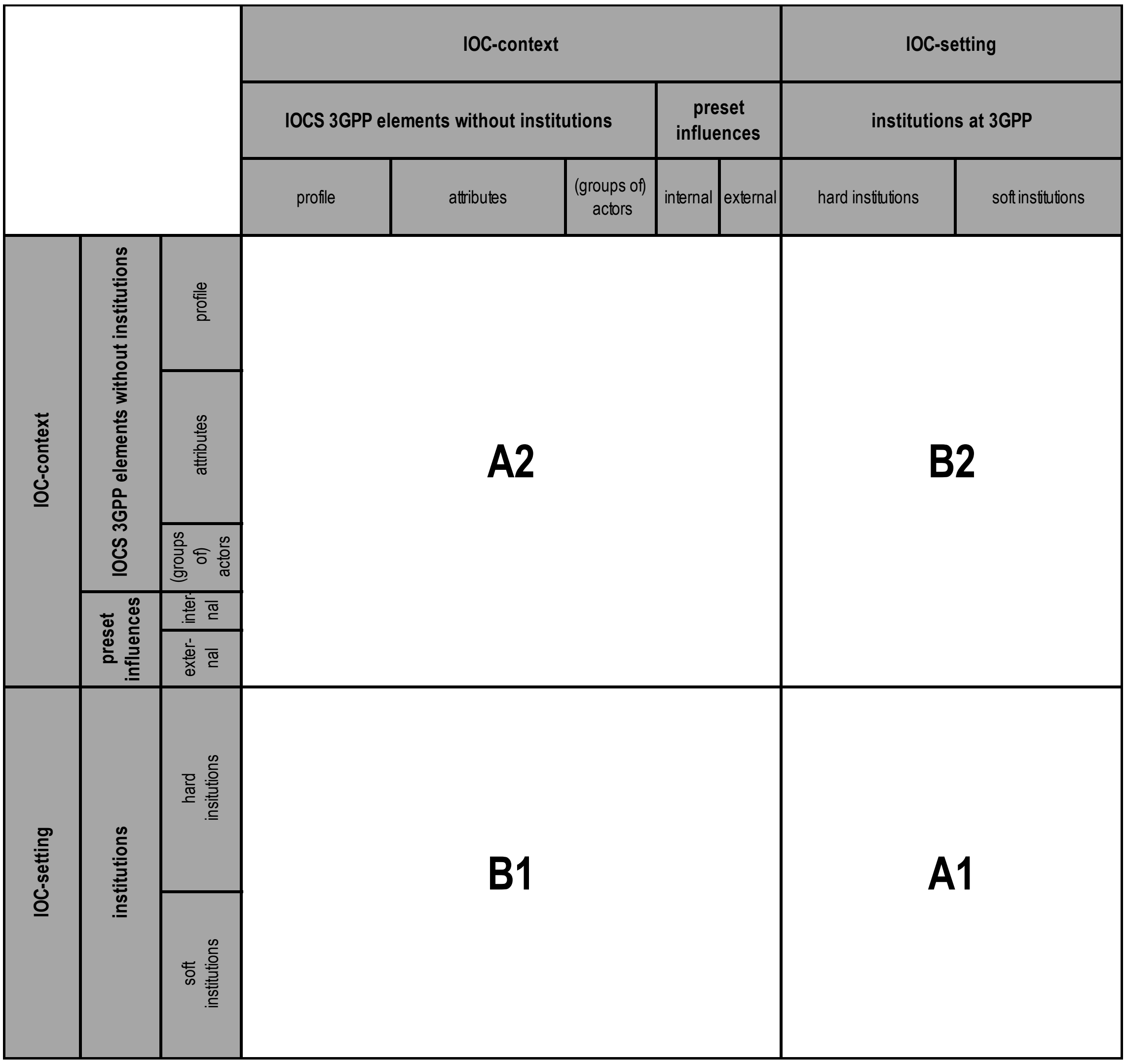

Figure 36: Segment structure of the interrelation matrix of the elements of the IOCS 3GPP

As a result, interdependencies between all elements can be analysed. However, the aim is not to compulsively describe each possible far-fetched relationship. Rather, the aim is to provide an overview and characterisation of the relevant perceived interdependencies concerning other perceived interdependencies as a basis for further use and analysis. In the beginning, a qualitative, non-numerical scaling system from XXX (high influence) over XX (medium influence) to X (low influence) was used to specify the strength of the interdependencies. However, it was found that a merely strength-based characterisation was not specific enough to describe the different types of perceived interrelations and hence the scale for the analysis was advanced by a coding system (see Appendix E), which further classifies the type of relation and influence. For example, it allows for distinguishing between supportive and hindering effects. The resulting evaluation for each segment is shown in detail in Appendix E, Figure 56 to Figure 59.

To identify (1) the most affecting and (2) the most affected elements, the incidences of perceived high interrelation are used as indicators. It is defined that elements and factors that are in a strong interrelation with at least 25% of all other elements are counted as exceedingly affecting or affected. Because of the total of 41 matrix items, each element can be interrelated to 40 other items, which means that all elements with 10 or more counts of high interrelation fulfil the defined criterion. In Figure 60 of Appendix E, all high interrelations are marked in dark grey. By counting the number of incidences in each line, six exceedingly affecting factors are thus identified, which are highlighted in light grey in the item column of the matrix in Figure 60. Accordingly, nine exceedingly affected items are found by counting the high incidences per column, which are shown in grey in the item line of the matrix in Figure 60. The interrelations of the most affecting and most affected elements identified are shown in Figure 61 and Figure 62 respectively.

(1) Most affecting elements in the IOCS 3GPP

A detailed overview of the identified elements with an exceeding effect on other elements is provided in Figure 61. Concerning system characteristics, the boundary that is permeable in both ways of the IOCS 3GPP is found to be the most affecting which indicates that it strongly affects IOC if members may discretionarily decide to enter or exit an IOCS. Closer analysis reveals that the both-way permeable boundary mainly has two effects on IOC. Firstly, actors do not influence the actor composition and, as a result, they have to collaborate with whoever decides to join the IOCS. This is concomitant with high uncertainties, relational risk, and low relational trust. Secondly, the fact that actors may leave the IOCS at any time makes the attractiveness for all relevant players a mandatory requirement to fulfil the objective of developing globally conjoint specifications. This fact greatly influences both the social intercourse and the choice of institutions (no use of coercive power) at 3GPP.

With regard to IOCS attributes, the matrix reveals that the social path that has to be taken in IOC, and the high level of continuity of delegates at 3GPP, which is described to have a strong stabilising and directing effect on actors' behaviour at 3GPP, are perceived as most influencing elements for the IOC processes and outcomes. This indicates that it is the human factor – and more precisely their mode of (inter-)action – more than any other aspects in the IOCS, which are regarded as a decisive factor for IOCA. This is in line with the finding in Chapter 6.2.1.1. This perception is aligned with and substantiated by theoretical findings concerning complexity research in organisations. Ralph Stacey, a pioneer in the complexity science of organisations theory, used the metaphor of a 'body of people' for organisations to epitomize his corresponding notion of an organisation as the interaction of different people towards a common goal (Atzberger, 2021, p. 148).

At the actor (group) level, the only group that is considered to be especially influential for IOCA by the interviewees is the compass delegates, whose stabilising and exemplary function for the IOCS culture and IOCA at 3GPP is emphasised.

At the institutional level, the mechanisms of consensus, moderation, and corporate IOCS culture are evaluated as having the greatest influence on IOCA. It has to be noted that several interviewees highlighted the importance of the organisational setup (see Appendix D.5) as an obligatory basic prerequisite. As such, the interviewees' relative insensitivity towards organisational factors does not indicate their unimportance but rather that the efficient institutions of the organisational setup are beyond the interviewees' focus and conscious perception. The importance of the mechanism of consensus is not surprising, because it was mentioned by most interviewees as the centrepiece of the entire IOCS and the IOCA therein.

Analysing the above-average importance of the mechanism of moderation and the mechanism of corporate IOCS culture with regard to the other mechanisms of collaboration, the relevance of the social path is once more highlighted. The mechanism of IPR-based economic participation is an institution that is of little relevance for the 'battlefield of delegates' and thus the course of IOCA, but more associated with the 'battlefield of organisations' which is consistent with the low perceived relevance for IOCA by the interviewees. All other mechanisms predominantly affect the 'battlefield of the delegates'. However, the mechanisms of progress, informal exchange, political capital, and the critical mass are concerned with the way consensus and solutions may be 'technically' generated as an informal exchange is a means to reveal true incentives and needs as a basis for the development of compromises and/or win-win solutions on a technical level, while the mechanism of progress is the main constituent of the delegates' willingness to compromise and cooperate. Both the mechanism of the critical mass and that of political capital describe means to pursue a solution in the IOCS and thus eventually provide a tool to find consensus. The mechanism of targeted activity determines a lean scope of IOCA with a strong focus on the IOCS's core function. As such, it also does not deal with the social (inter-)action of delegates at 3GPP. On the contrary, the mechanism of moderation is concerned with arbitrating between delegates to guide the course of IOCA and prevent heated debates from getting out of hand. Hence, the mechanism of moderation directly influences the course of IOCA at 3GPP. The mechanism of corporate IOCS culture, on the other hand, influences the mindset, expectations, and behaviour of the delegates and thereby directly impacts the way they (inter-)act and collaborate. It can be stated that the latter two mechanisms, which are perceived as highly affecting for IOC, are both concerned with shaping the social (inter-)action of the actors and reducing (perceived) relational risk by making actor behaviour more predictable and rational.

(2) Most affected elements in the IOCS 3GPP

The overview of the most affected elements in Figure 62 shows that the objective, as well as its sub-function and sub-functions 1 and 2, are perceived to be especially influenced. However, differential analysis is necessary: 3GPP's objective, its function, and the first sub-function of creating global attractivity are predominantly positively affected by the other elements and especially the institutions. This indicates that the IOCS with its attributes, setup, and institutions is strongly and effectively tailored to the IOCS's objective and primary functionality in the perception of the interviewees. This indicates a high IOC-context sensitivity, which is in line with the positive experience and high level of satisfaction of delegates and organisations at 3GPP and the sustained success of the IOCS. With regard to the second sub-function, the reduction of (perceived) relational risk, which mostly is a hindering influence, is detected which substantiates that (perceived) relational risk is a cardinal challenge in IOC, which even remains challenging in a well-established, efficient, and highly successful IOCS. This confirms the approach of this research to focus on (perceived) relational risk to enhance IOCA to positively affect the success rate of IOC projects.

Concerning the IOCS's social pathway attribute, the effects are two-edged as the IOCS and its attributes have a negative effect on the social pathway. This means that they make it more complicated to travel along the social path since the number of problems on the sociocultural and relational levels increases. However, a look at the institutions shows that they effectively counteract this: there is a large number of institutions that strongly positively affect the social pathway. It can thus be concluded that, according to the perception of the interviewees, the challenge of the social pathway, which requires solving socio-cultural and relational issues is successfully faced by the institutions at 3GPP, although the problem of (perceived) relational risk is not equally well controlled.

Concerning the most affected mechanisms of collaboration, it can be shown that according to the perception of the interviewees, the mechanism of consensus, moderation, and corporate IOCS culture is regarded as particularly necessary (highly required) and decisive (highly determining) for IOCA. This may indicate a highly concerted set of institutions, in which the most essential mechanisms are especially supported by other institutions. However, the congruency between these highly affected mechanisms of collaboration and the previously identified highly affecting mechanism of collaboration is striking. Without further investigations, this correlation cannot be thoroughly explained. However, the interpretation of the great affection for these mechanisms of collaboration is not unambiguous: instead of indicating a highly concerted set of institutions, the above-average high counts for these mechanisms of collaboration may simply result from a more conscious perception of influences on those mechanisms which are dominant for their IOCA.

With regard to the GP, the principle of 'knowing the value of the number', which is strongly related to the 'no-loser' policy, is perceived to be significantly influenced by the IOCS. Most importantly, in an IOCS which aims toward the development of one unitary standardized solution, this GP is not a choice but a mandatorily required mindset and attitude for the attainment of the IOCS's objective. This is in line with the significant effect of the IOCS's function to develop global standards and the corresponding subfunction of causing global attractivity. In the case of 3GPP, because the requirement for one globally accepted solution results from the product, which is related to the output of 3GPP, the GP in this special case is strongly triggered by the product itself. The importance of the GP for the IOCS is explicated by the large number of institutions that support the GP and thus indicate a strong alignment of the institutions at 3GPP to this GP.

7 The LD²M

In this chapter, the lead user-centred double diamond method (LD²M) is introduced for the design of an IOC-context-specific IOC-setting by a tailored set of institutions to enhance the baseline for IOCA and IOC. The guiding idea for this design building process is to adopt and adapt established findings in related research areas to solve the research problem at hand. By transferring and combining valuable solutions for similar research problems, a novel approach for the development of IOC-context-specific institutions can be provided. Design thinking as a method is identified as a bedrock of the LD²M because it naturally supports the development of specific solutions for what is needed instead of what is possible by putting the problem space and its users, namely the IOCS, in the focus of problem-solving. Within this primary method, the LD²M faces its main challenge and prerequisite, namely, how to determine the specifics and characteristics of an IOCS, including social and behavioural patterns. In addition, the LD²M also aims to provide a new way to integrate and make use of existing research findings and practices on IOC management which do not conflict with the uniqueness of each IOCS.

The chapter is structured into six sections. First, the requirements that the method has to meet are specified on the basis of the findings from the preceding chapters. In the second section, the relevant components of the method are each theoretically introduced and then adapted to the research context. Based on the customized components, the resulting method is built in the third section and partially tested in a demonstrator version. The chapter closes by presenting and discussing the expert interviews that were conducted to validate the plausibility, integrity, and benefit of the LD²M for practitioners.

7.1 Requirement specification

The requirements for the LD²M are derived from three sources: the research objective, existing IOC research, and the case study findings, mainly from interview set 1. While the research objective of this study implies rather generic requirements, the latter help to specify concrete requirements. Significantly, requirements for a universal method cannot directly be derived from the specific insights which are provided by a case study. However, case study findings may disclose potential pivots which can initiate and guide the course of the literature review and theoretical considerations for requirement specification. As a result of this bipartite procedure, seven requirements – five functional and two non-functional – were defined as constitutive for the LD²M and its purpose in this study, namely the enhancement of IOCA. If they are to assist the enhancement of another aspect or function in the IOC process or the IOCS, the requirements have to be adapted accordingly.

Functional requirements:

- requ (1): Requirement for IOC-context-specific solutions

This requirement is directly deduced from the unique nature of each IOC project and subsequently each corresponding IOCS and can be regarded as the generic overarching requirement as the outcome of the LD²M has to be a set of institutions that is directly tailored to the specific IOC-context of the IOCS under consideration. To fulfil this requirement, several subordinated requirements are derived. This need for IOC-context-specific solutions is substantiated by the findings from the case study – and especially the second interview set – which pinpoints that the (sets of) institutions vary significantly between different successful IOCSs depending on their individual composition and characteristics.

- requ (2): Requirement for reducing perceived relational risk

The case study highlights the importance of the 'social pathway' for successful IOC, which one interviewee describes as being equally important to the technical work (see Appendix D.2.2 and *Interview 8*, p. 4). This is in line with IOC research, which undisputedly regards relational processes in IOC as a key factor for both the specifics of IOC and its unique (management) challenges. Das and Teng's (1998; 2001) concept of relational risk describes the uncertainty in IOC that accompanies partner interaction (see Chapter 4.3). According to this theory, a reduction of perceived relational risk results in better, enhanced IOC processes and IOCA which is in line with the purpose of the LD²M. A reduction of perceived relational risk can thus be defined as a requirement to attain its objective.

- requ (3): Requirement for using insider knowledge including
  - identification
  - explication

Based on the key role of relational risk and social interaction among partners for IOC processes and outcomes stated under requirement (2), a main task of the LD²M is to identify and integrate appropriate sources of knowledge for the disclosure of social processes and relational habits/customs and as a basis for the development of IOC-context-specific institutions. Other than economic facts, knowledge concerning social and relational aspects within an IOCS cannot sufficiently be disclosed by external analysis. Insider knowledge is thus regarded as the best source for the development of a substantiated knowledge of the IOCS and especially its social processes. The case study points out that there is a relevant number of actors in the IOCS who have the required deep knowledge and understanding of the IOC process and underlying social and behavioural patterns. However, the use of insider knowledge as a knowledge source is concomitant with two challenges. First, there is the identification of suitable 'knowledge carriers', which refers to the identification of actors in the IOCS whose knowledge on this topic is expected to be particularly fruitful and productive both in terms of quantity and quality. Second, this knowledge has to be explicated because the knowledge is still inherent in the actor whose aim is generally to conduct and not to analyse IOC and/or IOCA. In addition, the topic itself comprises 'soft' aspects which are often not obvious and/or unconsciously perceived. As a result, it has to be expected that the relevant knowledge is partially or even mostly implicit and requires active explication to become useable in the LD²M.

- requ (4): Requirement for creating a positive total

This requirement is derived from the interrelation and synergic effects of institutions (see Chapter 4.3.5). This finding from the research is in accordance with the interviewees' notion that a good IOC process cannot be attributed to certain institutions but is created by a balanced interplay of all institutions. As a result, the impact of an institution cannot be analysed in isolation, but only in the context of the entire set of institutions, the time of analysis, and the IOCS in which institutions are installed, but this is not the focus of this requirement). Therefore, this requirement defines the (contribution to) the positive total as a decisive assessment factor for the institutional evaluation: it is not the (expected) effect of a single institution which decides on its suitability, but its contribution to the positive total as a component of a specific set of institutions which implies two things. First, the LD²M should promote the identification and consideration of institutions that are unorthodox and/or do not seem promising in isolation but have the potential to develop a positive effect in the interplay with other institutions. In addition, the LD²M has to provide a means to assess the expected impact of a whole set of institutions. This requirement is substantiated by the findings from the case study's second interview set which pinpoints that very different (sets of) institutions can create a good environment for IOC.

- requ (5): Requirement for creating progress and improvement

This requirement defines the outcome of the LD²M as a set of institutions which enhances the IOC process and promotes its progress, but not a perfect or best solution in particular. The requirement is derived from the purpose that the set of institutions resulting from LD²M is supposed to serve, namely the development of an improved baseline for IOC(A). However, a clear, universal definition of an 'improved baseline for IOC(A)' especially by means of objective – and best measurable – determinants or performance indicators, is difficult to find because IOC and IOCA are complex social phenomena, whose multi-faceted nature provides a multitude of different (sets of) aspects, functions, and features that the definition of the best solution could refer to. In addition, their total quality is not ensured by or cannot be reduced to the fulfilment of some performance criteria. Instead, there are various obvious and unobvious ways – meaning combinations of adjusted IOCS elements and characteristics – which are all suitable to improve IOC(A). However, one best way cannot be defined. As a result, this requirement does not just define the objective of the LD²M but also implies the need for an appropriate termination criterion for the LD²M process as there is no certain threshold that can be defined as an abort criterion. The process rather terminates if the LD²M-user determines that what is developed by the institution will create 'sufficient' progress and improvement to the IOC process.

- requ (6): Requirement for time- and cost-efficiency

This requirement is a non-functional requirement which is defined in the light of the IOCSs in the scope of this study which are voluntary associations for the joint solution of a common problem (see Chapter 4.1). The resources remain in the actors' responsibility and under their control and there is generally no umbrella organisation with relevant (financial and human) resources. This is why all IOC(A) – including the application of the LD²M – requires actors' voluntary appropriation of resources. Resources for activities that are not directly directed to the problem-solving process of an IOCS are thus generally assumed to be limited. The improvement of the IOC process by an adjusted set of institutions is such a kind of activity and this is why the LD²M is more likely realized and applied in IOCSs if it does not require many resources. This requirement is substantiated by findings from the case study's second interview set which clearly reveals the dynamics in IOCSs. This indicates the need to frequently review and adjust the installed set of institutions in the light of alterations in the IOCS and thus to repeatedly apply the LD²M.

- requ (7): Requirement for intuitive use

This non-functional requirement is in line with requ (6) and the case study finding that delegates tend to be highly engaged and have their hands full with diverse tasks and responsibilities both in their delegating organisation and in one or more IOCS(s). As the actors – meaning the delegates – in an IOCS are regarded as the main target group for the LD²M, the design must take the limited available capacity for LD²M application into account. By providing a design which allows rather intuitive application without further prior experience, knowledge, and/or familiarization, the attractiveness and thus the likelihood of the application of the LD²M is enhanced.

7.2 Design Thinking in the LD²M

7.2.1 How to create choices – means for divergent thinking

7.2.1.1 Lead user method in the LD²M

A key prerequisite for the LD²M is a detailed analysis of the IOC-context and its specifics, especially at the social and cultural levels. This is why the identification of suitable knowledge sources that have the necessary insider and expert knowledge is a pivotal element of the method and is essential for its success. The lead user method, which was already introduced and allied for sample selection in the case study, is a promising approach for both efficiently identifying high-quality knowledge sources and suitable users for the LD²M.

In line with Schmidt (2019, p. 57, see Appendix F.1.2), the lead user method for the LD²M is adapted as follows:

> In the **lead user method of the LD²M**,
>
> - the *product* or artefact to be developed is defined as the IOC-setting and thus the set of institutions for the IOCS under consideration
> - the *market* is defined as the generally available knowledge related to IOC and the IOC-setting
> - *lead users* are cutting-edge actors in the IOC-setting.

The definition of the product as a ‘set of institutions’ – and not for example as IOCS – highlights two important facts. First, the users of the product are the actors (individuals and/or organisations) in the IOCS. Second, while all actors are interested in the IOCS as a vehicle to pursue their individual objectives, some actors are more interested in the actual process of IOC than others: actors have very different needs and motives to participate in IOC. With regard to both IOC and IOCA, they result in intrinsic or extrinsic motivation as needs that are satisfied by the outcome or product of the collaboration process provide extrinsic motivation for IOC. Such actors see IOC as the means to an end. The needs of intrinsically motivated actors concerning IOC are satisfied by the IOC process itself. Intrinsic motivation is linked to the ambition for improvement and competence which is why actors who are intrinsically motivated with regard to the IOC process are the focus of this method. A functioning IOC process is of interest to all actors because it is an essential aspect of success and a good outcome. However, only intrinsically motivated actors concerning the IOC process have an extraordinarily high level of interest to improve institutions to satisfy their needs and thirst for improvement of the IOC process. Additionally, their desire for competence in the field of IOC will generally result in high levels of experience and knowledge, often based on insights into several IOC-settings. Due to their personal interest in IOC, their knowledge may often be explicated to a high degree. As a result, the lead user in the LD²M can be characterised as follows:

Characteristics of **lead users in the LD²M**:

Lead users are characterised by their

(1) intrinsic motivation concerning the IOC process,

(2) extraordinarily high need for and interest in an improved set of institutions,

(3) comprehensive knowledge and experience concerning potential solutions, IOC, and the specific IOCS, and ideally

(4) good reputation in the IOC community.

The fourth characteristic is not a hard criterion, but it became obvious in the case study that users with the lead user characteristics (1) to (3) outlined above tend to enjoy a good reputation among all interview partners because of their mediating, outcome-oriented, and constructive role in the IOC-setting, which positively affects the IOC process. Their integration into the LD²M may support a greater acceptance of the LD²M's result among the actors of the IOCS. For this reason, (4) is a beneficial criterium to facilitate the practical implementation of the set of institutions that are designed with the LD²M.

7.2.1.2 Analogy reasoning in the LD²M

In the LD²M, reason by analogy is applied as a primary means of idea generation in the divergent 'develop' phase in the solution space, because it encourages a reflected analysis and evaluation of existing solutions in other IOCSs (referred to as the base domain) to the own IOCS (referred to as the target domain, for details see Appendix F.1.3). This technique is suggested for the LD²M because past and current IOC projects provide a multitude of different institutions and ways to conduct IOC – both successfully and unsuccessfully. However, generalised conclusions on the conduciveness of an institution to successful IOC(A) cannot be drawn because the effect of an institution is both influenced by the other implemented institutions and the IOC-context. This does not make successful institutions worthless for other settings, it just demands appropriate handling: Designs of other IOC-settings and the performance of the corresponding IOCSs provide a valuable 'source of inspiration' which assists the identification, adaption, and development of suitable (sets of) institutions for the IOC-setting in the target domain and additionally to evaluate the expected effects. With regard to the information on IOCSs in the base domain, data may be classified according to four types, namely primary and secondary data on institutions, which each may or may not provide (detailed) IOC-context information (see Figure 37).

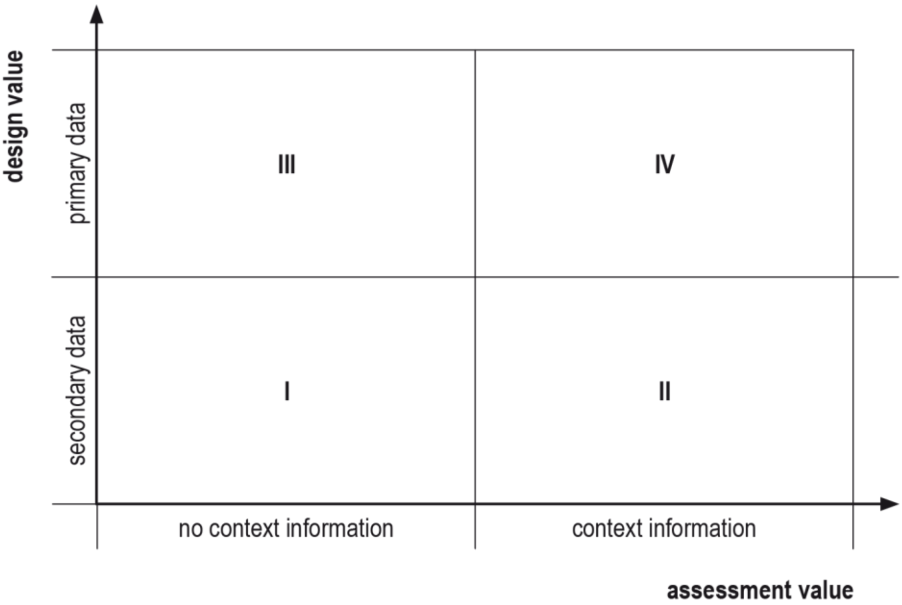

Figure 37: Types of data for analogy reasoning

One can generally say that the amount and degree of detail of IOC-context information are decisive for analogy reasoning and the data's explanatory power for evaluation as the better the understanding of the reference IOCS and the IOC-context is, the more easily similarities can be detected (or negated) that leads this data to better support the assessment concerning the expected effects of similar institutions in the target domain. For the design process of suitable institutions, data from a base domain that is closely related to the target domain is valuable because it is more likely to be transferable without major adjustments. However, data on IOC-settings from diverging IOCSs may initiate highly creative, unconventional, and novel solutions and may thus have a higher inspirative value.

It can be assumed that primary data which is specifically collected for a certain application of the LD²M will generally be more tailored to the needs of the IOCS under consideration than secondary data. The suitability of secondary data includes two aspects. Firstly, how comparable are the target and the base domains? Secondly, how similar is the focus of the reference data to the scope of application of the LD²M? As IOC is complex, data may centre around different aspects of IOC like attracting new members, making IOC sustainable, managing IOCA, etc. As a result, type IV data generally has the highest value for analogy reasoning: because it is primary data, a base domain that shares relevant features with the target domain can be chosen. In addition, data collection is focused on the purpose and scope of application. The case study which is conducted in this research provides type IV data for generic FPHTI IOCSs because 3GPP and FPHTI projects share core characteristics (see Chapter 7.5.1). Besides the identification of concrete institutions and their effect in the IOC-context of 3GPP, the case study particularly aims to capture the IOCS with its specifics to allow analogy reasoning for other IOC-contexts as well. However, as collecting primary data including the IOC-context analysis is time-consuming, it will in most cases not withstand a cost-benefit calculation of an LD²M application. However, in case the effort to collect primary data is made, there should be a clear objective to generate type IV and not just type III data, because the additional value of IOC-context information is significant, while the additional effort for the IOC-context analysis is moderate. An exception is of course the own IOC experience of members of the LD²M team which may be ad hoc recapitulated and integrated their experience with institutions in other IOCSs, while the effort for a thorough system theoretical analysis of the IOCSs would be comparably high. Because of this, type III data might be the best format for the experiences of members of the LD²M team who are involved in the convergent prototyping phase where they can directly integrate their implicit knowledge about the base domain into the evaluation process. Due to the costs of primary data, which does not originate from lead user experience, analogy reasoning will often be based on type I and II data which is extracted from existing studies on institutions, strategies, and principles. Although less tailored, secondary data has the advantage that it is easily available which allows researchers to generate more ideas in the divergent phase. As a result, the source of inspiration becomes more extensive and may trigger creative and less obvious solutions. This is especially the case if data from similar base domains is complemented by data from rather different IOCS. Ideally, analogy reasoning includes and mixes all data types which are available to provide a motley potpourri of ideas.

7.2.2 How to make choices in the LD²M – means for convergent thinking

System theory is chosen for the LD²M to support both convergent cycles: during synthesis in the definition phase of the problem space, system theory may help to structure the findings. Additionally, the application of the three different system concepts may disclose unexamined areas which initiate another discovery cycle to gain a more comprehensive understanding of the problem space. By editing and processing findings in a matrix structure, interdependencies, patterns, and/or inconsistencies can easily be illustrated and highlighted. At the same time, this matrix serves as an assessment tool in the deliver and prototyping phases in which the best ideas and solutions are identified. Testing and prototyping of institutions are very difficult because of the highly synergetic effects and the time delay with which effects become measurable or at least observable. While the matrix cannot overcome these challenges, it helps to consciously assess which effects may occur in consideration of the interrelations between different IOCS elements, which may reveal indirect effects.

7.2.2.1 System theory in synthesizing – a tripartite system analysis

The recommended procedure for synthesizing is inspired by and based on the positive experiences that were made in this research by using the three system concepts according to Ropohl (2009, p. 76) to develop holistic multi-perspective models of IOCS in Chapters 5.4 and 6.2.3 respectively. This experience is used to adapt and elaborate the tripartite system analysis for the LD²M's synthesisation process.

Functional system analysis

The functional system concept – including the normative perspective – helps to synthesize the following information: (1) 'What does the system do?' and (2) 'What ought the system do?' The first part helps do define the status-quo of the system concerning the functions and sub-functions that it really fulfils. The second part of the analysis reveals which functions and sub-functions should be fulfilled (better and/or differently) by the system. This descriptive and normative functional system analysis has two advantages. First, it allows for a target-performance comparison to disclose any variances and dysfunctions. Second, it allows for the specification of the purpose of the LD²M by determining the (sub-)function that is to be affected by the set of institutions which is designed in the LD²M. By defining clear – and the best verifiable – target parameters, the scope of application and the objectives of the LD²M are also determined in the functional system analysis.

> The functional **system analysis** helps to synthesize (1) what the system does and (2) what it should do. More precisely, it may be used to:
>
> - describe the status quo of the system (functions and sub-functions)
> - define the IOCS's objectives (formal/intended functions and sub-functions)
> - define the objective and target parameters of the LD²M

In Appendix F.2.1, a checklist is provided that assists with synthesizing and structuring the findings related to the functional aspects.

Structural system analysis

Analysis by means of the structural system concept helps to reveal the inner structure and composition of the IOCS.

> The **structural system analysis** helps to synthesize the composition of the system and thus to identify IOCS elements including its components with their attributes, assets, and interrelations.

The level of detail of analysis varies according to the components' diversity, the size of the IOCS, and the scope of application of the LD²M. In addition to its function (which has already been defined in the functional system analysis), a system always possesses a boundary and a set of components. Both the system and each component are characterised by attributes that describe relevant properties. The components conduct certain activities in order to contribute to the system's objective. They bring assets in the form of tangible or intangible goods into the system. Most importantly, components are interrelated with each other, which is decisive for the system's performance.

Checklist (2a), which is found in Appendix F.2.2 helps to identify the different IOCS elements and their relevant characteristics. Kozuch and Sienkiewcz-Malyjurek (2016, pp. 106; 2016) have elaborated an exhaustive set of factors which may determine and/or influence effective IOC. These are provided in Appendix H as they might facilitate the development of a comprehensive set of IOCS elements. The complexity of the interrelation network can be illustrated using a checklist (2b), whose matrix form allows for detailed disaggregation and breakdown (see Appendix F.2.2).

It has to be noted that the identified elements in this part of the analysis are each regarded and handled as one component and not as a separate system of sub-systems. If an element is too complex to be considered as a component only, it needs separate analysis as a sub-system. The sub-system analysis is conducted in an extra step by means of the hierarchical system concept analogously to the supra-systemic system analysis (see the next section).

Hierarchical system analysis

The hierarchical system concept supports a supra-systemic synthesis. It is based on the core idea that every system is embedded in superior systems in which it conducts a certain function and by which it is influenced and affected. As a result, a system cannot be considered in isolation but only in its systemic context.

> The **supra-systemic (sub-systemic) system analysis** is used to synthesize findings on relevant elements and conditions of systems in the superior

(subordinate) hierarchy levels which affect the system and its performance due to existing interdependencies, interconnections, or other interferences.

The influences from the IOCS's superior system(s) are elaborated in this step to complete the understanding of the system. The aim is to identify all external factors, effects, and conditions that (1) define the IOCS's influencing surroundings, (2) affect the IOCS and its performance, and/or (3) have to be considered as frame conditions for the IOCS design and/or for the assessment of the effectiveness of institutions. In most cases, these external factors are beyond the IOCS's control and may be regarded as being predetermined. Examples of such external factors are provided by Kozuch and Sienkiewcz-Malyjurek (2016, p. 106) and can also be found in Appendix H.

Checklist (3) in Appendix F.2.3 helps to identify external factors that affect the IOCS. In case a sub-systemic analysis of one of the system's elements is required, checklist (3) may also be used analogously. It is important to note the different foci of synthesis of checklists (2a) and (3), which result from the different underlying system concepts. While checklist (2a), which is based on the structural system concept, aims to represent and define the inner setup of a system in its entirety, checklist (3) does not consider the analysis of the structures and inner setup of the supra-system. Instead, it aims to reveal entanglement, interconnections, and interdependencies of the supra-system with the IOCS under consideration which is why only those aspects and/or elements of the supra-system are considered that are relevant for the system's behaviour. These elements are only analysed with regard to their effect on the system, and not concerning their function or effect within the supra-system. This is equally valid for an analogous sub-system analysis, in which only those components and characteristics of the sub-system are considered that are relevant to the system.

Merging results of synthesizing in the system theory-based model (STM)

In this step, the findings from the above three analysis steps are combined into a system-theory based model (STM) of the IOCS as shown in Figure 38. The idea for the matrix form of the STM is inspired by the interrelation analysis and presentation of the case study findings in Chapter 6.2.3, which has proven its value for clearly representing and efficiently analysing interrelations of IOCS elements. All information which has been synthesized by the preceding tripartite system concept analysis is contained in the STM. Information that cannot be displayed by the matrix items and their interrelations may be added under notes. As a result, the STM provides a comprehensive yet condensed result of the problem space analysis, which simultaneously serves as a basis for the selection process in the solution space.

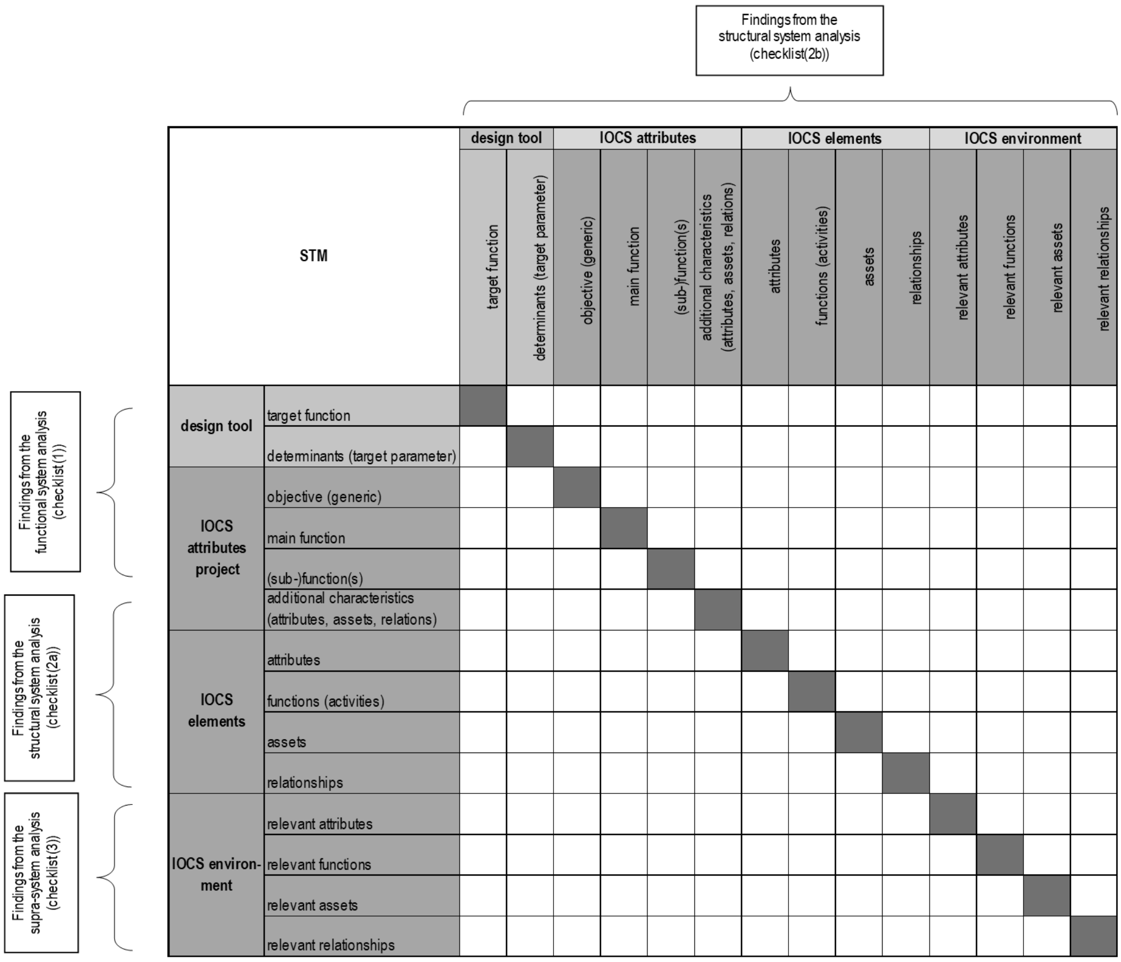

Figure 38: System theory-based model (STM) of the IOCS

7.2.2.2 System theory for testing and selecting

Based on the STM, which results from synthesizing and describing the problem space, and the findings from ideation in the development phase, an impact assessment matrix (IAM) can be developed for the evaluation of a certain set of institutions. It is important to understand the IAM as a decision support and not as a decision generator.

The impact assessment matrix (IAM):

- displays and structures interdependencies of all elements within an IOCS, and
- reveals (unexpected) indirect impacts,

in order to serve as a

- design and decision support to assist the development of a set of institutions which provides the best compromise between positive and negative impacts for a certain IOC-context and objective.
- reassurance and assistance for the LD²M team to take all components and aspects of a complex IOCS into consideration.
- factual substantiation and foundation for (the decision for) a certain set of institutions.

- validation of the suitability and quality of a set of institutions to cause the desired effects in an IOCS.

The IAM does *not*

- make or provide decisions, or
- offer (best) solutions.

By means of the IAM, the expected effects of (a set of) institutions on the IOCS (elements) are reviewed and analysed in the light of identified interrelations between the IOCS's elements. As such, the IAM enables the assessment of the suitability of a chosen set of institutions for the IOC-context of a particular IOCS and/or the conduciveness for the attainment of the LD²M's objective, which defines an aspired change or target state of the IOCS. A primary function of the IAM is to reveal and highlight crucial points concerning the expected impact of the (set of) institutions, which obviates to cause unexpected harmful effects by a developed set of measures. However, the design tool and the IAM do not provide a guideline on how to handle and judge cruxes. This remains the responsibility of the lead actor who can best estimate the resilience and robustness of an IOCS to certain (negative) impacts based on their experience, expertise, and understanding of the IOCS and its behaviour.

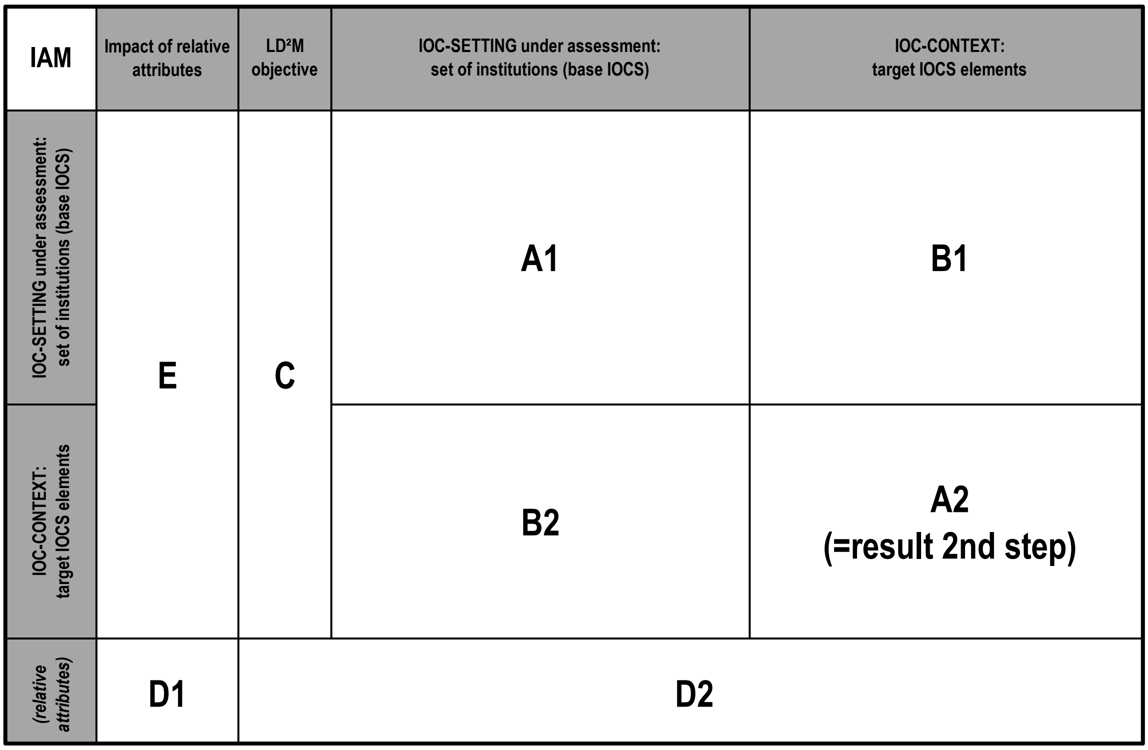

Figure 39: IAM segmentation

By combining the STM and a set of institutions in a matrix, different segments in the form of sub-matrices can be defined in the IAM as a basis for a step-by-step assessment as shown in Figure 39. While segments A to C define the core segments, which are always evaluated, segments D and E are only implemented if IOC-context information from the base domain is considered, which is the case if type II or IV data is available. In A1, the mutual influences and interdependencies between institutions are assessed. A2 represents the STM that was developed in the convergent analysis phase of the problem space and thus visualizes all interdependencies between elements of the IOC-context of the target domain. As such, they provide the basis to identify indirect effects based on existing interdependencies of different elements in the IOC-setting and IOC-context respectively. Based on these findings, the performance matrices B1 and B2 can be evaluated. The findings of the assessment are interpreted with regard to the objectives of the design method in matrix C. This procedure is described in the code of practice I in Appendix F.3, Table 12. For the case that IOC-context information about the base domain exists, the matrix is augmented with lines for relative attributes and a column in which the general effects of relative attributes are recorded (D1 and E). This enables the assessment of the expected impact of relevant differences between the base and the target IOCS on the effect(iveness) of institutions and the dynamics in the IOCS (D2). The corresponding augmented guideline with two alternatives is described in the code of practice II in Appendix F.3, Table 12. Depending on the chosen alternative, the findings from D2 are used to refine B1 and B2 (alternative I, Table 12) or conducted before B1 and B2 are evaluated at all (alternative II, Table 12). The two assessment alternatives accommodate the different mindsets of the users of an IAM and should thus provide two different assessment procedures which align with the flow of thoughts of the user and thus allow for a more intuitive and hence more productive and efficient IAM application. The assessment should ideally first be conducted for the IOCS (base or target) with which the user is more familiar at the instance of assessment. This will often – but not exclusively – be the target domain. In this case, alternative I is suggested for the assessment, because the evaluation is directly conducted in the target domain. If the user ‘thinks in the base domain’, alternative II (which is demonstrated in Chapter 7.4.2) will better accommodate the flow of thoughts, because it starts the evaluation in the base domain, leading to interim data in the temporary fields $B1^i$ and $B2^i$. This data is temporary because it represents the expected effects in the base domain. The user will refine the data in the interim fields $B1^i$ and $B2^i$ to the final evaluation for the target domain in fields B1 and B2 after they become more familiar with the target domain by completing fields D1, D2, and E. Finally, the conduciveness of the set of institutions to the LD²M’s objectives can be assessed in field C.

7.3 The LD²M design process

Before the LD²M design process can be described in detail, users of the LD²M have to be defined. The LD²M can be applied by a single user or a user team. In line with the design thinking concept, an LD²M team is preferred to a single user. The user may or may not be an actor in the IOCS under consideration. However, prior experience in IOC is highly recommended. For the development of an LD²M team, the following recommendations are given:

The LD²M team should

- represent all relevant groups of users and/or needs of the IOCS
- preferably include lead users of the IOCS and/or highly experienced lead users from related IOCSs
- meet general standards for team composition (like member roles, member personalities, member ability, member diversity, and team size)[33]
- ideally contain lead users who enjoy a good reputation for a better acceptance and easier implementation of a designed set of institutions in the IOCS (see not mandatory lead user characteristic (4) under Chapter 7.2.1.2).

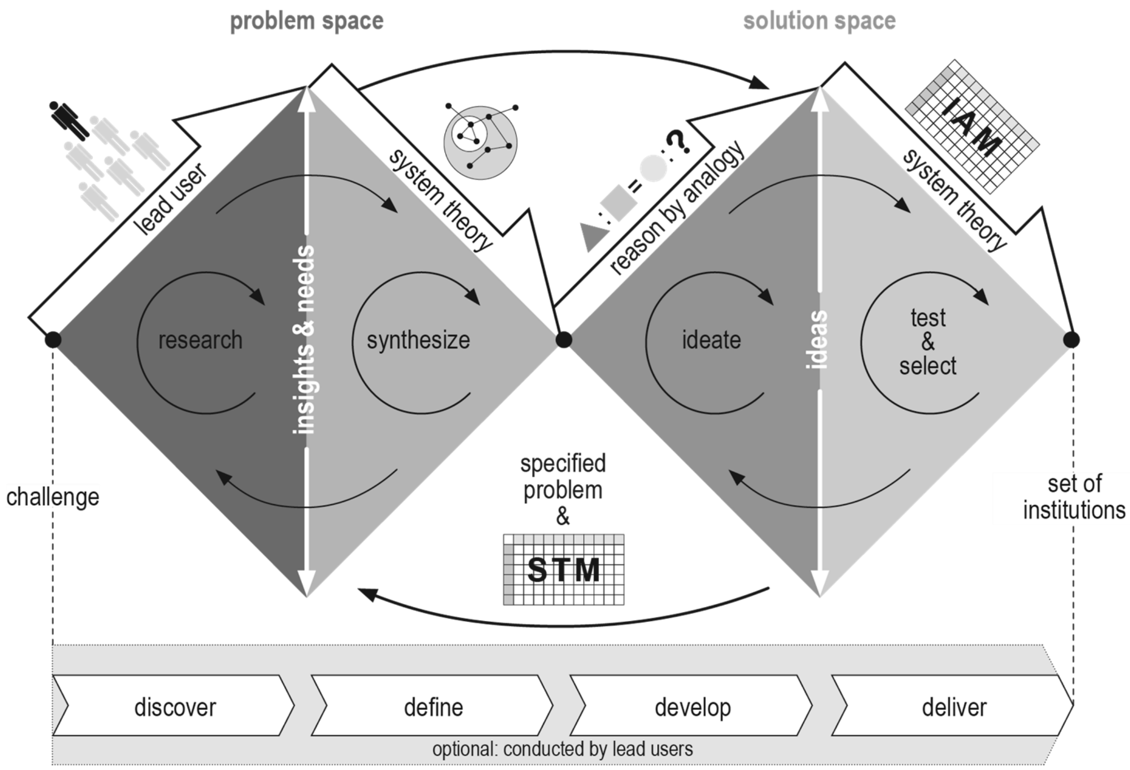

Figure 40: The lead user-centred double diamond method (LD²M)

Figure 40 illustrates how the elements introduced above are combined to form the LD²M. The design council's double diamond design thinking process provides the basis and underlying concept for the LD²M, in which the other elements are integrated and assigned to the different phases of the double diamond process.

(1) Lead-user based discover phase

In the discovery phase of the LD²M, the lead user method as it is defined in Chapter 7.2.1.2 is the main means to identify knowledge sources and to generate knowledge and a better understanding of the IOCS under consideration, including its specifics and its actors' needs and motives. For knowledge source identification, the LD²M suggests

[33] For more details see, for example, Bell and Brown (2018)

detecting lead users by pyramiding. The focus on lead users as the main knowledge source in the discovery phase has several advantages. First of all, the knowledge quantity of a lead user compared to 'average actors' is generally higher due to their comprehensive knowledge (see Chapter 7.2.1.2 and Appendix F.1.2). Secondly, the knowledge quality is expected to be higher because they have many years of IOC experience. In contrast to newcomers or external observers, the lead user is able to put insights and perceptions into an overall context to evaluate their relevance, persistence, and influence. Thirdly, because lead users have their own interest in the IOC process (improvement) (see Chapter 7.2.1.2), their knowledge of the same will already be better explicated than among actors who have not yet invested much thought in the IOC process. In consequence, the lead user method is a very time- and cost-efficient means for the generation of ideas and needs.

(2) System theory-based synthesizing

In the LD²M, synthesizing in the convergent phase of definition is based on system theoretical analysis. By using all three concepts of system theory – the functional, the structural and the hierarchal – and the corresponding checklists provided in Appendix F.2, a very comprehensive data set about the IOCS and its specifics is developed, which allows for modelling the IOC-context. This is because the different perspectives concerning the IOCS provide a basis to reflect whether all aspects have been considered in the discover phase and may thus initiate review cycles to complete the findings. Additionally, the application of the three system concepts with the checklists introduced above assists the first phase of synthesizing as they help to condense, interpret, and structure the potpourri of findings from the discover phase. The STM on the other hand is a tool primarily for the second phase of synthesizing. As a means for synthesizing, the STM summarizes and clearly illustrates the findings by showing patterns, inconsistencies, and especially interrelations. However, the STM is also the outcome of the problem space analysis. As an outcome, the STM illustrates the result of synthesizing and thus the analysis of the problem space as a basis for problem refinement, and especially for the evaluation of ideas in the convergent phase of the solution space analysis.

(3) Analogy reasoning in idea generation

The LD²M uses analogy reasoning as a powerful means for idea generation in the solution space. There is a multitude of different IOCSs and the corresponding experiences and knowledge, as well as findings from IOC research which can be used in the solution space. Analogy reasoning allows one to make use of existing solutions, gathered experiences, and lessons learned in other IOCSs. Such a diverse array of already implemented institutions can be used to deduce and develop a suitable set of institutions for the own IOC-context which is more efficient and reasonable than to 'start from scratch'. However, it does not – like most research and methods suggest – adopt institutions for their good performance in other IOCSs. Rather, by identifying similarities and differences between IOC-contexts of the base IOCSs and the target IOCS, institutions – both those that have passed the test in the base IOCS and those that have failed – can be assessed with regard to their suitability and/or value for the target IOC-context. Institutions which are expected to be beneficial for the IOCS under consideration are then adjusted and adapted to the own problem and IOCS.

(4) IMA-based idea selection

The selection and testing of a suitable set of institutions for an IOCS under consideration are very challenging. Ex-ante testing is difficult for a set of institutions because of the significant time lag with which effects occur. As a result, effects can only be retrospectively measured and analysed, and ex-ante testing is limited to assessment methods. However, the IOC-context-specificity of the impact of institutions makes even theoretical assessment difficult. Because the effect of an institution depends on the set of institutions in which it is applied, as well as on the application context and thus the IOCS, impact assessment always requires taking the entire IOC-context and setting into consideration. With the IMA, the LD²M provides an assessment tool which especially accounts for this challenge. By applying the IMA for potential (sets of) institutions, their effects can be estimated in light of the existing interrelations among the elements in the IOCS. This particularly helps to disclose unexpected side effects that are caused by interdependencies, and which are not conducive to the objective of the set of institutions.

A step-by-step introduction to the application of the LD²M is given in Appendix F.3, Table 13. It has to be emphasised that the attribution of the above methods to each double diamond phase is neither exclusive nor restrictive. This means that the LD²M provides one especially useful method as a primary tool for the conduction of each LD²M phase, which can and should be complemented by other techniques[34] in accordance with the expertise and preferences of the LD²M user(s).

7.4 Verification

In this section, it is discussed and evaluated how the LD²M meets the requirements defined in Chapter 7.1.

Verification of requ (1) – IOC-context-specificity

With the double diamond concept, the LD²M defines an equivalent treatment of the problem space (meaning the IOC under consideration) and the solution space, which means that the analysis of the problem space is equally important and as extensive as the considerations in the solution space. By attaching such great importance to the analysis of the IOCS, its specifics are placed in the focus of consideration and thus counteract the solution space-oriented way of problem-solving, which is especially common among engineers. Additionally, the central idea of design thinking is user-centricity, which means that the needs of users (in this case IOCS-actors) are put in the focus of the design process. In this way, the social and relational IOC-context-specifics are emphasised, which corresponds to the main challenge of IOC, namely (perceived) relational risk. The integration of lead user knowledge further ensures that first-hand information about the problems and challenges in an IOCS is gathered and exploited. Finally, by implementing analogy reasoning it is emphasised that existing solutions cannot be adopted without reflection but have to be assessed in the light of and adapted to the specifics of the IOCS under consideration.

Verification of requ (2) – reduction of perceived relational risk

The LD²M strongly emphasises the social and relational aspects of IOC by choosing a design thinking approach in combination with insider lead user knowledge (see verification of requ (1)). Correctly applied, the outcome of the problem space analysis – including the target parameters of the LD²M – will thus also focus on and highlight relational

[34] For an overview about the multitude of techniques and methods which support design thinking, see for example Alves and Nunes, 2013

challenges and specifics in the IOCS. This is why a set of institutions that are developed to meet the defined problem statement will aim to especially improve these challenges which are concomitant with a reduction of relational risk. The actual reducing effect on perceived relational risk can only be determined retrospectively (see Chapter 7.3). In line with the recommendations for LD²M team composition in Chapter 7.3, it is advantageous if LD²M users as designers of the set of institutions enjoy a good reputation in the IOCS. In this case, the new set of institutions might per se cause a reduction of perceived relational risk.

Verification of requ (3a) – identification of insider-knowledge sources

Lead users for a special problem have proven to be especially valuable sources of knowledge with regard to the quality of their knowledge (see Appendix F.1.2). Within the lead user concept, pyramiding is an efficient way to quickly identify relevant lead users.

Verification of requ (3b) – explication of insider knowledge

Lead users have a larger amount of explicated knowledge about the problem than average users due to their personal interest in both the problem and its solution which is why the lead user concept generally facilitates knowledge explication. However, the use of system theory for synthesizing is the main factor which ensures the ability to meet this requirement. It is expected that in IOCSs around technological solutions, lead users – for whom the LD²M is primarily developed – are predominantly engineers and scientists, who are very familiar with systemic thinking and thus a system theory approach for knowledge explication accommodate the features of the knowledge source which promotes and facilitates the explication process. It has to be stated that system thinking is widespread in many sciences (see Chapter 4.2) and may thus also accommodate knowledge explication from lead users with non-technical backgrounds.

Verification of requ (4) – Creating a positive total

To determine if a positive total is created, a tool which allows for assessing the (expected) total effect is a prerequisite. With the IAM, the LD²M provides such a tool, because it allows it to assess the effects of a whole set of institutions based on identified interrelations and interdependencies of these measures and of the IOCS's components.

Verification of requ (5) – Creating improvement and progress

With the abort criterion defined in step 7 of the code of practice (see Appendix F.3, Table 13), the LD²M meets this requirement.

Verification of requs (6) and (7) – time-/cost-efficiency

Because requ (7) also serves requ (6), they can be verified together. The selected elements of the LD²M serve the fulfilment of both requirements. The design thinking concept and especially the double diamond approach provide a very straightforward, clear, and mostly self-explanatory design process. Analogy thinking is inherent to human cognition and can thus be applied without specific prior knowledge and/or training. However, it enables stakeholders to not start from scratch but to build on existing solutions which saves time and effort in the develop phase. As stated above (see verification of requ (3)), the concept of system theory is specially chosen concerning the technical environment and the target group with its higher and often technical education and the resulting ways of thinking and approaching problems for the specific application domain of this research. Besides one main method for each phase, the LD²M refrains from making further specifications or even limitations to allow every user to integrate and apply their know-how. The use of the LD²M can thus be considered to be rather intuitive, especially for members of the target group. This greatly contributes to making the LD²M time- and cost-efficient, because it does not require prior training. Additionally, the LD²M does not require any specific hard- or software, which would generate costs. In order to enhance efficiency, the most cost- and time-efficient way of lead user identification, namely pyramiding, is suggested. The required time and costs can further be directed and adapted to the available resources – of course with an impact on the quality of the LD²M outcome – by adjusting the size of the user team, the number of questioned lead users, and the effort and extent of the analogy reasoning process.

7.5 Demonstration of the IAM

In this chapter, an exemplary demonstration of the IAM is provided. This demonstration is exemplary because the IAM as part of the LD²M is explicitly developed as an assessment tool to assist the design and selection of IOC-context-specific institutions. However, because this thesis does not consider a specific IOCS in the application domain of FPHTI IOCSs, the IAM functionality is demonstrated and tested for the generic characteristics of the group of IOCSs of FPHTI projects. The operational findings from the case study are used as a test set of institutions. In this way, it is demonstrated how the IAM is supposed to be used and its functionality can be tested. In addition, unique features of the IOCS 3GPP which determine their adaptability for other IOCS settings and especially FPHTI IOCSs can be elaborated. This allows for the detection of parallels between the IOCS 3GPP and FPHTI IOCs at a generic level as a basis for analogy reasoning in LD²M applications for FPHTI IOCSs.

7.5.1 Preliminaries

In order to apply the IAM, the following preliminaries have to be conducted. First, the function that will be enhanced by the institutions (generally the objective of the LD²M) is defined including the affected target parameters that will provide the determinants for a future (retrospective) evaluation of the functionality of a new set of institutions. Second, the IOC-context characteristics of both the base domain (3GPP, see Chapter 6.2.2) and the target domain (FPHTI IOCSs, see Chapter 5.4) are used to elaborate similarities and differences which provides the basis to deduce relative attributes and to evaluate the effect of the institutions of 3GPP in the IAM based on the perceived effects in the base domain.

In line with the scope of this thesis, institutions will be assessed with regard to their potential to provide an improved (or for new IOCSs, promising) baseline for successful IOCA in FPHTI IOCSs. Based on the risk perspective that is taken, three target parameters are defined. First, perceived relational risk as the main challenge for IOC(A) must be reduced. Second, institutions are assessed with their impact on institutional trust, which is a basis for the development of relational trust. Third, to reduce performance risk, the effect on efficiency and effectiveness of institutions on IOCA is defined as a target parameter.

The case study findings are type IV data (see Chapter 7.2.1.2), which is primary data with IOC-context information, meaning information about the IOC-context of 3GPP in which institutions are currently applied. This IOC-context information is mainly elaborated in Chapter 6.2.2 and Appendix D.6.1.1, and illustrated in the comb structure in Figure 55 and the IOCS model of 3GPP's IOC-context in Figure 34. The context information of the target domain, FPHTI IOCSs, is found in Chapters 5.2.3 and 5.3.2, in which Figure 21 and Figure 24 provide an overview of the findings in the style of Figure 55 and Figure 34 respectively. Based on these comparably edited and illustrated data, the target domain (FPHTI IOCS) and the IOCS of the base domain (3GPP) can easily be compared with regard to similarities and differences to provide a more substantiated basis for the following assessment.

Similar core characteristics of FPHTI IOCSs and the IOCS 3GPP:

(1) Both IOCSs are *coopetitive*, because – just like at 3GPP – FPHTI projects require competitors to collaborate. This is necessary both because of the complexity of the technological solution, which requires investment and know-how which exceeds the means of one (even large) player. Second, the most urgent problems of this time, which require FPHTI, need systemic and especially concerted solutions.

(4) Both IOCSs are *voluntary*, meaning that actors in both IOCSs decide on behalf of their own objectives and benefits and not on behalf of external enforcement if they want to participate in – or quit – IOC.

(5) Both IOCSs are *highly social*. This characteristic is valid for all IOCSs or at least voluntary IOCSs, in which actors are not coerced into behaving in accordance with a certain assigned role.

(6) Both IOCSs range *at an upper level concerning the size, diversity, and dynamics* of actor composition at an absolute scale. However, there are differences at a relative scale, which are analysed under point 1 of the differences in the following section.

(7) Both IOCSs evolve in a setting with a great *necessity to collaborate*. As such, although actors voluntarily decide to participate, the economic incentives to join in IOC are very strong and dominant. As a result, actors will often not have an economically acceptable alternative to IOC. The different sources for the need to collaborate in both IOCSs are analysed in the next section on differences (point 3).

Because of the similarity of several core characteristics, some institutions can likely be adapted for FPHTI IOCSs.

Main differences between the IOC-contexts of 3GPP and FPHTI projects:

(1) Different objectives: While FPHTI IOCSs have a nonrecurring task, the objective of the IOCS 3GPP, the development of specifications for wireless mobile communication standards, is perpetual and continuous[35]. It was founded in 1998 and thus builds on a history of over 20 years of successful IOC which is accompanied by a very good reputation. In consequence, FPHTI IOCSs and 3GPP differ in the following points:

   - FPHTI IOCSs cannot provide such a long continuity of delegates and will likely lack 'compass delegates' (see Chapter 6.2.2.2).
   - FPHTI IOCSs have a less confirmed and approved common culture and codes of conduct concerning both their proof of time and their IOC success.

[35] 3GPP has developed the specifications for 3G, 4G, and 5G and is currently working on protocols for 6G. The development of consecutive generations is overlapping.

This makes all elements of the FPHTI IOCS less robust against misuse, (re-) interpretation, and change.

- FPHTI IOCSs cannot build on an established, worldwide good reputation and success story like 3GPP which causes a certain 'natural attractivity' and high institutional trust.
- FPHTI IOCSs are comparably free of the 'formation heritages' which developed in another century.
- Although the diversity, and especially the number of actors in FPHTI IOCSs is regarded to be high, it is likely to be a lot smaller (at least in the first years) than at 3GPP, which at the time of the case study counted around 700 members and may thus be regarded as an outstandingly large IOCS.
- Both IOCSs have dynamic, growing actor compositions. However, in FPHTI IOCSs the relative dynamic in the first years can be expected to be much higher than in 3GPP at the time of the case study after over 20 years of development and a total number of over 700 actors.

(2) Patent/IPR affinity: The ICT sector is one of the most patent affine sectors in the world, which has strongly influenced 3GPP since it was formed in this sector in 1998. In FPHTI IOCSs, the lobby for IPR is much less dominant (if at all existing). This is because nowadays there are more diverse views on (the benefit of) IPR and because FPHTI IOCSs are by nature cross-sectoral. Consequently, in FPHTI IOCSs different sector-based views on IPR have to be considered right from the beginning.

(3) Product- vs. process-based incentives for collaboration: 3GPP provides specifications for a product (wireless mobile communication) which has very strong network effects. This can be regarded as a product inserted, a natural incentive to develop one concerted solution (to maximize and make use of network effects) and thus a motivator for IOC. Thus, the necessity to collaborate is originally product-based at 3GPP. This cannot be presupposed for FPHTI IOCSs in general (although it may occur). However, there are also other strong incentives for IOC. First, the development of complex and systemic FPHTI solutions generally requires the knowledge and commitment of many. Second, the economic effort for research, development, infrastructure, and production at large scale immensely exceeds the means of a single player which is why the necessity to collaborate in FPHTI IOCSs is process-based. This difference will often not matter in the analysis of institution adaptability. However, it has to be considered as different effects may arise.

7.5.2 IAM demonstrator application

In this section, the IAM-based assessment process is presented.

(1) Definition of the IAM items

In the IAM demonstrator, the set of institutions of 3GPP (base domain) as presented in Chapter 6.2.1.2, is tested for FPHTI IOCSs (target domain) which has been characterised in Chapter 5.4. This leads to the matrix items for the IOC-context and IOC-setting according to Table 3. In line with the scope of this research, the LD²M purpose is defined as the development of an improved baseline for IOCA. This set of institutions and their expected effects on the target domain (FPHTI IOCSs) is assessed according to alternative II of the code of practice II (see Appendix F.3, Table 12) because the institutions' interrelations were already analysed in Chapter 6.2.3 and Appendix E, Figure 56. The This leads to the asymmetric matrix design as shown in Table 4.

Table 3 IOC-context and IOC-setting matrix items for the IAM demonstrator

IOC-SETTING of 3GPP (base IOCS)	hard institutions	• membership policy • organizational structure • role of the IOCS • roles of the actors • (working) processes • data management system • mechanism of consensus • mechanism of economic participation • mechanism of moderation • mechanism of targeted activity
	soft institu-tions	• mechanism of corporate IOCS culture • mechanism of the critical mass • mechanism of informal exchange • mechanism of political capital • mechanism of progress • GP 'Knowing the value of the number' • GP 'Let the market rule the game' • GP 'No-loser policy'
IOC-CONTEXT of FPHTI IOCSs (target IOCS)	profile	• objective: technological innovation • Function: joint problem solving • sub-function 1: high attractivity • sub-function 2: perceived relational risk reduc-tion • sub-function 3: enhance institutional trust • sub-function 4: foster knowledge exchange • boundary with is permeable in both directions
	attributes	• coopetitive • voluntary • social pathway • high number of actors • high diversity of actors • highly dynamic actor composition • inter-organisational R&D activity
	actor groups	• horizontals (competitors) • verticals

Table 4: Asymmetric IAM demonstrator matrix: left – column items, right – line items (transposed)

*IOC-SETTING of 3GPP (base IOCS)**		
*IOC-CONTEXT of FPHTI IOCSs (target IOCS)**		
relative attributes	comparison base and target IOC-context	• no compass delegates • no corporate IOCS culture • no formation heritage • no reputation • smaller number of actors • lower diversity of actors • higher relative dynamics • less patent affine

Effect assessment for relative attributes		
LD^{2}M	LD^{2}M purpose	• improve IOCA • reduce perceived relational risk • enhance institutional trust • efficiency and effectiveness of IOC
*IOC-SETTING of 3GPP (base IOCS)**		
*IOC-CONTEXT of FPHTI IOCSs (target IOCS)**		

* *items according to* Table 3

(2) Definition of the scale and scores

For the IAM demonstrator, the coding system as it is developed for the interrelation analysis of the IOCS 3GPP (see Appendix E) is applied.

(3) Analysis

In this step, the IAM is evaluated according to alternative II of the code of practice II (Appendix F.3, Table 12) based on the segments shown in Figure 39. In segment A1, findings of the case study according to Figure 56 are presented, while the findings on FPHTI IOCSs from Chapter 5.4 are put into A2. In the next step, the IOC-context information is integrated into the form of the relative attributes in segment D1, which are derived from the preliminary analysis of differences between the base and target domains under Chapter 7.5.1. Their effects are analysed in segment D2, which makes it possible to reveal divergent effects and interrelations in the target domain. The deduced relative impacts and interrelations which are expected in the target domain are described and presented in segment E. They allow for the correction and refinement of the expected interrelations in A1 and evaluate segments B1 and B2. Finally, the conduciveness of the set of institutions to the LD^{2}M purpose can be assessed in segment C.

The assessment result is shown in detail for each segment A1 to E (according to Figure 39) in Appendix G, Figure 67 to Figure 72respectively. It provides the basis for the following interpretation.

(4) Interpretation

a. Identification of key challenges of the use of 3GPP as a base domain for FPHTI IOCSs

Three features of 3GPP pose a particular challenge for the use of 3GPP as a base domain for FPHTI IOCSs: its size, age, and patent affinity. While the patent affinity has a rather well-defined range of impact, namely the mechanism of economic participation, the size and age of 3GPP affect the entire dynamics of interaction and IOCA and thus the effects and effectiveness of institutions.

Both the size of 3GPP and its long history during which the IOCS and its institutions and practices have proven its worth and functionality over decades in a global setting built a very sound fundament for IOC and the effectiveness of institutions. The established and accepted IOC culture including a common mindset and interpretation of rules, concerted habits, and codes of behaviour and interaction is represented and advocated by long-established 3GPP delegates – so-called compass delegates – who represent a sizable and respectable group at 3GPP. This is why both malpractice and attempts of self-interested manipulation of IOC mechanisms, rules, and habits can hardly pose a threat to the IOCS 3GPP. Malpractice of one actor – regardless of whether it happens in good faith in the case of newcomers or in bad faith for self-interests or as a consequence of external influences – has a rather small impact and relative weight in a setting of 700 actors. In most cases, it will not make a difference for the overall outcome of a decision and can therefore be tolerated by the system and left to the process of group dynamics: the other actors, headed by the compass delegates, will make a stand against this kind of behaviour and 'reward' misbehaviours with a decrease in political capital. A similar effect occurs if actors try to manipulate or misinterpret rules or customs for their own advantages or interests. First, because of the size of the IOCS 3GPP, they have to convince – or manipulate – a large number of other actors to develop a considerable lobby. This is not likely to happen if the manipulation is not beneficial for IOC and its outcome, but only for a small group of actors. Second, the long story of success of established rules, norms, and habits makes it hard to both justify the need for change and the IOCS's inertness and will thus require very strong and substantiated arguments for any alterations regardless of whether they are in good or bad faith.

It can be concluded that this tripartite fundament of size, compass delegates, and field-tested IOC culture, measures, and habits provides a very unique playground for IOC, in which institutions can perfectly take effect and which can hardly be created or compensated by any other mechanisms. Regardless of the quality and effectiveness of institutions, they will hardly be able to create the effects in a less stable context. This is why the effect of 3GPP's institutions is expected to have a weaker or different effect in IOCSs with fewer actors and a less established, concerted, and actively advocated culture of IOC and interaction.

Table 5: Main challenges for the use of 3GPP as a base domain

Attribute	**Effect at 3GPP**	**Challenge for a base domain**
size age	results in the extraordinary effectiveness of institutions and outstanding robustness against manipulation, abuse, and misinterpretation	In smaller and/or less settled IOCSs, the effect and potential of institutions to provide and generate a stable, robust, and predictable framework for IOC activity and interaction is strongly depressed.
patent affinity	results in an IPR-based mechanism of economic participation	3GPP's IPR-based mechanisms of economic participation are inapplicable to most other IOCSs

It becomes obvious that the patent affinity with its isolated impact can be handled rather easily if 3GPP is used as a base domain. Of course, the installation of a new mechanism of economic participation also affects other mechanisms and elements (for example processes), however, it generally does not cause fundamentally different effects. This is different in the case of the overarching stabilizing effect of the attributes of age and size as they rather affect all elements, their interrelations, and their effect. As a result, the effect of institutions in a less robust and stable setting can hardly be predicted based on experiences, observations, and findings at 3GPP. However, the institutions that are perceived as IOC enhancing today, have already existed when 3GPP was much smaller and younger. Although it cannot be reconstructed if they were equally appreciated back then, the success story of IOC at 3GPP and the survival of the institutions prove the factual value of the set of institutions for successful IOC and IOCA which is why the robustness due to size and age can be evaluated as being highly supportive but not mandatory for the effectiveness of these institutions and their general functionality in (comparably) smaller settings can be assumed.

b. Evaluate the applicability of 3GPP's institutions in FPHTI IOCSs

In Appendix G, each institution of 3GPP is evaluated in detail with regard to its applicability to FPHTI IOCSs, its expected effects, and the need for adaption. Each institution is then analysed in Table 14 (see Appendix G) concerning its suitability for the IOC-context of FPHTI IOCSs and classified as follows:

(1) institutions, whose application is recommended without significant adaptions:

- Organisational structure
- Mechanism of consensus
- Mechanism of moderation
- Mechanism of targeted activity
- Mechanism of progress
- GP 'Let the market rule the game'

(2) institutions, whose application is recommended with minor adaptions:

- Membership policy
- Role of the IOCS
- Mechanism of corporate IOCS culture
- Mechanism of informal exchange
- Mechanism of political capital
- GP 'Knowing the value of the number'
- GP 'No-loser policy'

(3) institutions, whose application is recommended with moderate adaptions:

- Roles of the actors
- (Working) processes
- Mechanism of the critical mass

(4) institutions, whose application is not recommended:

- Data management system
- IPR-based mechanism of economic participation

This result can be used for the development of the setting for a specific FPHTI IOCS by refining this evaluation and adding further mechanisms that enhance stability and partially compensate for the robustness that 3GPP possesses due to its age and size.

7.6 Expert review of the LD²M

For expert validation, three highly experienced IOC practitioners have been interviewed. They are qualified as experts with regard to the assessed design artefact, the LD²M, because they have all several years of experience with the design of IOC-settings and processes of different IOC projects, at different stages of project development reaching from new foundations over process changes in existing IOC projects to splitt-offs and in different functions, namely at the operational, strategic, and advisory level. As such, they have a broad expertise and may evaluate the LD²M from different perspectives. The results of the expert validation of the LD²M are presented in the following. They are structured in four categories. In the first two categories, findings which refer (1) to the problem addressed, (2) to the design of the implemented solution are presented. In addition, (3) detected strengths and weaknesses and (4) recommendations stated by the experts with regard to the LD²M are presented.

(1) Evaluation of the addressed problem

The problem which is addressed by the LD²M is defined as the inadequate harmonization of IOC-settings to the specific IOC-context – especially resulting from actors' interaction and concomitant social dynamics – of an IOC project. When explicating the addressed problem of copying and adopting solutions of other IOC projects which have therein proven to be best practices, one interviewee immediately recognizes this course of action as established approach to design new IOC-settings (*Interview 11*, p. 1). He states that the use case- and best practice-orientation for the design of IOC-settings is commonly used for lack of better solutions, although it is known – yet strictly unverbalised – that it is trail ballooning (*Interview 11*, p. 2). Another interviewee states that he recognizes an increasing demand or at least openness for models among young IOC practitioners, which is currently not satisfied due to the lack of appropriate methods. With regard to the focus on actors and the concomitant social dynamics, the third interviewee attest the *'human aspect'* as *the* pivot for successful design and changes of IOC-settings from her own operational experience (*Interview 13*, pp. 13-14). Overall, the problem which is addressed by the LD²M is confirmed by all three interviewees and evaluated as significant for IOC practice management and the outcome of IOC projects.

(2) Evaluation of the design of the solution

Regarding the overall process design of the LD²M, it is assessed by the interviewees as '*classical, yet compelling solution*' (*Interview 11*, p. 6), '*super-exciting [...] and inspiring'* (*Interview 12*, p. 29) and a '*solution [that] does work*' (YS S.13). In fact, all three interviewees attest the LD²M to be closely in step with actual practice (*Interview 11*, pp. 20-21; *Interview 12*, p. 23; *Interview 13*, p. 9), because they recognize their unconsciously conducted course of action in IOC practice in the LD²M process design. As such, the LD²M process displays and systemises their own approach with regard to the development or refinement of IOC-settings. This formalisation and modelling is evaluated as conducive for a more purposeful and structured own future proceeding because it increases the awareness for the own doing (*Interview 12*, p. 23). The interviewees especially emphasise the significance of the iterative process design, which indicates that designing

IOC-settings is highly '*repetitive thing*' (*Interview 13*, p. 14), where previous process stages are continuously re-entered and/or repeated if indicated (*Interview 13*, p. 13, *Interview 12*, p. 23). This strongly reflects their experience and should thus be strongly emphasised in the LD²M (*Interview 13,* p. 14). The use of lead user knowledge and experience as knowledge source is found to be an established practice both for the development of an understanding of the IOC-context (*Interview 11*, p. 21) but also for the development of a specific IOC-setting, in which the expertise and experience of lead users from other IOC projects provides the basis for '*cherry picking*' or practices which are copied (free translation *Interview 11*, p. 6).

(3) Detected strengths and weaknesses

Strengths

The fact, that the LD²M is closely in step with the actual IOC practice for the design of IOC-settings is regarded as a main strength of the LD²M. As such, it is regarded as a truly practical method, which has already proven its effectiveness (*Interview 12*, p. 25) and is of value for both experienced and new IOC practitioners: While the LD²M provides a model to introduce established IOC practice to new IOC practitioners, experienced IOC practitioners may improve their IOC practice by acting more consciously, structured and purposeful because of their increased awareness for the underlying process (*Interview 12*, pp. 23-24). In fact, during the course of interviewing, several actual projects cross one interviewee's mind in which he will in future consider the increased process awareness, which is generated by the LD²M (*Interview 12*, p. 29). In addition, the iterative process design is emphasised as highly positive attribute of the LD²M (*Interview 13*, p. 14) as stated above, because it is an imperative characteristic of the practical course of action for designing IOC-settings. The integration of lead users as knowledge source is generally evaluated to be highly efficient and profitable (*Interview 12,* pp. 6 and 20). In addition, one interviewee depicts the resulting user centricity as pivot, because it strongly reflects the need to understand people's incentives as key for success – or failure – in the designing of IOC-settings (*Interview 13*, p. 13).

Weaknesses

There is agreement among the interviewees, that a clear yet condensed presentation of the LD²M and its objectives is regarded as main challenge and potential weakness of the LD²M, because it provides the basis for successful implementation. Several recommendations have been given on this aspect, which are presented in the next section. Concerning the success of the LD²M, the LD²M's user dependency is highlighted as weakness by two interviewees: It is rightly pinpointed, that the outcome of the LD²M is intrinsically tied to the quality of the LD²M user(s). In detail, one interviewee centres the composition of the LD²M team as highly determining for the success of the LD²M (*Interview 11*, p. 12), while the other interviewee regards the capability of an LD²M user to truly re-define and re-invent the own course of action in each LD²M application as main challenge (*Interview 12*, pp. 27-28). In addition, this interviewee sees the danger of misuse: By manipulating the lead user selection which are used as knowledge source and/or integrated in the LD²M team – for example by focussing on very conservative ones only – the LD²M could be used to foster rigidities in IOC projects with regard to the IOC-setting (*Interview 12*, p. 26).

(4) Recommendations

It is recommended by one interviewee to better emphasis the iterative nature of the LD²M process as well as of each of its stages (*Interview 13,* p. 14). Above that, recommendations mainly concern the way the LD²M and its purpose and performance should be presented to practitioners: With regard to the LD²M's objective, one interviewee recommends to better highlight that the LD²M is a tool which assists the development of a baseline to conduct IOC (processes), but that is does not instruct how the objective of the IOC project is attained and thus how solutions for the problem to be solved within the IOC project are developed (*Interview 13*, p. 14). As such, it should be pinpointed that it is a process which is conducted prior to the actual IOC activity, but not part of it. Another interviewee's recommendation takes the same line by suggesting to emphasise that the LD²M is a '*receipt for cooperation yet not for successful output of an IOC project*' (free translation, *Interview 11*, p. 11). This interviewee even proposes to limit the LD²M purpose not as a tool for designing IOC-settings but only for designing how set already defined IOC-settings are put into practice (*Interview 11*, p. 19). In line with the above-mentioned weaknesses and strengths it is in addition suggested to emphasise the importance of the '*human factor*' for the understanding of an IOC project (*Interview 13*, pp. 13-14) and to appeal to potential LD²M users to honestly reflect their openness to develop solutions off the beaten – and especially the own – track. Finally, the call for consideration of general advice for team composition is suggested by one interviewee (*Interview 11*, p. 12).

8 Validation

Based on the quality criteria framework of Gerber, Tuckerand and Hofer (2007) and M. Martensson's research on multidisciplinary quality criteria (see Appendix I), customized quality criteria for this interdisciplinary multi-method research are deduced as shown in Figure 41.

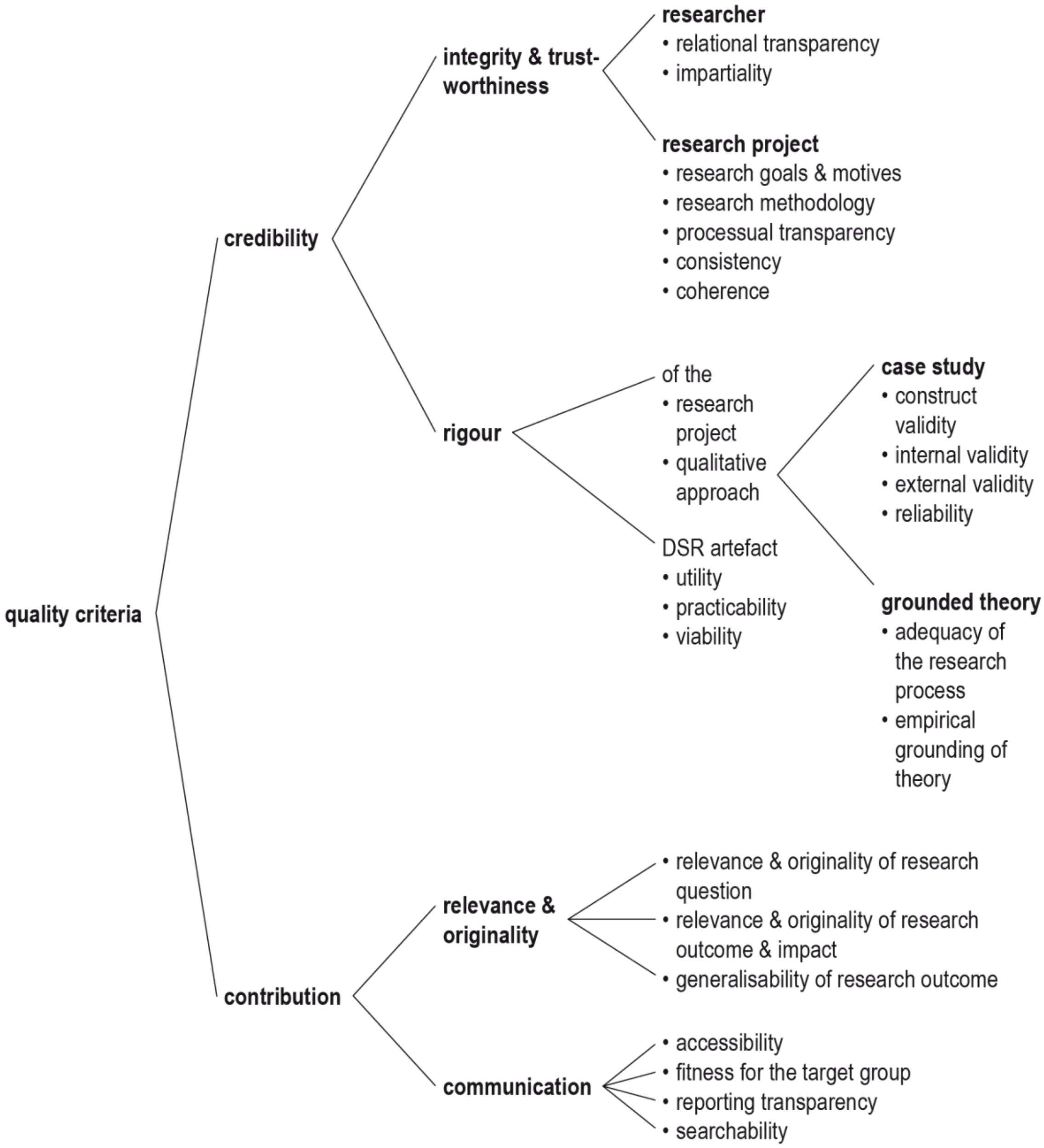

Figure 41: Validation framework for this research

In this validation framework, the qualitative approach of the case study, and the DSR artefact are recognized as research elements that require separate in-depth validation.

8.1 Credibility

Credibility describes the trustworthiness of research (Gerber, Tuckerand and Hofer, 2018, p. 11) and coherence, consistency, rigour, and transparency of the research are prerequisites for reaching credibility. However, credibility is not just founded in the research with regard to the content and processes, but also in the researcher. Especially in qualitative research, the role of the researcher becomes decisive for the credibility of the research and hence integrity, mainly on the part of the researcher, is pivotal for the credibility of such research (see Gerber, Tuckerand and Hofer, 2018). In multi-method and -discipline research, it is above all necessary to consider the sensibility for the special challenges of such research. Finally, the peer review, which is suggested as a quality criterion by Gerber et al. (Gerber, Tuckerand and Hofer, 2018) is evaluated as quality criteria for the qualitative approach and the design artefact.

8.1.1 Integrity and trustworthiness

8.1.1.1 Integrity of the researcher

Relational transparency

For the qualitative research of this study, namely the case study at 3GPP, ethical considerations and the integrity of the researcher are pivotal aspects for the validation of integrity with regard to both the outcome and quality of the overall research and the interviews. Relational transparency firstly is ensured by the renunciation of funding to prevent external influences on the research procedure or outcome. Secondly, a ‘neutral’ research setting, namely 3GPP, is chosen with regard to the researcher. Neutral in this context indicates that the researcher has no personal interrelations with the field and especially with members of the case setting, no bias or expectations due to prior experiences, and no own personal interest that exceeds the scope of this study. This ensures transparency and objectivity which promotes high quality concerning both the outcome of the interviews and the case study as an open mind is the prerequisite for open-ended interviewing and unbiased analysis and thus the generation of objective results. Furthermore, a detached interviewer is an important factor for an open and intimate atmosphere for interviews in which interviewees feel comfortable and safe to speak frankly even about sensitive issues.

8.1.1.2 Integrity of the research project

The integrity of the research project is achieved by a thorough justification of the research (goal), including the motivation, and chosen methodology. The study constitutes its motivation and research goal on both the identification of research gaps and the disclosure of a concrete problem in the application domain. To address the multidimensional and -disciplinary character of the ‘real-world’ research problem, namely inter-organisational collaboration, a methodology is chosen which allows for and supports the integration of methods from different disciplines, and which results in a concrete practical solution to the ‘real-world’ research problem: DSR. In addition, good research on a highly complex and multifaceted topic like IOC requires a clear delineation and limitation of the scope of research to the available time frame, data, and research goal to stay focused and not raise unattainable expectations. It is for this reason that this thesis dedicates one chapter to the clear description and delineation of the research project. To ensure objectivity and avoid conflicting interests, the study is neither directly funded nor commissioned by any third party nor embedded in any funded or commissioned research project.

Coherence and consistency

As with most DSR, this research is initiated from a problem in the application domain, namely the necessity of IOC in FPHTI projects which is accompanied by high failure rates. However, based on this starting point, a close alignment with and consideration of the existing bodies of knowledge is emphasised for the course of this study to ensure coherence, meaning the adequate consideration of existing knowledge, and consistency, meaning the logical linking to existing knowledge (Martensson et al., 2016). Existing research on both IOC and inter-organisational innovation research is analysed in detail (see Chapter 2) to theoretically justify the research problem and to evaluate existing theories and approaches with regard to their applicability for the solution of the research problem. The system theoretical perspective from the concept of innovation systems can thus be adapted as a theoretical fundament for the own research approach. In order to take account of the complex character of the research object IOC, existing knowledge from different disciplines including engineering, design science, organisational science, economics, management, and even psychology is considered. This allows for the use of well-established and -tested theories from other fields, whose suitability for the solution of the own research problem is indicated by existing applications. The thus chosen theories and approaches are recombined and reinterpreted for the research context.

Processual transparency

Combining the concepts of Gerber, Tuckerand and Hofer (2018) and Martensson et al. (2016), three aspects of transparency (processual, relational, and reporting) can be defined for qualitative research. The latter ones are considered under integrity and communication respectively. Processual transparency, which best refers to transparency as it is commonly understood and defined for validation, describes the visibility of data, analysis, methods, decisions and (interpretive) choices which allows fellow researchers to retrace and evaluate the research (Moravcsik, 2019, p. 2). Transparency of the course of research is ensured by a detailed presentation, description, and reasoning of the chosen research design for both the overall research approach of DSR (see Chapter 3.4), and also for the qualitative research component, the case study at 3GPP (see Appendix B). A particular challenge of this interdisciplinary study is to balance the different expectations in engineering and economic research concerning the depth of processual transparency. This challenge is met by describing the detailed methodological reasoning and elaborations in the Appendix, where it is optionally available but does not distract the reader's attention from the research context. In order to achieve analytical transparency (Moravcsik, 2019, p. 3), the research uses the overarching concept of relational risk for the analysis of the nature of the research object of inter-organisational collaboration (see Chapter 4.3). This defines a clear focus and perspective for the research and all analytical action, which provides a basis for fellow researchers to correlate the current findings to related work. Additionally, the research does not just publicize the final results but describes the processes of data measurement and interpretation. To ensure data transparency (Moravcsik, 2019, p. 3) a very detailed elaboration of all empirical findings is provided in Appendix D, which makes the interpretation retraceable and also allows fellow researchers to reuse the data for their research attempts. Second, because all interviews were recorded and transcribed, the findings themselves are based on a thorough word-by-word interview analysis which is itself retraceable because of the storage of both the audio data and the corresponding transcriptions[36].

8.1.2 Rigour

8.1.2.1 Rigour of the research project

The rigour of this research is validated in this section and the following two sub-chapters because it includes the in-depth validation of the research project (Chapter 8.1.2.1), the case study (Chapter 8.1.2.2), and the DSR artefact, the LD²M (Chapter 8.1.2.3). Rigour can be described as the effective use of knowledge, theories, and research methods throughout the research that suits the research problem and context (Gerber, Tuckerand and Hofer, 2018; Martensson et al., 2016; Martensson and Martensson, 2007). With the choice of DSR, this research applies a research method that aims to provide concrete solutions for a real-world problem. It is thus not limited to finding 'truth' or generating new knowledge, but to generating effective and utile solutions in the form of concrete artefacts. The selected research method serves the research objective to provide a method which helps to counteract the real-world problem of IOC failure (especially in FPHTI projects). In order to meet the research objective to gain new knowledge about how IOC can be conducted, the qualitative case study is chosen, whose rigour and overall validity are evaluated in Chapter 8.1.2.1. Rigour is also emphasised in the design process: for the design of the artefact, a multidisciplinary literature review is conducted including management, organisational theory, economy, engineering, and psychology to identify suitable methods and theories that can be implemented and/or adapted to design an artefact which best solves the research problem. This integration of existing theories and knowledge from different domains facilitates the design of a method, the LD²M, which builds on components that are each well-tried in other contexts. The theoretical embedding of the design process and its outcome, the artefact, is thus evaluated to be high.

8.1.2.2 Validity of the case study

To validate the case study, which is part of this research, the quality criteria for the evaluation of case studies and grounded theory research defined in Appendix B.4 are applied. As a basis for validation, the adequacy of the research process and the empirical grounding of the theory is evaluated based on Strauss and Corbin's checklists, before the quality criteria construct validity, internal validity, external validity, and reliability are considered.

Adequacy of the research process

The selection of the original sample was directed by the research question, and it was assumed that a chairman of an IOCS has detailed knowledge and experience concerning the IOCS and IOC therein. However, the first sample turned out to exceed those expectations by far which is why the quality and suitability of the original sample are evaluated as a lucky chance of pivotal impact on the overall success and quality of the case study. First of all, the data gathered in the first interview was optimally aligned with the research focus, because the interviewees presented aspects of inter-organisational collaboration and corresponding collaborative activity at 3GPP that fully matched and met the research intention. Second, in addition to the high quality of the presented data, the

[36] See Appendix C

recommendations of fellow lead users (1) initiated a very efficient and yielding pyramiding process and (2) provided the necessary 'door opener' for the acquisition of further interview partners. The recommendations significantly enhanced the motivation of further interview candidates to participate in the case study and for this reason, the selection within the pyramiding process could emphasise and realize the assortment of a representative sample with regard to the individual and organisational cultural background as well as sectoral affiliation. In consequence, based on this starting point, top managers with a tight schedule, but long – often decades of – experience in 3GPP and/or other IOCSs could be gained as interview partners, who all provided highly valuable data for the scope of this research. The quality of the samples is evaluated to be very high and exceeds the expectations of the researcher.

The process of theoretical sampling, which started with the identification of all mentioned influences in the open coding process, led to a general differentiation of those influences into determining (namely causal and intervening) conditions on the one hand and adjustable factors like strategies and organisational context on the other hand. This general differentiation guided the focus of the data collection process to the latter category of influenceable factors. Finally, the following major categories were developed during the process of coding to describe the most relevant influences on IOC: pre-set factors, actors, organisational aspects, GPs, and mechanisms of collaboration (primary and secondary). The development of these major categories is based on a central finding: the interview analysis consistently showed that it is the management and direction of social and sociocultural dynamics in an IOCS that determine the success of IOC. The major categories were thus developed with regard to the sociocultural nature of IOC. The pre-set factors that define the overall conditions and drivers for the social process IOC, and especially indicate the general nature of the IOCS, can be described by features. The social dynamics are both caused and directed by the actors who have a certain mindset, which can be described by GPs. The actors at 3GPP define and interpret the organisational setup and rules for IOC – referred to as the mechanisms of collaboration – based on their GPs. At the same time, the organisational setup and rules guide the actors' behaviour and the development of GPs. The GPs of the actors are thus highly mutual interrelated to the mechanisms of collaboration and the organisational setup of an IOCS.

The reflection of hypotheses was conducted during and after each interview. As stated above, the 'spontaneous' hypotheses that came up during the interviews were discussed with the interviewee at the end of the interview. Each interview[37] was subsequently transcribed and analysed to refine, reflect, and advance hypotheses before conducting the next interview. Thus, starting from the second interview, hypotheses of preceding data analysis could be discussed and reflected in the subsequent interviews. Using this approach, the hypotheses were refined and rendered more precise during the process of data collection and analysis. For example, the initial hypothesis that 'a consensus mechanism is essential for sustainable IOC' was refined to 'the mechanism of *full* consensus is essential for sustainable IOC'. However, because the perceptions of the interviewees were highly consistent, no major redefinitions of hypotheses were made.

Empirical grounding of the theory

The developed model is in line with the paradigmatic model of the grounded theory. The study builds concepts for each relevant influence on IOC. These concepts are all systematically related to the core category – with the focus on social dynamics – and also

[37] with the exception of two interviews that were conducted on the same day

interrelated to each other. For example, the mutual influence of GPs and organisational settings or the mechanisms of collaboration are elaborated. The conceptual density is evaluated to be very high because the findings from all interviews are highly consistent. Not even the consideration of interviewees' experiences in other IOCS settings such as IETF, IEEE, or W3C could fundamentally enhance the concepts. To develop a coherent set of categories which further provide a basis for both theory building and the subsequent use of the data in the research project, categories were iteratively refined during the process of coding and theory generation.

Variation is a pivotal aspect of this case study. This research pinpoints that the variation for qualitative IOC findings concerning the transfer of one IOCS to another is generally very low because of the uniqueness of each IOC project. In order to still make the findings exploitable for further use and research, a whole chapter is dedicated to the analysis and modelling of the IOC-context at 3GPP. By conducting a very detailed multidimensional system theoretical analysis of the specific IOC conditions that are found at 3GPP and their interrelations, a thorough understanding of existing interdependencies and the IOC-context sensitivity is developed. This facilitates an evaluation of the variation as feasible and even recommendable provided that the transferability of the findings is evaluated beforehand by a reflected IOC-context comparison and impact evaluation as proposed in the LD^{2}M.

The significance of the findings is evaluated as being high concerning the research objective because it provides detailed data which helps to close the research gap of how IOC can be conducted. The case study was not conducted to develop a universally valid theory, but to provide insights into how IOC may be realized. Additionally, the case study indicates which parameters can be considered to define and evaluate appropriate institutions for other IOC-contexts. It thus introduces a basis for more IOC-context-specific and less generalising handling and interpretation of qualitative findings in IOC research which could promote a sounder and less misleading way of presenting findings from qualitative research.

Construct validity

Construct validity describes how the researcher can correctly evaluate the studied concepts (Quinato, Andrade and Almeida, 2020, p. 277). The multi-scale approach that is chosen to study the research sub-question greatly contributes to the construct validity because it allows for the holistic approach towards the studied concept of IOC (see Chapters 2 and 4). According to Andrade (2009), corroboration and theoretical sufficiency also contribute to the construct validity whereby corroboration describes 'the act of strengthening [an argument] by additional evidence' (Hayward and Sparles, 1975, p. 253). In this study, the constant comparison of findings and built theory with empirical data is the main source of corroboration (see Appendix B.2.1). In addition, the findings and theory are questioned by the researcher in the light of and are compared to existing research findings in the field of IOC success factor research, although little research exists that equally focuses on the 'how-to' of IOC and not on the 'what to' (see II). This requires creative and flexible corroboration and the 'how-to'-findings of this study are aligned with the comprehensive findings on IOC-influencing factors at multi-scales (see for example Appendix H). As a result, it is found that the identified processes and institutions of this study address the key influencing factors concerning IOCA which indicates coherence, consistency, and sufficiency of the case study findings and thus construct validity. With regard to theoretical saturation (see Appendix B.2.2), the density concerning properties, dimensions, and interrelations have to be taken into account, which is considered to be very high in this study as the multiple interviews provided very consistent data that indicated theoretical saturation after only five interviews. This is why the study could even take comparative experiences from related IOCSs into account, which confirmed the theoretical saturation even in a slightly expanded scope of the investigation. The chosen multi-scale approach helps to generate density concerning dimensions and interrelations because variations and processes within the categories can be thoroughly considered as well as interrelations between the categories.

Internal validity

Internal validity requires the researcher to define correct cause-effect relationships both concerning the measured parameters and the confounding factors. As this research focuses on perceived relational risk and thus the determination of perceived drivers of IOC that are measured directly, the definition of measurands is not a critical aspect for the internal validity of this case study. However, the assortment of the sample is decisive, to identify and evaluate potential alternative confounders for the measured perceptions of the interviewees. This research accounts for internal validity by aspiring toward participant diversity with regard to (1) the individual cultural background which refers to the cultural background of the interviewee, (2) the organisational cultural background which refers to the cultural origin of the represented organisation, and (3) the sectoral affiliation which refers to an organisation's business segment with regard to the ICT industry in which an organisation's economic core activity takes place. The diversity of the sample promotes internal validity because the potential effect of individual, organisational, or cultural background and/or sectoral affiliation can be identified and evaluated. In the process of data analysis, a thorough pattern matching of all transcripts was conducted based on the coding principles of grounded theory. Special attention was given to conflicting perceptions of different interviewees although such hardly occurred.

External validity

External validity – meaning the statistical generalisability of case study findings – is evaluated as low for this research. In fact, it would explicitly contradict the basic understanding of IOC as a unique and complex phenomenon. This challenge of limited generalisability of qualitative findings is met by the introduction of an alternative approach for the use of the case study findings which emphasises contextualization instead of generalization. This is why this case study includes a thorough description and understanding of 3GPP's IOC-context. This IOC-context information which is modelled as IOCS is used to provide reflected transferability of the case study findings by facilitating and fostering a contextualized further use of the collected data and findings.

Reliability

Reliability in terms of repeatability of the case study is also very limited (Wurster, 2011, p. 130; Strauss and Corbin, 1996, p. 215). Naturally, qualitative research depends on the time, the interviewees, the interviewer, and the interview style and course. For example, one year earlier, interviewees had not had any experiences of IOC under pandemic conditions. However, this study aims to provide reliability in terms of stability and consistency of data interpretation and the drawing of conclusions, which enables fellow researchers to 'draw the same picture in their own shade'. This means that study repetition would neither lead to the exact same, nor to a completely different result, but would disclose a new perspective on the problem which is consistent with the presented research results (Andrade, 2009, p. 49; Mohajan, 2017, p. 10). All interviews are recorded and transcribed word by word which allows the researcher to conduct a reflected and thorough data analysis and comparison both with other transcriptions and existing research with the aim to reduce bias and intuitive conclusions. In addition, the transcripts may serve as a basis for other researchers to retrace and evaluate the course of interpretation and/or to draw their own – confirming or conflicting – conclusions. To minimize inter-subjectivity, feedback loops were installed whereby the interviewer first summarized her understanding of key statements and findings in each interview to obviate misinterpretations. Secondly, as the coding and interview process proceeded, the current state of the findings from the coding and analysis of previous interviews was presented to the interviewees at the end of the interview as a first review mechanism. Thirdly, the final result of the case study was provided to each interviewee for review. Together with the relational transparency of the researcher to the case, this reduces inter-subjectivity and, as a result, the reliability of the data collection is considered to be high for this study. In combination with the consistency and tractability of the data analysis and theory building process, which has been validated in the (1) adequacy of the research process and (2) empirical grounding of the theory, the overall reliability in the sense of the generation of trustworthy, consistent, and meaningful results is evaluated as being high.

Special emphasis was put on the ethical considerations which significantly contribute to the reliability of data generation and quality. An open and intimate atmosphere is promoted by a preceding and continuing noticeable sensibility of the interviewer for the potential sensitivity of interview data with regard to strategic or interrelation content. The independence of the research project, guaranteed confidentiality of the data, and anonymity was already emphasised in the first contact with potential interviewees. All candidates who agreed to participate were supplied with a confidentiality agreement in which (1) their rights, confidentiality, and anonymity, (2) the intended use and storage of data, and (3) the assurance of approval of dissemination of data was explicated in detail. Furthermore, a rough interview outline with the main topics of interest was provided prior to the interview to assure candidates concerning the innocuousness of the interview course. Because of the COVID-19 pandemic situation and the global distribution of the interviewees, all interviews were held by video calls. For each interview, a time frame of 60 to 90 minutes was scheduled to provide sufficient time to become familiar and build trust before the actual interview started. During this time, the rights, intended processing of data, the assurance of approval for dissemination of interview data, and the agreement to record the interview for reasons of transcription and detailed analysis were obtained. As a result, a very familiar atmosphere could be created in all interviews. The chosen interview style of PCIs allowed the interviewer to be responsive to the interviewees' perceived key aspects of IOC at 3GPP.

8.1.2.3 Validity of the LD²M

Gerber, Tuckerand and Hofer (2018, p. 14) recommend the quality criteria practicability, utility, and viability for the evaluation of a DSR artefact. In this study, ex-post validation of the artefact is conducted at two levels, which are each discussed in the following subchapters. First, the practicability of the newly designed component of the LD²M, the IAM, which has not yet been proven and tested in other contexts, is tested in the demonstrator IAM in Chapter 7.5. Second, the overall method is validated by expert interviews in order to evaluate the plausibility, practicability, and utility of the DSR artefact for IOC practitioners. In addition to this ex-post validation, this research provides a good indication of the practicability, utility, and viability of the LD²M's means for synthesizing, namely the tripartite system concept analysis and the system theory-based model (STM), by preceding practical application in this research. In Chapters 5.4 and 6.2.2, the tripartite system concept analysis has already been conducted twice, while the concept of the STM is derived from the practical experience in Chapter 6.2.3. Because the tripartite system analysis concept and the STM are inspired by and strongly built on the experiences gathered in these preceding research steps, the applications in this research can be regarded as ex-ante evaluation by practical application of the two LD²M elements of synthesizing, namely the tripartite system concept analysis and the STM.

8.1.2.3.1 Validation of the IAM

The IAM is developed for and implemented in the LD²M for a thorough evaluation of the expected effect of the chosen institutions in a certain IOC-context under consideration of identified interrelations and interdependencies. The IAM demonstrator, however, is not applied for the IOC-context of one specific IOCS but considers the generic type of FPHTI IOCSs with the characteristics defined in Chapter 4 as the target domain. This is not consistent with the objective of the LD²M to design IOC-context-specific sets of institutions. However, this deviation does not affect the functionality of the IAM and is thus harmless for the validation of practicability. The general utility of the IAM, namely its feasibility to conduct a comprehensive evaluation of institutions and their effects under consideration of certain (yet not IOC-context-specific) interrelations and interdependencies is tested. Thus, the utility for the ultimate purpose cannot be finally assessed. However, the evaluation of the utility of the IAM demonstrator with its related scope of the application provides a strong indication for a similar degree of utility of the IAM in the LD²M. By using the case study findings as input data for the tested institutions, the IAM demonstrator can be tested for the most complex application which is the evaluation of institutions that are derived from type II and IV data (see Chapter 7.2.1.2) and thus requires the consideration of IOC-context information. Significantly, the challenge to integrate IOC-context information of both the target and the base domain in the IAM was only detected in the demonstrator IAM. While different approaches were tested, the introduction of relative attributes of the base IOCS that describe the differences between the base and the target IOCS was found to be the most efficient and effective and were thus built into the IAM as it is presented in this thesis.

Practicability of the IAM (demonstrator)

With the sub-division of the matrix into different segments (A to E, see Chapter 7.2.2.2 Figure 39), the IAM guides the user step by step to consider different kinds of potential interrelations which helps to grasp the complex network of interrelations and interdependencies. This stepwise assessment of different sections provides very good practicability with regard to the manageability of interrelations evaluation. However, the use of the IAM demonstrator shows that the procedure may become lengthy and extensive if it is conducted in an overly sophisticated and elaborating manner. This reduces the practicability of the IAM and its efficiency. However, this is not a general shortcoming of the IAM, but an application error, which can be prevented by instructional countermeasures in the IAM guideline, as it is done by the general recommendation in the code of practice provided in Appendix F.3.

Utility of the IAM demonstrator

The IAM (demonstrator) guides the user to consider all possible interrelations at least once and provides a basis to consider indirect effects by tracing interrelation chains across the matrix. Its utility to reveal unexpected and unobvious interrelations is thus considered to be high. However, it lies in the responsibility and depends on the capability, experience, knowledge, and intuition of the user to identify actual interrelations of relevance and the quality of the assessment, whereby its utility remains highly user dependent. This fact is accounted for by providing two different IAM application procedures (see Appendix F.3, Table 12). The different codes of practice allow for the application of the IAM from either base of the target domain depending on the user's area of focus. By aligning the assessment process to the mindset of the user, the course of the assessment occurs more intuitively, which in consequence leaves more capacity for creative and open-minded evaluations. This enhances the assessment quality and thus the utility of the IAM.

8.1.2.3.2 Expert evaluation of the LD²M

In three interviews with highly experienced IOC practitioners, in particular with regard to the design of IOC-settings, the LD²M is validated in detail. Based on the presentation of the LD²M (see appendix F.4.2), the method was discussed in detail with special emphasis on their evaluation of the plausibility, practicability, and utility of the LD²M. By plausibility, the overall value of the LD²M for IOC practitioners is assessed. More precisely, it is checked if the LD²M is reasonable and comprehensive. As such, it is first discussed if the LD²M addresses a problem which is relevant and truly exists in IOC practice. Second, the overall method of resolution to this problem, which is provided by the LD²M, is evaluated with regard to its appropriateness and comprehensiveness. By utility, the effectiveness to solve the addressed problem is assessed in detail. As such, it is evaluated if and how the LD²M and its elements concretely help to cope with the problem. Third, by practicability, it is validated if the LD²M is applicable in practice.

Plausibility of the LD²M

All interviewees agree on the need to (better) harmonize IOC-settings to the specific IOC-context of an IOC project. Especially interviewee 11, who is an often-consulted expert for the design of IOC-settings, confirms a 'copy-and-paste' practice of best practices from other IOC projects when defining new IOC-settings (*Interview 11*, pp. 1 and 5-6). Although all interviewees are predominantly active in the ICT sector, in which IOC is well-established, the practice of non-reflected adoption of IOC-settings is state-of-the-art despite the awareness, that this course of action assimilates trail-ballooning (*Interview 11*, p. 2). As such, the problem which is addressed by the LD²M is relevant in IOC practice and the development of a solution is validated as highly reasonable and plausible. The provided design thinking-based solution is evaluated by all interviewees to be very intuitive, appealing, and user-friendly, especially because they all see their own course of action displayed in big parts. From the interviewees' perspective and experience, by the four-staged design thinking process, which uses lead-user as knowledge base, system theoretical models to structure and analyse findings and which promotes the integration of existing practices not by 'copy-and-paste', but by reflected analogy reasoning with focus on the specific IOC-context the LD²M all relevant and important aspects for successful designing of IOC-settings are covered. As such, they evaluate the LD²M to be a full-fledged and comprehensive solution. The plausibility of the LD²M is thus validated to be high by the experts.

Practicability of the LD²M

In line with the fact, that all interviewees see their own course of action formalised by the LD²M design process, they attest the LD²M design process to be strongly in step with actual practice and to represent a rather intuitively applicable solution. As such, they evaluate the practicability of the underlying process as high. Interviewee 13 highlights, that the chosen design thinking process does not just display the way she approaches design problems but also other challenges in IOC practice and beyond (*Interview 13*, p. 9). Interviewee 12 regards the modelling of findings – for example of the IOC-context – as very user-friendly, because it matches his experience how he himself and fellow practitioners tend to structure and model things. This is especially affirmative for the LD²M's practicability as the interviewee does not represent the target group of natural scientists but has a sociological academic background. However, all interviewees evaluate the explanation and presentation of the LD²M with regard to both its scope and its conduction as challenging and jeopardizing for the actual practicability of the LD²M. In fact, it required detailed explications and subsequent discussion with the interviewees to dispel misunderstandings concerning the scope and range of application of the LD²M within an IOC project (see 7.6). Although the weaknesses concerning the presentation of the LD²M have been considered and incorporated in this thesis' presentation of the LD²M, the ease of understanding is evaluated to have room for improvement. Especially, the integrated improvements have not yet been sufficiently tested on its effectiveness. As such, the overall practicability of the LD²M at its current stage of development is evaluated to be moderate and further refinement concerning the ease of understanding is recommended.

Utility of the LD²M

The utility of the LD²M to design IOC-settings, which are better harmonized to the specific IOC-context of an IOC project is evaluated to be very high by the experts. First of all, the LD²M procedure represents in most parts their own established course of action, which is overall evaluated to work very well. As such, they evaluate the effectiveness as high, interviewee 12 rates it as four of five (*Interview 12*, p. 25). However, the LD²M does not just formalise their course of action but advances the solution development by facing the established yet rather unsatisfactory 'paste-and-copy' practice (*Interview 11*, p. 1 and 5-6): With analogy reasoning, a more satisfactory and efficient alternative to make use of existing knowledge and experiences on the design of IOC-settings is provided. As such, the LD²M provides a solution which attains the defined objective, namely the better harmonisation of IOC-settings and IOC-contexts. That way, the LD²M does not only formalise the course of action for IOC practitioners, but even provides an alternative way to integrate existing knowledge which allows even highly experienced IOC practitioners to improve their output with regard to a better harmonization of IOC-settings. However, the pure formalisation, structuring and systemizing of their own doing is regarded as highly useful by the interviewees, because it allows them to act more consciously and thus more efficient, purposeful, and structured. The high utility of the LD²M even for experienced IOC practitioners becomes visible by the fact, that interview 12 spontaneously has several projects in mind in which the formalisation of the LD²M may be conducive (*Interview 12*, p. 29). With regard to the lack of methods in this field, the value and utility of the LD²M for newcomers is evaluated to be very high (*Interview 12*, p. 24). Interviewee 13 states the LD²M's emphasis on the actors, their incentives and social interactions which is assured by the method's user-centricity as highly useful, because it centres exactly this pivot which according to her experience is decisive for the success or failure of designed IOC-settings. As such, the utility of the LD²M to design and better harmonize IOC-settings to its specific IOC-context is evaluated to be high.

8.2 Contribution

8.2.1 Relevance

Gerber, Tuckerand and Hofer (2018, p. 19) recommend considering different aspects of a research project to evaluate its relevance, which is an established concept for relevance validation. These are the research question, the presented (generalisable) solution which comprises the research outcome in the form of improvements, innovations, artefacts, and/or theory, and thirdly the degree of impact and contribution. For DSR projects, the relevance has to be evaluated with regard to both theory and practice.

Relevance and originality of the research questions

The relevance and originality of the research questions – the primary research question and the three deduced sub-questions – are evaluated as high for theory and practice. Analysis of research on both IOC and inter-organisational innovation shows that, so far, there is little cross-disciplinary research between the two fields (originality of primary research question and sub-question 1). However, the interconnection of both research domains is very promising because increasing innovation such as FPHTI takes place in an IOCS and is thus contended with the challenges of IOC (relevance of primary research question and sub-question 1).

In the current research, the question of how IOC can be (and is) concretely conducted and managed is largely neglected and requires more attention (see Chapter 2), which indicates both the relevance and originality of the primary research question and sub-question 2. The concept of (perceived) relational risk provides a promising theoretical approach for explaining and understanding the high failure rates and difficulties in IOC(Ss). However, the research has not yet made use of this theory to generate and develop satisfying countermeasures or solutions for the problems in IOC which result in reduced failure rates of IOC (originality of primary research question and sub-question 3). Analysis of existing research (see Chapter 2) further reveals that existing research aims to solve the problem of heterogeneity of IOC, for example by developing categories of IOC(Ss) with similar attributes. However, there is little research that considers IOC heterogeneity as part of the solution as this thesis does, which indicates the originality of the research question (relevance of primary research question and sub-question 3).

With regard to relevance, the high failure rates in IOC projects and IOC innovation projects indicate a strong need for the development of concrete solutions to make IO collaboration and its outcome more predictable and successful (relevance of primary research question and sub-questions 1, 2, and 3). Among practitioners of established IOCSs, the level of awareness concerning the uniqueness of each IOCS is high (see case study findings in Chapter 6 and Appendix D). However, in line with the gap in research and theory, practitioners lack the tools that help them to develop management strategies and means which are tailored to the specific conditions and needs in their IOCS. The interview findings confirm that own experience and connections with fellow actors in other IOCSs are the interviewees’ sources for gathering information on how IOC is conducted in other IOCSs (relevance of primary research question and sub-question 2). In addition, to the best of the author’s knowledge, there are no methods or guidelines that help to evaluate and contextualize such knowledge and experience in other IOC-settings, which makes the transfer to other IOCSs difficult (originality of primary research question and sub-question 3). By not making use of existing experiences and ‘field-tests’, resources and know-how are wasted in IOC practice (relevance of primary research question and sub-question 3).

The quotes from actors in the European e-mobility sector (see Chapter 1) indicate[38] that the awareness of IOC, its challenges, and its upper management may only develop over time in evolving IOCSs but is not sufficiently present at the beginning (originality of primary research question and sub-question1). As a result, resources, trust, and time are wasted. By more precisely pointing to the importance of IOC in FPHTI projects and providing concrete means for the development of an IOC-context-sensitive IOC-setting and the assistance of IOC management, this research may contribute to a better – and earlier – awareness and management of IOC in affected innovation projects (relevance of primary research question and sub-question 1).

Relevance and originality of the research outcome

The relevance and originality of the research outcome as an initiator of new ways of handling IOC are evaluated as high for both theory and practice. By applying the design thinking concept for problem-solving to the research problem IOC this research directs the focus from the solution space to the problem space (originality of the research solution). As a result, the specific IOC-context of an IOC project with its unique nature is centred as a pivotal element in explaining, understanding, and meeting the challenges of IOC(A). This is the basis to develop IOC-context-sensitive theories, methods, and solutions (relevance of the research outcome). However, because contextualization requires a thorough understanding and elaboration of the entire (sociocultural) IOCS, the identification and integration of valuable knowledge sources is a prerequisite. The research meets this challenge by adopting the concept of lead users for the detection of IOCS actors with high (explicated) IOC(S) knowledge (originality of research). For the use of the case study findings, this research suggests context-sensitive analogy reasoning, which provides a new way of reflected handling of qualitative findings for IOC researchers and allows IOC practitioners to make use of existing experiences and knowledge on IOC (management) in a reflected, IOC-context-sensitive manner (originality of research). As such, the research may contribute to a more appropriate way of presenting and further utilization of qualitative findings in the field of IOC (relevance of research).

Generalisability and applicability of this research solution

The generalisability and applicability of this research solution cannot yet be fully validated because the method developed in this research, the LD²M, has not yet been sufficiently tested in theory or practice but rather is understood as a new proposal for a solution that provides a basis for alternatively approaching and handling IOC(A) and its challenges. As such, the LD²M and/or the new approaches and elements integrated therein have to be applied in theory and practice for a thorough validation and/or for further development and adjustments. The LD²M aims to allow for a maximum variance to leave the door open for refinement and further specification. This is why it gives a minimum of specification apart from the definition of key components and their application. To enhance the amenability of the main target group to the new method, the approach builds on system theoretical IOCS analysis, which corresponds to the education and mindset of the target group that mainly has a scientific, engineering, and/or scholarly background.

[38] This indication is not yet verified because it has not been substantiated and proven by qualified studies.

8.2.2 Communication

Communication is a pivotal quality criterion for research because it determines the accessibility of new knowledge and thus the de facto contribution that research provides for related research and practice. To minimize the language barrier, this thesis is written in English, which is the dominant language among researchers and practitioners in this field. Transparency of documentation and reporting is another quality criterion of communication. The structure of the documentation and the research procedure is aligned, and both are clearly outlined at the beginning and consistently delivered throughout the thesis. In addition, the development and reasoning of methodology, methods, procedures, and decisions are documented in detail to allow fellow researchers to retrace the course of research. The documentation tries to account for the multidisciplinary research topic between engineering and management by balancing the different demands for methodological depth. Finally, the target group has to be able to easily find and access the new knowledge and for this reason, a digital version of this thesis is made publicly available.

9 Discussion

After having validated the research and its core elements, the findings and contributions are discussed in this chapter. First, in Chapter 9.1 the value of the qualitative research in this study is analysed with regard to the selected case and the chosen way of interpreting and presenting the case study findings. In Chapter 9.2, the DSR artefact as the main knowledge contribution of this research is described and discussed in detail. This includes a description of its unique and characterising features and an analysis of its strengths and weaknesses. The latter provides the basis to draw conclusions on the scope of application for practitioners and on promising future development and research paths for fellow researchers. In Chapter 9.3, the value and course of the entire research project are discussed. This includes a reflection on the value contribution in the light of the defined research objective and research goals. In addition, the value of the research project for both the research community and practitioners in the field of IOC and inter-organisational innovation is discussed in one section each.

9.1 Value of the case study

The case study in this research is conducted to achieve the second research goal, which is to study the IOC-context and IOC-setting at 3GPP to gain a better understanding and knowledge of (1) the concrete design of this successful IOC-setting and (2) the perceived influences of this IOC-setting on inter-organisational collaborative activity. The case study reveals how IOC can be practically conducted, managed, and organised and how these practices and measures are experienced and perceived by affected actors.

To best approach sub-question 2, the researcher selected 3GPP as an appropriate case as it can be regarded as one of the oldest truly global technology IOCSs that continuously maintains a very good international reputation (Jonas and Leiponen, 2018, p. 3). This is linked to several advantages of the use of 3GPP as a research object, especially concerning research efficiency and effectiveness as well as the quality of case study findings. Because of the good reputation and the long existence of 3GPP, many delegates have accompanied 3GPP for years and even decades and are truly committed to the IOCS and their duties as delegates. In many cases, their experience in IOC is not limited to 3GPP but is also built on their representative duties in other IOCSs in the ICT sector. By identifying such experienced actors through pyramiding, the data which is gathered in this case study is exceptionally rich in content, quality, and density, as explained in the following three sections.

First, because of their true commitment to IOC, experienced actors at 3GPP have highly explicated and reflected knowledge about IOC(a), and the IOC-context and IOC-setting of 3GPP. Due to their long affiliation, they can even provide retrospective cause-effect observations concerning the delayed effects of certain actions and measures. This provides insights which can generally only be gathered using long-term studies.

Second, the high reputation of 3GPP is concomitant with a highly dynamic actor number and composition (Chapter 6.2.2.2), which results in an outstandingly large IOCS of more than 700 members at the time the case study was conducted. Highly experienced interviewees can thus provide data on how they perceive the effect of different institutions in the light of high actor dynamics including shifts in power contributions as well as concerning different IOCS sizes.

Thirdly, 3GPP is not just a dynamic, but also a very mature IOCS. As a result, the identified institutions at 3GPP stand the test of time both over decades and over a doubling of participants and several technology generations including the emergence of new markets and business models. This does not make findings on how 3GPP conducts IOC less IOC-context-specific, even though the institutions have proven to be robust over certain severe IOC-context alterations, which broadens, expands, and increases the set of IOC-contexts to which findings might context-sensitively be transferred.

As such, by choosing 3GPP as the case for this study, a comprehensive and meaningful set of data is gathered that exceeds the findings that can be expected from a single case study, because the interviewees can share their long-term experiences including the observation of severe IOCS-internal and -external IOC-context alterations and their impact on IOC.

In addition to the actual case study results, the presentation and interpretation of these qualitative findings in this research require consideration as they both counteract the trend to generalize prescriptive findings and confuse perceptions with actual determinants of performance. Identified institutions are simply presented as the way IOC is conducted at 3GPP and the study refrains from drawing any implications or generalizations from these findings. Instead, it encourages the reader to regard the findings as a source for creativity and provides detailed IOC-context information to promote an IOC-context-sensitive interpretation and further use of the case study findings. With regard to the effects of institutions on IOCA that are determined in this case study, the research question already pinpoints that it is perceptions and not actual determinants of performance that are revealed. This is in line with the overall research aim which focuses on the reduction of perceived relational risk and not on objective relational risk. The disclosure of perceived effects is emphasised throughout the case study presentation to avoid the likelihood of confusion with measured determinants of performance. As such, the case study in this research encourages a more authentic and representative presentation and handling of qualitative research findings and promotes adherence to the prescriptive character of findings from qualitative research on such a heterogeneous and context-sensitive topic as IOC.

9.2 Value of the LD²M

The LD²M at the current stage of development lacks sufficient field-testing and is thus not yet a mature sample solution. Instead, it is understood as a new approach to IOC which aims to stimulate and inspire the way IOC challenges are handled in both theory and practice. To determine the value of the LD²M, its knowledge contribution both concerning its methodical composition and its content is considered. In addition, the strengths and weaknesses of the artefact are analysed.

The LD²M builds on existing solutions from other domains. It adapts, adopts, and fuses existing solutions to solve the research problem, namely the development of IOC-context-sensitive institutions and management solutions. As such, the knowledge contribution of the LD²M can be classified as an exaptation according to the DSR knowledge contribution framework of Gregor and Hevner (2013, p. 345) presented in Figure 42. In this framework, Gregor and Hevner classify DSR contributions with regard to their solution maturity and application domain maturity. A low value of either determinant indicates a high knowledge contribution. The use of existing and well-proven methods – especially the design thinking paradigm and lead user theory – from other fields indicates a high solution maturity. However, as these are combined in a new way, the overall solution maturity is evaluated as being moderate. Their application in the problem context of IOC is new, wherefore the application domain maturity is low. According to Gregor and Hevner (2013, p. 347), for exaptation research, it is especially important to be nontrivial and interesting. The LD²M combines and adapts different methods in a novel way to introduce a completely new perspective on and approach to the highly heterogeneous and complex research object IOC. As such, it can be regarded to be nontrivial and interesting both for theory and (further) research.

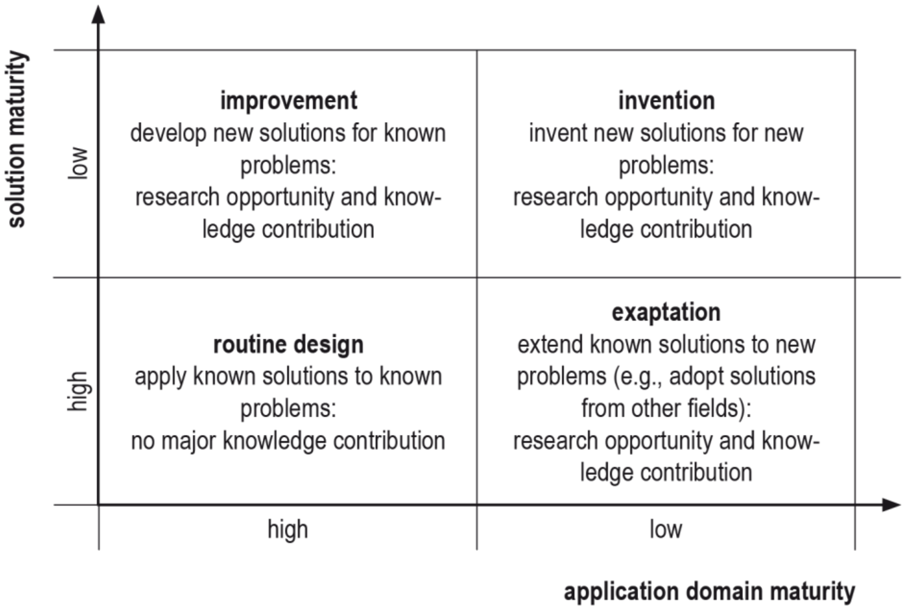

Figure 42: Gregor and Hevner’s (2013) DSR knowledge contribution framework

Concerning the context, the following three features of the LD²M can be regarded as novel and distinctive contributions to the knowledge base:

(1) The design thinking paradigm is applied to the complex problem of IOC and its challenges

By regarding IOC as a design problem, a new and promising path is taken as a result of the unique reasoning pattern in design science which fundamentally differs from the typical result-oriented problem-solving approaches in science (Dorst, 2011, p. 523) as displayed in Figure 43. Natural sciences aim to build theories and hypotheses to understand phenomena in the world. To do so, they use both inductive and deductive reasoning which respectively inform the discovery and justification of results in the form of the observed phenomena. Contrary to these analytical reasoning patterns, design thinking uses value-oriented abductive reasoning: instead of explaining or predicting results, abduction aims to create value as shown in Figure 43. Abductive reasoning is thus about identifying improvements and not best practices. As shown in abduction 2 in Figure 43, abductive reasoning neither requires information on what nor on how something is to be affected to create value (Dorst, 2011, p. 523) which is why the approach is regarded as particularly suitable for wicked problems (Appendix F.1.1.1). As this study emphasises, IOC is very heterogeneous, individual, and context dependent. In consequence, both the formulation of the research problem and the definition of a strived-for solution is challenging. There is neither a 'best way' to conduct IOC nor could this be specified or measured because different ways to conduct IOC can only be field-tested in real-life scenarios and are thus never comparable. As such, IOC can be defined as a wicked problem which indicates and justifies applying the design thinking paradigm for the solution of the research problem. Design thinking is generally a user-centred problem-solving approach, which is modelled in different processes. In order to best meet the research focus on IOC-context sensitivity, the double diamond process is selected as a suitable design thinking approach. In the double diamond process, the problem space – meaning the IOCS under consideration and thus the IOC-context in which IOC(A) is conducted – is put into particular focus and on one level with the solution space. Hence, by using the design thinking double diamond process an approach is introduced that is tailored to both the nature of the research object (IOC) and the special research focus (context-sensitivity) of this study.

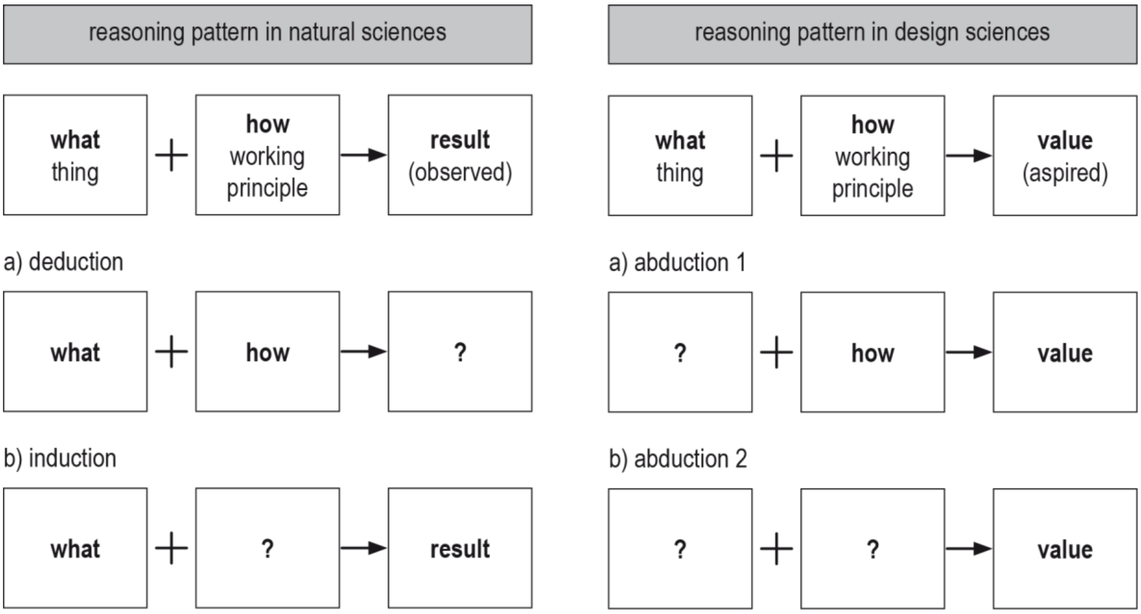

Figure 43: Overview of the contrast between the reasoning pattern in natural and design sciences (based on Dorst, 2001, pp. 523)

(2) The lead user concept is introduced (a) for the identification of insider IOCS-knowledge sources and (b) as method for exploring user needs in design thinking

(a) A thorough understanding of the IOC-context is a prerequisite for developing IOC-context-sensitive solutions. However, IOC is highly determined by socio-cultural and relational aspects, which especially account for (perceived) relational risk and thus for the special (management) challenges that distinguish IOC projects from other business activities. While hard facts like the actor composition or market analysis can be gathered by external studies and investigations, these essential and determining soft facts require insider knowledge. Especially for individuals who are not insiders themselves, both the acquisition and qualitative evaluation of insider knowledge are challenging and require special attention. This challenge is met by using von Hippel's lead user market research technique which he established to facilitate user-initiated product development and innovation. Inspired by Schmidt's (Schmidt, 2019) transfer of lead user theory as a research methodology, 'lead userness' can be defined with regard to IOCSs (see Appendix F.1.2).

In consequence, by adapting von Hippel's concept, the LD²M provides a highly efficient and well-proven technique for the identification of high-quality knowledge sources of insider knowledge. It can be stated that it is the integration of the customized lead user approach which makes it possible to explore the problem space at all and it is thus the pivotal element and basis for a substantiated IOC-context-sensitive approach to IOC, the development of IOC-context-dependent solutions, and the applicability of the design thinking paradigm.

(b) With the introduction of the lead user concept as a technique for exploring the user's needs in design thinking, the research brings two highly complementary concepts from different fields together. While the design thinking paradigm puts the users' needs and their exploration in the focus of problem-solving, it deliberately does not define a specific method to reveal these user needs. Instead, it is up to the designer to select a method of choice. In order to do so, there are recommended practices and methods that facilitate conducting design thinking. However, although lead user theory provides a well-proven concept and practice for how to efficiently reveal user needs as aspired to in design thinking, lead user theory was previously not recognized as a method for design thinking. By introducing lead user theory, the research thus enriches the set of design thinking methods with an outstandingly powerful method for the disclosure of user needs.

(3) Existing knowledge, experiences, and findings on IOC management practices and measures are regarded as a source of ideation and reflection, which is IOC-context-sensitively exploited

This study emphasises the highly heterogeneous nature of IOC and the resulting limited generalisability of existing experiences, knowledge, and findings on how to conduct IOC successfully. However, the limited generalisability of findings and experiences does not make it less valuable per se. In fact, not considering existing knowledge is highly inefficient, ineffective, and equates to an unjustified and unreasonable waste of resources concerning not just the knowledge itself, but also the additional time and effort that is required to build solutions from scratch. This is especially true for non-routine businesses like large global IOC projects, which pose an infrequent – and for some managers even a non-recurring – challenge and which are accompanied by high failure rates. The LD²M strives to provide an alternative way to exploit existing findings and experience for IOC projects, other than by drawing generalised conclusions. Therefore, it aligns with Huxham and Vangen's (2005) approach of 'reflected handles of practice' (see Chapter 2.1) and promotes the integration of existing knowledge in an IOC-context-sensitive way. More precisely, existing knowledge from other IOC-contexts is reflected and evaluated with regard to the IOC-context under consideration and its expected impact therein, but not concerning its performance in prior applications. As a result, the value of integrated findings is determined for the IOC-context in which it will be applied and no longer based on its experienced performance in other IOC-contexts. In this way, existing knowledge and findings are considered—not as best practices but rather as one possible alternative to handle or face a certain challenge. The existing knowledge base is thus exploited for the development of individual, IOC-context-specific solutions in which adopted, adapted, and newly created handles are freely combined to best suit a particular IOC-context.

To determine the scope of application and the further need for action, research, and refinement, it is a prerequisite to consider the strengths and weaknesses of an artefact and thus the three most prevalent advantages and drawbacks are presented and discussed in the following section.

Strengths of the LD²M

(1) The LD²M is tailored to the mindset of the target group

In order to be beneficial and applicable in practice, it is a prerequisite to consider the specifics of the target group, which is dominated by scholars from various scientific fields who naturally tend to apply the reasoning pattern of the natural sciences to problem-solving (Figure 43). This is strongly accounted for in two ways. First, systemic thinking and modelling are identified as a natural pattern of thought for approaching and structuring problems among members of the target group. Thus, by choosing system theory to analyse and describe the problem space, a vehicle for convergent thinking is provided which can be steered rather intuitively by users of the target group. This facilitates the application of the LD²M without prior training or extensive effort and concentration on the recommended method but allows users to focus on content instead. Second, the target group is used to strongly consider what is (technically) feasible when solving problems and is very much focused on the solution space. The LD²M accounts for this aspect with the double diamond design thinking process, which guides the user's attention to the problem space and thus directs the focus from what is possible to what is needed. The LD²M balances and counters the target group's tendency toward a rather solution space-oriented problem solving towards a problem-space based solution approach which is a prerequisite for the research objective to develop IOC-context-sensitive solutions.

(2) The LD²M provides a flexible multi-scale approach

With the STM, the LD²M recommends and ensures a multi-scale analysis of an IOC project's IOC-context and IOC-setting. This means that influences and measures at the micro, meso, and macro levels are considered (see Chapter 2.1). However, the relevance of different levels largely depends on the IOCS under consideration. For example, external factors like governmental policies may be a dominant influence in some IOCSs while other IOCSs that pursue objectives which are not of political interest are not particularly affected. For this reason, the LD²M applies the author's three-levelled interrelation analysis concept (see Appendix F.1.4 and Chapter 7) to flexibly adapt the intensity of analysis to the specifics of an IOCS and the LD²M finds a balance between efficiency and completeness and provides a method to conduct a holistic multi-scale analysis in an efficient manner.

(3) The LD²M maintains many degrees of freedom

The LD²M deliberately minimizes the specification of methods that should be applied for executing the LD²M and confines itself to the definition of a processual and methodological framework which is essential to guide and trigger the (mindset of) users toward the intended IOC-context-sensitive perspective on IOC and the creative solution of its challenges. The minimalistic approach is chosen to (1) enhance user-friendliness and (2) account for the early stage of development of the LD²M in several ways. (1) The many degrees of freedom make the LD²M very flexible to adapt to the individual preferences, knowledge, and mindsets of the users. It allows users to apply their own methods of choice wherever feasible. In addition, methods may be chosen in accordance with the specifics of the IOCS under consideration and the individually defined objective that is pursued by means of the LD²M to enhance efficiency and effectiveness. (2) In the light of the early stage of development, the large number of degrees of freedom is advantageous because it promotes the ability to scrutinize and challenge the artefact as elaborated solutions invite users to apply a tool without further reflection and questioning of the presented solution. In contrast, claiming own contributions and inputting a solution with remaining degrees of freedom activates and encourages a user to closely examine the artefact to complement the selectable elements and thus to reflect on and scrutinize both their own choices and the entire method. Thus, the free degrees of freedom support the enhancement of the LD²M. Especially the refinements that do not change any of the core elements defined here, but rather the remaining degrees of freedom can be regarded as further specifications but not a new version of the LD²M. This counteracts the development of parallel LD²M versions and the resulting confusion and ambiguity in communication.

Weaknesses of the LD²M

(1) The LD²M at the current stage of development has a low degree of maturity

As stated above, the single elements of the LD²M are all well-proven and field-tested in other domains. However, neither their combination nor the LD²M in its application domain is yet sufficiently tested and refined. This does not impair the potential of the LD²M or the value and quality of the LD²M as a knowledge contribution. Especially its function as a catalyst and inspiration to strike a new path to handle and approach IOC is not affected. However, it is important to clearly communicate and pinpoint the current stage of development and to delineate the presented method from well-proven, mature sample solutions.

(2) The output of the LD²M greatly depends on the capability of the LD²M users to exploit the knowledge bases in the problem and solution spaces

The introduction of insider knowledge as a primary knowledge source has great potential and enables the development of IOC-context-sensitive solutions that consider sociocultural and relational aspects. However, this makes the output of the LD²M highly dependent on the capability of the LD²M users to generate and explicate high quality and yielding knowledge in the problem space by applying the lead user method. First, in the discover phase of the problem space, the LD²M users need a good sensitivity and sedulity to immerse themselves in the IOC-context and to become familiar with its actors to reveal true needs, dynamics, and relations. In fact, the lead user inquiry should be conducted until a comprehensive understanding of the IOC-context is developed or reached that requires a thorough reflection on the broadness of the consulted knowledge sources. However, it also has to be borne in mind that it is not the LD²M users' capability alone which determines the quality of knowledge exploitation in the problem space but rather the quality and cooperativeness of the knowledge sources, the lead users, are a prerequisite which is only partially in the hands of the LD²M users. Second, in the solution space, the LD²M requires the pivotal yet rather rare and outstanding capability of the LD²M users to be truly open to new solutions for the design of IOC-settings. Because true open-mindedness is a capability which is hardly predeterminable and may deviate strongly from the individual's self-evaluation (see *Interview 11*) this LD²M user capability is a critical factor for a successful application of the LD²M and is a challenging capability, which may not be correctly evaluated beforehand. This is due to the fact that even if LD²M users consider themselves to be open-minded, they might be trapped in their own truth, values, and experiences.

(3) The LD²M does not guarantee successful IOC

This aspect refers to the purpose that the LD²M serves and is thus not truly a weakness. However, in the course of expert evaluation, it turned out that emphasis has to be placed on a clear description of the LD²M's scope to not generate misleading expectations concerning the LD²M and its output and performance. The LD²M assists the development of an improved baseline for IOC by better harmonizing an IOC-setting to its specific context.

However, it does not claim to guarantee a successful IOC and/or IOC outcome which, due to the high reliance on the human aspect, remains a highly social, dynamic, and unpredictable process. Although the LD²M purpose can be described as an improvement of the playing field and rules of 'the game IOC' it is not capable of affecting or determining the actual course or even outcome of this game, which remains in the hands of the actors as players of this game.

Concluding, it can be stated that the LD²M strikes a new, promising path to face the challenges of IOC by introducing a novel perspective on and approach to the heterogeneity and context-dependence of IOC. Although not yet mature, the LD²M provides (1) an artefact for field-testing and refinement as well as (2) a basis, inspiration, and trigger for a more creative and IOC-context-sensitive perspective on and approach to IOC and further related research.

9.3 Value of the research project

In this section, the overall value of the research project is discussed. In the first section, it is discussed how the three research goals, to which the secondary research questions are each dedicated, are attained to assess their individual and conjoint contribution to the overall research objective. In combination with the common theoretical research concept, this provides the basis to evaluate the research's value concerning the research objective. In the subsequent sections, the value of the research for the research community and practitioners is discussed in consideration of its relevance and its contribution, especially with regard to existing deficits.

9.3.1 Value concerning the research objectives

The overall objective of this research is to provide an improved baseline for IOC projects – and especially FPHTI projects – by harmonizing the designed IOC-setting with the specific IOC-context (the heterogeneous and unique inherent conditions) of an IOC project. In line with the research goals derived from this, the attainment of this objective is structured into three different research steps which will each be discussed in the following sections after considering the conjoining research framework as a basis for a holistic evaluation of the research project with regard to the primary research objective.

Contribution of the conjoining theoretical framework

The conjoining theoretical concept of the research makes two contributions to provide a common research ground for all three research steps. First, it defines a mutual 'modelling language' for and perspective on IOC-contexts and IOC-settings, and second, it specifies the type of IOC under consideration. The latter is a prerequisite because IOC is a very broad concept that covers a variety of different concepts, constellations, and types of IOC. In order to serve the research project, IOC is specified according to the characteristics that are relevant for the determination of the appropriateness and necessity of possible institutions and the assessment of their aspired and expectable effects. Besides the purpose of conducting IOC, the basic motive to participate in IOC (discretionary vs compulsory), which also gives information on the possibility to quit IOC, was found to be particularly important in this regard in addition to the hierarchical composition of an IOCS and the economic relationship of the actors. As a result, for the scope of the research, IOC is specified as and restricted to a rather loose type of IOC, in which coopeting actors discretionarily come together to mutually develop a solution for a common problem at eye level. System theory is selected as a common perspective and 'modelling language' for IOCSs.

The common perspective and 'modelling language' for IOCSs provides the basis to conjoin and fuse the results of the three rather self-contained research steps. The system theoretical approach to IOC is beneficial for the attainment of the research goal due to several advantages. Firstly, system theory is particularly suitable to describe and understand complex phenomena such as the research object of this study, namely IOC. Secondly, the core idea of system theory is that the understanding of the interrelations and interacting processes between different components in a system are the basis to explain the happenings in and functioning of a system and thus centres on relational aspects. As such, system theory aligns with the research objective that focuses on the (perceived) relational risk in IOC, which is the risk that results from the interaction and interrelation of actors in IOC. Thirdly, because different concepts exist in system theory (see Chapter 4.2), a system theory perspective facilitates conducting multi-scale research which is aspired to in this work. Finally, system theory is an interdisciplinary approach which is familiar to researchers from different fields. Hence, a system theoretical approach is perfectly aligned to the interdisciplinary research project which is tangent to IOC management, innovation management, and product development and should thus likewise appeal to engineers and economists in academia and practice.

Contribution of the first research step

The first research step defines the application domain of the DSR approach and focuses on attaining the first research goal which is to explore and analyse the generic IOC-context of FPHTI projects in modern economies to enhance the understanding of the specifics of such innovation projects with regard to IOC. The research strives to build on and make use of existing knowledge, research, and concepts. However, because of the conceptual and terminological confusion around the intensity dimension of innovation (see Chapter 5.1), an own definition for the innovation projects under consideration has to be developed to avoid ambiguity. To this end, Zeleny's (2012) output-based approach to technology is used to develop the introduced concept of 'frontier pushing high-technology innovations' (FPHTIs). This concept enables clear and unambiguous communication and simultaneously provides functional benefits for the research. Other than the commonly established input-based innovation concepts around the intensity dimension of innovation (see Chapter 5.2.1), the solely output-based definition of the innovation type allows one to draw conclusions on the nature of the concomitant IOC that aligns with the characteristics which define the type of IOC that is researched. The concept of FPHTI allows for the classification and benchmarking of IOC in FPHTI projects with regard to the type of IOC that is researched.

A macro-level investigation of the ecosystem context in which FPHTI is conducted, namely modern economies, complements the analysis of the IOC-setting. This is conducive to the research result and quality because it furthers the development of a holistic understanding of the application domain. In addition, it complies with the research concept to conduct multi-scale research. Thirdly, and most importantly, the main idea of this research is to use an IOC-context-sensitive approach to the heterogeneity of IOC, which is developed to attain the primary research objective and is put into practice by and requires the inclusion of a macro-level analysis. This is because the IOC-context is defined as the set of all influences that affect IOC from within but also from outside the IOCS.

The characteristics and interrelations of the IOC-context of FPHTI projects which could be derived from the results of the multi-scale analysis are system-theoretically interpreted and processed to define a corresponding IOCS model for FPHTI projects according to the conjoined theoretical concept. This provides a result for the first research step that is compatible with the results of the other research steps. Concerning DSR, in the first research step, the application domain is explored and defined and requirements for a DSR artefact are deduced.

Contribution of the second research step

In the second research step, the qualitative study, namely the case study at 3GPP, is conducted to attain the second research goal, which is 'to study the IOC-context and IOC-setting of the pioneer of global IOC, 3GPP, in order to gain a better understanding and knowledge of (1) the concrete design of this successful IOC-setting and (2) the perceived influences of this IOC-setting on inter-organisational collaborative activity'. By conducting a multi-scale study, the main scope of this study, namely the detailed exploration of the IOC-setting by gathering 'how-to' insights at the micro-level is attained, which can be complemented by the necessary IOC-context understanding that requires an investigation from different scales. This not only contributes to the second research goal but also to the overall research objective. The necessary IOC-context information and knowledge are generated that is required to exploit the findings on 3GPP's IOC-setting, including (1) the disclosure of all factors and dependencies that cause, and affect, interrelations at 3GPP, (2) the conduction of an IOC-context-sensitive analysis and interpretation of the IOC-setting, and (3) an IOC-context-sensitive further use of the findings on 3GPP's IOC-setting in this study and subsequent research.

As in the first research step, the conjoined system theoretical approach is used to interpret the gathered data. Concretely, findings are categorised as soft institutions and hard institutions, which together allow for modelling the IOC-setting of 3GPP. In accordance with system theory, a special focus is put on existing interrelations between the identified elements of the IOCS 3GPP, which are presented and traced in a levelled matrix structured interrelation analysis. With regard to the DSR approach, in the second research step requirements for the DSR artefact are revealed or at least inspired. In addition, new knowledge is generated on how IOC can be conducted which contributes to the knowledge base.

Contribution of the third research step

In the third research step, the third research goal is attained, which is to develop a method for the design of IOC-context-specific IOC-settings. It is in this step that the design cycle of the DSR approach is conducted and the centrepiece of the research, the LD²M, is designed. The functionality of the LD²M was already discussed in detail in Chapter 9.2. However, as a DSR artefact, the method has to make 'a clear contribution into the application environment' (Hevner, 2007, p. 91) and subsequently has to be applicable and useful for practitioners, which further demands efficiency. This is considered by three LD²M features. First, the LD²M uses system theory which can be regarded as 'a natural pattern of thought for research and problem specification among members of the target group' as discussed in Chapter 9.2. Second, the LD²M does not design solutions from scratch but makes use of existing knowledge by analogy reasoning. Third, the remaining degrees of freedom in the LD²M make it flexibly adaptable to the preferences and expertise of users, which further enhances efficiency. The LD²M as an outcome of the third research step thus does not only meet the requirements of the research objective (which were discussed in Chapter 9.2) but is also in line with the chosen research approach of this study.

Attainment of the primary research objective

The primary research objective is to develop a method for the design of IOC-context-specific IOC-settings. The chosen multi-method research design, which is realized by three rather independent research steps based on one conjoining theoretical framework, facilitates meeting this multifaceted objective. In each step, a different view on and aspect of IOC can be elaborated by means of the most appropriate methods for this particular step. Based on the three different views on the problem, a new perspective is developed that is tailored to the research objective. Thus, a thorough understanding of the phenomenon of IOC with regard to the defined research objective is developed which allows for the research objective to be achieved by a substantiated approach and solution.

Concerning the research content, the research objective is attained by introducing and promoting an IOC-context-sensitive perspective on IOC which is applied throughout the research. The IOC-context-sensitive approach to IOC leads the focus to the heterogeneous conditions – including relational and sociocultural aspects – in which IOC occurs which reveals the specific obstacles and needs within an IOCS. This is advantageous for the enhancement of the baseline for IOC, namely the IOC-setting because it allows IOC heterogeneity to be used to promote, as opposed to hinder, the development of targeted counteraction to the identified obstacles of IOCA. This research's DSR artefact, the LD²M, finally puts the IOC-context-sensitive approach into practice. However, its contribution is not limited to the exploitation of IOC heterogeneity. In fact, the LD²M also accommodates the bipartite and highly social path of IOC, which makes the alteration of user behaviour and interaction – for example by perceived relational risk reduction – a key parameter to influence IOC outcome. With the introduction of design thinking, which is a highly user-oriented paradigm that centres on users' needs instead of objectively analysed performance data, the LD²M gives special consideration to the users' key role in the success of IOC.

The LD²M can be regarded as the conjoining element of the research. First, its design is substantially influenced by and built on the findings and insights from the first and second research steps. Second, in the demonstrator version of the IAM, which is the LD²M's tool for convergent thinking in the solution space, conclusions for FPHTI IOCSs can be drawn under consideration of the findings from the qualitative case study in the second research step. Especially, the applicability and transferability of 3GPP's institutions for the IOC-context of FPHTI IOCSs are discussed and evaluated including an analysis of the effects that may be caused by these institutions in FPHTI IOCSs. As a result, a basic set of institutions that may be altered, adapted and enhanced for specific FPHTI IOCSs can be provided by this research. In addition, challenges for the application of 3GPP as a base domain in the LD²M are disclosed which facilitates a suitable and reflected further use of 3GPP as a base domain in the LD²M.

Concluding, with the LD²M as a major knowledge contribution and centrepiece of this research, the research objective is attained. Most notably, apart from theoretical findings, a concrete practical proposal for a solution for the primary research objective is provided and many innovative impulses to handle and approach IOC in both theory and practice are offered.

9.3.2 Value for practitioners

Relevance

As outlined in Chapter 1, there is a significant economic and societal need to conduct IOC successfully. In times of technological progress and globalisation, IOC becomes an increasingly heterogeneous phenomenon because the problems that are faced and the solutions required become more complex and additional digital possibilities of IOC emerge. The high failure rates of IOC projects show that the concomitant challenges of IOC cannot yet be met appropriately and there are few tools and techniques that currently concretely assist practitioners to manage IOC. This research provides a concrete solution for practitioners in this regard. By putting the heterogeneity of IOC in the focus, the designed LD²M facilitates and enables the development of IOC-context-sensitive solutions for IOC practice and management.

Contribution

The identified importance of IOC increases in most spheres and fields of the economy, including multi-actor innovation projects. However, the management focus in these projects is still on innovation management and neglects the relevance of IOC management (see Chapter 2.2). This research particularly considers the IOC management needs in FPHTI projects as one representative of inter-organisational innovation to pinpoint the relevance of IOC management for the success of such innovation projects. As a result, this research introduces a so far rather disregarded yet highly significant management field for innovation practitioners in multi-actor innovation projects such as FPHTI projects as a pivotal management element: IOCS management.

Because of the research shortcomings concerning how to conduct IOC, practitioners lack a basis of insights, experiences, and possible practices of IOC that they can use to derive their own handles of practice for IOC. This is highly inefficient and hinders the iterative advancement of IOC (management) practices. With the findings of this research's case study on how IOC is conducted at 3GPP, a pioneer of global IOC, practitioners are provided with insights and experiences at the micro-level. In addition, the presentation and handling of the findings in a contextualized and not a generalising way stand out against existing qualitative studies in this field. As a result, this research offers a first IOC-context-sensitive knowledge base and source for inspiration and ideation for practitioners that may be the starting point and initiator for the development of an IOC-context-sensitive database of IOC practices. Such a database could facilitate IOC management and drive a successive advancement of IOC practices.

With the introduction of design thinking and especially the double diamond process, the research also contributes to the IOC practitioners' mindsets. While the problem-solving approach among scientists, who are identified as the target group of practitioners in this research, typically prioritizes the solution space, the LD²M directs the focus toward the problem space. This broadens and shifts the practitioners' view on the challenges faced and provides a new perspective for solution development. In addition, the LD²M fosters creativity in the solution space. In the divergent phase, practitioners are encouraged to take new, individual, and tailored paths by means of open-minded and unrestricted ideation with or without consideration of existing practices. In this phase, innovativeness and creativity are promoted by the subsequent reflection and assessment of the developed solutions in the convergent phase, which allows for structured IOC-context-sensitive interrelation analysis and thus for the substantiated assessment of creative solutions. Finally, the combination of system theory and design thinking makes a contribution to natural scientific practitioners who apply design thinking since design thinking is an approach that aims to popularize the designer's approach to problem-solving and which is rather contrary to the approach scientists take for developing solutions. Thus, by introducing system theory as a method of convergent thinking, the design thinking approach is familiarized and thus made more appealing to and intuitively usable for natural scientists.

9.3.3 Value for the research community

Relevance

To better understand the heterogeneous and complex phenomenon of IOC, research is required that recognizes these features not as a problem but as part of the solution (see Chapter 2.1). In particular, this becomes even more relevant to provide research that faces and explores the emerging challenges in IOC caused by globalisation and technological progress. By defining the IOCS's heterogeneity as being key for the development of conducive solutions for the enhancement of inter-organisational collaboration and corresponding collaborative activity in the LD²M, the research's design artefact adopts this perspective. However, the consideration of heterogeneity as key to approaching IOC is not limited to the LD²M but defines the perspective on IOC for the whole research design. In both the analysis of FPHTIs and the qualitative study on 3GPP, the focus is on the disclosure of distinctive features to determine their heterogeneous, unique IOC-context. By choosing system theory for modelling the IOC-context, a method is chosen that in particular aims to reveal the very individual composition – including relational and sociocultural influences – of a system to understand and explore its complexity. With regard to innovation research, this work establishes an important yet so far disregarded link as it connects IOC research to multi-actor innovation research to consider the obvious intersection set which augurs synergies, in particular for inter-organisational innovation research.

Contribution

This research contributes to theory concerning its (1) content, (2) methodology, and (3) scale(s) of investigation.

(1) Contribution to the theory concerning content

As stated above, the research is novel with regard to the presentation of heterogeneity as part of the solution to explore and understand IOC. More precisely, an IOC-context-sensitive study of IOC is introduced that promotes a new perspective for IOC research. By using system theory for the modelling and exploration of the IOC-contexts, relational and sociocultural aspects of IOC are put into focus and pinpointed as crucial determinants of heterogeneity and thus the uniqueness and specifics of IOC. This is in line with Das and Teng's concept of relational risk whereby this research provides an application of their integrated framework of trust, control, and risk and thereby strengthens their approach.

(2) Contribution to the theory concerning methodology

By making use of the existing solutions, methods, and practices of other fields, this research contributes to both the scope of methods in IOC research and the scope of application for the adapted methods.

First, design thinking and especially the double diamond process is introduced as a means to explore IOC and develop solutions in IOC research. This is beneficial for IOC research because a more problem space-oriented and creative research approach to IOC is provided as an alternative to a rather imperative and solution-oriented perspective that focuses on what should be rather than on what is needed. In addition, the user-centricity of design thinking accommodates the highly social nature of IOC.

Second, the scope of application of lead user theory and methodology is augmented. This is advantageous because the current concept that is primarily established in product development also bears great potential for other fields, which is promoted by the application in this research.

Thirdly, the combination of the double diamond design thinking process with the lead user approach and system theory makes a novel contribution to the design thinking paradigm as both design thinking and lead user theory are user-centred concepts that aim to reveal the needs of users concerning a given issue. As such, the integration of the lead user concept as a method to disclose the user's needs in design thinking appears to be intuitive from the outset but has not yet been conducted prior to this work. By combining the concepts, this research offers a very efficient method for the exploration of the convergent phase in the problem-space exploration of the double diamond process.

Fourth, the research explicitly addresses a deficit in IOC research around the communication of qualitative research findings which are prescriptive (see Chapter 2.1). There is a trend in IOC research to handle and present qualitative findings in a rather imperative and/or generalising manner, which misleadingly implies that the findings represent best practices whose performance has been objectively determined. This is counteracted in this research by presenting qualitative research findings as *one* way to meet IOC challenges, which does not provide an ideal solution but a source of inspiration and data for (context-sensitive) reflected consideration, evaluation, and further handling and adaption. This research thus encourages a more authentic way to handle qualitative findings.

(3) Contribution to the theory concerning scales of investigation

The research explicitly aims to address the gap in multi-scale research that is identified in IOC research (see Chapter 2.1). This is why this research is designed as multi-level research, which takes the micro, meso, and macro levels into consideration to develop a holistic understanding of the phenomenon and relational entanglements of IOC. In addition, special focus is put on the exploration of IOC, and especially the IOC-setting at 3GPP at the micro-level provides data on practices and processes that reveal how IOC can be conducted in practice. With the highly IOC-context-sensitive and detailed analysis and presentation of the data, this research especially encourages and facilitates the further use of the generated 'how-to' data.

10 Conclusion

Summary

> *'The biggest sources of opportunity are collaboration and partnership. And today, with digital communication, there is more of that everywhere. We need to expose ourselves to that as a matter of doing business.'*
>
> Mark Parker

Collaboration is an undisputed factor for success in economics and beyond, which has long been recognized by various scientists and (business) practitioners as the above quote shows. However, in the light of globalisation, technological progress, and the urgent challenges of our time, its relevance has increased rather exponentially, and IOC becomes increasingly prevalent in the economy. As shown in Chapter 1, the relevance of IOC is no longer limited to the business economy as a decisive factor for the success of business activities that cross organisational boundaries. Instead, it has even become a crucial factor for political economies and society which is why a thorough understanding of the complex phenomenon of IOC and the development of solutions for practitioners that enhance the success rates of IOC projects is key. This need is further highlighted and emphasised by the sustained high failure rates of IOC projects.

In existing research, the heterogeneity of IOC projects is predominantly regarded as a problem, which is further exacerbated by grouping and generalizations. However, centring social dynamics which result from the actors' relationships and interaction in IOC as a key and basis to describe, understand, and meet the specific challenge of IOC projects and management[39] reveals that IOC projects are truly one-of-a-kind – at the very least because of their specific social dynamics – and that actors with their needs, behaviour, and interaction are a highly mission-critical factor for the outcome of IOC (projects). This perspective of IOC strongly indicates the need to consider an IOC project's uniqueness as part of the solution. This research provides such an approach by investigating how an improved baseline for successful IOC and inter-organisational collaborative activity (IOCA), especially in frontier-pushing high-technology innovation (FPHTI) projects, can be generated by harmonising IOC-settings to their individual IOC-context. More specifically, the approach enables the tailoring of the man-made, determinable IOC conditions of an IOC project, referred to as IOC-setting, to the IOC project's uniqueness which is described by the IOC-context as an IOC project's inherent, predetermined conditions.

The research concept is particularly designed with regard to the complexity of the research phenomenon IOC, the above-defined perspective on the same, and the interdisciplinarity of IOC research and application. A multi-method design science research approach is developed by which the complex phenomenon of IOC is investigated from different perspectives and at multi-scales. By using system theory for both analysis and modelling of IOC in this thesis, an interdisciplinary concept is implemented which (1) is especially suitable for complex problems like IOC, (2) puts special emphasis on relations between the system's elements as a key to truly understanding a system, (3) provides three different concepts for multi-scale investigations, and (4) makes findings from different research steps, which are generated by different research methods, comparable. As

[39] This approach on IOC is in line with Das and Teng's (2001) relational risk concept.

a result, the findings of an in-depth, literature-based theoretical study of the phenomenon of IOC and FPHTI projects as an application domain can be combined with the insights of a qualitative study on IOC(A) at a pioneer of global IOC, the 3rd Partnership Project (3GPP) to establish a sound basis for artefact designing.

With the design artefact, the lead user-centred double diamond method (LD²M), a prototype for the design of IOC-context-sensitive IOC-settings is provided. By applying the user-centred design thinking paradigm in the form of the double diamond process, an IOC project's uniqueness, which is caused by its specific basic conditions but especially by its actors and the social dynamics that accommodate their interaction, is centred as a pivot for the design of an IOC-setting. Efficiency is a key challenge of the LD²M to be applicable in practice, although the uniqueness of both the IOC project and the output of the method is purposed. Two features or measures are implemented in the LD²M to meet this challenge. First, lead user methodology and its pyramiding technique are applied to efficiently explore the specific conditions, actor needs, incentives and social dynamics within an IOC project. Second, a new way of handling and integrating existing knowledge in IOC (settings and practices) is introduced based on analogy reasoning. In the LD²M, it is proposed to regard existing findings not as best practices but as a source of inspiration and creativity for the design of an IOC-context-tailored, individual IOC-setting. More precisely, an IOC-context-reflected use of existing knowledge, experiences, and findings is suggested by determining the value of a certain institution of IOC practice not with regard to its performance in prior IOC projects and IOC-contexts but concerning the – previously defined by lead user methodology – IOC-context of the IOC project under consideration. This procedure is enabled and based on system theory, which provides a vehicle to analyse efficiently and clearly, model, compare and evaluate both IOC-contexts and potential ICO settings. In this way, the LD²M allows for designing improved baselines for IOC by harmonizing and tailoring IOC-settings to the specific IOC-context of an IOC project.

The LD²M at its current stage of development is a mature pre-test artefact, which is ready for a field-testing practical application. However, its value exceeds that of the delivery of a method that assists IOC practitioners in successful IOC management and conduction. Rather, it provides a new approach to and handling of IOC knowledge resulting from both practical experience and qualitative research as possible alternatives and ways to meet IOC challenges, whose value, however, can only be determined with regard to a specific IOC project but cannot be derived and generalised from its prior performance in other IOC-contexts. This may serve as an impulse and inspiration for more suitable handling of qualitative and practical knowledge in both IOC practice and research. By integrating lead user methodology into the design thinking process, the LD²M brings two meshing paradigms together and additionally provides another application for lead user methodology. With the qualitative case study, this research provides – so far little represented – findings of how IOC(A) can concretely be conducted in practice and presents them in an IOC-context-sensitive way to facilitate appropriate (reflected) further use. In addition, with the model of the 'bipartite path of IOCA' it is found that social dynamics also remain the decisive factor at the operational level of IOC, namely IOCA. Finally, this research bridges IOC research and multi-actor innovation research and introduces IOC management as a relevant element for multi-actor innovation research and practice.

Limitations

The timeframe of this research project leads to limitations that affect the type of analysis and the findings which are generated as well as the significance of the developed artefact.

First, the research does not conduct any long-term observations and analysis and neither a comparative analysis based on a multiple-case study approach, nor a longitudinal single-case study forms part of this research. Concerning the findings, performance measures cannot be conducted within the time frame of this research due to the time delay between the actual IOCA and the appearance of a measurable impact on IOC performance. The perception-based case study findings cannot be confirmed by performance measures.

Second, because of the time frame of this research project, the developed artefact of this research has a rather low maturity and thus significance at the current stage of development. First, validation of the LD²M's applicability and the field-testing, which is required in DSR research, is currently limited to a theoretical expert evaluation of the overall method and the practical application of the IAM demonstrator version in this thesis. In consequence, because of the missing full-scale practical application of the method, neither the practicability of the LD²M in the application domain nor its generalisability for other scopes and domains can be finally assessed. Second, the potpourri of data which is provided for analogy reasoning is still limited. In line with the above-mentioned single-case study approach of this research, only findings from 3GPP are provided. However, for the LD²M it would be beneficial to resort to a multitude of different handles for IOC challenges which are aspired to and desirable for fruitful and inspiring analogy reasoning. Thirdly, in line with the scope of this research, the LD²M in its current version aims to enhance IOCA, which requires influencing the actual behaviour of actors. As such, the focus and aim of the LD²M are to affect perceived relational risk and are limited to this scope of application. However, objective relational risk and performance risk – both perceived and objective – also determine the success of IOC. However, these challenges are not considered in this research and thus not faced by the LD²M, but require individual solutions and research which may or may not be in line with the LD²M.

In line with the basic idea of this thesis, it is of utmost concern to emphasise the limitation of the qualitative findings from the case study on 3GPP: the findings from the case study are IOC-context-specific and based on the perceptions of the interviewees. As such, they represent perceived and not measured factors and effects which positively affect IOCA. The comparability to findings from different studies is limited. The transferability of findings to other contexts is subsequently also limited and requires thorough reflection, for which the use of the LD²M is advised. The findings do not provide a basis for generalised conclusions on best practices for IOC.

Outlook

Concerning the LD²M as a centrepiece of the research and IOC management assistance for practitioners, further field-testing and theoretical elaboration has to be fostered to enhance the method's maturity. In particular, field-testing that applies the LD²M to practical IOC-contexts in and beyond the field of FPHTI IOCSs is key to verifying the strengths of the LD²M, identifying deficits and starting points to enhance applicability, and also to delineate its scope of application concerning context and domain. In accordance with these findings, purposive refinements and advancements can be made, including the suggestions for best practices for the remaining degrees of freedom with regard to methodological best practices. Further research is also needed at the micro-level of IOC, in particular on how IOC is conducted in different contexts to provide more IOC-context-sensitive data for analogy reasoning.

This research gives new innovative impulses for the approach to IOC in both theory and practice. However, more IOC research should align with this intention and strike new paths with respect to the way IOC is approached. In particular, more research should be conducted that considers the IOC's heterogeneity and complexity as part of the solution rather than as a problem to enhance the understanding thereof and to provide a basis for the development of more solutions that take this characteristic into account and thereby might contribute to enhance the success rates of IOC. Such research could align with the IOC-context-sensitive approach that is introduced in this thesis or may simply use it as inspiration to take on new approaches. In line with the highly social nature of IOCA, additional research is needed on relational and sociocultural aspects of IOC and (perceived) relational risk. This could help to reveal and address the distinctive management challenges of IOC management. To support the holistic understanding of IOC, more multi-scale and multi-method research on IOC is required. By conducting more multi-method research on IOC, findings from different views on IOC can be gathered most efficiently and effectively, and their combination may reveal new insights and perspectives that further enhance the development of a holistic understanding of IOC. Like this research, holistic approaches can provide a sound basis for the development of IOC solutions for IOC practice. As stated above, despite the need for multi-scale research, special focus has to be put on the micro scale to reveal more concrete handles of IOC practice both for research and management practice. With regard to multi-actor and especially inter-organisational innovation research, it is highly recommended to conduct more research that focuses on the relational aspects of inter-organisational innovation and the management of the IOCSs around such innovation projects. It is especially recommended to take the synergies with IOC research into account and, in consequence, to integrate the findings from IOC research into inter-organisational innovation research. This could help to establish IOC research as a new and relevant stream of inter-organisational innovation management research.

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Appendix

A IOC in innovation

A.1 IOC-related perspectives on innovation

There are several approaches to describe innovation. Most of them are complementary, but focus on different aspects (Johnson, 1998, p.2) as they evolve from research of different disciplines. The number of different models supports a multidisciplinary and multidimensional view on the complex issue of innovation. In this chapter, three perspectives to approach innovation are introduced. The perspectives are chosen with regard to two criteria: First, they are especially suitable and relevant to describe technological innovations. Second, they allow to draw conclusions on the need of IOC in innovation projects. The chosen perspectives focus on an innovation's a) product embeddedness, meaning the (in)dependence of an innovation from other parts of the business system (Sorli and Stokic, 2009, p. 105), b) relevant knowledge base and c) knowledge-intensity and its effect for process complexity. Due to the abundance of concepts and their multiple inconsistent use, neither the number of introduced models nor the introduced definitions of each model are exhaustive but represent an approach which is supportive for the research in this thesis.

A.1.1 An innovation's embeddedness – autonomous vs. systemic innovation

The concept of systemic innovation is a very popular – yet very little discussed (Sorli and Stokic, 2009) – innovation approach in twenty-first century's industry (and especially in the ICT (Information and Communications Technology[40]) sector (Sorli and Stokic, 2009, pp. 104). It is the answer to the increasing number of different non-incremental innovations during the last decades of the twentieth century (like internet, several generations of mobile telecommunication technologies, Linux, Java and others), which all required organisational and processual adaptions within the innovation activity and environment. To name some relevant concepts of non-incremental innovations, there are *architectural innovations*, which refer to innovations that change the linkage between core concepts (Henderson and Clark, 1990) but also the above discussed concepts around high innovation intensity (see Chapter 5.1) like discontinuous, disruptive, or radical innovations.

Although there is no consensus on one unique definition, systemic innovation is generally and consistently used to refer to innovations, which require additionally assets for their successful commercialization (Teece, 1996). This study follows the definition of systemic innovation, which is provided by Chesbrough and Teece (1996):

> '**Systemic innovation** is an innovation whose benefits can be realized only in conjunction with related, complementary innovations'

Some of the most important characteristics of systemic innovation are discussed below:

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[40] see Appendix D.6.1.1 for details

- *Non-autonomy*: Autonomous innovation is an innovation that can be pursued independently from other innovations (Sorli and Stokic, 2009).[41]Systemic innovations on the other hand are essentially dependent on considerable adjustments of other parts within the system (Laat, 1999; Teece, 1996). That means, that systemic innovation is reliant on other – complementary – innovations to be applied throughout the whole chain of system elements (Laat, 1999, p. 160). Thus, to benefit from a systemic innovation (vs a autonomous innovation), the coordination of change across several production stages and generally even throughout the entire system is required (Teece, 1996). That is why systemic innovation is often concomitant with the following attributes:

Coordinated innovation: To synchronize the required related and complementary innovations of a systemic innovation, all involved parts of the value network have to be coordinated. In many cases – especially for systemic innovation in complex high-technology sectors – that implies innovation beyond an organisation's own boundary and thus requires inter-organisational coordination of innovation, which indicates to contemplate the organisation of innovation activities in open innovation models (Sorli and Stokic, 2009).

- *Open collaboration*: The high-powered incentive structures of markets and the limited administrative control (Sorli and Stokic, 2009, p. 105) impede straightforward information sharing and coordinated adaption throughout a whole (business) system as it is required for systemic innovation. That is why successful systemic innovation requires institutions with low-powered incentives that reduce the risk of being exploited to promote the commitment and free sharing of information between involved economic entities (Laat, 1999, p. 219). According to Teece (Laat, 1999, 219), such institutions need mechanisms to monitor and resolve disputes between the participating actors in a timely way.
- *Creation of needs*: A unique feature of systemic innovations compared to all other innovation concepts may be the approach to proactively create new needs in the market instead of just responding to identified market needs. Although this is not a mandatory characteristic of systemic innovation, innovation activities may involve active work to create the new market needs which they aim to satisfy (Sorli and Stokic, 2009, p. 106)

A.1.2 An innovation's knowledge base – closed vs. open innovation

The open innovation paradigm, which was introduced by Chesbrough in 2003 (Chesbrough, 2003), is probably the most established, prevalent, and cited innovation concept among researchers and practitioners (Herzog and Leker, 2010, p. 19). His new innovation model considered the significantly altered innovation manners and patterns, which were particularly but not exclusively recognized in high-technology industries (Herzog and Leker, 2010, p. 19). That is why Chesbrough refers to his open innovation paradigm also as industrial innovation model (Chesbrough, 2012, p. 20). Furthermore, Chesbrough's model of open innovation tries to account for some 'anomalies of innovation', which could not be explained with existing models. There is for example the difficulty to capture spillovers from industrial R&D processes, which had to date been stigmatized as business costs. According to the open innovation approach, spillovers are a consequence of a organisation's business model[42], which is a potential opportunity to generate additional value (for example by expanding the business model or to spin off the

[41] As defined by Chesbrough and Teece (1996)

[42] See the last passage of this section for the definition of business model in this context.

spillover to locate a new business model) (Chesbrough, 2005, p.5). Another example is the new view on intellectual property, which is seen as an additional asset in open innovation instead of a solely protective mechanisms, which allows to explain why intellectual property should be offered to others and dealed with (Chesbrough, 2005, p. 6).

Closed Innovation

According to Chesbrough, closed innovation is a synonym for what he calls the traditional 'vertical' integration model of innovation'

> In the **closed innovation model** 'internal innovation activities lead to internally developed products and services which that are then distributed by the firm[43]'.

The constitutive and characterising thesis of closed innovation which puts the idea of closed innovation in a nutshell is:

> In a closed innovation model, 'successful innovation requires control: If you want something done right, you've got to do it yourself'[44]

A closed innovation process consequently takes place within a static boundary, which is always equal to a organisation's boundary. Every activity within the life cycle of innovation and its outcome is conducted within the innovating company, including the typical primary innovation activities from idea generation to commercialization, but also secondary activities like financing, marketing, service or distribution. (Herzog and Leker, 2010, p. 20)

Open innovation

Open innovation according to Chesbrough is the antagonist of closed innovation:

> **Open innovation** is 'the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation'.[45]

The underlying assumption of open innovation does not focus on control anymore, but on sources and ways of exploitation of knowledge (Faber and Bellmann, 2008, p. 25):

> **Open innovation** 'places external ideas and external paths to market on the same level of importance as they reserved for internal ideas and ways to market in the earlier era'[46]

In open innovation, organisation's boundary is no longer solid but becomes porous and semi-permeable (Herzog and Leker, 2010, p. 21) to outer sources, activities, solutions, and actors. With regard to knowledge exploitation, two main types of open innovation exist: Inbound open innovation (also referred to as 'Outside-in process' by Gassmann and Enkel (2004, p.8) describes the internal use of external knowledge (Huizingh, 2011, p4) meaning the enriching of a organisation's own knowledge base (Gassmann and Enkel, 2004, p. 1) by leveraging external sources of knowledge and innovation (Chesbrough and Crowther, 2006, p. 229; Brant and Lohse, 2014, p. 6). For example, a technology might

[43] See Chesbrough (2012, p. 20), West, Vanhaverbeke and Chesbrough (2006)

[44] See Herzog and Leker (2010), Chesbrough (2003)

[45] See Chesbrough (2006, p. 1; 2012, p. 20)

[46] See Chesbrough (2005, p. 2)

not be developed in-house but licensed-in. Outbound open innovation on the other hand (also referred to as ‘inside-out process’ by Gassmann and Enkel (2004, p.8) describes the external exploitation of internal knowledge, meaning the use of external pathways for the purpose of exploiting, developing and commercializing innovations (Chesbrough and Crowther, 2006, p. 229). That includes for example the out-licensing of products, intellectual property, or inventions for distribution. Finally, both types can be combined to the coupled process: The combination of the inbound and outbound dimension of open innovation is introduced by Gassmann and Enkel refers to working in alliances with complementary companies (Gassmann and Enkel, 2004). Such cooperation may reach from loose affiliation (for example in innovation competitions) to close (contractual or even equity involving) collaboration like joint ventures (Brant and Lohse, 2014).

Condensed, use of external knowledge sources in open innovation is concomitant with (1) a significantly enhances the complexity and diversity of the innovation process and a change of both (2) mindset and (3) existing business models:

(8) With regard to the innovation process, the most important modifications can be summarized as follows (according to Herzog and Leker, 2010, p. 21):

- The launch of an innovation may likewise be triggered by internal or external ideas and technology sources: For example, inventors or start-ups might be acquired as source of internal innovation.
- Ideas and technology sources may enter the innovation process at any time and by any means: For example, there might be venture investments to gain access to existing external innovations or technology insourcing by licensing external intellectual property rights (IPR).
- There are various alternative ways to commercialize an innovation: Despite the own distribution channel, organisations may use spin-off ventures to spin-out technologies or out-licensing.
- An innovation not necessarily enters the organisation’s original market (only), but others as well.

(4) Chesbrough six – apparently overstated – implicit principles which are given in Table 6 perfectly contrast the difference in mindsets between the open and closed innovation paradigm.

(5) A business model in the context of open innovation uses ‘external and internal ideas to create value, while defining internal mechanisms to claim some portion of the value’ (Chesbrough, 2005, p. 2). Such a business model is part of any open innovation process, because they define the requirements for the architectures and systems, to which the internal and external ideas are combined (Chesbrough, 2005, p. 2).

Table 6: Chesbrough's (overstated) contrasting of the mindsets in open and closed innovation (according to Marques, 2014)

Closed innovation	Open innovation
(1) All the smart people work in our organisation. (2) To profit from R&D we have to discover, develop, and supply everything ourselves. (3) Only if we discover it will we manage to get it to market first. (4) If our organisation is the first to commercialize an innovation, we will beat our rivals. (5) If we create the most and best ideas in our industry, we will win. (6) If we have full control over the innovation process our rivals will not	(1) Not all the smart people work in our organisation. (2) External R&D can create value for our organisation. (3) Internal R&D is needed to grasp that value. (4) We have to be involved in basic research to benefit from it, but the discovery does not have to be ours. (5) If we make better use of external and internal ideas and unify the knowledge created, we will win. (6) We should optimize the results of our organisation, combining the sale or licensing of our innovation with the purchase of external innovation processes whenever they are more efficient and economic.

The multiple ways of knowledge exploitation in open innovation indicate two things: First, the open innovation paradigm is strongly linked to interorganisational interaction and collaboration. Second, this interaction may take various forms depending on the specific open innovation context. This is consequential because the use of external knowledge and sources naturally requires interaction in form of a strategic and managed exchange of information with actors outside of the organisation's boundaries (Brant and Lohse, 2014, p. 7). However, interaction and collaboration are not key aspects of the open innovation paradigm, but a consequence of its focal principle to utilize external knowledge sources and paths to market. Especially, in the open innovation process as it is originally defined by Chesbrough there is no assumption at all on the way(s) of interaction or even a shift of (the solely) control over the innovation process away from the innovating organisation. Thus, the (control of the) innovation process may and generally does remain within the organisation's boundary. That means, a organisation (or organisation) innovating under the open innovation model may and often will preserve its autonomy concerning the control of the innovation activities, the definition of project and/or innovation objectives and all operational and strategic decisions. That is why the coupled innovation process with close integration, in which autonomy is given up for alliancing is just one possible type of open innovation, but not the core of open innovation (as it might be suggested in literature).

A.1.3 An innovation's process complexity – linear vs. non-linear innovation processes

Innovation can also be described from a process view which allows to classify innovation projects according to the (non-)linearity of the innovation process:

> In a **linear innovation** process, knowledge flows successively like a downstream cascade through the different – temporal and organisational ordered (Johnson and Lundvall, 2013, p. 1383) – stages of the innovation process. As main characteristic, subsequent stages are connected by one-

way links as the output of a previous stage is the input for the following stage.

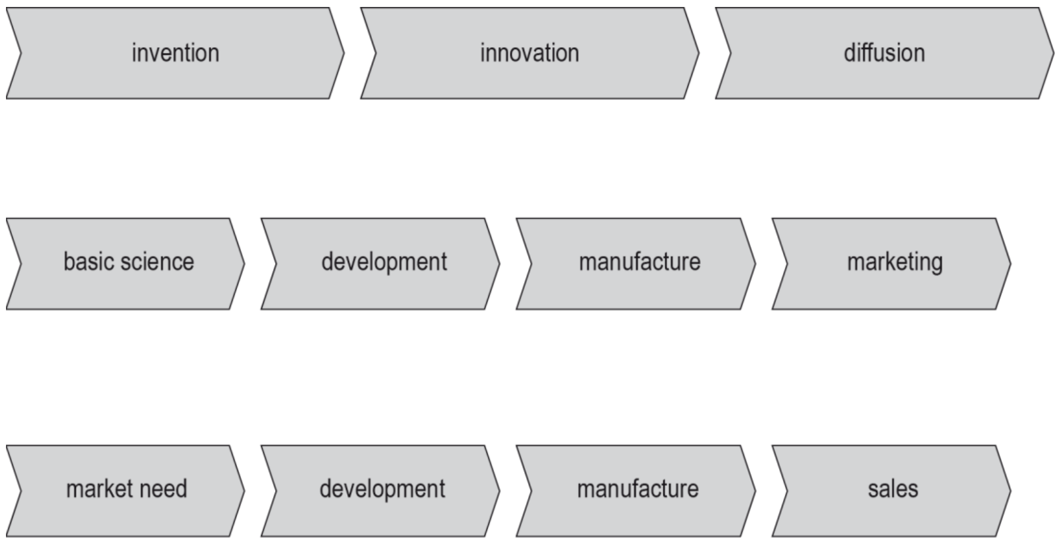

Figure 44: Examples of linear innovation processes (based on Russel and Smorodinskaya, 2018, p. 114; Alekseevna, 2014, p. 119)

Traditionally, innovation was regarded as such a linear process, which is exemplified in Figure 44. However, as the influence of globalisation increased, economic activities became more and more knowledge-intensive under global competition and proliferation (Russel and Smorodinskaya, 2018, p. 1). As a result, innovation processes more and more deviated from 'traditional' linear progression. That is mainly, because knowledge as the additional new 'production factor' behaves differently to traditional factors like labour and capital: knowledge has a significantly higher mobility and different kinds of knowledge and various acquisition opportunities in the learning process are available (Alekseevna, 2014, p. 121). In this much more complex and uncertain non-equilibrium (Russel and Smorodinskaya, 2018, p. 114) of the knowledge-intensive economy, innovations and new values increasingly rely on the co-creation of collaborating actors (Russel and Smorodinskaya, 2018, p. 115), which requires to conduct feed-back loops as displayed in Figure 45:

> In **non-linear innovation** processes the temporal and organisational order between the different stages of the innovation process is reduced or eliminated and feedback loops across different stages exist (Johnson and Lundvall, 2013, 1383).

As a result and main characteristic, the input-output dependency of subsequent stages is annulled and replaced by concurrent interaction within and across the actors in different stages allowing knowledge and innovation both to originate from any stage in the process and to diffuse along any trajectory of (not necessarily consecutive) stages. As such, non-linear innovations are not just accompanied by high interaction, but also require more collaboration[47], often at a multidisciplinary and multidirectional level (National Research Council, 2021). It becomes obvious, that the concept of non-linear innovation processes is highly interrelated to the concept of open innovation (see Appendix A.1.2): In many

[47] Not all interaction is collaboration, which can be regarded as an advanced type of interaction (for more details see for example Russel and Smorodinskaya, 2018, p. 116

cases, non-linear innovation processes are often found in open innovation projects. However, a separation of the two perspectives is expedient for two reasons: First, open innovation and knowledge-intense innovation do not have to be concomitant. While knowledge intense innovation may also occur within one organisation and/or innovation team and thus in closed innovation, open innovation may exploit external knowledge at some predetermined points of a linear innovation process without further feedback loops and cross-stage interaction and knowledge exchange. Second, and more important, the perspective of non-linear innovation processes – contrarily to the open innovation paradigm – shifts the focus towards the social dynamics of innovation processes and emphasise interaction, collaboration and relationships rather than structures and knowledge-sources (Russel and Smorodinskaya, 2018, p. 114; Alekseevna, 2014, p. 123).

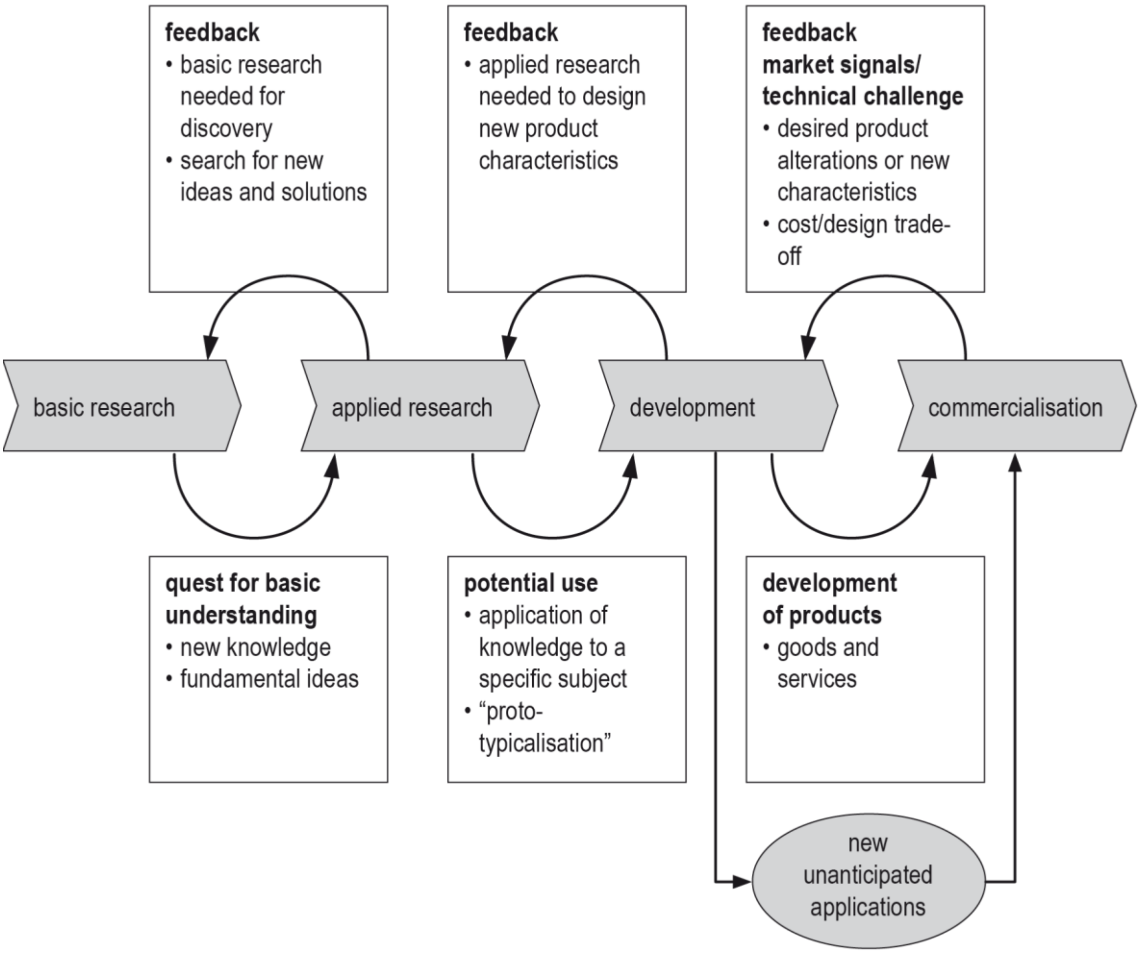

Figure 45: Illustration of a non-linear innovation process (based on Wessner, 2004, p. 29)

A.2 The IOC cube – assessing the need for IOC in high-technology innovation

The three perspectives on innovation can used to assess the need of IOC in technical innovation projects: First, the perspective on an innovation's embeddedness reveals, that highly complex and embedded products are generally accompanied by more interorganisational interaction. In combination with the high R&D expenses of technical innovations (see Chapter 5.1) and especially high-technology innovations, this interaction includes a good share of collaboration. That is why product complexity can be regarded as one determinant for the need of IOC in an innovation project: While autonomous innovations, which refer to innovations with a very small technology support network because of their low technological embeddedness, may be conducted without significant IOCA, systemic innovations, which are characterised by their complex technological support network and high embeddedness, require more entities and expert knowledge for the actual invention and innovation. Coordination of interfaces and systemic embedding has to be conducted and the exploitation may require complementary innovations.

> A technical innovation's **product complexity** is an indicator for the degree of technical embeddedness which determines how much inter-organisational interaction (including collaboration) with affected entities in the technology support network are required.

Second, the knowledge base is identified as second determinant of an innovation (project): Because of the strong influence of the exploited knowledge bases on an innovation project, innovations which require a broad knowledge base are even accounted for with an own innovation paradigm: Open innovation. It describes the inclusion of external knowledge bases in the innovation project and process which is obviously accompanied by a need for IOC. That is why it can be stated that the broader and more open a knowledge base for innovation is, the more interorganisational interaction has to occur. As knowledge transfer requires interpersonal exchange and a common mindset, optimal exploitation requires interaction and collaboration.

> The **broadness of an innovation's knowledge base** is an indicator for the degree to which innovations require inter-organisational interaction (including collaboration in outside-in processes) for external knowledge exploitation.

The third determinant for the need of IOC is the process complexity: non-linear innovation projects require that knowledge flows freely throughout the whole innovation process. Learning and (external) knowledge exchange cannot be conducted at one single stage of the innovation project but is a continuing activity during the whole innovation project. That is why not just (interorganisational) interaction but even collaboration is required at a permanent manner. For closed innovation projects, collaboration is intra-organisational, while open innovation projects also include the exchange with external knowledge bases and becomes thus also inter-organisational. As a result, process complexity can be regarded as indicator for the need of collaboration in innovation projects.

> An innovation's **process complexity** is an indicator for the degree to which innovations require inter-organisational (in open innovation) interaction between involved actors across and within process stages.

As such, while one indicator alone may not sufficiently assess an innovation's need for IOC, all three indicators together may allow for rough approximation for innovations which are technical – or even high-technology, open and include outside-in exploitation. As stated above, these limitations are necessary to assure that interaction is predominantly collaboration (product complexity and knowledge base) and occurs at inter-organisational level (process complexity). The qualitative correlation of the three indicators for the need for high-technology open innovations with outside-in knowledge exploitation is provided by the IOC-cube in Figure 46. The IOC cube does not allow for a quantitative or absolute evaluation of an innovation project's IOC need. It is rather implemental in order to provide a simple tool for a first qualitative estimation of an innovation project's need for IOC based on few indicators.

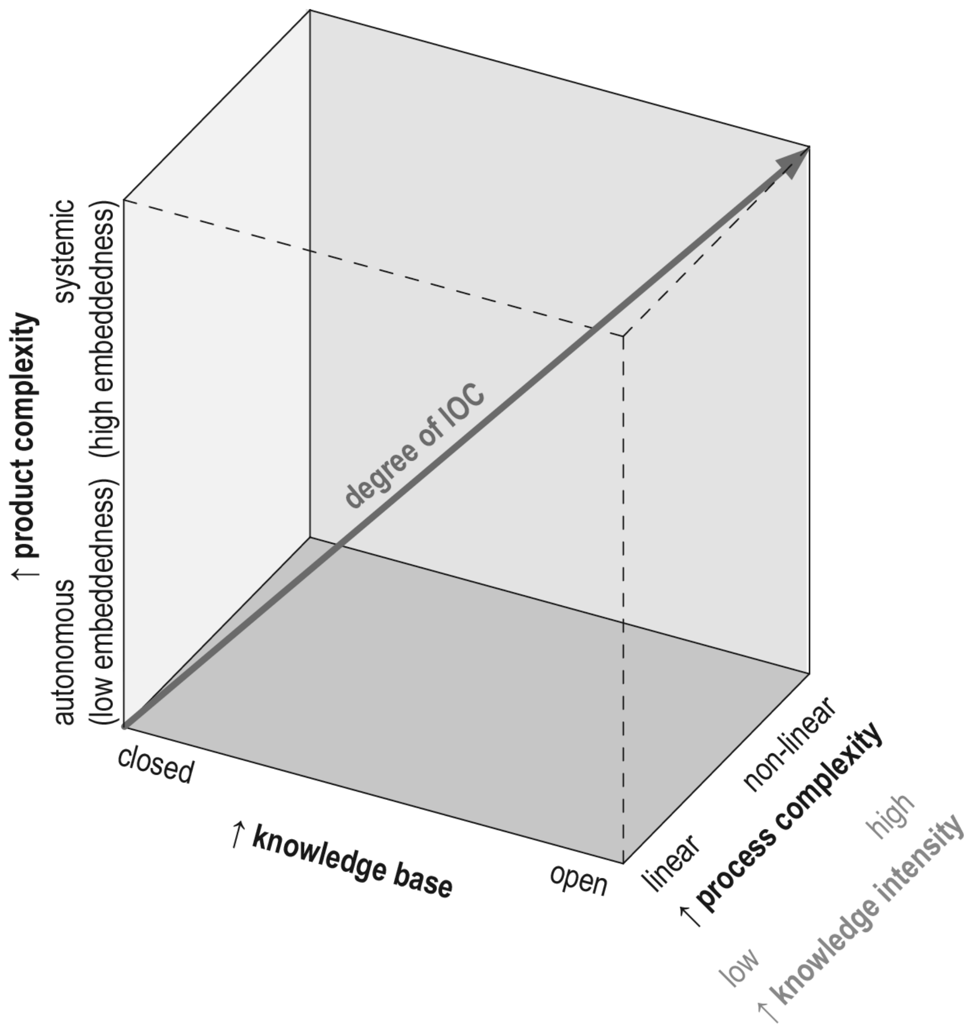

Figure 46: The IOC cube for the qualitative assessment of the need for IOC in technical innovation projects

B Case study design

B.1 Research model

With regard to the defined purposes of the study (see Chapter 6), an explorative approach – in which theory is output and not input (Fredebeul-Krein, 2012) – is chosen. Explorative research is dominated by qualitative technics which are especially qualified for research questions like sub-question two with little or fragmented empirical and theoretical evidence (Fredebeul-Krein, 2012, p. 65). A second indicator to choose a qualitative research approach is the interface position of this research question with engineering, economics and sociological aspects. Also, the complexity of IOC requires a holistic multi-scale approach. This is best provided by qualitative research, which refrains from standardized data collection but aims to record the complexity of a phenomenon (Fredebeul-Krein, 2012, p. 66). The most common qualitative approaches are phenomenology, ethnography, grounded theory, and case study. To answer the research question of this study, an interpretive grounded theory case study design is chosen. More specific, an interpretative approach is chosen which 'documents the [participant's] point of view and translates it into a form that is intelligible to readers' (Harrison et al., 2017, p. 5). According to Neumann (1997, p. 72), that makes an interpretive approach extremely interesting to research problems with interpersonal influences which findings are highly dependent and formed by the personal and individual experience and impression. As a result of interpretive research, the researcher's own findings and the perspectives of all inquiry participants can be presented (Andrade, 2009, p. 45). To gain a holistic understanding of a complex phenomenon by interpretive research it is essential to analyse various samples.

With a case study design, a 'comprehensive, holistic and in-depth investigation of a complex issue in context' can be conducted with focus on the unit of analysis and its boundaries (Harrison et al., 2017, p. 9). That makes the case studies valuable for research topics of high complexity with little theoretical foundation (Ebneyamini and Moghadam, 2018, p. 3) and for 'why' and 'how' research questions (Wurster, 2011, p. 132; Yin, 2003). Another criterion to choose case study design is its strength for theory building (Bhatta, 2018, p. 75). Grounded theory is chosen as overarching methodology, because it provides the best technics to examine rather unexplored contents, processes, and interrelations and assists the development of a holistic model (Fredebeul-Krein, 2012, p. 67). Above that, the iterative process of theory development allows for flexible and open reaction to new findings arising from data collection and analysis (Amar, 2017, p. 748). The complementary focus of case study on the unit of analysis and of grounded theory on the underlying processes, provides a very broad and founded basis for theory development (Andrade, 2009, p. 45). Interviews are regarded as the most powerful method to approach the research topic. As there is also concordance in grounded theory and case study to judge interviews as a preferred method of data collecting this study makes a clear choice for interviews as method to gather primary data. Figure 47 provides an overview of the research model:

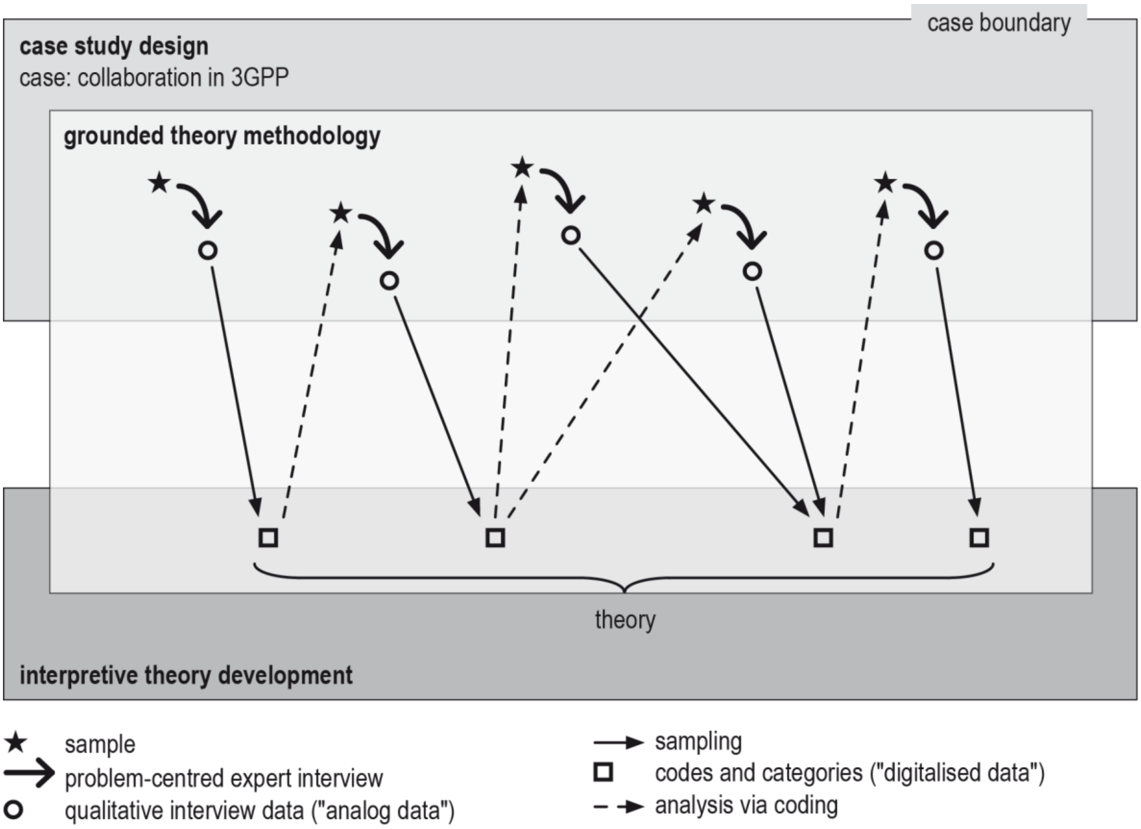

Figure 47: Case study research model

B.2 Research methodology – grounded theory

B.2.1 The concept of grounded theory

Glaser and Strauss introduced grounded theory 1967 with their seminal book 'The discovery of grounded theory: Strategies for qualitative research' (Glaser and Strauss, 1967)). Since then, different versions of methodology have been developed, which can mainly be divided into two strands, one in line with Glaser's further development and one with Strauss' and Corbin's (Vollstedt and Rezat, 2019, p. 82). This thesis uses the pragmatic approach of Anselm Strauss and Juliet Corbin (Vollstedt and Rezat, 2019, p. 82). Just like Glaser, they generate new knowledge strictly inductive (Wurster, 2011, p. 123; Knuth 2007), but Strauss and Corbin do not generally permit previous knowledge. Instead, they integrate it as an important determinant for the successful application of grounded theory (Wurster, 2011, p. 123).

The basic concept of grounded theory is to develop theories, which are 'grounded' in the empirical data, that is systematically collected and analysed (Vollstedt and Rezat, 2019, 2019, p. 83). Although grounded theory is strongly systematically, it does not stipulate a fix sequence of procedural steps (Knuth, 2007). Instead, grounded theory relies on theoretical sensitivity of the researcher (Vollstedt and Rezat, 2019, p. 84), which encourages creativity as an essential component for free associations, expedient questions, and fruitful coding, which produce new findings (Strauss and Corbin, 1996, p. 12). The main characteristics are timely parallelism and functional dependence of data collection, data analysis and theory development which requires a constant alternation between data collection and reflection (Strübing, 2004). The resulting iterative research process, in which planning, data collection, data analysis and theory development are strongly interrelated (Vollstedt and Rezat, 2019, 2019, p. 82) is illustrated in the flow chart in Figure 48 (Bitsch, 2005, p. 78).

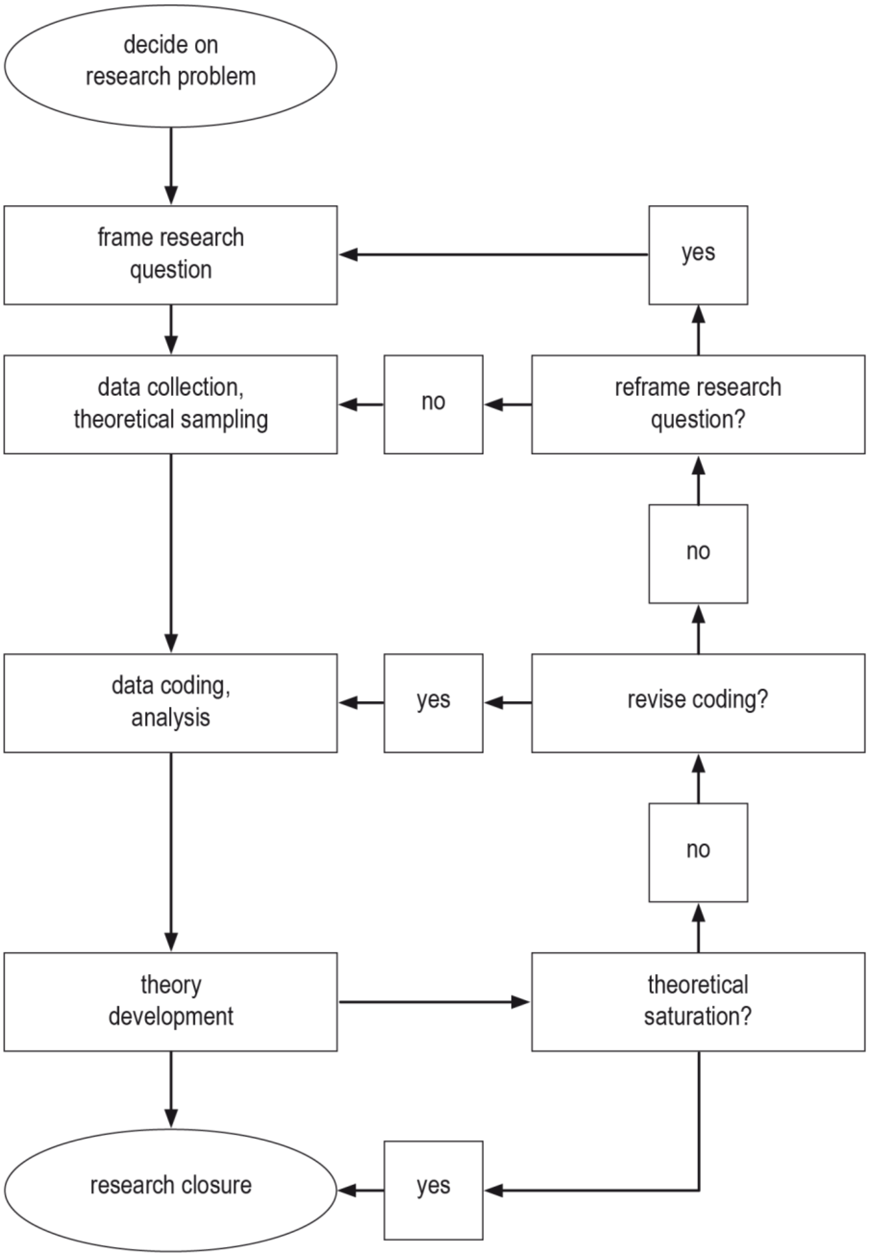

Figure 48: Iterative research process of grounded theory research according to Bitsch, 2005, p. 78

This constant comparison of theory and empirical data is an advantage of the grounded theory methodology, because it leads to an empirical verification of the theory right from the beginning of its development. As a consequence, a finalised grounded theory is inevitably verified and can thus never be completely wrong (Wurster, 2011, p. 125; Strübing, 2004; Knuth, 2007).

B.2.2 Methods of grounded theory

The main techniques of grounded theory are theoretical sampling as means for data collection and coding as means for data analysis. As aforementioned, all methods are applied several times during the iterative research process and always interact.

Theoretical sampling

Theoretical sampling describes the technic of non-statistical sampling for data collection in grounded theory, which is explicitly dynamic and guided by the research question and the unfolding theory (Wurster, 2011, p. 126; Vollstedt and Rezat, 2019, 2019, p. 85). That is why the set of data can never be predetermined in grounded theory. In fact, the researcher starts at some point and decides in the process – based on the findings of constant comparison – which data is collected next and where and how this new data is collected (Amar, 2017, p. 428). Consequently, theoretical sampling does not allow for full descriptive coverage. Instead, theoretical sampling according to Strauss and Corbin (1998, p. 201) aims to 'maximise opportunities to discover variations among concepts and to densify categories in terms of their properties and dimensions'.

Theoretical sampling may be dynamic concerning the technics of data collection, the sources of data and the aim of data collection and sampling: According to the pragmatic and more systematic approach of Strauss and Corbin, literature review is an approved first data source for orientation and to identify the research focus and area (Amar, 2017, p. 428). The major source of data in grounded theory to gain new findings is the interview (Elkatawneh, 2016, p. 6). In the beginning, samplings for interviews often aim to gain comprehensive information on the research topic which are likely to lead to new concepts and categories. As data analysis and theory development proceeds, samplings and interview contents and questions focus more and more on the refinement of hypotheses and densification of categories (which means the differentiation, elaboration, and consolidation of categories in terms of their properties, their dimensions, and their interrelations)

Theoretical sampling is conducted until theoretical saturation is reached. That means, that new data is gathered, and new cases are included in the analysis and constant comparison of the whole iterative process, until new data does not contribute to a substantial development of theory anymore (Vollstedt and Rezat, 2019, 2019, p. 83; Fredebeul-Krein, 2012, p. 70). Theoretical saturation has to be achieved in each category that evolves from data coding. Based on categories, theoretical saturation can be defined as follows (definition according to Wurster, 2011, p. 126):

> **Theoretical saturation** in grounded theory is achieved, if densification of all categories is accomplished, which means:
>
> - density with reference to properties: no more new or relevant data is expected for any category
> - density with reference to dimensions: all paradigmatic elements including variation and process are considered for each category
> - density with reference to interrelations: interrelations between categories are elaborated and validated.

Coding

Coding procedures are the main methods of data analysis in grounded theory with the aim of theory development (Vollstedt and Rezat, 2019, 2019, p. 86). Coding is a process of conceptual abstraction and systematization of data and findings: Incidences in the data are allocated to codes as general concepts (Vollstedt and Rezat, 2019, 2019, p. 86).

In line with the chosen grounded theory approach of Strauss and Corbin, this thesis applies their successive coding procedures[48] of open, axial, and selective coding (Strauss and Corbin, 1990). It is important to bear in mind, that the three types of coding are neither separatable procedures nor timely sequential phases, but rather provide three different ways to process and systemize textual data on a different level of abstraction (see Figure 49).

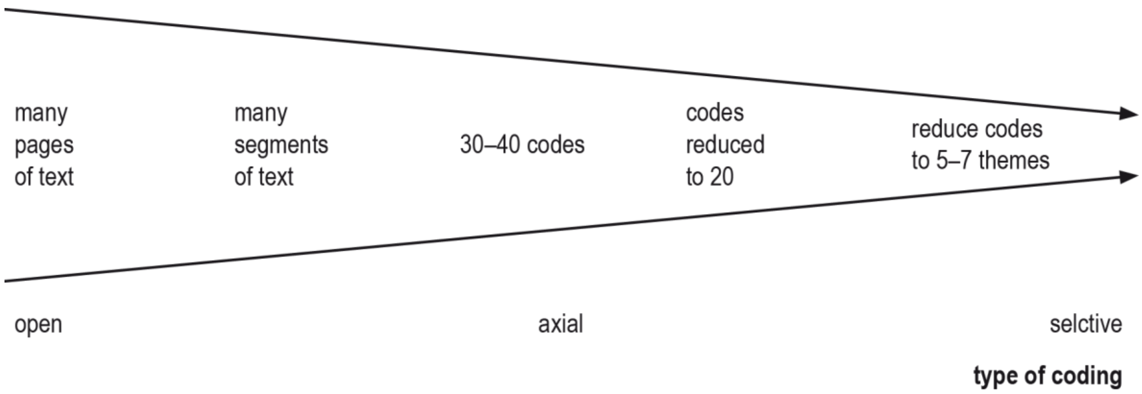

Figure 49: Williams' and Moser's (2019, p. 47) overview of Strauss' and Corbin's coding procedures

> **Open coding** describes the process of conceptualisation and categorization of phenomena with means of sensitizing questions and constant comparison of data and codes. (own definition according to Vollstedt and Rezat (715, p. 86))

Open coding is thus an important tool in the initial analysis phase to first approach data (Vollstedt and Rezat, 2019, p. 86). It aims to develop a comprehensive set of codes as systemised description of the data which grasps the core ideas. Conceptualisation refers to the process of transferring collected data into small, discrete data components: it describes the generation of codes by identifying attributes and concepts for singular incidences, events, and characteristics of a certain phenomenon (Wurster, 2011, p. 127). Codes may either be generated and developed directly from the data or with reference to relevant theories and/or technical literature (Vollstedt and Rezat, 2019, p. 86). Categorization describes the next step of abstraction, in which concepts, which describe of the same phenomenon, are classified and assigned to one category as a concept of higher order (Wurster, 2011, p. 127). Practically, the developed concepts are compared with respect to differences and similarities to group related concepts in one category (Vollstedt and Rezat, 2019, pp. 86-87). The dimension of a category is thus determined by the assigned codes and further explicated in code description (Vollstedt and Rezat, 2019, p. 87; Mey and Mruck 2011). As a result, a phenomenon is described by code and category. Vollstedt and Rezat (Vollstedt and Rezat, 2019, p. 87) provide a set of sensitizing questions in line with Böhm (2004), Mey and Mruck (2011), and Strauss and Corbin (1990), which may provide a basis for the conduction of a creative open coding process:

- What? – Which phenomenon is described?

[48] For other concepts see for example Glaser (1978), Mey and Mruck (2011), Strauss and Corbin (1990), Teppo (2015).

- Who? – Which people are involved? Which roles do they embody, or which ones are assigned to them?
- How? – Which aspects of the phenomenon are dealt with? Which are left out?
- When? How long? Where? – In what way is the spaciotemporal dimension biographically relevant or important for single actions?
- Why? – Which justifications are given or deducible?
- Whereby? – Which strategies are used?
- What for? – Which consequences are anticipated?

For further abstraction and theory development, Strauss and Corbin provide axial and selective coding. Both procedures are very similar and mainly differ in the level of abstraction (Vollstedt and Rezat, 2019, p. 87; Strauss and Corbin, 1990). Beside constant refinement of concepts and categories, they aim to build a comprehensive theoretical framework with one core category based on the developed concepts and their relationships.

> **Axial coding** describes the process in which relationships of concepts and categories are elaborated with means of the coding paradigm. (own definition according to Strauss and Corbin, 1990).

By axial coding, categories are clustered (Heath and Cowley, 2004, p. 146) and relationships between categories and concepts are developed. The coding paradigm is a linear model which consists of six[49] interdependent elements. Strauss and Corbin provide it as a tool which helps to (re-)organise categories, subcategories, and concepts with the aim to develop and plot their unique interrelations. Causes, intervening conditions, and consequences are modelled to explain the phenomenon, the context[50] and all actions and interactions (Heath and Cowley, 2004, p. 146). The phenomenon, which is generally one category, is the central point of the coding paradigm. It represents the central occasion, idea, or incidence, on which (inter-)actions are focused. Causal conditions cover all aspects which cause the phenomenon to appear or develop (Wurster, 2011, p. 128; Vollstedt and Rezat, 2019, p. 88) and which impact the phenomenon and incidences (Amar, 2017, p. 430). The context describes the specific conditions in which the phenomenon, (inter)actions and strategies are embedded. Intervening conditions on the other hand covers all factors which influence (inter-)action strategies. All actions or non-actions which are intended or unintended directed to the phenomenon are represented in the element strategies. Consequences contain all results and outcomes of actions, interactions, a lack of action and applied strategies. Consequences might be of real or hypothetical nature. Depending on the examined phenomenon and the point of time, consequences might become causal conditions for another phenomenon. Figure 50 shows a model of the coding paradigm with its interdependent elements:

[49] The coding paradigm may also be applied with five elements: The intervening conditions are then regarded in the element ‘context’.

[50] Strauss and Corbin’s ‘context’ does not have the same meaning as the IOC-context which is defined in this research as the inherent, project specific conditions of an IOC project.

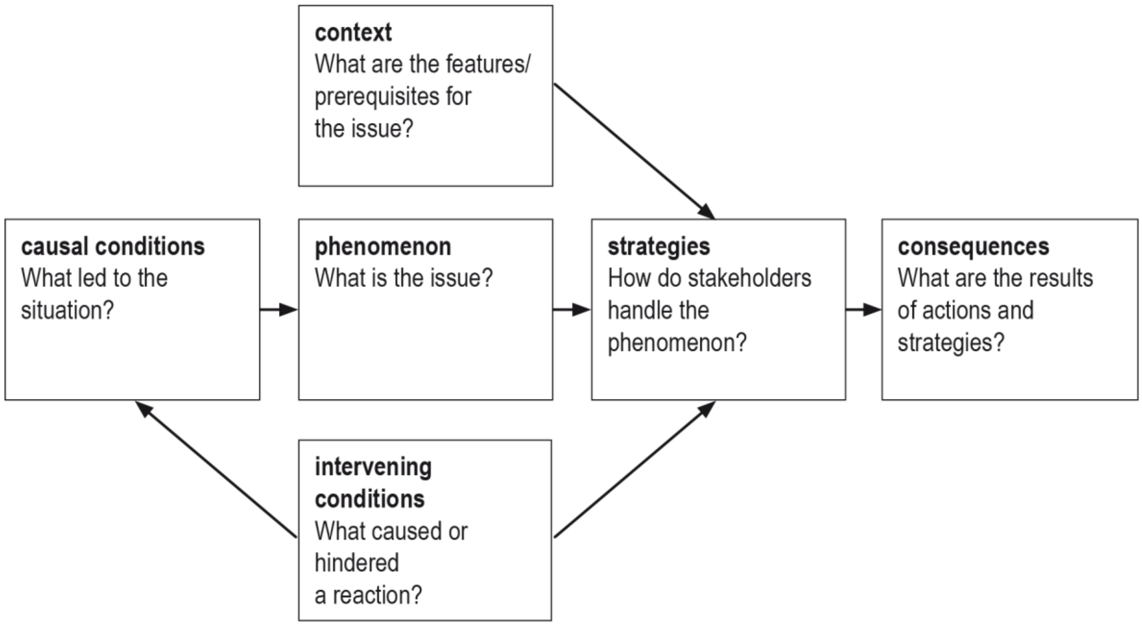

Figure 50: Coding paradigm based on Eschebach (2018) and Strauss and Corbin (1996, p. 75)

> **Selective coding** describes the process of highest abstraction based on the definition of a core category (own definition according to Corbin and Strauss, 1990, p. 116).

In selective coding findings are further abstracted to define a core category and develop its interrelation with categories and concepts as basis for a cohesive theory. The core category describes 'the central phenomenon around which all the other categories are integrated' (Corbin and Strauss, 1990, p. 116). According to Strauss and Corbin (1998), a core category is characterised by the following attributes:

> Characteristics of a **core category** in selective coding:
>
> - It should be central so that all minor and major categories can be linked to it.
> - It should be the recurrent theme to which all incidences and actions in the data point.
> - It does not force data but linking categories and concepts to the core category leads to a logical and consistent theoretical framework and interpretation.
> - Its name is sufficiently abstracted and representative for the core idea to enable further research in other substantive areas with the aim of generalising the theory.

In the process of selective coding, the integration of concepts and categories causes analytically refinement. As a result, the explanatory power and depth of the developed theory is advanced.

During the process of coding, all three coding procedures are repeatedly applied to revise and advance the findings towards a cohesive and consistent theoretical framework. The coding process is successfully accomplished, if the developed theoretical construct is able to both highlight the centre point made by the data and to explain variation and/or alternative cases. That means that the theoretical construct remains valid even if conditions vary or an alternative central idea is examined (Strauss und Corbin, 1998, p. 147). After successful coding, the researcher is able to deduce a detailed and dense theory with high explanatory power with reference to the examined data set.

B.3 Research method – problem-centred expert interview

For primary data gathering, this study adopts Döringer's (2020) approach of a problem-centred expert interview (PCEI). This method combines the theory-generating expert interview, which focuses on an expert's interpretive knowledge, with the problem-centred interview (PCI), which aims to highlight the individual perspective of an interviewee. As a result, PCEI is a tool to reveal implicit expert knowledge. That makes it powerful for research which aims to understand influences on decision-making processes (Döringer, 2020, p. 1). The research problem – namely the success of collaboration and knowledge transfer – is substantially reliant on the involved individuals and their decisions. That is why Döringer's PCEI is perfectly tailored to the requirements of this research problem. In the following, aspects of the theory-generating expert interview and the PCI are given which are relevant for the application of PCEIs in this research context.

There are three types of expert interviews: exploratory, systematizing and theory-generating expert interviews[51]. In line with Bogner and Menz (2009), Döringer (2020) defines the theory generating expert interview as follows:

> 'The **theory-generating expert interview** stresses inductive theory development based on empirical data and thereby aims at revealing interpretative knowledge, which is defined as subjective relevancies, viewpoints, or perspectives on which experts draw when enforcing their orientations.' (citation of Döringer, 2020, p. 3):

Bogner and Menz (2009, p. 53) emphasise that interpretive knowledge generally does not exist a priori, but is developed during the process of analysing interview data. Interpretative knowledge includes both the interviewees subjective viewpoints, pattern of explanation and perspectives but also his or her objectives, evaluations etc (Bogner, Littig and Menz, 2002, p. 19). The focus on the subjective dimension is not to be mixed up with the individual perspective of the interviewee. While the individual dimension of an interviewee's knowledge can be regarded as his or her very unique knowledge which sets the interviewed expert apart from other experts, the subjective perspective rather refers to the interpretive dimension, which is collectively shared among all actors withing an organisation or group of actors. Although interpretive knowledge remains always perspective and intrinsically tied to the interviewee, the focus on the subjective rather than individual perspective allows regarding an interviewee not as a private person, but as the representative of a certain group (Döringer, 2020, p. 3). As a result of the focus on the shared, collective dimension of the interviewee's knowledge, in theory-generating expert interviews, the interviewee is interesting for the researcher as representatives of a certain actor group rather than as an individuum. Nevertheless, all knowledge, which influences the interviewee's scope of action is in the focus if the interviewer, which goes beyond mere technical knowledge (Bogner, Littig and Menz, 2002, p. 25). It is

[51] For more information on exploratory or systematising interviews see for example Bogner, Littig and Menz, 2002

In line with the idea of Witzel who introduced the research method, *PCI*s can be defined as follows (Witzel, 2000, p. 1):

> **Problem-centred interviews (PCI)** enhance the applicant's knowledge and by a continuing interplay of induction and deduction (741, 1). They focus on the interviewee's subjective perceptions, experiences and reflexions on a certain problem with the aim to gather objective evidence on the studied problem.

The choice for this method for data collection has two reasons: Once, the identification of success factors for an interpersonal issue like collaboration and knowledge transfer is highly dependent on the individual's personal and subjective experience. A suitable research method has to account for and focus on this aspect. Second, PCIs with their inductive deductive interplay generally follow the methodological principle of grounded theory. That is why the application is especially convenient for grounded theory research.

Due to the combination with grounded theory methodology, the PCI approach of Witzel is not applied in its entirety in this study. With the PCI approach, Witzel offers a method for data gathering and analysis. For this study, only the part for data gathering is applied, because the analysis is conducted with grounded theory methodology. In the following section, the key points of data gathering with means of PCIs and their conduction is introduced according to Witzel (2000, p. 2): The *problem-centred orientation* describes, that an interviewer bases his or her questions, interview guiding and the understanding and interpretation of the interviewee's statements on his or her previous study of objective conditions and findings on the research problem. First interpretation of subjective explanations already during the interview allows to guide the interview more precisely towards the research problem. *Object-orientation* describes the methodical flexibility to best approach the problem in face of its special requirements. Flexibility does not only refer to the flexible interview design (for example the switch between more narrative or structured interviews depending on the interviewees abilities) but also to the use of a combination of different methods which complement the interview. *Process-orientation* is focused on the course of research and aims to enhance a cooperative and trustful interview ambience, which encourages the interviewees to be self-reflective and to unfold their subjective view including redundancies and contradictories.

Combining PCI's 'guided open narrative' interview technique with theory-generating expert interviews, which are designed to meet the special requirements of expert knowledge and experts as interviewees, creates an interview method, which is especially useful to gain interpretive knowledge among experts (Döringer, 2020, p. 12): The interview design of PCIs, which are targeted to the disclosure of an interviewee's individual perspectives, contribute to the focus of theory-generating expert interviews on the effects of implicit expert knowledge on the research problem (Döringer, 2020, p. 5). At the same time, the problem-centred expert interview is a very ambitious type of interview, which requires high sensitivity and flexibility of the interviewer in both the data collection and the data analysis process: (1) The interviewer has to manage the alternation between rather open and structured interview styles depending on the degree of data coverage during the interview course, on the provided time frame and on the individual interviewee. (2) To maximize the quality and output of an interview, the interviewer has to perform 'in-time interpretation' of revealed data during the interview to amplify relevant aspects and guide the interview by follow-up questions. (3) Concerning personal aspects, the interviewer needs to be sensitive to separate between information which is merely of interest for the individual dimension and those aspects, which influence the for the shared, collective dimension. That is both during the interview and in the process of data analysis. (4) In the process of data analysis, the shared collective dimension has to be thoroughly elaborated.

B.4 Research validation – quality criteria

Due to the multitude of qualitative research methods, there is no universal set of quality criteria for qualitative research (Charmaz and Thornberg, 2020, p. 8). Instead, general quality criteria need to be constituted in view of the conducted research method and its specifics. Yin's approach for case study evaluation is a well-established concept for case study evaluation (Wurster, 2011; Andrade, 2009): He suggests using the four quality criteria construct, external, and internal validity and reliability as quality criteria and describes specific case study tactics which help to meet each criterion (see columns one to three in Table 1). Especially for theory building interpretative research, Andrade (2009, p. 47) proposes grounded theory principles for the evaluation of each of Yin's quality criteria which are also displayed in column four of Table 1.

Table 7: Yin's (2003, p. 34) case study methodology criteria (column 1 to 3), extended by Andrade's (2009, p. 47) grounded theory principles (column 4),

Criterion	**Definition**	**Specific case study tactic**	**Grounded theory principles**
Construct validity	Establishing correct operational measures for the concepts being studied	• Use multiple sources of evidence • Establish chain of evidence • Have key informants review draft case study report	• Corroboration • Theoretical sufficiency[52]
Internal validity	Establishing causal relationship as distinguishing from spurious relationships	• Do pattern matching • Do explanation-building • Address rival explanations • Use logic models	• Theoretical coding
External validity	Establishing the domain to which a study's findings can be generalised	• Use theory in single-case studies • Use replication logic in multiple-case studies	• Theoretical generalisation
Reliability	Demonstrating that a study can be repeated with the same results	• Use case study protocol • Develop case study database	• Chain of evidence as afforded by grounded theory method

Strauss and Corbin (1990) have introduced checklists whose application in grounded theory research may help readers to evaluate the adequacy – meaning the quality – of the

[52] Andrade prefers theoretical sufficiency to theoretical saturation, because – also both terms refer to the same – the latter implies exhaustiveness and completion (Dey, pp. 116–117).

research process and the quality of empirical grounding of the theory[53]. Because this thesis applies Strauss' and Corbin's grounded theory approach, the checklists complement the case study validation concept for this study.

The following seven questions help to evaluate the adequacy of the research process (Corbin and Strauss, 1990, p. 17):

- How was the original sample selected? On what grounds (selective sampling)?
- What major categories emerged?
- What were some of the events, incidents, actions, and so on that indicated some of these major categories?
- On the basis of what categories did theoretical sampling proceed? That is, how did theoretical formulations guide some of the data collection? After the theoretical sample was carried out, how representative did these categories prove to be?
- What were some of the hypotheses pertaining to relations among categories? On what grounds were they formulated and tested?
- Were there instances when hypotheses did not hold up against what was actually seen? How were the discrepancies accounted for? How did they affect the hypotheses?
- How and why was the core category selected? Was the selection sudden or gradual difficult or easy? On what grounds were the final analytic decisions made? How did extensive 'explanatory power' in relation to the phenomena under study and 'relevance' as discussed earlier figure in the decisions?

Empirical grounding of a theory can be assessed by the following questions (Corbin and Strauss, 1990, pp. 17–19):

- Are concepts generated?
- Are the concepts systematically related?
- Are there many conceptual linkages, and are the categories well developed? Do categories have conceptual density?
- Is variation built into the theory? Have the concepts been examined under a broad range of conditions, and do they offer several dimensions?
- Are the conditions under which variation can be found built into the study and explained?
- Has process been considered and identified?
- Do the theoretical findings seem significant, and to what extent?
- Strauss and Corbin (1990, p. 17) emphasise, that 'some reasonably good grounds' which allow the reader to evaluate this quality criteria are sufficient and a great amount of details is not necessary.

The case study evaluation based on these criteria is conducted in Chapter 8.1.2.

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53 They do not give grounded theory-specific recommendations on the other two quality criteria ('quality of data' and 'plausibility) which they recommend In addition, there are many other quality criteria concepts for grounded theory (see Charmaz and Thornberg, 2020, p. 9 for details).

C Case study interviews

C.1 Interviews

The anonymized interview transcripts are digitally stored in accordance with common rules of good scientific practice for ten years at

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Institut für Maschinenelemente und Maschinenkonstruktion

Technische Universität Dresden

under supervision of my doctoral advisor

Prof. Dr.-Ing. Kristin Paetzold-Byhain

where they are available upon request.

Interview 1: personal phone interview by Natalie Theissen at 26 May 2020

Interview 2: personal phone interview by Natalie Theissen at 30 June 2020

Interview 3: personal phone interview by Natalie Theissen at 09 October 2020

Interview 4: personal phone interview by Natalie Theissen at 12 October 2020

Interview 5: personal phone interview by Natalie Theissen at 14 October 2020

Interview 6: personal phone interview by Natalie Theissen at 15 October 2020

Interview 7: personal phone interview by Natalie Theissen at 15 January 2021

Interview 8: personal phone interview by Natalie Theissen at 15 January 2021

Interview 9: personal phone interview by Natalie Theissen at 01 February 2021

Interview 10: personal phone interview by Natalie Theissen at 12 February 2021

C.2 Interview guideline

INTERVIEW GUIDELINE

Introductory question: Can you give a brief summary about
a. your IOC experience and background and
b. your position and work at both 3GPP* and your delegating organization?

1. What is your company's main benefit from joining 3GPP*?

2. How do you judge the quality of output in 3GPP concerning
   a. technological excellence
   b. standard quality
   c. Benefit for your own company?

3. At 3GPP*, how do you judge
   a. the quality and efficiency of collaboration and knowledge transfer among (competing) participants
   b. the level of (perceived) trust among (competing) entities
   c. culture of welcome (meaning the possibility for newcomers to become an accepted and successful member)

4. Which elements, factors, and mechanisms at 3GPP* do you experience as most supportive/hindering for successful collaboration and for the above-mentioned points (question 3)? What could be improved (and how)?

5. Why do you think has 3GPP* been so successful with regard to international and cross-sectoral coopetitive collaboration?

Regarding the under 4 mentioned "success factors" and the following mechanisms of collaboration in 3GPP:

A) IPR policy
B) Consensus based decision making
C) Constancy of delegates
D) "No loser policy"
E) Informal exchange and discussions
F) Chairman as mediator

6. How do these mechanisms influence the collaboration and output of 3GPP* with regard to
   a. the attainment of the objective of 3GPP*
   b. successful knowledge transfer
   c. (perceived) trust among competing entities

7. Are there additional mechanisms, which could enhance trust, successful collaboration, and knowledge transfer?

8. Do you regard these mechanisms as determining factors for the long-lasting success of 3GPP?

9. Do you think these mechanisms are equally beneficial and attractive for all groups of participants (operators, manufacturers, service providers…)?

* adapt or extend accordingly if the interviewee is experienced in other consortia in the ICT sector.

Figure 51: Case study interview guideline

D Case study results

In this appendix, the case study findings according to the result of selective coding are presented in detail as basis for traceable analysis and interpretation and in order to make the case study findings valuable and exploitable for further research. Starting with the core category of selective coding, each subcategory with its elements is in detail elaborated in one sub-chapter. This is namely IOCA at 3GPP, the GPs, primary mechanisms of collaboration, secondary mechanism of collaboration, the organisational setup and finally pre-set factors which have been identified as influencing.

D.1 IOCA at 3GPP

One interviewee practically describes IOC(A) at 3GPP from an actor's point of view as follows:

> *'You have to dedicate people, send them to the meeting, knowledgeable people, and then you have to do the work. You have to do the footwork, the lobbying, the technical work, everything.'* (*Interview 1*, p. 9)

While the first part to dedicate knowledgeable people and send them to meetings is concerned with the organisations' contribution to IOC, the second part describes what IOCA which is conducted by these dedicated people actually incorporates. It already indicates that IOCA is much more than the joint technical resolution of a problem. However, all results have to be elaborated and analysed in order to draw substantiated and sound conclusions on the nature of IOCA. As such, IOCA is analysed in detail in chapter 6.2.1.1 based on the entirety of results presented in Appendix D, while this section focuses on the analysis of 3GPP as essential element of the core category which is based on both primary and secondary data.

3GPP is an engineering, industry-led organisation that develops technical specifications, which can be transferred into standards by standard development organisations (SDO). As the name 3rd Generation Partnership Project indicates, 3GPP was initially founded for the joint and concerted development of technology specifications for the third generation (3G) of cellular networks based on the GSM (Global System for Mobile Communications[54]) standard. 'The original scope of 3GPP (1998) was to produce Technical Specifications and Technical Reports for a 3G Mobile System based on evolved GSM core networks and the radio access technologies that they support' (3GPP, no data). Yet not just the technology was based on GSM, but also the IOCS 3GPP evolved from ETSI's GSM working group Special Mobile Group 'SMG' when the European Telecommunications Standards Institute (ETSI) partnered with other SDOs from around the world in December 1998. That is why the rather collaborative spirit at ETSI and SMG was and still is – according to the interviewees perception (*Interview 3*, p. 2) – strongly formative for 3GPP and its today's culture and spirit. When the need for the fourth generation of wireless

[54] Earlier, GSM referred to the Groupe Spécial Mobile, which was the name for the working group of 26 ICT companies at CEPT, which was in charge of the development of a pan-European standard for wireless mobile communication loped the standards, which is nowadays referred to as GSM or 2G. When ETSI was founded in 1988, the working group GSM of CEPT became ETSI Technical Committee (TC) GSM in 1990, and was renamed 'Special Mobile Group', SMG, in 1991. (Meredith, no date)

mobile communication (4G) crystallized, 3GPP developed specifications for the standard called ‘Long Term Evolution’, better known as LTE. As LTE evolved from a pan-European into the dominant global standard, 3GPP eventually outrivalled its equivalents in other regions of the world – especially the 3rd Generation Partnership Project 2 of the United States – and become the global IOCS for the concerted development of technical specifications and technical reports for wireless mobile communication standards. More precisely, the initial scope of 3GPP has been amended ‘to include the maintenance and development of the Technical Specifications and Technical Reports for evolved 3GPP technologies, beyond 3G.’ (3GPP, no date) As a result, 3GPP nowadays unites the seven telecommunications standard development organisations ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC[55], known as ‘Organisational Partners’ and provides their members with a stable environment to produce the Reports and Specifications that define 3GPP technologies.’ (3GPP, no date). While in 1998, 350 partners were involved, 3GPP counts in December 2021 773 members (Flynn, 2022). As a result, today’s actor composition at 3GPP can be described as equally dynamic and diverse: It includes many small, but also big, mature players (*Interview 5*, p. 7), both newcomers and incumbent members, and different market representatives like manufacturers, operators, and verticals[56]. Verticals at 3GPP as technology applier represent a potpourri of different application domains like for example the agriculture, automotive, public safety, energy or broadcast sector, the satellite industry or online commerce and social media.

3GPP is a very open IOCS: It allows free – meaning unrestricted, not free of costs – access for all members of its Organisational Partners who are eligible for the participation in 3GPP’s technical work and for MRPs who are invited by one Organisational Partner, because they can contribute market advice and needs to 3GPP (3GPP-Working Procedures, 2022). Yet, participation requires to agree in the FRAND-based IPR policy – and concomitant licensing – and to pay a fee, which is graded according to an organisation’s annual ECRT band (Electronics Communications Related Turnover) (3GPP, no date). Actors at 3GPP who fulfil these requirements, cannot be excluded from IOC by 3GPP, yet they may leave 3GPP at any time on their own request (3GPP-Working Procedures, 2002). 3GPP’s working procedures moreover do not contain any other means of coercive power, which indicates that 3GPP’s primary means to penalize and/or discipline malpractices at 3GPP by coercive power is – euphemistically spoken – limited.

3GPP is organised in groups, which is found to be a widely used and dominant way to structure IOCSs: At 3GPP, there are three group levels, of which the first two are mandatory and officially defined, while the design and implementation of third level groups is optional and in the responsibility of the groups at second level. The superior group is the Project Co-ordination Groups (PCGs) to which three Technical Specification Groups (TSGs) are subordinated, which – if required – themselves define working groups to facilitate the conduction of their work, namely the development – including the preparation, approval, and maintenance – of technical specifications (3GPP-PCG, no date)

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[55] Association of Radio Industries and Businesses (SDO Japan, ARIB), Alliance for Telecommunications Industry Solutions (SDO USA, ATIS), China Communications Standards Association (SDO China, CCSA), European Telecommunications Standards Institute (SDO Europe, ETSI), Telecommunications Standards Development Society (SDO India, TSDSI), Telecommunications Technology Association (SDO Korea, TTA), Telecommunication Technology Committee (SDO Japan, TTC)

[56] Verticals of a certain sector and/or with similar needs generally unite as MRPs, which enable technology users to join 3GPP although they might themselves not be member of one of 3GPP’s Organisational Partners and to bring their market requirements into 3GPP (Flynn, 2022).

According to 3GPP's official website, the PCG's responsibility can be summarized as follows (3GPP-PCG, no date, literal quotation):

- Determination of overall timeframe and management of overall work progress.
- Final adoption of work items within the agreed 3GPP scope.
- Allocation of budgeted human and financial resources to each TSG as provided by Organisational Partners.
- Allocation of additional voluntary human and/or financial resources to each TSG as provided by Individual Members.
- Appointment of TSG Chairs
- Appointment of PCG Chair
- Handling of appeals from Individual Members on procedural matters.
- Handling of appeals from Individual Members on technical matters.

It becomes obvious, that 3GPP is entirely member-driven which means that 'there is no 'Mr. or Mrs. 3GPP'' (Casaccia, 2017), who pursues own interests of objectives. Instead, all functions at 3GPP (like chairmen) are fulfilled by periodically elected members and everything – including 3GPP's collaborative objectives and projects with their time schedules – is defined and decided by its members on basis of consensus. Furthermore, all engineering, problem-solving work at 3GPP is conducted in a self-organised manner without a top-down leader (Trust-IT Services, 2017, p. 19) and is based upon and depending on the members' problem-solving activities (like R&D) both within and outside of 3GPP, which they contribute to their working group in form of proposals which contain new features of items to work on. (Trust-IT Services, 2017, p. 20).

D.2 Actors

D.2.1 Organisations – the members of 3GPP

Analysis of the interviews reveal that the decision for and motivation of organisations to join in IOC at 3GPP follows the metaphor, which is used in Chapter 4.1 to describe the discretionary nature of IOC: For organisations, inter-organisational collaboration (IOC) at 3GPP is one vehicle to pursue an organisation's individual objectives. This metaphor puts the essence of IOC constitution at 3GPP in a nutshell: Individual objectives of organisations are the pivotal element and driver for collaboration. Interviewees consistently regard an organisation's individual benefit is the only long-lasting motivation for organisations to invest in collaboration and thus the only sustainable fundament for long lasting collaboration on a voluntary basis. The organisations' individual benefit may be quite different in nature: For verticals, the placement of their use cases and concomitant requirements, which a technology should meet, is the main incentive to participate, while public institutions may aim to foster technological solutions which best support directives or political aims. The list of individual incentives is probably as long as the list of participating entities. But in an industry led IOCS like 3GPP, the predominant incentive is found to be economic benefit. Economic benefit is both determined by the organisation, its objectives, products business model, and strategy, but also by the market in which an entity is active. That is why the market and the product are regarded as a key influence for the constitution of collaboration at 3GPP by the interviewees. Because the organisations' incentives – especially among horizontals – are (partially) conflicting, collaboration at 3GPP is competitive which results in coopetitive dynamics at 3GPP. Interviewees therefore describe a main task of an IOCS to provide structures and procedures which cause a healthy balance between competition and cooperation: If competition is too dominant, collaboration cannot succeed, because the defined goal is not reached. In the case of 3GPP, no concerted, roundly accepted specifications would be developed. Imbalance towards cooperation in an economic setting causes eventually two problems: First, an antitrust issue is generated if many relevant market players are involved. Second, a main driver for technological excellence is missing: the incentive to exceed technological solutions of a competitor to pursue and maximize the personal benefit. Taking cooperation to extremes would result in a perfectly harmonized collaboration towards one common goal without any conflicting interests. This could be better assimilated by principles of intra-organisational collaboration than by interorganisational collaboration theory. The second important aspect for collaboration in 3GPP is that collaboration is just *one* alternative: Collaboration in 3GPP is not *the* vehicle, but *one* vehicle to pursue an organisations' individual objectives. That means, that there are always different alternatives to pursue the own objectives – even if alternatives appear to be not realistic at some incidents in time. Members of 3GPP will continue collaboration as long as they have an individual benefit. As soon as there is a more beneficial alternative, an organisation will quit pursuing the less attractive alternative 'IOC'.

As such, three IOCA-determining characteristics for IOC can be derived from the consideration of the constitution of IOC at 3GPP:

IOCA-affecting characteristics of IOC in 3GPP:

- **Organisations' individual incentives** are the driver for collaboration.
- IOC is **coopetitive**.
- IOC is **voluntary**.

D.2.2 Delegates – the operators of IOCA

While IOC is constituted by organisations, the actual practical conduction of IOC, namely the IOCA, is up to their representing delegates. As such, delegates are the relevant actor group with regard to IOCA, because it is delegates who are formative for the way IOCA is actually conducted. First, it is the delegates who possess and exchange the expertise and knowledge to develop high-technology, meet objectives and create outcome. Second, it is the delegates, who bring the organisation 3GPP with its structures, rules, and mechanisms to life. And third, it is the delegates who can build social relationship and capital to tread the social pathway of IOCA (see Chapter 6.2.2.1) successfully. As a result, not every expert with regard to technical knowledge is, can be, and wants to be a delegate as the following statements of interviewees pinpoint:

> *'[…]in 3GPP, it's just as important to be able to get social as it is to be technical' (Interview 8, p. 4)*

The quotation shows that all delegates are technical experts, but not vice versa: Instead, it requires an additional strong disposition for social (inter-)action which accompanies IOC(A) along its social pathway (see Chapter 6.2.1.1): *'[We have this saying] 'Once a delegate – always a delegate.' It's the personal affection to this kind of work. You either have it or you don't. Many times, we had new delegates come in from companies who were great technical experts. But they left after two meetings because they realized it wasn't for them. Because it is networking, it's understanding the intricacies of how to get* *your things through. And for some people, it's in their veins. Some people left quicker than they came in.'* This strong dedication to IOC is often accompanied with a deep loyalty for the IOCS (and the fellow actors) which exceeds the loyalty for the delegating entity at which an actor is employed (*Interview 2*, p. 12). In fact, for some individuals, being a delegate is their primary career: they may change the employer and thus the entity they represent but remain as actor in the IOCS. A strong dedication to the IOCS and technology might appear disloyal against the own employer at the first glance, however these actors turn out to be most successful and productive in IOC(A) and thus for the outcome of an IOCS, which is beneficial for both the IOCS and the delegating organisation. One interviewee describes the true stroke of luck for an IOCS, if delegates assemble, which in addition pursue and stand up for a technical solution regardless of external pushback and interference (*Interview 9*, p. 25).

It becomes obvious, that the role and choice of actors in IOCSs is a complex and diverse topic, which is worth further research and consideration. But this is not within the scope of this research.

D.3 Guiding principles

The guiding principles (GP), which are presented in this sub-chapter, are amongst others -strongly interrelated to the delegates' mindset and thus their collaborative action. GPs overarch the entire system of collaboration at 3GPP. They can best be described as 'dicta of action', which aim to make a system internally and externally stable. With internal stability, the fragmentation of an IOCS due to inner conditions is minimized. External stability, on the other hand, is reached if the potential to achieve an IOCS's objectives and to have successful outcome is maximised which can be regarded as factual 'right to exist' of an IOCS. Other than explicit policy recommendations, GPs are not officially stated and recommended, but become only visible and indirectly traceable in the course of action of participants and in the organisational design. Actors are often not even aware to apply GPs in their course of action but adhere to dicta unconsciously.

> Guiding principles (GPs) as (unconscious) 'dicta of action' can be defined as the **underlying conceptual and mental fundament** for both the IOC-setting and IOCA which provides a basis for the **internal and external stability** of an IOCS.

As (unconscious) basis for decisions and course of action of all actors concerning both the IOCA and the IOC-setting, GPs are a very essential element to understand, characterise and influence a collaborative system. At the same time, they can generally not be identified directly: As latent variable, GPs are inferred from observable variables and findings by interpretation. That includes a thorough cross-analysis and comparison of observable findings in consideration of sentiments and implicitly indicated information. Because GPs are no explicit mechanisms or structures, it is exceedingly difficult to influence and modify GPs. In the following sub-chapters, the characteristic values of GP at 3GPP are analysed in detail.

D.3.1 'Knowing the value of the number'

The GP 'knowing the value of the number' contributes both to the internal and external stability. It indicates that the success of 3GPP is essentially dependent on maximization of 'quantity'. This does not indicate a minor significance of quality in the IOCS. But it highlights the indispensability of quantity for interorganisational collaboration. It can be regarded as a mandatory complement to quality, which distinguishes IOC projects from single actor projects. That is why an IOCS like 3GPP can only succeed if all elements of the IOCS are aware of this fact and act accordingly. Because the principle 'knowing the value of the number' developed from a one-dimensional to a multifaceted approach as the course of interviewing and coding proceeded, quantity cannot be defined in general. In fact, quantity turns out to be a decisive parameter at different levels of perspective. That is why the quantity which 'the number' refers to has to be defined individually at each determined level, which is the product level, the market level, the system level, and the actor level.

Product level

At product level, for which the relevance of 'the number' was first identified, the relevant quantity, which 'the number' represents are the IOCS's participants: The success of the product elementary relies on an extensive number of IOCS participants, which should comprise as many relevant market players and requirement representatives as possible. It is than – and only than – that an IOCS may provide a globally and technological fully interoperable and/or uniform product, which perfectly suits the needs of the market. Because the declared objective of 3GPP to provide specifications for one global standard for wireless mobile communication, 'the number' is not just an advantage, but a necessity. Of course, the development of one solution without competing alternatives, which promises more profit, is a secondary effect, which makes collaboration to the full extent even more attractive. Telecommunication standards are a good example to illustrate the absolute relevance and significance of 'the number' for the success of a product: If 'the number' – meaning the IOCS members – covers all relevant market actors, there is one worldwide telecommunication standard. As soon, as 'the number' decreases just by one market leader, who is potent to install an individual rival telecommunication system, complexity in the whole market explodes in a global world which results in – unnecessary – effort, costs and time: Beside a doubling of R&D costs, interoperability solutions have to be developed and/or devices have to be equipped with two systems, if customers shall not have to use two devices for global communication. At 3GPP it becomes obvious that disadvantages are so severe, that the worst compromise which a single actor might has to accept to build consensus for a solution, will remain more advantageous and attractive than the fragmentation of 3GPP and the development of different technological systems: That is why the highest aim of all interviewees and the institutions is to prevent fragmentation and to act according to this knowledge about 'the value of the number', meaning to be willing to compromise and not to intimidate other participants. One interviewee remembers this 'knowledge of the value of the number' from the very first hour on: *'So there was so much effort being put into 'let's make sure that everybody [...] feels welcomed and heard'. Because if we don't do this, they'll leave. And we fragment again.'* (*Interview 1*, p. 9).

Market level

At market level, 'the number' refers to the expected sales volume of a technological solution or a product. In line with 3GPP's GP 'let the market rule the game' and the general principle of market economy, profitability is a mandatory criterion for the implementation of a technology. That is, of course, not special to IOCS. But as more and more verticals entered 3GPP, who represent markets with comparably small sales volumes, the necessity and motivation to form 'customer alliances', for example as MRPs, grew. As a result, beside the alliances to build up the critical mass for a solution, participants also form 'customer alliances' to make the development of a technological solution for their problem profitable.

IOCS level

At the IOCS level, the value of 'the number' lies in the stabilization of processes and group dynamics. It follows simple arithmetic and refers to the total number of IOCS participants: The higher the number of members, the higher the number of possible solutions and alliances, the smaller the influence of individual actors in the IOCS and thus the more balanced the level playing field and the smaller the probability and possibility of tortious interferences, manipulation, blocking or power imbalances.

Actor level

At the actor level, 'the number' refers to 'the critical mass of allies' which an actor has to convince of his or her solution (see Appendix D.4.2.3). Because each actor has one vote regardless of market dominance or other factors, the only way to succeed – meaning to push and realize the own solutions within the IOCS – is to build up a critical mass of supporters. Of course, depending on the standing in the IOCS and in the market, it might be more or less easy for the actor to convince enough participants of the own solution. But at the end, each actor has to go the same way of lobbying and/or can contribute one vote to the critical mass, which highly supports to generate a level playing field and to communicate in a cultivated manner. Above that, the 'knowledge of the value of the number' at actor level highly stimulates the participants' motivation to interact with other participants to find common denominators, true incentives and outstanding technological solutions.

D.3.2 'Let the market rule the game'

The GP 'let the market rule the game' determines the internal and external self-conception of 3GPP which is strongly aligned to and oriented at the market (economic principle). As such, this GP refers to (1) the market-led justification and qualification of 3GPP as sustainable basis for long-term IOCS, (2) the market-based overarching aim of IOC and all players at 3GPP to *'make the pie bigger'* (*Interview 1*, p. 6), and (3) the market-affirmative credo at 3GPP to 'induce as little influence and changes to the existing superior system as possible'.

(1) The GP 'let the market rule the game' becomes visible in the incentives to join 3GPP, which are market-induced and not actively created by the IOCS. Interviewees state industry alignment and risk reduction, the economic advantages of standardization and interoperability and the higher attractiveness of products with a global footprint, global scrutiny, and the approval of 3GPP. Obviously, these incentives are all primarily rooted in the market (economic principle) but not in artificially created benefits of the IOCS. There is agreement, that it is essential for the long-term success and survival of an IOCS that its attractivity is 'market-pushed' and not 'IOCS-pulled', meaning that an IOCS needs a unique selling point which is not 'artificially' created by the IOCS but lies in the market and the market economic principle. In fact, it is regarded as the only sustainable fundament for industry-led IOC that the primary incentives to join an IOCS are the market and an organisation's market economic activity and strategizing. More generally spoken, the motives to build and join an IOCS should always be rooted on a need or condition in the environment of an IOCS. However, it is the responsibility and duty of an IOCS to provide (economically) fair mechanisms and structures for collaboration (see Appendix

D.4.1.2), which compensate for imbalances of the distribution of investment and profits which may be accompany joint economic activity in an IOCS.

(2) Analysis of 3GPP's common objective displays the commitment to market economy and its rules. One interviewee states that *'the top-level interests of 3GPP and the companies is to make the pie bigger. [...]. Of course, then it is number two, if you are a share of this pie'* (*Interview 1,* p. 6). This statement shows that the objective of 3GPP – *'to make the pie bigger'* – is in line with the conception of the superior system – the market which itself displays the member-driven nature of 3GPP: IOC(A) is led by and aligned to its actor's economic interests. In addition, this statement shows, that it is below the line even a market-economic incentive of actors to prioritize the overall success and excellence of outcome over the maximisation of individual success – meaning the maximisation of the own share of the pie – at 3GPP.

(3) With regard to the self-conception of 3GPP, this GP expresses the intention to make it possible to satisfy demands and markets which cannot be served by one single actor but require IOC but to refrain from any unnecessary additional intervention. Neither 3GPP nor its actors regard the IOCS as a parallel economic system, but as a necessity to meet the demands in the market. They do *not* aim to override market economic principles or anti-trust issues, although that might be a common first association with IOCSs. The interviewees' experiences in other IOCSs suggest, that this GP is widely used, at least in other industry-lead IOCSs like W3C, for which one interviewee attested a similarly strong dedication to the principles of market economy. An interesting result from this case study is, that the affirmation of this GP remains unbroken, even if it is disadvantageous for the actor. 3GPP officially equates its members by equal voting rights. But it avoids interfering in the group dynamics, which result from external – meaning market – relationships of the actors, unless a severe power imbalance jeopardises the IOCS's objectives and existence. As a result, interviewees, who represent rather small players at 3GPP, consistently state that they had experienced their restricted power at 3GPP compared to other actors, which have a more powerful position in the market: These actors have more influence due their more prominent and exposed position at 3GPP, due to their power in the market, their personal and financial means, their relationships and/or the expected sales volume. Regardless of these experiences, all interviewees who represented small players rejected additional institutional intervention but endorsed the existing system at 3GPP. That is once because they regard market economy as the only sustainable driver for IOC and also, because it displays the reality to which they, their incentives and their activities are strongly committed and in which the outcome of 3GPP and its related products have to draw profits: market economy.

D.3.3 'No-loser policy'

The GP 'no-loser policy' is fundamental for the internal stability of 3GPP and for the sustainability of IOC. It translates the GP 'knowing the value of the number' concerning the IOCS participants to a guidance for social interaction and behaviour, which results in two important credos for social interaction at 3GPP: First, everybody's face is to be saved at all times. Second, ensure *'nobody losing big and nobody winning big'* (*Interview 1*, p. 20) in IOC(A). It thus defines the social intercourse at 3GPP and is the foundation for all behaviour pattern at 3GPP. Especially the credo to save all faces is decisive for the creation of sustainable processes which have to be designed in a way that allows maintaining efficiency and functionality in the IOCS without making anyone lose countenance (see Appendix D.5.4). The second content of the statement 'nobody losing big and nobody winning big' is the most ambitioned and enhanced interpretation of a no-loser policy, because it considers not just the absolute but the relative measure of loss and success: For sustained satisfaction among the actors in an IOCS, it is crucial that there is no actor who takes constantly more advantage out of the IOCS than others, *'[b]ecause as soon as you have somebody winning big, all others will feel like natural losers and they will leave.'* (*Interview 1*, p. 20) From an absolute perspective, the 'no-loser policy' requires to avoid that *'nobody is losing all the time'* (*Interview 1*, p. 32) More practically speaking, if a decision is taken for a certain package, it has to be assured that *'[n]ot everybody will get everything, but everybody will get something out of the package.'*. (*Interview 1*, p. 8). That can generally be achieved, because a solution 'package' contains plenty of advantages and possibilities to generate winner: It ranges from intellectual property rights or the participation in certain sales volumes over the prevention of a competitor's solution, the possibility to cooperate or to accomplish a partial success in an area of personal interest to the establishment of an alley which is of advantage for other decisions. So, not every actor might feel like a big winner, but at least nobody is empty-handed or completely left out. This is especially important against the background of cultural diversity: For the participation of representatives from cultures in which a loss is equivalent to lose countenance and might have existential effects for the persons or at least for his or her career, this GP is a mandatory prerequisite of an IOCS. It is only than that they can do the splits between their 'loss-intolerant' home cultures and 3GPP's 'loss-advocating' culture of *'you lose today, you win tomorrow' (Interview 1*, p. 4), which does not just tolerate, but even requires to accept losses in favour for compromises. To accommodate to the cultural balancing act of those participants, the GP does not just influence the intercourse within 3GPP, but also the external communication: Members at 3GPP and especially chairmen put special emphasis to the way decisions are communicated, even more if affected actors do not win the day.

It becomes evident in the interviews, that this GP is very deep-seated not only in the institution and its rules and processes, but especially in the mindset of the interviewees and most actors. They naturally attempt to save each participant's face and to find win-win situations. That is because all participants are aware of the fact, that if player leave, *'the whole pie gets smaller'* (*Interview 1*, p. 6). This is against the overarching market economic aim of all actors and thus avoided. Because of this overarching concerted objective, actors expect an according behaviour of fellow participants as a matter of course. A more detailed view on mutual expectations of the actors is given in Appendix D.4.2.4.

D.4 Mechanisms of collaboration

Mechanisms of collaboration include instruments, measures and conventions which highly affect IOCA. It contains both primary and secondary mechanisms. While primary mechanisms are deliberately installed to guide and manage IOCA, secondary mechanisms evolved or have been established for other reasons but turn out to have significant influence on the way IOCA is conducted. Mechanisms of collaboration primarily constitute and inform interaction and the spirit of collaboration in an IOCS. There are two distinctive features of mechanisms of collaboration, which make them a challenging object for research and analysis. Once, there are few general conditions and specifications which limit or determine mechanisms of collaboration, their nature, and their scope of influence. Instead, mechanisms of collaboration may and should follow highly creative, individual, and unfamiliar pattern to meet the unique conditions of collaboration of a certain IOCS. Second, it is always the entirety of mechanisms of collaboration which make a certain impact. That is why the effects of a certain set of specific mechanisms of collaboration for a defined IOCS can be determined, but a generalised statement on the effectiveness of a single MOC isolated from its set of mechanisms of collaboration in which it is embedded and the IOCS in which it is installed, cannot be made.

Analysis of the interviews reveals that there is one overarching, constitutive mechanisms of collaboration at 3GPP:

> *'The overarching principle [of collaboration at 3GPP] is to build up consensus […]. This process is very powerful, very efficient, and very mature and I think it should be an example for many organisations on how to do that.'* (*Interview 10*, p. 2)

The mechanism of consensus is not just decisive for how IOC and IOCA is conducted and organised but turns out to determine and influence the formation of the other mechanisms of collaboration at 3GPP, which are presented in the following sub-chapters on primary mechanisms of collaboration (D.4.1) and secondary mechanisms of collaboration (D.4.2).

D.4.1 Primary mechanisms of collaboration

D.4.1.1 Mechanism of consensus

Description

Consensus is undisputed the dominant and overarching formative mechanism of collaboration at 3GPP. When the interviewees were asked to intuitively state what comes to their mind in association with successful collaboration at 3GPP, eight of ten interviewees mentioned consensus without further consideration in the first sentence. That reveals that consensus at 3GPP is far more than a claim in the decision-making process to find solutions which 'lack of (sustained) objection'. With regard to both IOC and IOCA at 3GPP, consensus turns out to be the predominant and pivotal centrepiece:

> **Consensus** as 'lack of (sustained) objection' is experienced as the *'overarching principle'* **(***Interview 10*, p. 1) and *'the biggest concept policy'* (*Interview 5*, p. 8) at 3GPP. It is a very *'powerful, efficient and mature'* (*Interview 10*, p. 2) mechanism of collaboration, which is *'the only way to make people join'* and which *'guarantees cohesion'* of an IOCS.

The quotations display the definite commitment and conviction in the mechanism of consensus as driver for successful collaboration and satisfied participants among the interviewees. But consensus as mechanism of collaboration is not a ticket to harmony and perfect happiness among all participants. Rather contrary it is hard work and aims to minimize and distribute the concessions, compromises and losses which are required to produce an excellent product. That becomes evident in the following description:

> As mechanism of collaboration, consensus is about and requires to 'rotate the ones who are unhappy' or making everybody 'equally unhappy'. It means '[n]ot everybody will get everything, but everybody will get something out of the package.' (*Interview 1*, p. 8)

This definition can be regarded as the translation of 'lack of objection' to the practice of IOCA. Above that, it perfectly displays, embodies, and implements the GP 'no-loser policy' as it aims to not leaving anybody out. It is important to note, that the negatively phrased description does not at all hint to a negative experience or impact on the participants' satisfaction at 3GPP, but catches the reality of successful IOC, which requires to compromise on all hands.

The mechanism of consensus as it is described and experienced by interviewees assumes that *full* consensus is built up. That means, that it is state of the art that 100% of the actors get invested and absolutely no one is left out. It becomes evident in all interviews that full consensus is a highly valued principle to which all interviewees are bound in honour and committed to the core. This seems to be symptomatic for the vast majority of participants: All interviewees who experienced one of the rare exceptional incidences of deviation from full consensus report of a lasting negative effect for an actor's political capital (see Appendix D.4.2.4) and noticeable resentment against the responsible party throughout the whole community.

The (functionality of the) mechanism of consensus is highly reliant on an IOCS's embedding into a market economic system and thus the GP 'let the market rule the game': It is the competition among actors, which fosters technological excellence and encourages each individual member to perform. It is the (time to) market and economic pressure which makes actors compromise, find solutions, and build consensus. If the market economic setting does not exist, there is no need to progress and to generate output in a certain timeframe.

It is a matter of fact, that consensus finding generally gets more challenging as the group increases, which is also reported by interviewees (*Interview 4,* p 10). In consideration of this fact, the excellent performance and functioning of the mechanism of consensus at 3GPP among up to 500 – partly competing – experts is equally remarkable and inscrutable. But there are two elements, which help to understand the success and functioning of consensus at 3GPP: This is once the reference system in which consensus is built and second its ecosystemic approach. The reference system describes the frame conditions which influence consensus building. In an inter-organisational and industry-lead IOCS like 3GPP, consensus is built in the triangle of technological innovation, time to market and complexity (*Interview 3*, p. 3). Especially the timely component in the triangle has a propellent function: It does not allow for stagnation but requires developing solutions in time and thus to compromise in order to build consensus.

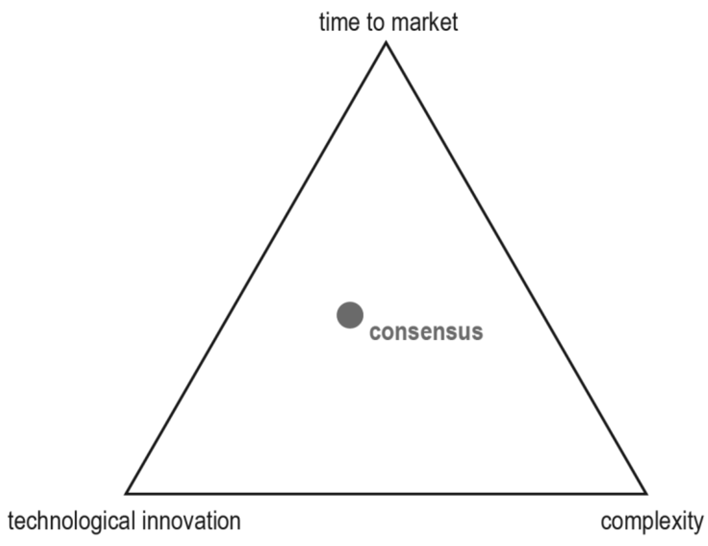

Figure 52: Triangle of frame conditions for consensus building at 3GPP

At 3GPP, the whole ecosystem is represented. That is a crucial element for the success of consensus as mechanism of collaboration, because it causes several important effects: (1) The diversity of participants increases, which significantly lessens the competitive atmosphere, because there are also business partners in IOCSs and the overall percentage rate of competing actors among in the plenary decreases. (2) The number of participants, perspectives, incentives, and objectives increases, which leads to very diverse levels of aspiration. As a result, the potpourri of possible solutions, compromises and concessions snowballs which makes it easier to find a solution which leaves no one out. Above that, the group dynamics change significantly: A broader variety of participants with different levels of aspiration open up new possibilities of allying, which lowers the power of each individual participant. (3) Each technological solution is contested against requirements and business cases, which are brought into the IOCS by verticals. That might eliminate certain solutions without further discussion. Above that, discussions in an ecosystemic setting generally indicate the participants when a battle is lost (*Interview 4*, p.4). (4) The high total number of participants hampers block building of certain actors and or peer groups. At the same time, a peer group develops for each topic of decision which mainly drives the discussion and consensus building process. This peer group generally evolves naturally according to the expertise and interest in a topic but may be influenced by the chairman (see D.4.1.3).

Perceived effects

In line with the experience of the interviewees of consensus as overarching mechanism for collaboration, consensus affects IOC and IOCA at many levels:

(1) *Commitment*: Consensus requires cooperation of all participants and the development of a common intention and objective (*Interview 4*, p. 16). If consensus as a mechanism of collaboration is understood as full – meaning 100% – consensus like at 3GPP, consensus causes that *'[e]verybody gets invested, even if he loses, [because] you were there and you were part of the process'* (*Interview 1*, p. 18). That is why generally all participants are committed to the decided solution and do not quit participation and/or the realization and implementation of the chosen solution.

(2) *Level playing field*: With regard to consensus, each actor has the same weight and importance: He may support of object a solution. As such, the interests, and concerns of all players regardless of their size, means and power have to be heard and considered. That supports IOC(A) between participants with truly diverse economic and personal means approximately at eye level at 3GPP.

(3) *Allying*: To convince other players and meet their demands, it is necessary to reveal the true needs, to understand the positions and motivations of other actors, and to convince other participants of the advantages of a certain solution. That results in a strong social interaction which creates mutual understanding and confidence in the participants' expertise, credibility, and their expected behaviour.

(4) *Knowledge transfer and disclosure:* The fact, that other experts have to be convinced of the own technological solution has a – if not *the* – decisive effect to make collaboration in knowledge-based environments successful: *'If companies don't understand a proposal, they can never agree to a proposal. So this is the interesting situation. Even though companies are competing … [i]t is important to make sure that other companies understand a company's proposal to get agreement from other proposals. And that is the basic motivation why people are sharing their knowledge and understanding with others in the forum.' (Interview 5, p. 2).* This statement reveals how the mechanism of consensus

positively influences the knowledge sharing process at 3GPP and thus pushes creativity, mutual inspiration, and technological excellence. That results in a fundamental advantage for collaboration: The necessity to assure that other participants understand the own idea and its brilliance creates a strong motivation for participants to disclose knowledge. More precisely and importantly, the resulting incentive to share knowledge is stronger than the participants' attempt to conceal their knowledge as the most valuable asset from competitors.

(5) *Technological excellence*: The attempt to convince other players of the advantages of the own technological solution by knowledge disclosure and technical arguments initiates a highly creative process of knowledge exchange and discussion. At 3GPP, there are numerous intelligent minds with different experiences and perspectives who feed of each other's ideas to create enhanced solutions. At a competitive level, the knowledge disclosure triggers a technological race to excel the presented solution of competitors: *'Of course, that means other companies may develop new proposals, better proposals, based on my proposal. But then, I also have the opportunity to develop better proposals based on other companies' proposals. So that's-, I think there's fair game, fair process.' (Interview 5*, p. *23)*

(6) *Pace of consensus*: As a result of the above stated effects, consensus is always a time-consuming process. That is both at a social and at a technical level: Finding compromises and alliances needs time. But also the creative way to technological excellence is a time-consuming process which cannot be sped up arbitrarily without losses: The relation triangle 'time to market-technological innovation-complexity' (see Figure 52) helps to estimate the effects on technological excellence caused by an disproportionately accelerated pace of consensus: The process of consensus can be sped up to meet a certain time to market, but at the expense of a higher complexity due to a broader set of technological varieties and options and/or at the expense of technologically less advanced solution because the creative process towards technological excellence is not maxed out. 5G can be mentioned as an example for enhanced complexity due to too many technological options in the standard caused by time pressure. (*Interview 1*, p. 12).

D.4.1.2 Mechanism of economic participation

Description

The mechanism of economic participation defines how the 'pieces of the cake' are distributed among the actors, namely the organisations. As such, the mechanism of economic participation is the only mechanism of collaboration which does not aim to directly affect the IOCA and behaviour of the delegates but is rather an issue at organisation level: The mechanism of economic participation determines how and if investment in and contribution to the IOC(A) is rewarded in an IOCS: It defines the proceeds and yield which an organisation earns for their contributions to and investments in an IOCS like 3GPP in order to fairly counter and balance an unequal distribution of investment and profit-drawing of IOC between different actors. It thus makes IOC and an IOCS attractive for actors who have a lot to invest (and are thus important for a successful outcome) but may not equally be involved in the exploitation of the solution in the market by which profit is drawn. Because the actual distribution of the pieces of action are not negotiated at operational level, this is not in the scope of responsibility and interest of delegates but discussed at an own 'battlefield' at organisations level. However, the mechanism of economic participation indirectly affects IOCA, because it provides a requisite basis to conduct IOCA: It is the mechanism of economic participation which defines the main incentive and framework to exchange knowledge and contribute to IOC as the following statement of one interviewee highlights:

> *IPR policy [as 3GPP's mechanism of economic participation] actually is helpful for companies to be motivated to share their proposals in the meeting. [...] basically, companies have to be motivated to develop technical proposals. And also, they have to understand they have to pay properly for technologies from other companies as well. And in order to set a fair and proper ground or basis, or fair discussion and fair competition, IRP policy is important.* (*Interview 5*, p. 3)

As the quotation says, at 3GPP the mechanism of economic participation is based on intellectual property rights (IPRs), which is in line with and founded by the strong IPR affinity which exists in the ICT sector as core market and industry of 3GPP (see Appendix D.6.1.1). The case study reveals that the mechanism or economic participation varies a lot across different IOCSs and especially with regard to 3GPP because of its – rather unique – strongly patent affine industrial origin. However, it also becomes obvious, that IPRs are somehow or other a constituent element of implemented mechanisms of economic participation in the IOCSs under consideration: At 3GPP, there is one uniform and mandatory IPR model, which specifies IPRs in combination with the principles of FRAND licencing as the only means to gain access to technology and proceeds. While this a very clear mechanism of economic participation, it is less flexible (*Interview 2*, p. 15). In contrast, at IETF actors assign their personal licensing solution to their documents with technical solutions, which may reach from royalty-free to FRAND. As such, it is more flexible and allows different solutions to co-exist but is also more complex. A look at W3C, which is an IOCS which is highly known as advocate of royalty free access to technology, reveals, that IPRs are even part of their mechanism of economic participation. However, in this IOCS, IPRs are not used between its participating actors, but as protective mechanism against external market participants: IPRs are used to protect the members and technologies of W3C against external hazards concerning intellectual property rights: In case of an attack, the entirety of patents which the members of W3C hold – regarding W3C technologies or not – are directed against the offender in order to protect W3C technologies, its members, and their concept of royalty free, non-assert technology access.

As a result of the established mechanisms of economic participation at 3GPP (and others), individual agreements between each technology user and the concerned IPR owners were and are prevalent. According to the consistent experience of the interviewees, this principle of free negotiation works very well and does not lead to excessive licencing fees due to market regulation: Both, the IPR holder's and the IPR user's proceeds are reliant on the market success of the end product, which is strongly bound to its price. In fact, it is especially the IPR holder, who is interested in and relies on the market success of a product in order to receive the return for the immense advanced input and investment. In addition, the licencing behaviour of an organisation directly affects the political capital (see Appendix D.4.2.4), which is decisive for an actor's long-term success in the IOCS. As such, the principle of individual negotiations which is established in the mechanism of economic participation at 3GPP (and others), is evaluated to be fair and reasonable by all interviewees, which represent both licensees (for example *Interview 3*) and licensors (for example *Interview 4*). One interviewee uses the example of LTE, for which the maximum licencing fees of 15 dollars per computer device was defined in a voluntary agreement of the licensors, but the actual licencing fees are found to be in the lower one-digit range (*Interview 4*, p. 9).

However, there is another reason for the trend towards new licencing solutions: As new business models evolve and the distribution of technologies spread across more and diverse industry sectors, pooled licencing solutions at least for the end users who are not members of the IOCS or at least not technology developer and holder of affected IPR, become more and more attractive and requisite. One interviewee for example remembers a meeting with a leading company from the automotive sector concerning the use of 5G technologies, in which a common view of vertical technology users to IPR and royalties, was advanced by the company's representatives: Technology users are willing to pay for a technology, but they are not willing to get involved in the internal distribution among the technology owners (*Interview 4*, p. 10), meaning to get in negotiations with each involved IPR owner. So far, this need is not answered within but outside 3GPP and does thus not directly affect the mechanisms of economic participation: With regard to wireless communication technology, which is based on the output of 3GPP in form of specifications, is AVANCI, which is an independent, one-stop marketplace for wireless essential patents with the aim to transform the licensing of technology for the Internet of Things (Avanci). It is important to note that AVANCI is not related to 3GPP, but an independent association of organisations which hold wireless essential patents and may or may not be member of 3GPP. However, they indirectly affect the mechanism of participation because such pooling solutions for end users determine (at least partially) the 'size of the cake' which can then be distributed among the IPR holders. In addition, they replace the individual agreements between those 3GPP actors who also join AVANCI which *may* eventually become the new standard of IPR licencing within 3GPP as well. Regardless of the actual development, it is expected by the interviewees and the interviewer, that the claim for pooled licencing solutions of end users may in the long run affect the mechanisms of economic participation at 3GPP and other IOCSs.

Perceived effects

According to the perception of the interviewees, the mechanism of economic participation is (1) the basis for IOC among actors who contribute to a technology life cycle at very different stages. With regard to actual IOCA, the mechanism of economic participation mostly affects (2) knowledge transfer and (3) consensus finding.

(1) At 3GPP, the mechanism of economic participation compensates for the unequal distribution of risks and investment on the one side and profit making on the other side as the following statement describes:

> *'[Manufacturers] make money out of standards by bringing their (patented) ideas in…the industry makes money out of selling things to people.'* (*Interview 3*, p. 2)

At 3GPP, there is a very high gradient among the actors concerning their (advanced) investment in a technology's development and provision and their profit drawing from this technology placing end products which are based on this technology in the market. As a result, the risks and investment of technology development at 3GPP is primarily pooled on a group of actors, of which many are not – or at least not noteworthily compared to their input – active in the retail market, while other actors predominantly draw the profits in the retail market. This unequal distribution is accommodated for and corrected by the mechanism of economic participation.

(2) The mechanism of economic participation is regarded as essential for knowledge exchange, the exceeding of proposed solutions, and joint problem solving at 3GPP, which enables the development of and fosters technological excellence: First, it is the foundation

to exchange knowledge at all as the following statement of an interviewee on the IPR- and FRAND-based mechanism of economic participation at 3GPP specifies:

> *That's an essential for that your idea does not get stolen. So, you can really freely explain your idea […]. You have the legal balls around it, so people don't just come around, steal it, and run with it. So that […] allows companies and delegates to come in and discuss about technical ideas and strategic technology notion's freely* (*Interview 1*, p. 4)

Second, it is perceived as main incentive for the contribution of own proposals to the problem-solving process.

> *And that's [the FRAND-based mechanism of economic participation] basically also a way to get some money out of our knowledge transfer […and] R&D investments. So, in that sense, […] we [provide] our knowledge and we get paid with FRAND.* (*Interview 2*, p. 4)

(3) With regard to consensus-finding and a cooperative atmosphere at 3GPP, the IPR-, FRAND-based mechanism of economic participation is perceived as rather hindering:

> *[That IPR- and FRAND-based mechanism of economic participation] makes the environment inside of 3GPP more competitive because you don't make your money after the standards are done, you make your money while the standards are being developed and that's a key difference.* (*Interview 8*, p. 19)

As stated in the previous quotation, for some organisations at 3GPP, their proceeds are based on the distribution concept, which is defined by the mechanism of economic participation, which at 3GPP is FRAND-licensing. As such, the primary objective of the organisations is to foster solutions in which a maximum of their own (patent protected) solutions, which they bring in the IOCS by proposal, are realized in the final solution. That complicates consensus-finding, because it is not the functionality of the solution, but the composition with regard to the included and excluded technical proposals, which is decisive for the proceeds of some organisations. As a result, these organisations tend to adhere to their own solutions as long as there is a chance to bring them in. At the same time, it is a motivation to present the best solution by outdoing and exceeding alternative solutions which fosters technological excellence.

D.4.1.3 Mechanism of moderation

Description

The mechanism of moderation at 3GPP is conducted by the chairman of each technical group which is elected by its participating actors for a two-year period. It is generally[57] in the chairman's responsibility that a group delivers results in time (*Interview 7*, p. 22). However, the means of chairmen differ according to the group they lead. The case study reveals, that in voluntary IOCSs like 3GPP, the chairmen are not supported by defined roles which make it possible to claim certain tasks or results of its assigned actors (as managers in companies can), nor can they use coercive power to call for results or

[57] As a matter of fact, the importance of a chairman for joint activity is widely recognized and not at all new or special in IOC or at 3GPP. In fact, the election of chairmen is generally one of the first official actions if a new organisation is founded. However, the means to conduct his or her role may differ.

contribution. Instead, chairmen in voluntary IOCSs like 3GPP, IETF or others are '*leading people who are not really reporting to [them], […] which is very special and requires special tools to make them collaborate [and deliver work]*' (*Interview 2,* p. 29). The case study reveals, that in such voluntary IOC-settings, the mechanism of moderation is the most powerful mechanism which a chairman has to directly influence IOCA processes and outcome. In addition, the mechanism of moderation also assists the chairman in his or her responsibility to assure that IOC(A) is conducted in a sustainable manner which does not have a lasting negative effect on actor's relationships. More precisely, the chairman uses his or her moderating function to ensure that discussions and disputes stick to facts and do not get out of control – meaning to get personal or too emotional. There is agreement among the interviewees, that the mechanism of moderation is the most conductive and effective means to make a working group perform strongly. However, it is described as a very challenging task by all interviewees with chairman experience: Being a chairman and moderating IOCA requires to understand, guide, and positively influence the real group dynamics in a working group while assuring and actively realizing compliance of IOCA and IOC processes with an IOCS's GPs and culture. As such, the mechanism of moderation can be described as follows:

> The **mechanism of moderation** is the most powerful mechanism of collaboration to
>
> (1) directly foster the achievement of IOCA results (in time), which requires to understand, guide, and positively influence the real group dynamics in order to bring together the right people and support compromising, and
>
> (2) assure the implementation and realization with the corporate IOCS culture and an IOCS's GPs in IOCA.

In order to avoid divided loyalties and support the unbiased and trustworthy moderating function of the chairman, elected chairmen for the period of election do not act as delegates of their organisation anymore but solely as leaders of the group. As a reward for their challenging duty, good chairmen are regarded as real authorities by fellow IOC actors and have a lot of power at 3GPP (*Interview 7,* p. 22). Because of the power and responsibility for both the IOC process and outcome, which a chairman has with his or her moderating function, and the corresponding honour to be elected, becoming a chairman is being *'almost a career'* for some delegates (*Interview 7*, p. 24). One interviewee further emphasises the importance of the mechanism of moderation, which is conducted by the chairman, by defining chairman development as an essential task of talent management in IOC to assure an IOCSs long term success (*Interview 2* p. 22 and 24).

Perceived effects

As described above, the concrete effect on the conduction and outcome of IOCA is perceived as very high by all interviewees. In line with the above description, especially the following effects have been analysed as most prevalent:

(1) *Facilitates and fosters constructive exchange and compromises*: As mentioned above, it is a – and according to some interviewees (*Interview 1,* p. 14) even *the* – main function and task of the chairman to understand real incentives, motives, and group dynamics, which go beyond what is said '*in a microphone in front of 400 people'* (*Interview 1,* p. 14). This understanding provides the basis to use the mechanism of moderation to disclose potentials and common ground for compromises and/or alternative, more satisfying solutions, but also to dissolve disputes between conflicting parties by issuing informal

exchange in side-meetings. By bringing the right actors together and make them talk, the chairman's moderating function is pivotal to find full consensus, to foster progress, to realize a no-loser policy and to balance the times each actor uses and wins.

(2) *Executes and assure fair IOCA in compliance with the GPs and corporate IOCS culture*: By thoroughly using the mechanism of moderation, the chairman has the power and responsibility to control and guide IOCA processes and proceedings. First, by admitting the floor to different actors, it is in the responsibility of the moderator to assure a balanced fair distribution of speaking time between actors with different positions but also with special focus on minorities and/or actors who may not rise to speak uncalled but have to be asked to make a contribution due to their cultural imprint. Second, moderators have to assure by wise moderation that the real benefits and reasons for a final solution are communicated to all actors in order to get them invested for the final solution. Third, it is up to the moderator to best foster solutions, which follow the no-loser policy at 3GPP, and thus to '*fairly rotate the ones who are unhappy in a working group'* (*Interview 1*, p. 8). Fourth, a moderator always has to assure that solutions are presented and communicated in a way that every party's face is saved. That way, the mechanism of moderation is pivotal for sustainable IOC(A).

(3) *Prevents disputes to get personal and/or out of control*: The mechanism of moderation is highly related to the control of disputes between conflicting parties, which according to the interviewees experiences may – especially if time units of a project are distributed – get so heated that they are on the verge of getting physical. More precisely it is up to the moderator to prevent debates to get too personal, emotional, or otherwise out of control in a way which could cause interrelation harm between actors and would thus result in a lasting negative effect for IOC(A). As such, it is ascribed to the mechanism of moderation to assure constructive, factual debates as basis for sustained collaboration.

D.4.1.4 Mechanism of targeted activity

Description

The mechanism of targeted activity refers to the fact that 3GPP follows a very lean and minimalistic concept concerning its scope of action and intervention, which can best be described by the credo 'as much specification and action as necessary, but as little interference as possible', which strongly aligns to the GP 'let the market rule the game' and its paradigm to avoid unnecessary influence. At IOCA level, which is in the focus of this study, the mechanism of targeted activity describes that the IOCA is limited to core activities and issues which have to be solved concertedly in order to attain the IOCS's mission. The mechanism of targeted activity is put into practice by means of the time unit concept, which is used to practically organise and plan IOCA for a project. This includes the definition of targeted activities and their prioritisation: For each project, time units are determined based on the available manpower and working hours. These time units are then distributed to different topics and tasks within the project. As a result, the most heated disputes are often found in these meetings of time unit distribution, because it decides on the weight and ranking of the issues of own interest in the project. As such, time units provide a means and basis to plan and organise IOCA and project progress. It has to be mentioned, that the credo is not just implemented at IOCA level, but also at IOC level, which however is not in the focus of this study. At IOC level, this becomes – for example – visible in the IPR policy, which defines FRAND as basic principle to make technologies accessible but leaves concrete arrangements up to its member's negotiations.

Perceived effects

The mechanism of targeted activity at IOCA level mainly affects the efficiency and effectiveness of IOC(A). The resulting effect on progress and mission attainment is perceived to be in particular important for 3GPP's actors' long-term satisfaction and commitment both at organisation and delegate level. However, the mechanism of targeted activity also affects the sustainability and pace of problem-solving at 3GPP:

(1) *Effect of efficient and effective IOC(A) at organisation level*: According to the interviewee's perception, the long history and sustained success of 3GPP with the high continuity and growing number of participating organisations, can – amongst others – be traced back to the mechanism of targeted activity: The mechanism of targeted activity directly affects if and how missions – and thus the IOCS's objectives – can be and are successfully, efficiently, and effectively achieved. As such, the mechanism of targeted activity is decisive for an organisation's evaluation of the advantageousness of IOC and in particular of the conduciveness of IOC to its individual objectives. As stated above (see Chapter 4.1 and Appendix D.2.1), in voluntary IOCSs, the organisation's participation in IOC depends on this evaluation. It is only if the organisation – and its incentive to join IOC – is satisfied, that an organisation stays committed to its participation in and IOC. As such, by contributing to an efficient and effective mission attainment, the mechanism of targeted activity positively influences the attractivity and sustained commitment and participation at organisation level.

(2) *Effect of efficiency and effectiveness at delegate level*: The mechanism of targeted activity has two important effects at operational level: First, by focussing on and limiting activities to the necessary issues with regard to concerted problem-solving, the mechanism of targeted activity reduces the social pathway, which has to be trodden with each additional activity. That way the mechanism of targeted activity reduces the instances at which social, sociocultural, and relational difficulties may arise. As such, the mechanism of targeted activity obviates unnecessary conflicts and relational difficulties which may enhance relational risk and negatively affects relational trust. Second, it is a matter of fact, that the efficacy of the own action influences job satisfaction. This is especially true for the job of delegates whose daily activity and engagement is conducted in an organisation which does not decide about their renumeration. As such the mechanism of targeted activity with its positive effect on efficient and effective IOCA and goal-attainment directly contributes to the satisfaction of the delegates in the IOCS and thus supports the continuity of delegates.

(3) *Effect on the sustainability of solutions:* With regard to the development of sustainable solutions, some interviewees perceive the mechanism of targeted activity as rather hindering and negative: That is, because the mechanism of targeted activity and the time unit concept fosters – and even calls for – a high pace of development but does not take sustainability of solutions and development (processes) into consideration. As such, the mechanism of targeted activity encourages to produce and invest in solutions which meet the available time units and targets of this project, but gives little space and incentives to develop long-term, cross-project inputs. As countermeasure, one interviewee proposes to reserve a certain amount of time units of each project for cross-project inputs (*Interview 6*, p. 20).

D.4.2 Secondary mechanisms of collaboration

It has turned out that it is especially important yet challenging for newcomers to understand, get used to and align to the secondary mechanisms of collaboration because they are soft institutions which define the social rules of the game. That is why at 3GPP mentoring has been introduced for newcomers a couple of years ago (*Interview 4*, p. 21). A mentor is assigned to each newcomer who helps the newcomer to get used to and understand the 'rules of the game at 3GPP'.

D.4.2.1 Mechanism of corporate IOCS culture

Description

The mechanism of corporate IOCS culture is strongly affected by and in line with the GPs at 3GPP. It refers to a common mindset and the code of conduct and ethics within an IOCS and thus defines a foundation for interaction and IOCA especially among actors with different regional and industrial backgrounds. For the mechanism of corporate IOCS culture continuity of delegates and a system's inertia to change is most important. Reaching back to its origin in GSM (see Appendix D.1), 3GPP has up to date a rather cooperative and little antagonizing corporate IOCS culture. Of course, 3GPP's culture was challenged and to some degree altered when the IOCS was extended to other regions of the world (*Interview 2*, p. 14) and new industries, yet its nature was preserved. This is because of the high continuity of delegates whose importance for the development of a common IOC culture was described by one interviewee as follows:

> '*People who came in later looked at their ways to work together and to act and followed them.*' (*Interview 3*, p. 2)

The culture of (1) making everybody feel comfortable, (2) respecting everybody who contributes to IOC(A) and (3) generating and preserving an atmosphere of constructive debates and interaction is found to be most formative for the mechanisms of corporate IOCS culture at 3GPP.

(1) Although it is '*natural, [that] incumbent players may not want to lose their piece of cake [to newcomers]*' (*Interview 5*, p. 7), 3GPP is described as a rather welcoming IOCS. While this also results from the multicultural and multiregional roots and actor distribution at 3GPP, it is mainly based on the strong incentive and need to keep all actors on board of 3GPP as the following statement of an old-established interviewee shows: *'So there was so much effort being put into let's make sure that everybody – the Chinese, the European, the Americans – they all feel welcomed and heard. Because if we don't do this, they'll leave. And we fragment again. I think that's where it probably roots in. And it was really an inherent desire to make sure that all the different cultures feel comfortable coming here, feel comfortable speaking up, feel comfortable losing.'* (*Interview 1*, p. 10). This culture of making actors feel welcomed and comfortable is strongly aligned to and puts the GPs of 'knowing the value of the number' and 'no-loser policy' into practice.

(2) Interviewees who rather recently joined 3GPP emphasised the culture at 3GPP to hear and respect anybody who contributes to IOC(A) regardless of his or her duration of participation or regional and industrial background (*Interview 6*, p. 12). This strongly distinguishes the corporate culture at 3GPP from other IOCS cultures in which respect and reputation is often bound to the duration of membership of an organisation or delegate. As a matter of fact, giving newcomers a fair chance to get integrated can be regarded as prerequisite or at least as highly supportive for the attraction and integration of new members and thus for the growth of an IOCS.

(3) At 3GPP, an atmosphere of constructive and sustainable debates which is decisive for the way actors interact, debate, and stand out for their favoured solutions, is an important

and distinguishing factor of the corporate IOCS culture at 3GPP: Concretely, the behavioural culture between actors at 3GPP is determined by high aspiration of all actors to appreciate, preserve and cement ties with fellow actors across sectoral and national boundaries. The following quotation of one interviewee helps to understand this cultural phenomenon: *'...you're in a different boat today, but you might be in the same boat on the next issue tomorrow.'* (*Interview 1*, p. 11). It becomes obvious that this appreciating and constructive culture at 3GPP can be traced back to the way of making decisions at 3GPP by full consensus, which requires to 'play the numbers game' (see Appendix D.4.2.3): All actors know that today's rivals may be the tomorrow's allies and that it is disadvantageous to burn the own boats, which are the basis for future IOC success, in favour of one victory. As a result, there is a high awareness of the value of being on familiar terms with as many actors as possible for the own sustained success at 3GPP and to preserve such ties by focusing on technical arguments and refraining from personal disputes in order to avoid discords which go beyond the issue under discussion.

Perceived effects

The most prevalent perceived effects of the mechanisms of corporate IOCS culture for IOCA can best be described as providing the common ground and framework (1) for the conduction of IOCA and (2) the development of a *Wir-Gefühl* (feeling of unity)

(1) It is the corporate IOCS culture which defines common behavioural and interactional pattern and standards. These patterns are essential as orientation guide for the own behaviour and (inter-)action but also and in particular for the interpretation, prediction, and predictability of the fellow actors' behaviour. As elaborated in Chapter 4.3.1, (un-)predictability of partner behaviour is a main criterion for relational risk in IOC. By enhancing the predictability of action of fellow actors, the mechanism of corporate IOCS culture essentially contributes to the foundation of a basis to conduct IOCA at all. In daily IOCA, the mechanism of corporate IOCS culture facilitates all (processes of) interaction and IOCA: By defining a concerted framework for (inter-)action, IOCA can be conducted effectively and efficiently, because behaviour in accordance with the corporate culture is taken as granted. With special regard on the highly established and deep-seated corporate IOCS culture at 3GPP, interviewees emphasise the positive effect on the resilience and robustness of 3GPP against actor deviance: While malpractices are a very rare phenomenon at 3GPP, in the few incidences of – externally manipulated – malpractices the mechanism of corporate IOCS culture has proven to successfully absorb such misconduct, meaning to prevent a lasting negative effect on the trustful and stable ground and atmosphere for IOCA. Some interviewees describe the mechanism of corporate IOCS culture as source for institutional trust: A situation of misuse, when politically manipulated actors intentionally misused installed processes or more precisely used a technical loophole to gerrymander voting, impressively proved the delegate's institutional trust: Although the loophole became public, actors did not call for advancement of the processes, but believed in 3GPP's resilience and power to heal itself (*Interview 7*, p. 17). That can only be explained by the common IOCS culture which is so deep-seated and widespread among the actors at 3GPP, that actors are convinced of its power to prevent, compensate for, and absorb destabilizing effects of deviant behaviour of single actors.

(2) A second important perceived effect of the mechanism of corporate IOCS culture is the development of a *Wir-Gefühl* (feeling of unity) which is strongly developed at 3GPP according to the interviewees: *'...many times the standardization people [meaning the delegates] they are more loyal to, you know, their SDO [meaning 3GPP] than to their own employer.'(Interview 2 p 12).* This is concomitant with a strong commitment and

dedication of the delegates to 3GPP and the work in the IOCS, which is pivotal for active participation and contribution of the delegates to IOCA in a voluntary IOCS without coercive power. At 3GPP, all interviewees describe the motivation, investment, and involvement of delegates to be very high, which they trace – amongst others – back to the corporate IOCS culture and the *Wir-Gefühl* (feeling of unity). In addition, the remarkable continuity of delegates at 3GPP which is equally special and formative for 3GPP and IOC(A) at 3GPP, is strongly interrelated to the corporate IOCS culture at 3GPP: It is the *Wir-Gefühl* (feeling of unity) which makes delegates stay at 3GPP, while it is the 'compass delegates' who promote, spread and put the corporate IOCS culture into practice.

D.4.2.2 Mechanism of informal exchange

Description

The mechanism of informal exchange describes how direct interaction and communication beyond the official meetings at 3GPP assists IOCA. Simplified, the mechanism of informal exchange may be described as all communication which does not occur via microphone or other official communication channels. In particular, it also includes side-meetings between a subgroup of actors – like the in Appendix D.4.1.3 mentioned side-meetings between conflicting parties which moderators may arrange– even if it has a rather formal nature and/or if their outcome is made a prerequisite for the proceeding of the official meeting. Consequently, informal exchange with regard to the mechanism of informal refers to informal exchange not just in a narrow, but also in a broad sense and can be defined as follows: Beside typical socialising while 'taking a beer or coffee' during breaks or evenings which is the primary source to develop personal relationships and relational trust, informal exchange in the broader sense of this mechanism includes all *'necessary conversations, discussions and problem-solving processes which take place outside of the official meeting of a working group'* (free translation of *Interview 4*, p. 10). It is especially because of the informal exchange in a broader sense, that this mechanism can be regarded as the main platform in IOCA for creative processes and for the exploitation and evolution of synergies and additional value of joint problem-solving and expert accumulation, which best yields brilliant and/or path-breaking solutions.

At 3GPP, the planning of official meetings[58] takes special account of the importance of the mechanism of informal exchange for IOCA: Official meetings are generally scheduled for a whole week in order to provide enough room and opportunity for informal exchange in both a narrow and a broad sense. Especially in the very unique time of physical distancing during the COVID-19 pandemic in which the interviews were taken, interviewees highly perceived the value of the mechanism of informal exchange: There is agreement, that the loss of informal exchange both in narrow and broad sense is a *'big loss'* (*Interview 2* p. 13, *Interview 1*, p. 15), which is however absorbed a in mature IOCSs with established networks and personal relationships because *'everybody is trying to basically get this personal side of things remotely, which is more difficult, but doable'* (*Interview 2*, p. 13).

One interviewee points out an interesting mutual dependence between formal and informal exchange which he observed: It is not just informal exchange which fosters formal exchange and progress, but also the other way round: Especially for newcomers, active contribution in form of *'to go up to the microphone and make a point'* (*Interview 3*, p. 5) – which in fact needs a lot of confidence – may highly promote informal exchange. That

[58] Because of the COVID-19 pandemic there were no physical meetings in 2020 and 2021.

is because *'[p]eople tend to talk to people they know. If you've been at the meeting, you've spoken on the microphone, and you've said something that sounds sensible, even if you disagree with someone else, they will come up to you and talk to you and you can [get in informal exchange].'* (*Interview 3,* p. 5)

Perceived effects

The importance of the mechanism of informal exchange is undisputedly and very strongly perceived by all interviewees in nearly all aspects and processes of IOCA. One interviewee uses the metaphor of oil which makes rusty interaction and IOCA smooth (*Interview 2,* p. 13) to describe how he perceives the effect of informal exchange at 3GPP. This metaphor perfectly depicts that the mechanism of informal exchange affects the whole 'gearbox' of IOCA at 3GPP. In the following, perceived effects will be elaborated with regard to the four most important contributions, namely to the development of (1) personal relationships, (2) mutual understanding, and (3) creative solutions and to (4) efficient IOCA.

(1) The mechanism of informal exchange and especially informal exchange in a narrow sense is – as a matter of fact – the basis for the development of personal relationships. Personal relationship is again the basis for the development of relational trust and pivotal for (trustful) interaction. As such, the mechanism of informal exchange assists the development of a foundation for IOCA in general, but in particular for allying and thus for the individual success of an actor at 3GPP, which is emphasised by one interviewee: *'There is a social connection with those people and so because that is a big enabler to actually being successful with the 3GPP'* (*Interview 8*, p. 4). In addition, personal relationships are regarded as the primary source for relational stability which is prerequisite in IOC and especially in coopetitive IOC to harmlessly absorb the stresses of competing and conflicting positions with the concomitant disputes. As such, the mechanism of informal exchange has a strong positive effect on the resilience and robustness of an IOC network which allows for technical contests and dissent.

(2) The mechanism of informal exchange is the primary source to reveal real motives and objectives and develop mutual understanding. That is *'[b]ecause a lot of things are set online in a meeting, in a microphone in front of 400 people. That's one thing what companies say there. But there are always underlying dynamics and reasons, [… T]hey are never actually said in the online meeting there. They might be exchanged in the corridors amongst two or three people.'* (*Interview 1,* p. 14). This phenomenon is natural – and not at all IOC-specific – to official meetings which are generally tightly scheduled, rather unpersonal events in which official interests and objectives are communicated and defined. In contrast, informal exchange both in a narrow and broad sense takes place among two or few actors. As such it is much easier and likely for a trustful atmosphere to develop which is the basis for private conversation in which real incentives, motives and objectives may be revealed. In addition, there is no tight schedule for informal exchange which further facilitates to go in detail, dig deeper and really take an interest in the counterpart and his or her positions. Lat but not least, because informal exchange is not a formal, reported act, it is up to the exchanging actors to define if and what is documented and made public (for example in case of formal side-meetings). In consequence, delegates are less bound to their role as representative but may act, interact, and discuss also as expert and individual, which also supports to reveal and understand the true motives and objectives. Because the understanding of true motives and objectives is essential for the identification of common ground for compromises and allies, the mechanism of informal

exchange is pivotal for consensus building and decision-making and thus highly conducive for IOC(A) progress and outcome.

(3) A main advantage and additional value of solving problems by IOC is undisputedly the pooling of expert (knowledge), which causes mutual stimulation, motivation, and inspiration of the development of both creative and surpassing approaches of resolution. However, in order to make use and disclose this potential, exchange among the experts in form of technical discussions and peer reviews, in which the different perspectives, knowledge and experiences are fused, are requisite. The development of unorthodox, ground-breaking approaches of resolution is in particular fostered by creative thinking where thoughts flow rather freely without consideration of constraints. As a matter of fact, this is not possible in official meetings, but is left to informal exchange both in a narrow and a broad sense. As such, the mechanism of informal exchange at 3GPP is an important means to foster and enable creativity and technological excellence.

(4) The mechanism of informal exchange is an essential mechanism for constructive, efficient, and effective IOC(A), especially if it is consensus-based. Some interviewees even experience informal exchange as essential for the general feasibility of IOC at 3GPP. That is, because the way of resolving issues by means of informal exchange is much quicker, shorter, and often much more effective than the formal, official way whose mills grind slow, because of the formal procedures and the number of actors who get involved. As such, it may be questioned if in an IOCS like 3GPP with hundreds of actors joining a working group IOC(A) could at all proceed and succeed without the mechanism of informal exchange. In any case, the mechanism of informal exchange is pivotal to make IOC(A) (time) efficient and effective. In particular, it facilitates the (timely) building of a critical mass and compromising as basis for consensus-based decision taking.

D.4.2.3 Mechanism of the critical mass

Description

> *'[IOC] is the continued best investment of the critical mass. It's a numbers game in some sense. So, you can say the numbers are to some extent even more important than the actual optimal nature of the technology'* (*Interview 1* p. 21).

The mechanism of the critical mass refers to this *'numbers game'* (*Interview 8* p. 3) at 3GPP which can be regarded as the concrete practical implementation of the mechanism of consensus. It is intrinsically tied to the relevance of the GP 'knowing the value of the number' at actor level (see Appendix D.3.1). In fact, progress of IOC(A) and the success of both the delegates and the IOCS and its outcome is based on the mechanism of the critical mass. While the above statement does not imply a lack of technological excellence at 3GPP (see Figure 53 below) it rather pinpoints the mandatory necessity to get everybody invested for one – in any case technologically excellent[59] – solution in order to attain 3GPP's objective to develop one concerted solution which is uniformly promoted and implemented by all actors. This essentiality of building a critical mass is formative and decisive for the way IOCA is conducted at 3GPP:

[59] There is agreement among interviewees (see section perceived effects in this chapter) that at 3GPP due to expert pooling and concomitant peer reviews and competition the decision is between different, yet all excellent, technological solutions.

> The **mechanism of the critical mass** describes that IOCA at 3GPP is all about playing the '*numbers game'* (*Interview 8* p. 3), which is the only way for (1) individual success at 3GPP, (2) IOCA progress and, (3) concerted, roundly accepted and supported IOC(A) outcome.

Playing the numbers game primarily refers to building momentum for the own solution by allying and coalition building, which requires to convince other delegates of the own solution. This is done by technical arguments and compromising. As such, the mechanism of the critical mass provides the reason for the necessary – informal -exchange between experts which leads to the development of creative, highly excellent solutions. As such, it can be stated that the mechanism of the critical mass is decisive at actor and system level: While at actor level the individual success is determined by the mechanism of the critical mass, at system level progress, consensus-based decision taking, and generally accepted outcome of IOC(A) is affected. For verticals and small players, who represent niche markets with relatively small sales volumes, the mechanism of the critical mass is in addition used to build economic momentum meaning the creation a profitable market for certain user requirements.

Perceived effects:

As stated above, the mechanism of the critical mass is perceived as highly formative for the way IOCA and interaction at 3GPP is conducted. Especially in an IOCS like 3GPP with big working groups, the mechanism of the critical mass is key for (1) a level playing field and (2) an IOCS's robustness and resilience against misuse. At the same time, building critical mass, playing the numbers game, and allying (3) takes time and effort and (4) promotes 'horse-trading'. Finally, it (5) allows small players to create the necessary economic momentum to make their arguments and requirements heard. In consequence of the high interrelatedness of the mechanism of the critical mass and the mechanism of consensus, the perceived effects are very similar to the ones described in Appendix D.4.1.1. However, as the mechanism of the critical mass may evolve independently from the mechanism of consensus, its effects are elaborated separately.

(1) There is agreement among the interviewees that mechanism of the critical mass is the primary and essential source for the development of a level playing field at 3GPP. In fact, it is because of the mechanism of the critical mass that the only way to succeed at 3GPP is by coalescing and allying regardless of the economic means or market power of an actor and because for the critical mass each actor has the weight of one vote. Of course, 'big player' with high reputation – within or without 3GPP – and/or high market power, and/or multiple business relationships with fellow actors at 3GPP may more easily build the critical mass because they find supporter of the own solution more easily. However, even a big player may not outflank or avoid the mechanisms of the critical mass. At a big IOCS like 3GPP in which the critical mass requires a three-digit number of advocators, even big players have to court for support beyond their own (business) relational network. In consequence, each actor regardless of the size, economic means, relations and or market power may be the vote which tips the scale. As a result, even small player like verticals, who may at the end represent the decisive vote, are heard, treated at eye-level and can pursue their own interests. As such, the mechanism of the critical mass balances power among different actors at 3GPP by making big players depended on the support of small players (and vice versa).

(2) The highly positive effect of the mechanisms of the critical mass for the robustness and resilience of an IOCS is undisputed and correlates with the size of an IOCS and its working groups. That is why the effect at 3GPP is very high, where building critical mass

requires to convince a three-digit number of actors. As more and more actors join, the critical mass increases and the power of the individual actor or even actor groups decrease. In order to make the positive effect on the robustness and resilience against misuse visible, two extreme examples may be considered: Let the critical mass be defined as 50% of the actor group, which is a solely hypothetical value: In an IOCS of 5 actors, a player has to convince – or in worst case manipulate – two other parties to generate the critical mass. Manipulation of two actors is possible and may likely be supported by business relations outside of the IOCS. In an IOCS of 500 members, on the other hand, the actor has to bring 250 other players on their side to build the critical mass, which is much less likely to happen. That is why one interviewee who stated the tendency of regional block building as danger for successful IOC at 3GPP, regards the attraction of new and more participants as one of the best countermeasures to this development (*Interview 8,* p. 19)

(3) An – at the first glance negative – effect of the mechanism of the critical mass is the time and personal effort which it inevitably requires which has already been mentioned in Appendix D.4.1.1. Building critical mass is about convincing fellow actors by technical arguments, compromises, and mutual concessions. While this itself is a timely and highly interactive process, it prerequires informal exchange in order to build trust and/or personal relationship and to reveal true motives and objectives of fellows as basis to compromise. As such, the mechanism of the critical mass is a mechanism which in general slows progressing of IOC(A) down and impedes very quick solutions. However, the development of 5G which had a very tight and accelerated schedule has shown two things: First, fast progressing remains possible with the mechanism of the critical mass if all actors get invested and collaborate for the accelerated pace of a project and development. Second, while fast progressing is possible, it is not advantageous for the quality of the solution, because the number of options increases if too many compromises are taken which complicates the implementation of a solution in the market (*Interview 1,* pp. 6 and 12). As such, while the slow pace of IOC(A) which is determined by the mechanism of the critical mass is negative with regard to (fast) progressing, it turns out to be essential and conducive for the development of mature technological solutions. This seems even more reasonable as it is during the technical discussions of informal exchange which is encouraged and promoted by the mechanism of the critical mass that the positive effects of expert pooling with regard to the fostering of creativity and excellent solutions unfold.

(4) Because the mechanism of the critical mass requires and fosters compromising and mutual concessions, it is also related to 'horse-trading' as the following quotation shows: *'And you can think of this as in game theory, as a game that you are repeating all the time. And as I said, then it goes like, you know, this horse-trading, right? So, if I support you today, maybe you can support me tomorrow, or if I'm a reasonable guy, maybe [I am] willing to lose this battle, because next time it will be my turn. So, you get this reciprocity which is working quite well.'* (*Interview 2* pp. 12-13). This statement again (see the beginning of this chapter) implies that the critical mass and thus consensus for a solution is not build for technical arguments but for personal advantages, which is contrary to an IOCS's aim to produce technological excellence. However, this effect has to be put into the context of expert pooling and joint problem-solving at 3GPP, in which technological excellence of all presented solutions due to peer review and the aspiration to exceed rival solutions is outstandingly high: In such an environment the negative impact of compromising and 'horse-trading' on technological excellence is undisputedly regarded as minor among the interviewees in comparison to the gain in technological excellence from expert pooling and the benefit of one concerted and generally accepted solution as shown in Figure 53.

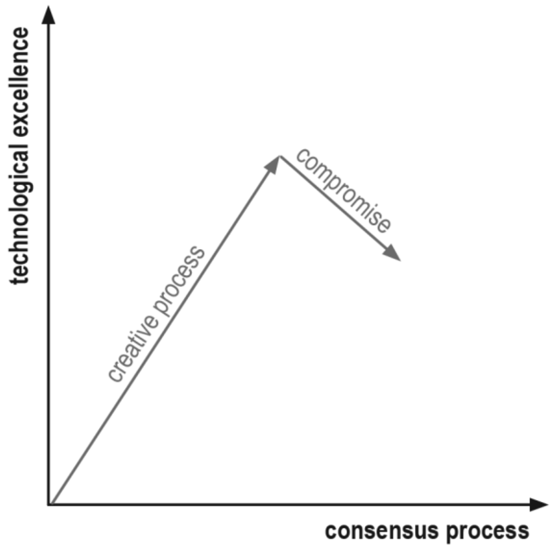

Figure 53: Contrasting the IOC effects of compromising vs. expert pooling and peer reviewing with regard to the impact on technological excellence

On the other hand, horse-trading is an important source of power and means for pursuing the own interests and technological requirements for small players at 3GPP. One vertical interviewee states *'[that] it's an advantage that you as a vertical are not really interested in many aspects which are discussed. […] I mean, you can easily say, 'okay, I agree with you in other parts because I don't care [if you in tourn meet my requirements].''* (*Interview 8*, p. 11). That is why what appears to be a negative impact of the mechanism of the critical mass at the first glance turns out to be an effective means and contribution to balance power at 3GPP.

(5) Verticals generally do not provide own technical solutions, but they bring in requirements for a new solution. However, these requirements will just be considered by technology developers, if there is a market with relevant sales volumes and concomitant prospects of profit which makes the development of a solution w advantageous and viable. One vertical interviewee recalls from their time as newcomer at 3GPP, that *'we recognized quickly that 3GPP is a number's game and that if we were going to provide incentive to other operators or manufacturers, that we need to have a bigger potential user base from the technologies that we wanted to build. So, the first thing that we did is [..] we went out and we built a coalition of other governments and called this the 'group of governments''* (*Interview 8*, p. 3). For verticals and/or small players, the building of a critical mass with regard to creating a significant market for certain requirements and corresponding solutions is thus a main yet different application of the mechanism of the critical mass. However, this building of critical mass for economic momentum differs from the building of critical mass for a certain solution: First, it takes place earlier, namely before the actual numbers game for – and best development of – different solutions at 3GPP starts, and sometimes and/or partially even before verticals enter 3GPP. Second, it is not limited to the members of 3GPP but may include allying with actors outside of 3GPP who are not (yet) participants: In fact, verticals aim to build coalitions with any other technology users who have the same requirements in order to present one concerted and uniform set of requirements for which a significant market exists. At 3GPP, both the syndication of verticals in 'official' external organisations as MRP and in 'informal' clusters of actors with similar needs who provide a profitable market (*Interview 8*, p. 3) has proven to be successful means to build economic momentum at 3GPP.

It can be concluded, that the (positive and negative) effects of the mechanism of the critical mass strongly correlate with the group size: While the critical mass is comparably easy to build among few actors, the mechanism is also more easily misused in small groups, because only few actors have to be manipulated to win the numbers game. Regarding an upper limit, the at 3GPP, where critical mass and consensus is regularly built among up to 500 participants, is the living proof for functionality 'without limitations'. This is, because in big groups the number of possible alliances increases as the critical mass does likewise. As a result, the power of a single actor and more importantly the potential to misuse the mechanism of consensus and/or the critical mass decreases significantly. But it is undisputed, that the process to build up critical mass and find consensus becomes more challenging as the group size increases which demands for additional absorbing mechanisms of collaboration: First of all, the mechanism of moderation becomes a pivotal complement to guide an efficient consensus process. Because the time in official meetings is limited, the mechanism of informal exchange gains importance. Another supportive component is the mechanism to progress, which averts the danger of a stagnating consensus process.

D.4.2.4 Mechanism of political capital

Description

The mechanism of political capital may be described as mechanism of self-discipline, which directly results from the fact that allying is the only way to success at 3GPP (see Appendix D.4.2.3). In consequence, the most valuable – and in fact even the only – asset which an actor at 3GPP may possess with regard to its success and power at 3GPP is political capital.

> **Political capital** is an actor's key to success in IOC and can best be described as the reputation of an actor within the IOCS which is achieved – beside active contribution to IOC(A) in form of technical expertise and/or user requirements – by behaving and acting in accordance with the corporate IOCS culture and concomitant codes of ethics and conduct.

At 3GPP, this concretely requires conducive, outcome oriented, fair, predictable, and reliable behaviour and interaction. However, one interviewee pinpoints that the existence of a peer group with the same basic idea is also supportive to build political capital based on his experience concerning the integration of newcomers: *'[I saw newcomer who] fitted in straightaway because they were operating the same kind of thing as [established actors at 3GPP]. So, they produced chips, there were other people who produced chips, and they were able to be part of the committee very quickly. When [a newcomer has] a different idea, something that's kind of unique to the newcomer, it's more difficult, it takes probably a couple more years to get integrated'* (*Interview 3*, p. 6). As a matter of fact, there are other factors as well which determine a newcomer's time of integration like active contribution and (physical) participation, the own incentives, and/or the time to get used to the codes of conduct and to playing the numbers game.

Political capital is built over time by repeated conform (inter-)action. However, political capital is jeopardized and/or impaired by only one deviant (inter-)action. As such, it is the mechanism of political capital which makes a win and short-term success today, which is attained by deviant (inter-)action, misuse, or malpractice, inevitably the loss of tomorrow and the days after tomorrow.

Perceived effects

The by far most prevalent and essential effect of the mechanism of political capital which is emphasised by all interviewees is self-discipline. As such, the mechanism of political capital outweighs the absence of coercive power at 3GPP as means to discipline and prevent malpractices. Because the vast majority of actors – organisations, but in particular delegates – are highly aware of the fact that *'if you burn a reputation, the game is over'* (*Interview 2*, p. 9), the mechanism of political capital exhorts actors to behave according to the corporate IOCS culture and codes of conduct and ethics although there are no means of coercive power at 3GPP. Instead, it is in the actors own interest and thus an intrinsic motivation to behave in accordance with the corporate IOCS culture and codes of conduct and ethics of a delegate – and predominantly of an organisation – in order to preserve long-term success at 3GPP. This includes to prove oneself as a reliable, reasonable, and trustworthy partner who actively contributes to and pushes IO(A) progress and the development of a concerted solution even if – or better although – it requires to compromise and make concessions.

D.4.2.5 Mechanism of progress

Description

The mechanism of progress can best be described as the '*desire to make progress [and meet deadlines]*' (*Interview 7*, p. 7) of members of a working group at 3GPP and thus at operational level. It is important to emphasise that the mechanism of progress refers to an intrinsic motivation and aspiration of the delegates, which is not to be confused with extrinsically constraints or project management means which also affect progress. The mechanism of progress is founded in the involvement and commitment of the delegates to IOC in general and the projects with their objectives in particular. As such, there is a strong relation with the mechanism of corporate IOCS culture and the concomitant *Wir-Gefühl* (feeling of unity) and actors' dedication to IOC (see Appendix D.4.2.1).

The link of the mechanism of progress with the extrinsic constraints are deadlines: The deadlines which the mechanism of progress adheres to re derived from strategic considerations and in particular from the necessity to meet the window of opportunity in the market to launch a solution: Such strategic and economic issues like the time to market or cost-benefit calculations are considered in the higher-level plenary meetings. The therein determined project timelines for the projects are the input parameter for the executive working groups, which define the schedule and deadlines for a project's IOCA. A rapporteur is often determined for each project, who is responsible to deliver in time and to keep track of the project's progress.

Project management means which are associated with progress are especially the mechanism of targeted activity and the definition and distribution of time units (see Appendices D.4.1.4 and D.5.4). Both the mechanism of targeted activity and the time unit concept are concrete means to organise and plan a project and its concomitant IOCA in order to practically realize and enable progressing in time. However, the do not refer to and describe the mindset of actors and their own and mutual aspiration to deliver in time as the mechanism of progress does.

Perceived effects

The mechanism of progress mainly affects IOCA and contributes to successful IOC by causing constructive, outcome-oriented behaviour and activity of all actors. This effect is mainly based on the group dynamics and socialisation which results from this progress-oriented mindset, which is dominant among the actors at 3GPP: 'The group', meaning the majority of delegates in the working groups at 3GPP, have very little tolerance and understanding for – unjustified and/or sustained – progress-stopping behaviour. As a result, there is a very strong disapproval of (sustained) objections, which are more precisely a no-go for most actors at 3GPP. That does not mean that it is frowned upon to stand out for the own solutions. However, there is agreement among the interviewees, that at some point it becomes obvious that an alternative is lost. If the supporters of such an alternative keep insisting on their solution by objecting the solution which is clearly favoured by the majority, strong pressure is built on the minority camp (*Interview 7*. P. 7). As such, the mechanism of progress is highly supportive for the mechanism of consensus, because it fosters to cooperate, compromise, and find full consensus.

> *'And culturally, in 3GPP being objective has not been seen, is not [appreciated]. So, objecting actually looks back to you, because effectively you are blocking progress.'* (*Interview 7,* p. 7)

However, some interviewees also see the danger of the mechanism of progress because it leads some actors to attach more importance to a high pace than to sustainable and reliable solutions.

D.5 Organisational setup

The following statement underlines how essential the organisational setup is for the success of a collaborative system:

> *'If the organisation behind does not work, personal relationship is not the solution!'* (*Interview 2* 17)

That is because it substantially and predominantly defines the collaborative setting. To best support collaborative success of an IOCS, the organisational setup has to be *'conductive to cooperation'* (*Interview 2*, p. 13). In line with the long-lasting success of 3GPP, interviewees state a high overall satisfaction with the organisational setup with regard to the criteria 'conductivity to cooperation'. In this chapter, the organisational elements which have been identified as main influences for the conductivity of cooperation are examined. First, there are structures which deal with the configuration of an IOCS and thus describe the structural framework for collaboration. Second, there are roles and activities which define both what activities are in the scope of the collaborative system and what activities may be performed by its participants. Third, there are processes, which cover all procedural aspects which define how activities and collaborative work is conducted. The last element focuses on the data and document management system. Although hard- and soft-ware devices of IOCA are not in focus of this study, the perceived effects of the data management system are presented because many interviewees referred to it.

D.5.1 Membership policy

Description

The membership policy defines the conditions for participating in 3GPPand thus the options to become part of the IOCS. Main aspects of regulation are:

(1) *Types of participation*: What types of memberships do exist?

(2) *Requirements of participation*: Who can participate?

(3) *Conditions of participations*: Which benefits, commitments and codes of conduct are attended by participation?

(1) With the definition of one type or different *types of participation*, the membership policy is able to categorise levels of participation and participants. Different types of participation may concern the right to vote, the right to make own contributions and/or the right and conditions to physically join meetings. The decision for one or several types of participation is elementary, because it is the decision between homogenous field of participants or a 'more-class society' in an IOCS. The importance of the decision on types of participation became obvious in the interviews because all interviewees emphasised the participation at eye level at 3GPP. Most interviewees with experience from other IOCSs which have different types of participation like for example ITU (International Telecommunication Union) and CEPT (European Conference of Postal and Telecommunications Administrations) additionally accentuated the fundamentally different atmosphere and attractiveness to participate in these 'two-classes' regulatory institutions (*Interview 6*, pp. 23-24; *Interview 1*).

(2) With the definition of *requirements of participation*, the membership policy may limit access to an IOCS and thus defines the maximum boundary of the IOCS. All actors, who fulfil the requirements of participation are free to become part of the IOCS. But all actors, who are defined beyond the maximum boundary according to the requirements of participation, are definitively excluded from the collaborative system. Possible requirements might be the incorporation as legal entity, a certain minimum (or maximum) volume of sales, the affiliation of the core business to a certain industry or the membership in another organisation. For example, at 3GPP, the membership in one of 3GPP's Organisational Partners is prerequisite for the participation in 3GPP[60].

(3) *Conditions of participation* are an essential element for the attractiveness of a collaborative system. The characterising maxim for conditions of participation in voluntary IOCSs is best deduced from the following statement of one interviewee:

> *'You don't want to be a slave in a system.'* (*Interview 1*, p. 20)

Members will only decide to become part of the IOCS and thus of the IOCS if conditions of participation are beneficial to them. As stated above, beneficial in this context means supporting the pursuing of individual incentives. In consequence, renunciation of punishment and moderation of intervention are 3GPP mottos to design appealing conditions of participation: moderate financial commitment, moderate persona commitment, very moderate use of mandatory regulations.

> **Conditions of participation** are a main organisational element to determine the attractiveness to join an IOCS like 3GPP. That is why there are two mandatory maxims for conditions of participation at 3GPP: (1) *renunciation of punishment* and (2) *moderation* of commitment and regulations.

These maxims determine the main characteristics and limitations of conditions of participation at 3GPP. Depending on the concretely implemented conditions of participation, actors and/or certain actors are more or less attracted. By modification of the conditions of participation, certain actor groups can be more or less attracted than others and/or even

[60] For more details see Appendix D.1

indirectly excluded. Interesting parameters in this context are the amount of financial and/or personal commitment, and the mandatory regulations and codes of conduct. For example, in 3GPP the commitment to their IPR policy is mandatory. Depending on the policy design, some actors – like IP holders in the case of 3GPP – are more attracted than others.

Perceived effects

3GPP knows just one type of membership and has not significantly changed its conditions of participation over the years. The requirements of participation are very open and allow all members of one of the seven Organisational Partners of 3GPP[61], to become a member in 3GPP. Nevertheless, analysis of the interview data reveals some interesting findings on the effects of membership policy on ICOA and the IOCS:

(1) All interview partners highlight the level playing field which they regard – amongst others – as a result of the membership policy. Equality and collaboration at eye level is perceived as a key factor to cause a trustful and harmonic atmosphere and thus a sound basis for highly motivated and effective IOC. It gives the participant the feeling of being in charge of his or her individual success in the collaborative system. Interviewees' experiences in other IOCSs disclose, that different types of participation bear a higher potential to cause frustration and dissatisfaction – especially among participants with limited options to participate, because they feel constraint and disadvantaged. They have the feeling of being the above stated 'slave in a system'.

(2) The interviewees' statements on physical attendance allow deducing an understanding on the potential impact of the types and conditions of participation on IOCA and an IOCS: Physical attendance in official meetings is not a condition of participation at 3GPP. Yet, as a de-facto necessity for an actor's success in 3GPP, actors hold physical attendance dear. But it is evident that it is impossible for small entities to be personally present in all meetings. Thus, if physical presence in official meetings was defined as mandatory condition of participation, small entities would or had to refrain from participation: The factor 'mandatory physical presence' would outweigh all other factors in the cost-value equation, regardless how attractive they are for small entities. A possible solution could be the introduction of a second type of participation, which does not require personal attendance at the price of – for example – renouncement to vote or make own contributions in meetings. This 'passive membership' type of participation would attract small entities whose main incentive is to gather technological trends to align the own research and/or development activities. This finding shows, that the above identified advantages of one type of participation over several types of participation cannot be generalised. In fact, different types and conditions of participation might have beneficial effects for the IOCS which outweigh the advantage of a level playing field, if they better satisfy the demands and incentives of the involved actor groups.

(3) Analysis of the operators' power in 3GPP shows the impact of membership policy on the power structures and group dynamics: As above mentioned, 3GPP has a very open and unrestricted membership policy. As a result, combined with globalisation, digitalisation, and technological progress, 3GPP has expanded significantly over the last decades: When 3GPP was founded to develop 3G, the IOCS was made up of about 350 actors, which were mainly network vendors, phone manufacturers and telecom operators. Operators had a lot of power in this composition. By 2020, it counts over 700 entities.

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[61] See Appendix D.1 for details

Interview data proves, that operators today are *'not as dominant as they used to be because of the expansion of the ecosystem*[62] *'* (*Interview 1*, p. 20). An alteration of membership statutes towards a more restrictive – for example the exclusion of verticals – or a less attractive policy had probably maintained more dominance and thus power of operators in the collaborative system.

D.5.2 Organisational structure

Description

The organisational structure defines the hierarchy of the IOCS with corresponding competences and responsibilities. To support the success of IOC, the organisational structure has to be *'conductive to cooperation'*. Data analysis discloses three main aspects as driver for conductivity to cooperation:

> **Conductivity to cooperation** requires that organisational structures
>
> (1) support efficient and effective goal attainment,
>
> (2) support the participants' dedication, personal commitment and activity,
>
> (3) hold little potential for conflicts concerning hierarchy, competences, and responsibilities.

Conductivity of cooperation always depends on the characteristics of an IOCS and especially the specifics of its product. But two elements of organisational structure are found to influence conductivity to cooperation most: That is management embodiment and an IOCS's structure at operational level.

For management embodiment in IOCSs, the primary decision is between two concepts: One can either establish a management body comprised of full-time officers, which are employed by the IOCS, or the management body is periodically filled by volunteering members. The latter is the concept of 3GPP, while many interviewees have experienced a full-time management body in other IOCSs like for example standard development organisations[63]. The main advantage of the concept of volunteering participants as management body is the higher acceptance of management decisions. That is once because members of a management board of volunteers 'feel and act' like IOCS participants, which they themselves are before and after their time in the management board. As a result, management decisions of such a management body will tend to be rather practical and operational oriented. In addition, it is a psychological effect that decisions which come from the own ranks are generally better accepted than decisions which are imposed by a third party. To fill the management board with 'regular participants' contributes to a level playing field, because members of the management board remain non-preferential actors in the collaborative work. Periodic elections of a management board provide a diplomatic way to replace less successful members of the management board without affronting anyone. That diminishes avoidable dissonances on staffing decisions and thus contributes to a harmonic atmosphere among the participants. Yet, the concept of volunteering participants as management body requires to have pool of volunteers which de-facto allow for democratic elections and regular replacements. Beside the dedication of actors to

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[62] In the context of the interview, 'ecosystem' refers to the IOCS 3GPP.

[63] All entities in 3GPP are member in at least ono of 3GPP's seven partner organisation. As delegates in their company, many interviewees represent or have represented their company in several IOCSs

volunteer, it requires an organisation's means to contribute time and effort without compensation. That means, that there have to be enough organisations which have the means to absorb the expenditures which result from volunteering. As less potent entities are de-facto excluded from the management board, there remains a certain potential for imbalances. As all management tasks are conducted on a voluntary basis in 'part-time', there is no projectable volume of manpower which can be planned for projects. That is where a management board of consortia-intern full-time managers has a clear advantage. This concept also guarantees continuity in the management board. Because a full-time management board is not dependent of staff decisions within the participating entities, the management body is more robust to actor changes in the IOCS and within participating organisations. A such, an IOCS -driven systematic talent management is facilitated.

For the organisational structure, one concept is clearly dominant in all investigated IOCSs: A divisional structuring in working groups. That is in line with the narrow and goal-oriented mission of these IOCSs: The pooling of competences and expert knowledge to create a product – in form of a service, standard, soft- and/or hardware – which promises maximum market success. That is why it has proved to be beneficial to compartmentalize the product based on the properties and conditions of the main product. Based on the thus defined 'sub-products', scopes of operations are defined which are allocated to different working groups. Each working group pursues the realization of its 'sub-product(s)' and is responsible for implementation of the assigned work packages. Such a divisional structure clusters actors according to their scopes of expertise and interest and enhances thus productivity and the cost-value ratio for participants. Depending on the level of segmentation of a product, the group size can directly be regulated.

Perceived effects

Interviewees rarely mentioned the management body of 3GPP in the discussion on collaboration. Yet, other IOCSs like standard development organisations, are predominantly referenced with regard to their management body of permanent full-time officers and its influences. That implies the following: First, the management body does affect IOCA and the collaborative spirit in an IOCS. Second, disruptive effects of management bodies are noticed by the participants while good practice at management level with regard to conductivity to cooperation is not recognized. The installed management body of periodically elected volunteering participants seem to be a good practice for the specific IOC-setting of 3GPP. Third, a detailed comparison of the way interviewees spoke when talking about either 3GPP or other IOCSs discloses an interesting difference with regard to the perception of their own role in the collaborative system: In IOCSs other than 3GPP, which they always defined as having an in-house management body of full-time officers, interviewees differentiated between 'the IOCS', which is represented by the management body, and themselves as individual participants or representative of their delegating entity. With regard to 3GPP, interviewees mainly use the first-person plural. It can be deduced, that 3GPP achieves to create a *Wir-Gefühl* (feeling of unity) which causes participants to identify with and as part of the IOCS. One interviewee states:

> *„…if you are member at 3GPP, you are just part of it. And if you say something, it just counts'* (*Interview 6,* p. 12)
>
> (free translation of the originally German quotation: „…wer Member ist in 3GPP ist einfach dabei. Und wenn der was sagt, dann gilt das einfach.')

In other collaborative systems, this is not achieved: The IOCS is regarded as own entity, the own person as a second entity, which is connected to the IOCS by participation.

> *„If I have something to say, I can go to my management body. And they can decide if my request is considered or not.' (Interview 6, p. 12)*
>
> (free translation of the originally German quotation: „…'Ich kann dann zu meiner Verwaltung gehen. Und kann sagen: Leute könnt ihr mal bitte dafür sorgen das folgendes passiert. Und dann können die sagen ja machen wir oder wir machen es nicht.')

Of course, this finding cannot solely be deduced from the different management body concepts but also from the concomitant allocation of competences and other differences between the IOCSs. But the fact, that interviewees always mention the management body with its competencies in this context, indicates its relevance for identification with an IOCS and the development of a *Wir-Gefühl* (feeling of unity).

Data analysis with regard to organisational structure reveals, that interviewees are consistently content with the structuring in working groups: Although collaboration is unquestionably described as time consuming, no interviewee associates wasting time with IOC at 3GPP. At the same time, they emphasise a significant impact of concrete segmentations on group dynamics and thus on the collaborative work and the consensus process:

> *'The bigger a group, the more challenging is it to develop solutions.'* (*Interview 4*, p. 12)
>
> (free translation of the originally German quotation: „…[man] versucht gemeinsame Lösungen hinzukriegen. Und man merkt, je größer diese Gruppe wird, weil das ist natürlich eine Herausforderung.')

The higher the segmentation, the smaller are resulting working groups. A second determinant to influence the size of a working group is the limitation of experts per participating entity. That makes IOCA and especially decision-making much easier. At the same time, small working groups may increase the number of working groups which the same experts and participants have to join. That results in a higher timely and financial effort and less efficiency for the individual actor. Additionally, in small working groups the number and diversity of experts, knowledge, and manpower is reduced. Thus, defining working groups too small may hamper technological excellence. As a matter of fact, big players delegate more experts to working groups than small players. That causes some imbalance, but significantly augments the manpower to work on work packages and to develop solutions. Interviewees evaluate the benefit of augmented manpower much higher than the balance displacement caused by the different number of experts per delegating organisation.

D.5.3 Roles and activities

An important element of the organisational setup is the definition of roles with assigned activities, and competences regarding both the IOCS and its participants. Concerning the IOCS, the scope and means of intervention is determined. For the participants, their roles, competences, and mandatory and admissible activities are defined. The definition of roles and activities determines where and how the IOCS and the actors can participate in and influence the processes of the following section.

D.5.3.1 Role identity of the IOCS

Description

The IOCS's role within the collaborative system is formative: It may vary from a mere platform character over the implementation and execution of a strict regulatory system for collaboration to a constituent entity with own incentives and goals. An IOCS's role is concomitant with its activities and competences. Activities and competences of an IOCS can best be described as the 'scope and means of intervention': The scope of intervention defines the issues which are subject matter of an IOCS's influence and regulations. The means of intervention define the executive means to enforce compliance with the IOCS's rules and regulations. As consequence the elements, in which the role identity of an IOCS becomes most apparent, are the regulatory framework, the management body with its competences and the funding structures and sources. They highly influence the attractiveness of an IOCS but may also cause (or reduce) institutional trust. Placing the IOCS's role on a scale which ranges from 'platform' to 'constituent entity', the scope of intervention can be integrated to this scale: While an IOCS which aims to take the role of a platform will minimize its scope of intervention to act on the maxim 'as little influence as necessary', the scope of intervention will increase the further the role is ascending the scale towards a constituent entity, which favours the principle 'as much influence as possible' to pursue the own goals. The interrelation between the role identity and the scope of intervention is shown in the following figure:

Figure 54: different role identities of IOCSs

Although the means of intervention will generally be intensified with increasing influence of an IOCS, they are not integrated in the scale, because of the voluntariness of participation in the IOCSs under consideration: If participation is voluntary, the primary maxim for means of intervention is to avoid the feeling of being *'... a slave in a system.'* (see Appendix D.5.1), which would put participants off. As a result, voluntary IOCSs may refrain from most enforcement measures even if they take the role identity of a constituent entity.

3GPP is a good example for an IOCS which displays the self-conception of a platform for collaboration. One important fact is, that 3GPP is not a legal entity. That is in line with the above-mentioned *Wir-Gefühl* (feeling of unity) which participants associate with 3GPP. They experience 3GPP not as separate entity, but identify themselves as part of a collaborative system, which uses 3GPP as platform. Analysis of the scope of intervention reveals that 3GPP acts upon the maxim 'as little influence as necessary', which becomes most evident in the volume and depth of 3GPP's regulatory statutes: There is a very manageable number of regulations, which are kept on a rather general level of detail. That has two reasons: On the one hand, 3GPP does not want to wield more influence than necessary for several advantages: First, loose guidelines obviate the creation of an antitrust issue. Second, it maximizes the freedom of action of participants which fosters satisfaction and motivation of actors and provides flexibility to best meet obstacles, the needs of each individual case and changes over time. Third, loose guidelines put the collaborative work best possible in the natural environment – meaning market economy – which determines the self-motivation and incentives of participants. That is why the influence of the natural environment is regarded to be the best condition for enduring and long-lasting collaboration. On the other hand, 3GPP applies Occam's razor, because 3GPP *cannot* wield more power: That is once because it is not a legal entity. But beside this fact, which could be changed, there is a more severe reason: the voluntariness of participation. That limits the means of intervention of 3GPP substantially. All means of intervention with a compelling character generally tend to cause the above-mentioned feeling of being *'a slave in a system'*. An installation of such mechanisms is thus not productive: It might either prevent actors to participate from the first or motivate them to leave as soon as they are compelled. Both is not helpful for the IOCS's aim of attracting actors and even less in line with the later discussed GP of 'knowing the value of the number' and the objective to develop globally accepted and implemented specifications for mobile telecommunication standards.

Besides, all interviewees attest 3GPP a very lean scope of intervention with regard to the scope of duties: Collaborative work is strongly focused and tailored to 3GPP's objective: the definition of specifications for mobile telecommunication standards. As a result, the scope of duties is strictly limited to technology aspects. One interviewee highlights this:

> *'3GPP is much of a technology and engineering dominated organisation– legal aspects (details of IPR agreements) are kept out [at IOCA level]…that is a plus.'* (*Interview 1,* p. 27)

This is in line with the experiences of the other interviewees, who consistently emphasise the strong technology focus as beneficial for the collaborative work. The exclusion of legal aspects and lawyers from official meetings at 3GPP – and from the scope of intervention of 3GPP – is evaluated as essential requirement for collaborative progress and success.

Perceived effects

IPR policy at 3GPP is a good example to show the effect of the self-conception as a platform on the regulatory scope: Interviewees agree on the necessity of this intervention for the following reason: In 3GPP as in many IOCSs for high-technology solutions, there is a high degree of segregation between profit participation and research and development investment among different actors. That is why it has to be part of the scope of intervention of an IOCS like 3GPP to provide a compensation system which both guarantees technology access for the profiteers and return of investment for the technology developer. As a result, 3GPP installed a mandatory IPR policy, which claims the acceptance to license at FRAND conditions. But the regulation refrains from a detailed design and leaves the concrete implementation to its participants and their individual negotiations and the solution of possible discrepancies and conflicts to courts of justice.

Due to the above-mentioned problems and disadvantages of enforcement measures, 3GPP completely abandons such means of intervention. That culminates in the effect there is not even a mechanism installed at 3GPP to dismiss participants who continue to misbehave in form of acting in contrary to the spirit of 3GPP[64]. Instead of spending energy and effort in questionable internal enforcement mechanisms, 3GPP trusts in and relies on its own performance and efficiency of its GP 'let the market rule the game' (see Appendix D.3.2). And the rare examples of misbehaviour have proven the strategy of 3GPP successful: Of course, harsh words are exchanged with misbehaving participants, but eventually malcontents can pursue their plans without hindrance of 3GPP: The market proves their concept to be not successful which eventually brings the participant back on track. Better than any enforcement mechanism, this strategy produces convinced and intrinsically motivated participants in line with the GP of 'knowing the value of the number'.

[64] The only way to terminate an individual membership is "by dissolution, abolition, resignation or expulsion from the related Organizational Partner" according to 3GPP, Working Procedures (2022) Article 9

However, one interviewee (*Interview 11*, p. 14) pinpoints the lack of transparency if disciplining of misbehaviour is left to group dynamics in IOCSs without formal enforcement and/or punishment measures like 3GPP.

The lean scope of duties has generated a strongly technology-focused code of conduct, which all interviewees highly value:

> *'[The] basic code of conduct is that all the discussions have to be based on technologies and science. And also ... on the potential for business opportunities of the players in the industry.' (Interview 5,* p. 6)

As a result, IOCA focuses on the common technological denominator among participants while dodging all controversial aspects out, which do not contribute to the collaborative objective. A concrete example is the story of radio broadcasting at 3GPP (*Interview 6*, p. 2): When representatives of radio broadcasting entered 3GPP they looked back on a history of hostility between the mobile telecommunication sector and radio broadcasting due to years of disputes on the allocation of radio spectrum. A representative fo the radio broadcast sector describes their key to success at 3GPP as follows:

> *'And we excluded one issue from discussions – that was actually the key to success: We did not talk about radio spectrum. Though, we always said we talk about technologies. And not about spectrum.'* (*Interview 6,* p. 2)
>
> (free translation of the originally German quotation: „Und wir haben eine Sache ausgeklammert das war der Schlüssel eigentlich zum Erfolg. Wir haben nicht über Spektrum geredet. Also wir haben immer gesagt wir reden über Technologie. Und wir reden nicht über das Spektrum.

Comparative analysis of IOCSs with different role identities helps to further reveal the impact for IOCA. ITU is a perfect representative for an IOCS with the role identity of a constituent entity and is therefore chosen for comparison. The ITU is the United Nations specialized agency[65] for information and communication technologies with the goal to 'connecting all the world's people' (ITU, no date). ITU currently has a membership of 193 countries and some 900 non-Member State entities, including private companies and academic institutions. As a matter of fact, at ITU as a public-private partnership, there are differences beyond the role identity. Nevertheless, several differences are at least partly originated in the role identity of ITU:

(1) There is a Plenipotentiary Conference which is the supreme organ of the ITU. In this four-yearly Conference both the policies, direction, and activities of the ITU are defined and the members of other ITU organs are elected. Participation – and voting – is for the 193 Member States only. The exclusion of all non-Member State entities from voting is consistent in all formal voting situations which includes all decisions on recommendations which contain policy or regulatory implications (Fishman, 2013). Under consideration of the fact, that these 193 Member States make up the United Nations, the right to influence the IOCS's orientation and constitution is de facto a privilege of the United Nations. A closer look at the funding of ITU reveals: The United Nations is not just the founder of ITU but also its main sponsor: For example in 2016, over 60% of ITU's revenue came from Member State contributions (ITU, 2018) Nevertheless, the ITU is aware of the importance of agreement of Sector Members for the approval of technical recommendations (Fishman, 2013). That is why some non-Member states (who belong to the

[65] Founded 1865 by the United Nations, it is the oldest intergovernmental organisation for technical cooperation

more privileged membership class of Sector Members) have the right to vote on recommendations which do not contain implications for policy or regulations.

(2) At ITU, consensus is also regarded as the foundation of global standardization (Fishman, 2013). Nevertheless, it is implemented differently: First, as stated above consensus regards only certain member groups, which is Member States and in some cases Sector Members. All other members are excluded from decision-making at all. Second, consensus is the basis for most decisions, but not for all (Fishman, 2013, p. 4). Third, in chaired groups at ITU, consensus is defined by the chairman, who decides whether consensus has been reached or not (Fishman, 2013). Fourth, some quantifiable criteria to describe definite decisions are provided which regard unanimity, unopposed agreement, and the degree of consensus: For some decisions, 70% affirmation of the Member States is defined as quantifiable criteria for a definite decision (Fishman, 2013, p. 6). Other decisions require unopposed agreement of all Member States, which in extreme covers the case of one Member State in favour and 192 abstentions. The lowest criterion for definite decisions is that no more than one Member state is in opposition. That displays the significantly different interpretation of consensus at ITU compared to 3GPP, in which unanimous consensus is invariable and exceptions from the principle of unanimous vote is indispensable.

(3) ITU has three main areas of activity organised in the following three sectors: The Radiocommunication Sector which coordinates radiocommunication service and the international management of radio-frequency spectrum and satellite orbits. The Telecommunication Standardization Sector, which produces recommendations for defining elements in the global infrastructure of information and communication technologies. Third, there is the Telecommunication Development Sector which aims to provide solutions to bridge the gap regarding telecommunication and ICT equipment and networks between industry nations and developing countries. That discloses the significantly wider scope of duties: While the Telecommunication Standardization Sector resembles to the scope of duties at 3GPP, the Radiocommunication Sector contains rather regulative tasks and objectives. With the Telecommunication Development Sector, the ITU even assumes social engagement. This scope of duties clearly exceeds the scope of collaboration for collective technological innovation and development. The regulatory function of ITU also shows that the scope of intervention is much wider than at 3GPP:

D.5.3.2 Role and activities of the participants

Description

Roles with assigned activities and competences specify conditions for participation of the membership policy. The detailed definition of roles and their scope of action provides the basis to implement processes, in which all tasks, functions and possible actions of each role in the course of collaboration are elaborated. Most important aspects for the role definition are:

(1) *Classification*: Which types of roles are implemented?

(2) *Representation*: Who can represent a role?

(3) *Subcategorization*: Are subcategories defined?

(4) *Activities*: Which activities may or must be performed by which roles?

(1) *Classification* of roles is an important tool to differentiate between different types of actors in the IOCS. The most important types, which have to be clearly distinguished, are

roles of participating entities and roles of their physical representatives. That is why in all IOCSs in which participating entities are not restricted to physical, individual persons, more than one role needs to be defined regardless of the number of types of participation in the membership policy: One role, which can be referred to as entity role, is necessary to assign actions, competences, and responsibilities to a participating unit, which is often – and at 3GPP always – a legal entity. The participating entity has to define an authorized physical person as representative to conduct the tasks and functions which are assigned to the legal entity. The role can be defined as representative role. A third role type is the delegate role, which defines the actions and competences of each 'ordinary' delegate who is sent by the legal entity to participate in the collaborative work. In IOCSs, in which also natural persons can participate, all roles may be personified in one individual.

(2) The *representation* of roles including the mechanism of authorization is another important element of a role. This is especially important for roles which do not address individuals but certain functioning or legal entities, which will be explained at the example of the entity role. The first question which needs to be answered is: Who – and how many – can represent a legal entity and fulfil its duties and tasks? A role may limit the alternatives of representatives by defining requirements which have to be met by delegates with representative duties. One requirement could be the limitation of authorization to delegates of the own legal entity, which made proxy voting impossible. Another important aspect which a role needs to define is the number of representatives which may be authorized per role. For the sake of clarity, it can be defined that only one physical person may be authorized as representative of a legal entity. Another choice could be that different duties and competences may be assigned to different representatives. If more than one representative is allowed by role definition, there might be a maximum number, or the restriction of segregation according to duties or structural elements. That means, the role could define a maximum number of five delegates or a certain percentage of delegates who can be authorized with representative duties. Alternatively or additionally, a role could allow one representative per structural element like for example per working group or one representative per scope of duty like for example one representative for technological aspects and another representative for business case questions. To avoid confusion, especially if several representatives are allowed, a formal and official way of authorization should be defined. That could best be an official letter of authorization, which is handed in to the management board and distributed to all participants. The definition of fix dates for changes of representatives can also be defined for different role classes for more clarity and continuity.

(3) *Subcategories* need to be defined if it is necessary or requested to define certain group compositions for actions or process steps, in which several actors are involved. One example could be the introduction of actor groups according to their core business to assure that decisions are taken under consideration of different expert views. For example, roles could be subcategorised according to the organisations' industrial background as network operator, upstream or downstream manufacturer, vertical or non-industrial. Regional location could be another criterium for subcategorization if there is a need to foster intercontinental collaboration or prevent regional block voting.

(4) The assignment of *activities* and competences which may or have to be conducted by certain roles is the substantial part of role definition. It defines 'who does what and when', which follows the general rules for the organisation of business processes. One important aspect which needs to be defined for actions in the context of interorganisational collaboration is the maximum and minimum 'contribution quota'. This quota may define, how many delegates per organisation or organisation size may or have to get involved in a

certain activity or process step. While this might remain unrestricted, a contribution quota may anticipate both superiority and nonparticipation of participants. Concretely, a contribution quota could define the minimum or maximum number of actors in a delegate role per entity.

Perceived effects

(1) The classification of roles provides the basis for unrestricted collaborative work without negative impact on the formal power structure: By assigning certain competences – which could for example be the rights of co-decision and voting – to the entity role, the formal power of each participating entity is uncoupled of the number of sent delegates. As consequence, small entities are not discriminated against on account of the fact that entities with more personal means send more delegates to participate in collaboration. At the same time, if there is a lack of dedication and manpower to fulfil collaborative objectives the re-classification of the delegate role to a representative role is a highly effective countermeasure to enhance motivation among participating entities to send more delegates: In this case, each additional delegate is concordant with more power in the collaborative system.

(2) The approval of external representatives is the most impacting factor for the specification of acceptable representatives. At 3GPP, external representation is realized at two levels: First, at the level of role classification by means of Market Representative Partners and the access for legal entities of representative nature like EBU (European Broadcasting Union): They are legal entities which participate in 3GPP to represent the interests of a certain actor group in form of a consensus view of market requirements. But 3GPP accepts external representation not just by official and/or legal organisations but also at an internal 'inhouse level': External representation by appointing a proxy enhances the flexibility for participation especially for small entities: It allows to partner with other participants at 3GPP to form an interest group which could then be officially represented by just one delegate. For members with little financial and personal means, this is an attractive choice. On the other hand, the representation of several participating entities by one delegate equates an accumulation of votes, which facilitates both power imbalance and even external influences: At the worst, participating entities could be urged or even forced to install or accept a certain representative by external persons or elements of influence like for example political regimes or market leaders. That is why external representation should always be carefully installed and linked to strict criteria like company size, business volume or the number of delegates which can be represented by the same delegate. For example, at 3GPP the number of proxy votes per Voting Member in Technical Specification Groups (TSGs) and its Working groups (WGs) is limited to five and are not considered for the determination of the quorum. (3GPP-Working Procedures, 2002, Article 26, p. 19) per Voting Member.

(3) The definition of subcategories may impact collaborative work in mainly two ways: First, broad-based decisions and collaboration can be fostered. Second, weight can be added to certain actor groups leveraging their influence and power in collaborative processes and activities. A good example are the submission requirements for proposals of new work items: According to the Working Procedures of 3GPP (3GPP-Working Procedures, 2022, Article 39, p. 25), a proposal is accepted if at least four other participating entities support the new work item. This concept is working very well. Nevertheless, by specifying the four supporters with regard to certain subcategories collaborative work and group dynamics could be affected: For example, subcategorizing according to the regional provenance of the registered office could be defined in order to counter regional

block voting (*Interview 7*, p. 14). Based on these subcategories, a multi-regional support can be stipulated to foster intercontinental collaboration and approval. Subcategories with regard to the industrial background of participating entities could be used to enhance cross-sectoral collaboration and the influence of certain actor groups: For example, verticals tend to have rather little power at 3GPP because they bring in use cases and requirements but do not develop solutions. If the support of at least one vertical would be mandatory, their influence would be significantly augmented, and they would gain stages to express their view.

(4) A 'contribution quota' may help to assure the necessary manpower to pursue and conduct collaborative objectives and at the same time might prevent imbalances. One interviewee states:

> *I think some of the [big players] have an advantage because they send more people because they spend more money in it. [A restriction of delegates] is a possibility. The question is, if you use it too much, you may find that you don't make as much progress because you don't have that many people working on things in parallel. So, you have to get the balance right.* (*Interview 3*, p. 8).

If the above states advantage of big players causes significant imbalances in the IOCS, a maximum contribution quota could be an effective measure to counteract this imbalance. As a result, one single entity in a working group could not be overpowering and as a result limit the scope of action and influence for delegates of other participating entities. On the other hand, if there is a lack of contribution, a minimum number of delegates can be defined with regard to certain criteria like an entities size or volume of sales. Of course, the impact of this measure is limited because not (just) the number of delegates but in the first instance the quality and expertise of delegates is necessary to elaborate excellent solutions. The latter cannot be influenced by a 'contribution quota'.

Concluding it can be stated that the definition of participants' roles is a powerful tool to significantly influence the power structures and dynamics in an IOCS in the disguise of one and the same membership policy. It becomes evident, that the devil is in the details: While the membership policy provides a very general framework for participation and the exertion of influence, the detailed and creative definition of roles is where power structures are defined and affected. That is why role specification is both an efficient and an effective measure to subtly induce a shift of power among participating entities. As a matter of fact, an alteration of roles which are generally not in detail defined in an IOCS's statutes, but rather in subordinated implementing provisions, is much more informal and generally perceived as much less severe than a change of the official membership policy. It has to be bear in mind, that the changes in role definitions may cause unexpected indirect effects which amongst others depend on the installed mechanisms of collaboration and their concrete design: If decisions require a 100% consensus, the effects are smaller because a single vote is enough to yield the power of veto. But if decisions are based on – for example – a 70% approval, the effects of role specifications can cause a serious shift of power and influence. That is why a change of role definitions needs thorough review of potential direct and indirect impacts, especially for a level playing field and the satisfaction of all actors concerning their influence, equality and means of participation and contribution.

D.5.4 Processes

Description

Processes are an important element in all organisations. But in organisations with limited scope of enforcement measures like 3GPP, processes including their organisational implementation become one or maybe even the essential tool to guide control, manage group dynamics and generate efficiency of working groups. That makes the design of processes in IOCSs a highly strategic issue for IOCA. In particular, routines and procedures which allow to subtly correct miscasts in official IOCS's functions (like the chairman) and/or enable the procedural, face-saving disposure of progress-stopping actors from a process are pivotal. Additionally, the attempt to separate competitive and collaborative processes wherever possible is a key contribution of processual design to make coopetitive collaboration work. But working procedures do not just affect the internal workflow, but also the output: Processes and the pace of development are strongly interrelated and have thus influence on the quality, sustainability, and reliability of products and deliverables and on the time to market. Processes are thus one of the most important means to create institutional trust and also help to reduce (perceived) relational risk.

Of course, processes in IOCSs follow the rules of general process management. That is why this analysis focuses only on processes and aspects thereof which have special impact for the success of collaboration at 3GPP and/or diverge from general process management rules. Five processes have been identified to be most influential for IOCA at 3GPP:

(1) *communication process*: How does communication work at 3GPP?

(2) *decision-making process*: How are decisions taken?

(3) *meeting procedures*: How are meetings conducted and organised?

(4) *prioritizing and screening process*: How is the work schedule defined?

(5) *working process*: How is the work executed and organised?

(1) Decisive aspects in the *communication process* determine which channels of communication are used, who communicates with whom and how information is spread. Communication channels include all means of communication from mailing lists, conference calls to different types of personal meetings. But beside the tools for communication, there might be clear guidelines on who is allowed to spread certain information and who may use a certain communication channel and for which purpose. Above that, there might be strict regulation for the path of communication for certain data meaning the sequence in which data is given to certain actors. For example, some issues might have to be handed to the chairman only who is then in charge of spreading the information to the working group.

(2) The *decision-making process* defines the exact procedure of how decisions are made. That is why most aspects of this process may cause significant impact on collaboration in an IOCS. One important element is the general voting procedure(s) including casting of votes and the escalation procedures to press a decision if consensus cannot be reached. In the voting procedures there will be defined which standard voting procedure is applied referring to and differentiating between certain decision-making situations if required. The reason why there might be different standard voting procedures for different decision-making situations is that there is a broad set of frame conditions which

fundamentally influence (possible) voting procedures: A main aspect is the definition of casting of votes because it may call for certain conditions to be able to conduct or participate in voting: For example, acoustic or optical voting like making a certain noise or showing of hands can hardly be conducted electronically but requires physical meeting. The definition of suitable voting procedures requires to take further frame conditions into account: Are votes open, by roll call or secret? Are there alternative ways of participation accepted for voting like early or absentee (online or postal) voting or proxy votes? How many voters are entitled? How often is a voting expected? Which consensus conditions are defined? Consideration of all frame condition will result in a voting procedure which is strongly tailored to the requirements of a certain IOCS and/ or certain decision-making situations. Even if an IOCS applies the principle of the unanimous decisions, there is the need to install escalation procedures to provide a way to come to a decision even if consensus cannot be found and/or one entity deliberately blocks a decision. Escalation procedures could allow for ballots with different consensus conditions, the definition of a certain organ or actor – for example the chairman – who is assigned with a decisive vote, or the transfer of decision-making power to a parent body.

(3) *Meeting procedures* define how formal meetings are conducted. Once, general aspects have to be determined like the frequency and duration of meetings, the access conditions and – in case of physical meetings – the location. Second, the course of the meeting has to be defined. Naturally, the agenda is a substantial part for the course of a meeting. It is often the details which cause the best effects: Are critical points put at the beginning or at the end of a session? How much time and scope is provided for informal exchange or informal meetings? Is there a social programme to foster informal exchange? Data analysis reveals that organisational aspects also influence the course of a meeting significantly: How is the observance of the time schedule ensured? Who may rise to speak? Is there a time limit for each request to speak? How is the procedure if a delegate rises to speak? How are seats arranged? It turns out that these little details tend to have most impact on the course of meetings and the collaborative spirit and success.

(4) *Prioritization* of work subjects in IOCSs sets the course for the potential individual success rate which each participant may expect from the upcoming work period which means that the course is set for the size of the individual piece of action which each actor may snatch. In the prioritization process it is defined how much time and/or manpower of a working group is assigned to which work item[66]. As a consequence, it is the prioritization process where the competitive aspect of a coopetitive setting is embodied and becomes in particular visible. That makes the prioritization of work subjects one of the most crucial and emotional processes in IOCSs. The process design has a significant stake on the fierceness of prioritization. First, there are again procedural aspects regarding both the course and the setting of prioritization. To define the course of prioritization, it needs to be defined how work subjects are clustered, presented and/or discussed and how the priority is finally determined. Who and how many participate in the process and who represents work subjects? The setting of prioritization defines the frame conditions in which the prioritization process is embedded: How often are work subjects defined or otherwise spoken how long is the duration of one work period? What happens to subjects which do not make it in the agenda for the next work period? Are they rejected or to some extend earmarked for the next prioritization process? Is budgeting of work subjects limited to the planning horizon of one work period or may it include the distribution to several periods? Beside procedural aspects, there are again organisational aspects which fundamentally influence the actual course of prioritization and the probability for emotional

[66] At 3GPP, time units are assigned to all proposals which are prioritized, see Appendix D.4.1.4

escalation and lapses: Which channels are used for discussion? Who is in charge to admitting the floor to different speakers? How are contributions terminated? Are prioritization meetings open or for members of the prioritization process only? It must be an aim of the prioritization process to provide a platform to discuss and resolve competitive dissonances but at the same time to keep friction at a level that it remains in the process and does not burden the collaborative spirit which is pivotal for the IOCA and the success of IOCSs.

(5) The *working procedures* define how work, which is necessary to reach defined collaborative objectives, is actually executed and organised. Decisive for the collaborative success are especially the following aspects: Who is allowed or has to participate in a working group? How are working groups organised? Which roles exist in the process? Which competences and responsibilities are assigned? Which milestones, deadlines and meeting modalities are defined? Which measures are installed to handle delay? How can the focus on common and/or technological goals be assured? It is found that the voluntariness of collaboration and contribution is the main difference between working processes in IOCSs and intra-organisational working processes:

> *'So, it's actually interesting because you are basically managing as an area director or as a working group chair, people who are not really reporting to you in a sense.'* (*Interview 2*, p. 19)

As stated above, chairmen at 3GPP consequently have no means to enforce contributions. Above that, it must be refrained from all mechanisms which would show individual actors up. Instead, corrective measures focus on general remedial actions and incentives to meet deadlines.

Perceived effects

(1) The consequences of the COVID-19 countermeasures[67] reveal the impact of communication processes on collaborative work impressively. At 3GPP, physical meetings – at least with a three-digit number of participants and/or international participation – were not possible or strongly regulated for over one year. All interviewees state a significant impact on the quality and quantity of collaborative work caused by the abolition of physical meetings. One interviewee quantifies an efficiency decline in big working groups to 30% in the first time without physical meetings. Due to the topicality of this issue and the own experiences, all interviewees had already questioned the reasons for this immense impact by themselves. Amongst other aspects, the special group dynamic of each communication channel, which can hardly be imitated, was consistently highlighted. By switching to electronic communication channels for the discussions which were formerly held in physical meetings, both the number of participants and the number of contributions escalated. That is once because it requires less effort to join in electronic discussions than travelling to physical meeting. aSecond, the barrier to make a contribution in front of a full plenary hall is much higher than pressing the enter button at the computer. That example shows that the communication process needs to be designed under consideration of the particular case and its specifics: Interviewees who are delegates in different working groups and IOCSs consistently state that the impact of the abolition of physical meetings was less significant in smaller working groups.

[67] Governmental responses to the coronavirus disease 2019 (COVID-19) included mandatory preventive measures like social distancing and travelling restrictions

(2) As before mentioned, all IOCSs which the interviewees were experienced in practice some kind of consensus-based decision-making. Nevertheless, the implementation differs a lot between different IOCSs: At 3GPP, consensus is defined as the *'lack of objection'* (*Interview 7*, p. 6), which means, that when the going gets tough, a decision is taken in favour for the alternative with less objections rather than for the alternative with more supporters. It is state of the art at 3GPP to take decisions – except for official elections of chairmen – by informal methods like a show of hand and to avoid formal technical voting[68]. Thus, in a first step, supporters for each alternative are counted by show of hands. In a second step, objections are recorded and discussed. If there is a clear majority of supporters, the alternative will in most cases make the race. But if there is a close run, decision is made in favour for the alternative with less objections. If there is a deadlock, it is up to the chairman to decide if a decision is delayed, taken by simple majority, or otherwise. After deciding for one alternative, the chairman asks for 'sustained objection' against this alternative. If there is none, the decision becomes an agreement. If a sustained objection cannot be solved by discussions, a 'working agreement' is opened which enforces to conduct a formal vote according to the working procedures of 3GPP: Interviewees agree, that there is strong incentive and effort among (most) participants and the chairman likewise to avoid sustained objections and technical votes. That is why most decisions can be taken be means of the informal procedure. All interviewees support this decision-making procedure and state a high satisfaction resulting from it. But this procedure is not without drawbacks: To minimize objections can be a very time-consuming process which is above that amenable to horse-trading. At IEEE, on the other hand, decision-making is based on rough consensus, which is practiced by means of an acoustic procedure: The support for each alternative (especially technical proposals) is sequentially inquired by the chairman. All participants may make a 'hmmm'-sound for their favoured alternative. The alternative with most acoustic support, which is determined by the chairman, wins. Obviously, this procedure may be less time consuming but gives a lot more power to the chairman. At the same time, to successfully propose an alternative one does not need to bring every single participant in, but the key is to present technical arguments which convince the majority. Interestingly, at IEEE the acoustic rough consensus decision-making process seems to be equally well established among its actors as the decision-making procedure at 3GPP. Analysis of the different actor constellation in both IOCSs helps to explain this finding: At IEEE, all actors participate as individuals, whose main incentive is their own reputation. Thus, for actors at 3GPP it is mainly important what happens to their own contributions but there is rather little strategic interest in the choice of a particular solutions in other technical areas. 3GPP on the other hand, is industry-led and economic entities participate for economic and/or strategic incentives. As a matter of fact, they are more interested in the overall solution and profit than in the outcome of a single decision. But most of all, it is the voting entities which have to bring the product of 3GPP – meaning the specifications which define standards – into the market by implementing it in their products and technologies. Consequently, for the success of 3GPP's specifications it is essential that all – or at least the critical mass – market actors are without objections to implement the standard in their products and solutions or to produce the relevant technologies. That shows once again that there is not *the* best solution for IOC but that the IOC-setting has to suit the IOC-context.

(3) It is important that the meeting process balances the number of participants: Being too restrictive excludes experts who could make valuable contributions from the process

[68] Of course, escalation procedures are defined with formal voting methods, but informal methods are states as preferred mechanism (3GPP-Working Procedures (2022), Art. 25 pp. 18-19)

which may negatively affect the excellence of technological solutions and/or may cause dissonances among participants. On the other hand, if participation gets out of hand, efficiency of meetings decreases rapidly. A fair system to rise to speak has to be established under consideration of the group dynamics: In small groups, rather free discussions with little intervention of the chair might be appropriate. As soon, as meetings are getting bigger, more regulation is necessary like fixed talk times or defined spokesmen per entity. But interviewees especially highlight the power of organisational setup which considers psychological effects wisely to cause a more or less conductive environment for requests to speak: If participants stay seated during their contribution (or – as stated above – might even just need to push the enter button at the computer), the inhibition threshold to rise to speak is much lower than in a setting where speeches are only given from the podium. Strategic scheduling might also help to prevent endless discussions and can thus support decision-making: Difficult topics should best be placed before noon or at the end of a meeting session when participants tend to be most cooperative and willing to compromise. Another advantage of this kind of scheduling is that the chairman can tell parties of dispute to subsequently go in an informal meeting until they find consensus. The meeting process also significantly affects informal exchange beyond – voluntary or mandatory – informal side-meetings of few actors: Seating arrangements are one aspect to prevent block constructions which supports entrenched fronts and may instead facilitate informal exchange among certain expert groups and/or conflicting parties by seating them next to each other. Another important aspect is the place and duration of a meeting including the length and organisation of breaks, but also the entertainment and evening program. A meeting place which requires to stay overnight and/or best in the same hotel will significantly support informal exchange just like an attractive organisation of breaks and side program. The impact is less significant in meetings of working groups in which members are already familiar with each other.

(4) Interviewees state that the prioritization process at 3GPP is always a fierce battle because the priority of the own proposals defines how many time units the working group will budget for a work subject. Thus, if a proposal does not make it to the top level of prioritization, its content will not be realized and/or considered at all. As a result, there is much effort and emotion in the process and all means are used to defend and/or augment ‘the own piece of the cake’: This includes not only intensive body language but sometimes even physical commitment if it is to snatch or defend one of the few microphones which are placed in the plenary. The intensive ‘prioritization battle’ has an important affect for the collaborative work: It provides a defined and controlled stage for competitive issues and discussions. All interviewees state that competition is not a necessary evil but an essential contributor to the success of the work at 3GPP. That is why the prioritization process has two important effects for collaboration: First, it embodies competition and concentrates a fair number of competitive aspects to a controlled active area. That makes it an important counterbalance to and assistance for mainly cooperative processes. Second, it shows that competitive aspects are an inherent – and even valuable – part of IOC. Ideally, the process should thus not suppress fierce battles in general. Instead, it should be designed in a way that allows for and even facilitates heated debates and competitive disputes on a factual level but prevents extravagating to a personal level which would harm cooperative collaboration in other process. But there is another very fundamental influence of the prioritization process: Interview data reveals, that the pace of development tends to be high and speed up more and more due to the competitive pressure among participants. What is generally beneficial to spur collaborative work to success may become disadvantageous if sustainability and reliability fall by the wayside. The prioritization process is jointly responsible for the pace of development in the IOCS or at least the working group: The duration between two prioritization periods determines how much

time is available to work on a work subject in order to bring it to success. Second, it triggers how often knew proposals have to be handed in, because every actor aims to retain the own piece of the cake in the next prioritization period. The prioritization process has thus to strike the balance between too long and too short work periods: While long work periods support sustainable and reliably technological solutions, prioritization at frequent intervals allows to include the latest trends and developments which supports technological excellence. Additionally, the design of the prioritization process can impact – and especially lower – the pace of development by blocking a certain amount of time units for special work subjects. For example, that could be proposals of the last period which had much potential but did not make it to the top of the priority list. Or there could be time units reserved for long term projects, which are terminated for several periods in advance to allow for sustainable projects and the inclusion of latest developments (*Interview 6*, p. 20).

(5) Interviewees state the importance of working procedures to steer a course without showing anyone up or using enforcement measures. By defining general regulative working procedures, disadvantageous structures, results, and behaviour can be eliminated without embarrassing the responsible person: That could be a defined period for a chairman or the regulation, that a work item which does not meet deadlines three times will be eliminated. Although both procedures aim on different disruptive factors – like a miscast of the chairmanship or a work item which blocks time units without being pushed – they both affect collaboration in the same way: They provide procedures to eliminate disruptive factors without finger pointing and thus enhance efficiency of collaborative work. The installation of a dropping mechanisms for work subjects without progress has also a motivating effect to collaborate with the necessary dedication. At 3GPP, there is also a rather new working process installed which defines how newcomers are introduced to the IOCS. The need for a defined integration procedure necessitated when more and more participants – often verticals from other industries – entered 3GPP. It became obvious, that it is hard for newcomers to become familiar at 3GPP due to the specific corporate culture with its codes of conduct but also due to the special terminology of 3GPP which is mainly acronyms. As a result, new participants either failed to become part of 3GPP or acted as disruptive factor because they unintentionally violated codes of conduct. Both effects were disadvantageous for 3GPP and the new participants likewise. In consequence, a mentoring procedure has been established which successfully resolves the problem: A mentor is provided to each newcomer who assists the newcomer to smoothly become familiar with 3GPP by introducing them to the formal and informal codes of conduct and helping them to get along in the jungle of acronyms. Of course, that does not guarantee successful integration of all newcomers, but it provides a fair and fruitful basis which allows newcomers to be integrated and become part of 3GPP if they participate with the necessary dedication.

Interviewees agree that the level of trust in processes at 3GPP is very high (*Interview 7*, p. 16). This provides a sound basis for the development of institutional trust among participants at 3GPP,

D.5.5 Data management system

Description

The data management system as management tool for the most important resource and asset of IOC, the knowledge (contributions), is an important means for efficient collaboration. It mainly contributes at two levels: First, it enables or at least faacilitates intuitive accessibility and traceability of data. In a big and dynamic IOCS, where up to several hundreds of actors collaborate, some actors leave, and new actors join, who have to familiarize with structures and contents of the IOCS, a referencing system which provides intuitive back and forward traceability of documents based on references is de rigour. Second, by defining ambiguous, consistent, and uniform usage of technical terms, special characters, and acronyms a data management system may prevent misunderstandings and redundant discussions around words. That requires the installation of a comprehensive and updated listing system for technical terms, acronyms, and special characters. Additionally, wherever possible, systems and meanings, which are established in the environment from which most participants come, should be adopted. As such, the data management system has a strong effect on the effectiveness of the IOC process and also influences both the attractiveness of the IOCS and the satisfaction of its actors. However, it has little impact on the (perceived) relational risk in an IOCS.

Perceived effects

Interviewees criticize the document management system at 3GPP as the following quote shows:

> *'You make an input, and a reference number is assigned to this document. After discussing the input, changes are made which come back as an update. This update gets a new reference number. This has nothing to do with the reference number of the original input. [...]. That makes it extremely confusing.'* (*Interview 6*, p. 3)

> (free translation of the originally German quotation: „Sie machen einen Input, das Dokument kriegt eine Nummer, dann wird diskutiert. Dann heißt es okay, dann müsst ihr Änderungen machen. Kommt mit einem Update zurück, dieses Update kriegt eine andere Nummer. Die mit der vorigen nichts zu tun hat. [Das heißt sie müssen praktisch-, sie müssen immer verfolgen, also wo-, welches war das erste Dokument? Und wie heißt dann die Folgenummer von diesem Dokument?] Das macht das extrem unübersichtlich.'

The effect for newcomers is stated to be extremely overwhelming because it is nearly impossible to make it through the jungle of incoherent references. Beside the negative impact for newcomers, it remains very inefficient and – unnecessarily – time consuming for all participants to always keep track of document relations on their part. Furthermore, a document management system should aim to reduce the mass of documents to the necessary minimum. At 3GPP, interviewees criticize the very unthrifty number of documents which are produced.

Because of their membership at one of the Organizational Partners of 3GPP, participants at 3GPP are generally familiar with the special character system which is established at the United Nations (UN). That is because their system is used at all political levels and standard development organisations are strongly influenced by governmental habits. Especially interviewees with experience in different IOCSs emphasise the facilitation of a consistent use of special characters and symbols compared to the individual system which is established at 3GPP and significantly disimproves readability and understandability.

When it comes to terminology and technical terms, interviewees agree on one phenomenon in discussions and decision-taking:

> *'I found that a lot of debates that I've been present have been around words. [...]. When you have words on the document, people argue about what the*

words mean, and whether they mean this thing or that thing.' (Interview 3, p. 4).

Several aspects have to be considered to identify the reasons for this phenomenon: First, ambiguity is in the nature of language. Second, in international collaboration with a high gradient of language skills and ability among participants with regard to the official IOCS language there is a significantly increased proneness to ambiguity and misunderstandings. Third, the meaning of technical terms often differs significantly between sectors. That is why disputes and misunderstandings are more likely in inter-sectoral collaboration. Interviewees experience these discussions around words to sometimes being excessive and too time-consuming. But, while some interviewees would favour to substitute language by coded description wherever possible, other interviewees experience language as highly necessary and useful and the discussions as constructive and productive for the collaborative progress. Yet, to prevent disproportional discussions around words, IOCSs should strive to provide an updated and comprehensive list of technical terms and their definition within the scope of an IOCS and/or a working group.

The strong propensity to use a plethora of acronyms at 3GPP makes it extremely hard for newcomers to gain ground in meetings and discussions. Although this established and timesaving habit will remain an obstacle for newcomers, they could be assisted by the availability of a comprehensive list of acronyms and their meaning.

D.6 Pre-set factors

Both internal and external pre-set factors have been identified. The market, economy, politics, society and/or technological changes are typical sources for external factors. Resulting factors of influence maybe respectively be a new dominant player in the market who strongly affects and changes the market and its dynamics, an economic crisis like the banking crises, government funding or severe political conflicts, changing moral concepts or a disruptive technology. The market and political interference are found to be the most important external pre-set influences at 3GPP. Influencing internal pre-set factors are the products which are based on the output of 3GPP and the formation heritage which exists at 3GPP due to its long heritage. While the political external influence and the internal formation heritage are predominantly elaborated based on primary research data, secondary research data is the main source for information about the external factor 'market' and the product which is an internal element.

D.6.1 External pre-set factors

D.6.1.1 The core market – the ICT sector

The Information and Communications Technology (ICT) sector has evolved from the telecommunication industry: Focussing on a spatial dimension, telecommunication (Greek prefix tele (τηλε), meaning distant, far off, or afar and the Latin communicare, meaning to share) aims to transfer information over long distances. The ICT sector is extended by a timely and processing dimension to handle information, which leads to the following definition (in line with Comino and Manenti, 2015):

> **Information and Communications Technology (ICT)** covers the set of electronic and digital technologies, which allow to manage information in

> form of processing, storage and transmission. (Comino and Manenti, 2015, p. 9)

The mobile wireless communication industry as an important part of the ICT sector has very unique features: (1) It is the pioneer of IOC, (2) it is structurally and technologically highly dynamic and (3) it is of utmost significance for economy and society. The following analysis of those three characteristics will impart the relevant knowledge and understanding about the research object 3GPP.

(1) Pioneer of IOC and standardization: The long history of inter-organisational and even international collaboration in the telecommunication sector on goes back to the middle of the 19th century, when technological advancement enabled the development of large-area telegraphy networks. There was one obvious hazard for the success and benefit of telegraphy: Incompatible telegraph systems caused by different national telegraph standards required de- and re-coding, which put the key asset of telegraphy – the speed with which messages were transferred – at risk (Wenzelhuemer, 2010, p. 5). That is why all involved entities were soon aware of the need and desirability of interoperability and strived for international standardization. As a result, Prussia, Austria-Hungary, Bavaria and Saxony confederated in the *Deutsch-Österreichische Telegraphenverein* (DÖTV, German-Austrian Telegraph Union) in July 1850[69] with the aim to set standards related to technology, operating and tariffs. Above that, a main goal of the DÖTV and its participants was to attract more members in order to realize desirable large-scale standardization, which resulted in the foundation of the first international standardization organisation 'International Telegraph Union (ITU). This sector-wide ambition to collaborate is since then continuing and a unique feature of the ICT sector. It is mainly founded in the nature of ICTs and the features of their related products and services (see Appendix D.6.2.1), which make IOC for economic reasons (cost sharing) and for technological reasons (interoperability by standardization) desirable. What was once attractive to maximize economies of scale, scope, and speed (see Holgersson, Granstrand and Bogers, 2018, p. 307) is nowadays an essential and renders such complex solutions possible in the first place.

The long and intensive history of interorganisational collaboration and standardization has given rise to specific customs, which – in this intensity -distinguishes the ICT sector from other industries: Actors in the ICT sector have always made extensive use of IPR. As a comparison to other high-technology sectors discloses, this affinity to IPRs (Holgersson, Granstrand and Bogers, 2018, p. 310) is inhered in sectors, which are characterised by short product-life cycles compared to the long development periods (Theissen, 2018, p. 5), high technological complexity and cumulative innovation processes (Comino and Manenti, 2015, p. 9). The second habit, which is strongly related to the ICT sector, is the institution of and commitment to standard development organisations (SDOs) as means to conduct consensus-based standardization to ensure interoperability.

(2) High structural and technological dynamic: The ICT sector has gone through fundamental structural and technological changes through the last decades, which makes this industry in particular suitable for longitudinal studies. These substantial changes are mainly triggered by the deregulation of the telecommunication market and the fundamental developments of mobile wireless communication technologies. In the following, a condensed version of the developments in the European ICT sector since 1985 is given

[69] Inspiration came from the eventual success of the metric system, which started to spread over Europe around 1850 as the first systematic – and European – standard.

as background for a better understanding of the specifics and high dynamics in this industry.

Deregulation in the European telecommunication industry: Until 1985 (Bekkers, 2001, pp. 87), there was a special situation in the telecommunication sector because of state-owned national operators, who dominated the market and had exclusive rights and a range of privileges like monopoly on telecommunication terminal equipment, standardization, and regulatory competencies[70]. In most countries, an exclusive cooperation between the operator and its suppliers of infrastructure and terminals existed. General competition rules of the Treaty of the European Commission were not applied to the telecommunication sector, because they were considered public utilities[71]. This situation only changed after a decision of the European Commission in 1985[72] initiated the process of deregulation and liberalization. This process can be described by three phases: The first phase, in which competition was introduced (Bekkers, 2001) to the telecommunication sector, lasted until about 1999 and followed the motto ‘as free as possible’ (From and Eliassen, 2017, p. 51). This phase of deregulation focussed on sector-specific liberalization, standardization, and harmonization initiatives (From and Eliassen, 2017). In consequence, there was a significant proliferation of new actors in all segments of the market. In the telecommunication market, small firms used their chance to stimulate the market and outrivalled previously dominant, large operators with new and innovative services[73]. In the mobile market, two developments were triggered: Once, new applicants for licenses and service providers virtually mushroomed the market. At the same time, the trend of forming alliances and joint ventures across national borders became popular. As a result, the market in the second phase, which lasted for the last ten years of the 20th century, can be described by the motto ‘as big as possible’ (From and Eliassen, 2017) and is defined by concentration, conglomerates, and cartels The trend of (transnational) allying and merging was intensified by the convergence of the telecommunication, media, information sector, the development of the European Single Market and technological changes. From 2000, the market started to do the ‘aftermath of convergence’, which heralds the third phase: After the ‘overshoot of liberalization’ into intensive concentration in the second phase, actors strive for consolidation in a more rational way. That is why this third phase can be described by the marked motto ‘as rationale as possible’ which has up to date generated a rather balanced and highly competitive (Wen and Yang, 2010, p. 2116) market, which is yet not a fully functioning single market. In fact, although the market is highly technical and thus prone to change, there are still dominant incumbents which partially take advantage of their close relation with governments.

Technological development in mobile wireless communication technologies: Mobile wireless communications technologies stand for an unquestionable success story, which is characterised by radical change (Gawas, 2015, pp. 3130–3132). The stepwise launch of innovation in mobile communication in so called generations (G) at a rather constant frequency of approximately 10 years simplifies to trace technological changes and their manifold effects: The first generation (1G) of mobile wireless communication, which was brought on the market in the 1980s (Gawas, 2015, p. 3130) was analog. It provided voice service only and was mainly attracting business users (Lemstra, 2017, p. 3). Developed

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[70] Partially they were even entrusted with the supervision of national legislation and the management of the radio frequency spectrum

[71] Governments had claimed immunity to the general competition rules based on art. 86 (ex art.90), clause 2 (Treaty of the European Commission)

[72] Case 41/83 Italy vs Commission ECR 873

[73] Like for example combined entertainment-internet-telephony applications

in regional clusters of few nations, there were different technological implementations coexisting, which made cross-cluster roaming impossible due to the resulting technological incompatibilities (Wen and Yang, 2010, p. 2116). The change to second generation (2G) mobile wireless communication was tremendous (Hess and Coe, 2006, p. 1210): At a technological level, the switch from an analogue to a digital solution was consummated. The reform of digitalisation was attended by new additional services like text (short message service, SMS) and multimedia messaging (multimedia message service, MMS) (Gawas, 2015, p. 3130) and the introduction of new devices: Cell phones were born (Lemstra, 2017, p. 3 and 10), which made it possible to enter the mass market (Lemstra, 2017, p. 3). With the development of 2G, critical improvements concerning interoperability and harmonization of technologies were achieved: Initiated by the supranational organisation CEPT (Committee of European Posts and Telephones) and directed by the operators, a pan-European standard, the Global System of Mobile Communications (GSM) was developed (Lemstra, 2017, p. 10). This standard allowed for international roaming (Gawas, 2015, p. 3130) and spread throughout the world.[74] Based on the success of GSM, the GSM Association (GSMA) was founded by operators to coordinate further developments, which could no longer be achieved individually by the operators due to the fully liberalized market environment (Lemstra, 2017, p. 10). The resulting product was the third generation (3G), which was launched in 2000 (Gawas, 2015, p. 3131): With 3G the shift from voice services to data services with multimedia support due to higher data transmission rates and increased capacity (Gawas, 2015, p. 3131) was completed. This development opened the market to completely new services, business models and players, which affected the ICT market and power structures significantly. In spite of the requirement of compatibility with previous generations, the 3rd Generation Partnership Project (3GPP) achieved to further advance harmonization by reducing the coexisting technological solutions to three regional standards worldwide[75] (Lemstra, 2017, p. 32). The switch to all-IP (Internet Protocol) as common platform for all technological solutions provided the basis for the first worldwide standard in the fourth generation (4G): The LTE(-Advanced) standard (Gawas, 2015, 30130). Together with terminal mobility, data services could be considerably enhanced concerning speed, capacity, quality, and security. At the same time, the price for data and voice services could be significantly reduced. In the fifth generation (5G), the perfect worldwide wireless web shall be realized (818, p. 3131): 5G aims to ‘provide unlimited access to information and the ability to share data anywhere, anytime by anyone for the benefit of the world’ (Gawas, 2015, p. 3131).

(3) Significance of the ICT sector for economy and society: The ICT sector has always been in the focus of governmental and European interest. This interest has become evident in strong governmental activity in form of promotional programs, directives, and regulations. Due to the essential importance of the ICT sector, the course of action has been determined at the European scale for decades. It aimed to pursue the following three objectives: market liberalization, technological harmonization, and the transformation from sector-specific regulations to common competition policy (From and Eliassen, 2017, p. 51). The 1980s can be regarded as the first regulatory period, in which sector-specific policy-making was used to liberalize the market (From and Eliassen, 2017). From 1990 on, there were mainly two reasons for a new course of action: Once, liberalization efforts had been successful, which made sector-specific regulations obsolete. Second, the

[74] At their peak of success in 2015 number of subscribers of the GSM standard exceeded its nearest competing technology CDMA by a factor 10 (Gawas, 2015, p. 3)

[75] The regional standards are UMTS (Universal Mobile Telecommunication System) in Europe, CDMA2000 in America and TD-SCDMA in China. (Gawas, 2015, p. 3131)

technologically induced, increasing convergence of telecommunication, media and information technology necessitated a consistent set of regulations for all sectors (From and Eliassen, 2017, p. 91). That is why a horizontal approach was pursued from 1990. This approach aimed to transfer the successfully liberalized telecommunication sector to the jurisdiction of general competition policies: The 1990s were dominated by the attempt to counteract the prevalence of concentration in the telecommunication sector by general antitrust policies and to complement and readjust the former specific liberalization and harmonization initiatives by overall competition and antitrust law (From and Eliassen, 2017). From 2000 on, the regulatory framework has been on electronic communications, which distinguishes no longer between telecommunication and media. The aim is now to balance overall competition law and sector-specific regulations on the one hand and on the other hand EU and specific member state's initiatives (From and Eliassen, 2017).

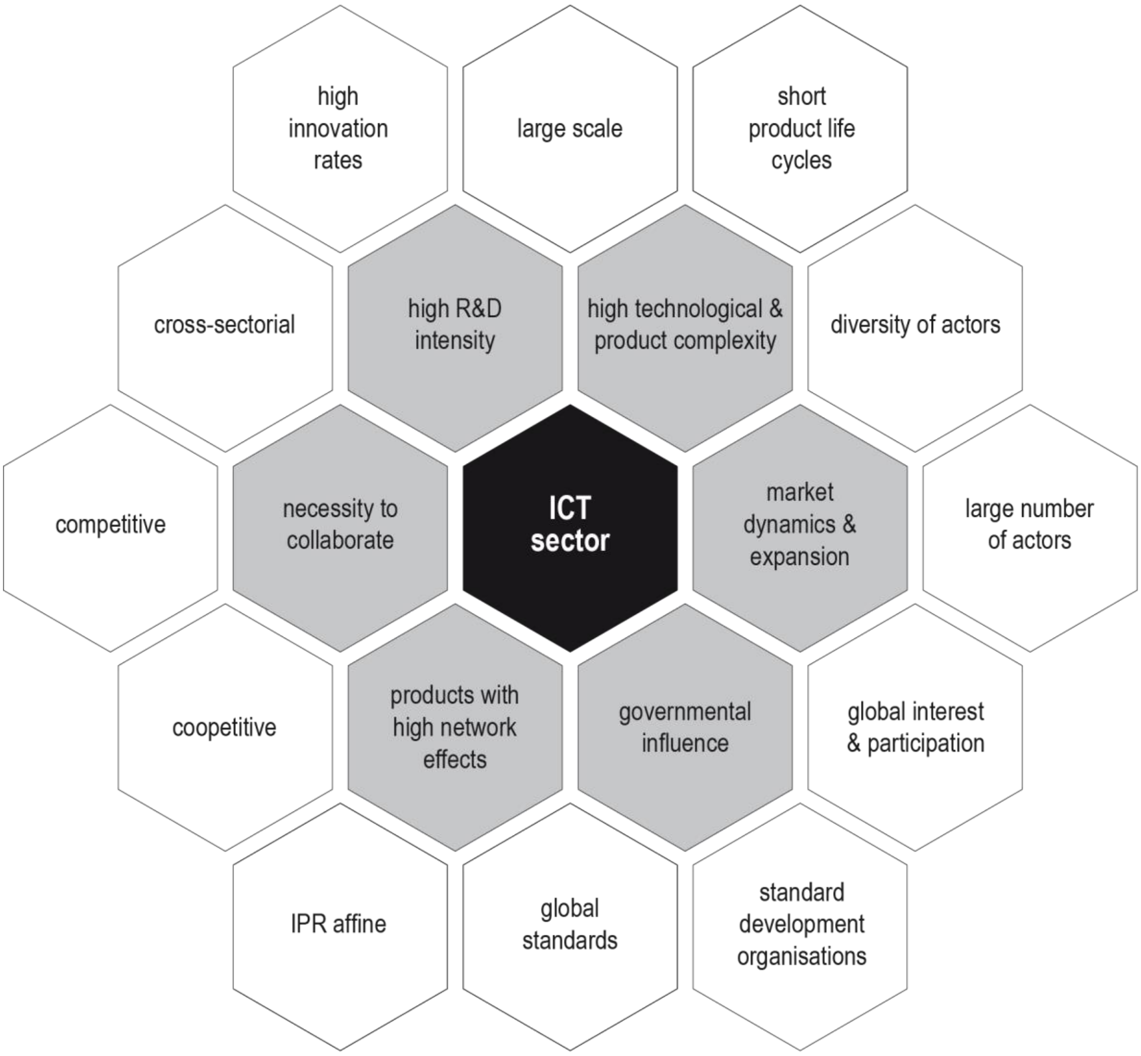


Figure 55: Summary – overview of important characteristics of the ICT sector

D.6.1.2 Politics

At 3GPP, it is mainly political interference which influence IOC(A). As a rather unique and little threatening exception, there is the political countermeasures against the Covid-19 pandemic in the years 2020 and 2021 which cause a very exceptional kind of political influence. For an IOCS like 3GPP, whose IOCA was strongly dominated by physical meetings, the prohibition of the same necessitated to find new and creative ways for

IOC(A) which compensated the loss of informal exchange and group dynamics of physical meetings. This political measure influenced efficiency at 3GPP significantly and caused changes regarding the IOCS's tooling, its processes, its communication, and its interpersonal exchange. For the IOCS W3C, on the other hand, the pandemic countermeasures had no relevant influence on IOC, because physical meetings did not play a major role for the course of IOCA, which had long before mainly occurred online with means of specific tools. That example shows how individual and diverse the influence of one and the same external influence might be for different IOCSs.

Beside this exceptional and temporary influence on IOCA at 3GPP, there are political influences of existential impact which result from the growing political power struggles at global level. Once, there are political regimes which use their power to manipulate the economic action of their players with the aim to enhance economic and political power. An experienced example at 3GPP is the enforcement of regional loyalty from and among economic entities from one political regime which becomes visible in block building and voting at 3GPP. That is dangerous for the mechanisms of collaboration at 3GPP – mainly the mechanism of consensus and the mechanism of the critical mass– which fundamentally rely on a free and flexible system of allying. In addition, it coerces actors to behave not according to the GPs which results in a severe loss of political capital for these actors. The resulting disequilibrium of actors and actor groups concerning their power and the code of conduct, may in worst case cause the fragmentation of an IOCS if it does not manage to install countermeasures. What is even more severe and hazardous for a global IOCS like 3GPP is the politically enforced exclusion of relevant actor (groups) from technological and economic participation: The ban of Huawei from 5G technologies in some regions of the world is like the sword of Damocles for a global IOCS like 3GPP. The danger of such a severe political influence highly distresses all actors because it puts the existence of 3GPP as global IOCS at risk.

D.6.2 Internal pre-set-factors

D.6.2.1 Product

As stated before (Appendix D.1), 3GPP does not develop marketable products, but technical specifications as basis for wireless communication standards. However, the nature of the ICT devices and services, which are based on these specifications, are the primary source for the unique selling point of 3GPP and thus for the success and attractivity of 3GPP. ICT products and services are generally characterised by (Holgersson, Granstrand and Bogers, 2018, p. 307; Comino and Manenti, 2015, p. 8) the following characteristics:

- High complexity of ICT solutions
- Large economies of scale, scope and speed required
- ICT development requires large-scale R&D investment
- Short product-life cycles
- High innovation rates
- Strong network effects
- Most ICT-based innovations are systemic
- Most ICT-based innovations are cumulative

The product with its potential to draw profits as motive for and outcome of IOC is naturally a pivotal element for the market-based attractivity and justification of an IOCS. The attributes of a product mainly influence the attraction for IOC and thus of an IOCS and the course of IOCA in an IOCS concerning both processual and behavioural aspects. The case study reveals that it is beneficial for the success and attraction of an IOCS, if it is built around a product, which 'requires consensus' like wireless mobile communication standards at 3GPP. The requirement of consensus does not regard the market economic advantage at vendor level, which can be generated by a reduction of competitive products in the market. Instead, the requirement of consensus is ideally at user level and/or at risk management level. The case study presents a perfect example of the need for consensus at user level: In wireless mobile communication, consensus and thus one concerted solution causes significant infrastructural, interoperability and network advantages. That is why products, which rely on or provide infrastructure, networks and or interoperability are generally in particular suitable for IOC(Ss). At risk management level, it is the complexity of a product, its need for immense R&D investment and/or for industry alignment, which make IOC attractive in order to pool risks and to enhance the probability of market success. That is why products with high technological complexity and/or a high degree of innovativeness and radicalness are most likely to be successfully developed in IOC(Ss).

The product is also decisive for the deployment model, which itself influences the processual and structural design of an IOCS as the following findings illustrate: At 3GPP, whose product is a new standard which includes hard- and software aspects, a rather low-risk deployment model is pursued which follow the triad 'develop the standards, develop the product, and deploy it.'. At IETF, on the other hand, where software is the outcome, the process of standardization and development – meaning the production of running code – occurs simultaneously, which requires a different design of IOC and puts the actors at much higher risk to lose investment. As a matter of fact, the processes and structures for IOCA at an IOCS have to display the deployment model, but also have to meet the emotional and behavioural effects which are generated by the implemented deployment model and the individual risk for the actors.

Another important attribute of the product as outcome of IOC is the prospects and options to draw profit: Is the outcome itself the profitable product or is it the basis on which profitable products are built? This affects both (1) the profit-investment gradient among actors and (2) the actor's objectives which influence how IOCA is conducted.

(1) At 3GPP, the IOCS outcome is not itself a profitable product. As consequence, there is a strong gradient between investment and profit-making among actors: While one group – the manufacturers – who develop the specification invest in and build the basis for profitable products, it is another actor group who draws profit from this infrastructure by providing products and services to end-users, which are based on the investment of the former actor group. That is why at 3GPP the mechanism of economic participation is essential to counter this gradient between investment and profit-drawing as (see Appendix D.4.1.2)

(2) The significance of the nature of a product for the setup of an IOCS and especially for the course of activity and the behaviour of its actors can be illustrated on basis of an example, which was given by one interviewee (*Interview 9*, p. 38): Let us assume, the product of an IOCS is roads. Then, the course of collaboration will vary significantly depending on the profit prospects: Is profit made by the road construction itself, by toll collection or by business opportunities which are enabled by the road like hotels, shops etc. If the product itself – the road construction – is the means to make profit, actors have

high incentives to maximize their share of contribution to the development of the product. They will be very motivated to reel in as many portions of the building process as possible. If it is the aim to generate profit from toll, the actors' primary goal is to possess as many toll gates as possible while it is rather irrelevant who builds which share of the road. In both cases, the fellow actors are competitors who fight for the same pieces of the cake. As a result, the atmosphere of collaboration will be rather aggressive and the efforts to push the own contributions – in worst case regardless of technological quality and arguments – are high. If, on the other hand, an IOCS builds roads as basis to realize individual business ideas, the road and the construction process is regarded as a more or less common project and good. The atmosphere in such an IOCS will be more cooperative because the individual interest is in the business opportunities which evolve from the product. Actors will not care if the road is paced or tarred as long as the exits are at the right place to realize planned businesses like for example hotels. In this case, the definition of the product will be less driven by individual incentives, but by a cost-benefit analysis, which can be both advantageous and disadvantageous for the quality of the outcome. That is why it cannot be generalised which profit model is more beneficial for an IOCS and/or its outcome. But the design of an IOCS and its IOC-setting has to take account of the specifics and group dynamics which are caused by the product attributes.

D.6.2.2 Formation heritage

> *If we want to change anything with the way we work – like the smallest things – this is a massive ship. And just making it change its course by five degrees is so difficult. People will complain, they don't understand: 'Why are we changing this?' etc.. They like it the old way.* (*Interview 1* p. 13)

The 'formation heritage' describes the persistence of once established habits or procedures to change. It refers to the fact, that it is comparably easy to implement institutions in an IOCS but requires a multiple of effort to change them. This could be described as 'the power of the first hour'. That is why there are habits and procedures at 3GPP which cannot be justified by their positive effect, but only with customariness and a system's sluggishness to structural change. While this differentiation is of little importance for the development of an IOCS, it has to be born in mind if institutions are assessed and/or transferred to other IOCS. At 3GPP, the document management system is a good example for a little efficient yet established element, while the patent-based mechanism of economic participation of 3GPP is a deeply-seated – yet effective and successful – heritage, which is not likely to be eliminated although more and more actors of less patent affine sectors join the IOCS.

The formation heritage and the concomitant resilience and sluggishness to change may have a positive or negative impact on IOCA: If there is an attempt to alter, modify and/or manipulate established processes, mechanisms, structures of customs for the benefit of a single actor or actor group, the formation heritage is advantageous because its sluggishness hampers such manipulative changes. On the other hand, it also impedes to improve or alter once established processes or customs which turn out to be – no longer – effective and/or conducive for IOCA. As such, it is important to be aware of the 'power of the first hour' and to accommodate to it by wisely considering and designing the IOC-setting of new IOCSs.

E IOCS 3GPP – matrix-based interrelation analysis

As stated in Chapter 6.2.3 a coding system is used for evaluation. It allows in addition to the qualitative strength of a perceived interrelation to describe the type of interdependency. According to this coding system, an element may determine (D), require (R), support (S), obviate or hinder (O) or affect (A), positively affect (P) or negatively affect (N) another element. In case that a perceived dependency cannot be classified to one of those categories, it is labelled as mutual interdependence (M). For reasons of presentability, the strength of a perceived interrelation is expressed by the prefixes H-, M-, L-, which each represent a high, moderate, or low perceived effect.

D = determines
A = affects
P = positively affects
N = negatively affects
R = requires
M = mutually interdependent
S = supports/causes/enables
H = hinders/obviates

L- / M- / H- = low / moderate / high effect

	membership policy	organisational structure	role of the IOCS	roles of the actors	(working) processes	data management system	mechanism of consensus	mechanism of economic participation	mechanism of moderation	mechanism of targeted activity	mechanism of corporate IOCS culture	mechanism of the critical mass	mechanism of informal exchange	mechanism of political capital	mechanism of progress	GP 'Knowing the value of the number'	GP 'Let the market rule the game'	GP 'No-loser policy'
membership policy			L-D	L-D				H-D										
organisational structure			L-M	L-M	M-D								M-P	L-P				
role of the IOCS	L-D	M-M		L-D	L-D		L-P	L-D		M-D						L-D	M-D	L-D
roles of the actors		M-M			M-D		L-P		M-D						L-D	L-D		
(working) processes		M-D		L-M			M-P	L-D	M-R	M-S		L-D				L-S		
data management system					L-D													
mechanism of consensus		L-D	L-D		M-D				M-R		M-A	H-R	H-R		H-R	H-R		H-S
mechanism of economic participation	H-A				L-D	L-D							L-N				M-S	
mechanism of moderation		L-R		L-R	M-R		H-S			M-S	H-S	M-S	H-P	M-R	M-P	H-S	H-S	H-S
mechanism of targeted activity					L-D										H-P		M-S	
mechanism of corporate IOCS culture							L-S		M-S				M-P	M-S	M-P	H-D	H-D	H-D
mechanism of the critical mass							H-S		M-R		M-S		M-S		M-N	H-D		
mechanism of informal exchange							H-S		H-R		H-S	H-S		M-S	M-N			M-S
mechanism of political capital							H-S				L-P	M-S			L-P			
mechanism of progress							M-S		M-S	M-S		L-S	M-P				M-R	
GP 'Knowing the value of the number'	H-D		M-D		M-D		M-S	M-P	H-R		H-D	H-M	M-P		M-N		L-D	M-D
GP 'Let the market rule the game'	L-D	M-D	H-D				L-S			H-P	H-D				L-P			
GP 'No-loser policy'					L-D		M-S		H-R		H-D		M-P	M-S	M-N			

Figure 56: Segment A1 of the perceived interrelation analysis matrix (see Figure 36) for the IOCS 3GPP

D = determines A = affects P = positively affects N = negatively affects R = requires M = mutually interdependent S = supports/causes/enables H = hinders/obviates L- / M- / H- = low / moderate / high effect	objective (develop specifications)	function (develop global 'standards')	sf 1 (attractivity)	sf 2 (relational risk)	sf 3 (institutional trust)	sf 4 (effectiveness and efficiency)	boundary (permeable)	coopetitive	voluntary	social pathway	large number of actors	high diversity of actors	highly dynamic actor composition	continuity of delegates	patent affinity	compass delegates	verticals	market competitors	actors under political influence	product	formation heritage	market	politics
objective (develop specifications)		H-D	M-S					M-R			M-D	M-D	M-D	L-P	H-D	L-P	L-D	L-D	M-D	M-D			M-D
function (develop global 'standards')	H-M		M-S				H-D	M-R			H-P						L-D	L-D	M-D				
sub-function 1: enhance global attractivity											H-P		M-P	M-S		M-S	L-D	M-D					
sub-function 2: reduce relational risk	H-S	H-S	H-S			L-S		M-P		H-P				M-S		M-S		M-P					
sub-function 3: cause institutional trust	M-S	M-S	M-S	H-S		L-S				L-P				L-S		L-S							
sub-function 4: cause effectiveness and efficiency	H-S	H-S	M-S						L-P					M-P		M-P							
boundary which is permeable in both ways	M-S	H-S	M-S	H-H		L-H		M-S	H-D	H-N	H-S	H-S	H-S	L-N		L-N		L-N					
coopetitive	H-S	H-S	L-H	M-H		M-A				H-N						M-R		H-N					
voluntary	L-H	L-H	M-S	L-H		M-H	H-R			M-N	M-A	M-A	M-A	M-H		M-N							
social pathway	H-H	H-H	M-H	H-H		H-H								H-R		H-R	M-P	M-N	H-N				
large number of actors	H-S	H-S	M-S	H-H		L-H				H-N		L-P		M-R		M-R							H-H
high diversity of actors	L-S	L-S	M-S	H-H	L-R	M-H		M-P		M-N	L-S		L-S	M-R	L-N	M-R	L-R	M-P					
highly dynamic actor composition	M-H	M-H		H-H	M-R	M-N				M-N	L-R	L-R		M-R	L-N	M-R							
continuity of delegates	H-S	H-S	L-S	H-S		M-S		M-P		H-P						H-M		L-P	L-P				
patent affinity			M-A									L-N		L-P		L-P	L-N						
compass delegates	H-S	H-S	L-S	H-S		M-S		M-P	M-P	M-P				H-M			L-P	M-P	M-P				
verticals	M-S	M-S	M-S	L-S		L-S	M-R	M-P		M-P	L-P	M-P			L-N			M-P					
market competitiors	M-S	M-S		M-H				H-P		M-N													
actors under political influence	M-H	M-H	M-H	M-H		M-H		M-N		M-N						H-R							
product			H-S								M-D	M-D	M-D	L-P	M-D	M-P	M-D	L-P	L-N		M-D		
formation heritage			H-S		M-P	L-A									H-D								
market			H-S								M-D	M-D	H-D		H-D		M-D	L-P		M-M			M-H
politics (here: manipulation)	H-A	H-A	H-H	H-H						H-N									H-N				

Figure 57: Field A2 of the perceived interrelation analysis matrix (see Figure 36) for the IOCS 3GPP

D = determines A = affects P = positively affects N = negatively affects R = requires M = mutually interdependent S = supports/causes/enables H = hinders/obviates L- / M- / H- = low / moderate / high effect	objective (develop specifications)	function (develop global 'standards')	sf 1 (attractivity)	sf 2 (relational risk)	sf 3 (institutional trust)	sf 4 (effectiveness and efficiency)	boundary (permeable)	coopetitive	voluntary	social pathway	large number of actors	high diversity of actors	highly dynamic actor composition	continuity of delegates	patent affinity	compass delegates	verticals	market competitiors	actors under political influence	product	formation heritage	market	politics
membership policy	L-S	M-S	H-S	M-H		L-H	H-S		H-D	M-N	M-S	M-S	M-S				L-S						
organisational structure	L-S	L-S	L-S		M-S	H-S			M-P					M-P		M-P							
role of the IOCS	L-S	L-S	L-S		M-S	H-S			L-P					M-P		M-P							
roles of the actors	L-S	L-S	L-S		M-S	H-S			L-P					M-P		M-P							
(working) processes	M-P	H-P	M-P		M-P	H-P			M-P					L-P		L-P							
data management system	L-H	L-H	L-H		L-H	L-H																	
mechanism of consensus	H-S	H-S	H-S	M-S	M-S	L-H				H-P	L-R			L-R		L-R	L-R						H-H
mechanism of economic participation			M-A		L-S										H-R			M-P					
mechanism of moderation	H-S	H-S		M-S		H-S			M-R	H-P				L-P			L-P	M-P	M-P				M-H
mechanism of targeted activity	L-S	L-S	M-S			H-S			L-P	L-P				L-P									
mechanism of corporate IOCS culture	L-S	L-S	H-S	H-S		M-S		L-P	H-P	H-P				H-P		H-P		M-P	H-P				
mechanism of the critical mass	M-S	M-S				L-H				M-P							M-P	M-P	H-H				
mechanism of informal exchange	M-S	M-S		M-S		M-S		M-P	M-P	H-P				M-P		M-P		M-P					L-H
mechanism of political capital				M-S		L-S				M-P								M-P	H-P				M-H
mechanism of progress	M-s	M-S	L-S			M-S			M-P	L-P				L-P				M-P					
GP 'Knowing the value of the number'	M-S	M-S	M-S	L-S				L-P		H-P	M-S	M-S		L-P		L-P	H-P	H-P	M-P				
GP 'Let the market rule the game'	L-S	L-S	H-S	M-H				M-A										L-P					
GP 'No-loser policy'	M-S	M-S	H-S	L-S				L-P		H-P				M-P				M-P					

Figure 58: Field B1 of the perceived interrelation analysis matrix (see Figure 36) for the IOCS 3GPP

D = determines A = affects P = positively affects N = negatively affects R = requires M = mutually interdependent S = supports/causes/enables H = hinders/obviates L- / M- / H- = low / moderate / high effect	membership policy	organisational structure	role of the IOCS	roles of the actors	(working) processes	data management system	mechanism of consensus	mechanism of economic participation	mechanism of moderation	mechanism of targeted activity	mechanism of corporate IOCS culture	mechanism of the critical mass	mechanism of informal exchange	mechanism of political capital	mechanism of progress	GP 'Knowing the value of the number'	GP 'Let the market rule the game'	GP 'No-loser policy'
objective (develop specifications)	M-D		L-D				M-R	H-D	L-R									
function (develop global 'standards')	H-D		M-D				M-R		M-R							H-D		M-D
sub-function 1: enhance global attractivity	M-D	L-D	L-D	L-D	L-D		H-R	M-D	M-D	M-D	H-R					H-D	H-R	H-D
sub-function 2: reduce relational risk				L-D	M-D		H-P	L-D	M-S		H-R	L-R	M-R	H-R		M-R		M-R
sub-function 3: cause institutional trust		L-D	M-D		M-D	L-D	L-R	M-R			M-R	M-R				M-R		M-R
sub-function 4: cause effectiveness and efficiency		M-D	M-D	M-D	H-D	M-D			M-R	H-R			M-R				M-R	
boundary which is permeable in both ways	H-R							M-R	H-R		H-R		M-R					
coopetitive					L-R		H-A	H-R	H-R		M-R	L-R	H-R		M-R	M-R	L-R	L-R
voluntary	H-R		L-D	L-D	L-D		H-R	M-R	M-R			M-R			H-R	M-D	H-D	M-D
social pathway	H-N				M-R		M-R		H-R		H-R		H-R	H-R				H-R
large number of actors		L-D			M-D		M-N	L-R	H-R	L-R	M-R	H-P	M-R	L-N	L-R	L-R		L-R
high diversity of actors				L-D	M-D		M-S	L-N	H-R	L-R	M-R	M-P	M-R				L-S	
highly dynamic actor composition							M-N		M-R		H-R		M-R	L-R	M-N			
continuity of delegates					L-P		M-P		M-P		H-P		M-P	H-P		H-P	M-P	H-P
patent affinity	M-D				L-D			L-D										
compass delegates					L-P		H-P		H-P		H-P		M-P	L-P		H-P	H-P	H-P
verticals	M-R				L-D		H-P	L-N			M-R	H-P	M-R		M-P	M-R		
market competitiors							M-N	H-R	H-R		L-R		M-R		M-R	H-R	M-R	H-R
actors under political influence							M-N		H-R		M-N	H-R	M-R	H-R			M-R	
product	L-D															H-D		L-D
formation heritage	L-D	M-A	M-D		L-D	M-N		H-D										
market								H-D							H-P		H-R	
politics (here: manipulation)				L-N			M-N		M-N		H-N	M-N	M-N	M-N	M-N	M-N	H-N	H-N

Figure 59: Field B2 of the perceived interrelation analysis matrix (see Figure 36) for the IOCS 3GPP

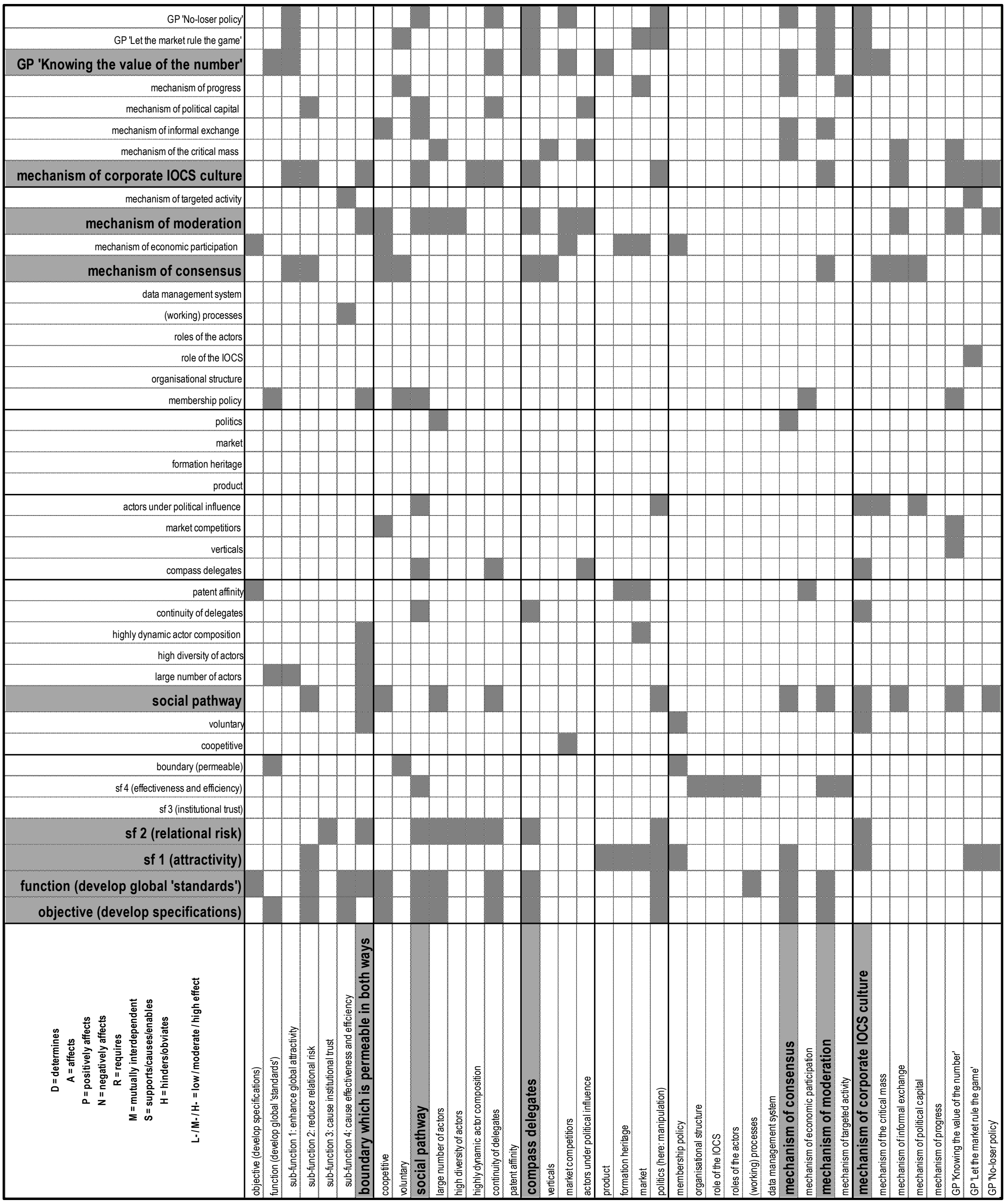


Figure 60: Incidences of high interrelation (highlighted in grey) in the 3GPP perceived interrelation matrix

D = determines A = affects P = positively affects N = negatively affects R = requires M = mutually interdependent S = supports/causes/enables H = hinders/obviates L- / M- / H- = low / moderate / high effect	objective (develop specifications)	function (develop global 'standards')	sf 1 (attractivity)	sf 2 (relational risk)	sf 3 (institutional trust)	sf 4 (effectiveness and efficiency)	boundary (permeable)	coopetitive	voluntary	social pathway	large number of actors	high diversity of actors	highly dynamic actor composition	continuity of delegates	patent affinity	compass delegates	verticals	market competitiors	actors under political influence	product	formation heritage	market	politics	membership policy	organisational structure	role of the IOCS	roles of the actors	(working) processes	data management system	mechanism of consensus	mechanism of economic participation	mechanism of moderation	mechanism of targeted activity	mechanism of corporate IOCS culture	mechanism of the critical mass	mechanism of informal exchange	mechanism of political capital	mechanism of progress	GP 'Knowing the value of the number'	GP 'Let the market rule the game'	GP 'No-loser policy'
boundary which is permeable in both ways	M-S	H-S	M-S	H-H		L-H		M-S	H-D	H-N	H-S	H-S	H-S	L-N		L-N		L-N						H-R							M-R	H-R		H-R		M-R					
social pathway	H-H	H-H	M-H	H-H		H-H								H-R		H-R	M-P	M-N	H-N					H-N				M-R		M-R		H-R		H-R		H-R	H-R				H-R
compass delegates	H-S	H-S	L-S	H-S		M-S		M-P	M-P	M-P				H-M			L-P	M-P	M-P									L-P		H-P		H-P		H-P		M-P	L-P		H-P	H-P	H-P
mechanism of consensus	H-S	H-S	H-S	M-S	M-S	L-H				H-P	L-R			L-R		L-R	L-R						H-H		L-D	L-D		M-D				M-R		M-A	H-R	H-R		H-R	H-R		H-S
mechanism of moderation	H-S	H-S		M-S		H-S			M-R	H-P				L-P			L-P	M-P	M-P				M-H		L-R		L-R	M-R		H-S			M-S	H-S	M-S	H-P	M-R	M-P	H-S	H-S	H-S
mechanism of corporate IOCS culture	L-S	L-S	H-S	H-S		M-S		L-P	H-P	H-P				H-P		H-P		M-P	H-P											L-S		M-S				M-P	M-S	M-P	H-D	H-D	H-D

Figure 61: Elements in the IOCS 3GPP, which are perceived as most affecting

D = determines A = affects P = positively affects N = negatively affects R = requires M = mutually interdependent S = supports/causes/enables H = hinders/obviates L- / M- / H- = low / moderate / high effect	objective (develop specifications)	function (develop global 'standards')	sf 1 (attractivity)	sf 2 (relational risk)	social pathway	mechanism of consensus	mechanism of moderation	mechanism of corporate IOCS culture
objective (develop specifications)		H-D	M-S			M-R	L-R	
function (develop global 'standards')	H-M		M-S			M-R	M-R	
sub-function 1: enhance global attractivity						H-R	M-D	H-R
sub-function 2: reduce relational risk	H-S	H-S	H-S		H-P	H-P	M-S	H-R
sub-function 3: cause institutional trust	M-S	M-S	M-S	H-S	L-P	L-R		M-R
sub-function 4: cause effectiveness and efficiency	H-S	H-S	M-S				M-R	
boundary which is permeable in both ways	M-S	H-S	M-S	H-H	H-N		H-R	H-R
coopetitive	H-S	H-S	L-H	M-H	H-N	H-A	H-R	M-R
voluntary	L-H	L-H	M-S	L-H	M-N	H-R	M-R	
social pathway	H-H	H-H	M-H	H-H		M-R	H-R	H-R
large number of actors	H-S	H-S	M-S	H-H	H-N	M-N	H-R	M-R
high diversity of actors	L-S	L-S	M-S	H-H	M-N	M-S	H-R	M-R
highly dynamic actor composition	M-H	M-H		H-H	M-N	M-N	M-R	H-R
continuity of delegates	H-S	H-S	L-S	H-S	H-P	M-P	M-P	H-P
patent affinity			M-A					
compass delegates	H-S	H-S	L-S	H-S	M-P	H-P	H-P	H-P
verticals	M-S	M-S	M-S	L-S	M-P	H-P		M-R
market competitiors	M-S	M-S		M-H	M-N	M-N	H-R	L-R
actors under political influence	M-H	M-H	M-H	M-H	M-N	M-N	H-R	M-N
product			H-S					
formation heritage			H-S					
market			H-S					
politics (here: manipulation)	H-A	H-A	H-H	H-H	H-N	M-N	M-N	H-N
membership policy	L-S	M-S	H-S	M-H	M-N			
organisational structure	L-S	L-S	L-S					
role of the IOCS	L-S	L-S	L-S			L-P		
roles of the actors	L-S	L-S	L-S			L-P	M-D	
(working) processes	M-P	H-P	M-P			M-P	M-R	
data management system	L-H	L-H	L-H					
mechanism of consensus	H-S	H-S	H-S	M-S	H-P		M-R	M-A
mechanism of economic participation			M-A					
mechanism of moderation	H-S	H-S		M-S	H-P	H-S		H-S
mechanism of targeted activity	L-S	L-S	M-S		L-P			
mechanism of corporate IOCS culture	L-S	L-S	H-S	H-S	H-P	L-S	M-S	
mechanism of the critical mass	M-S	M-S			M-P	H-S	M-R	M-S
mechanism of informal exchange	M-S	M-S		M-S	H-P	H-S	H-R	H-S
mechanism of political capital				M-S	M-P	H-S		L-P
mechanism of progress	M-s	M-S	L-S		L-P	M-S	M-S	
GP 'Knowing the value of the number'	M-S	M-S	M-S	L-S	H-P	M-S	H-R	H-D
GP 'Let the market rule the game'	L-S	L-S	H-S	M-H		L-S		H-D
GP 'No-loser policy'	M-S	M-S	H-S	L-S	H-P	M-S	H-R	H-D

Figure 62: Elements of the IOCS 3GPP that are perceived to be most affected

F LD²M supplements

F.1 Theories of adapted methods

F.1.1 Design thinking

F.1.1.1 Design thinking theory

Leading actors of the design thinking community (Vetterli et al., 2012, p. 4: for example, Tim Brown, CEO of IDEO and Larry Leifer, Stanford University) emphasise that it is in the nature of design thinking, that it cannot clearly be defined. Although design thinking is also regarded as a culture (Meinel and von Thienen, 2016, p. 1), it is mainly used and defined as a method or methodology, which can be described as follows (see for example Hoffmann et al., 2015, pp. 244; Grots and Pratschke, 2009; Przybilla et al., 2018; Brown, 2008).

> **Design thinking** is about the creative generation of user centred innovative solutions, in particular for 'wicked' problems.

As design thinking is about using a designer's sensibility and methods to generate user-centred– yet technologically feasible and economically viable – innovations (Brown, 2008, p. 2), it integrates many tools and methods from design discipline (Przybilla et al., 2018, p. 17). The task of a designer in this context is not limited to creative work, but refers to creative problem solving (Berger, 2014, p. 27) which also includes conceptional and technological design of systems and objects (Hoffmann et al., 2015, p. 244). That makes it suitable for product, process, service, and business model innovations. It is nowadays applied in several domains like for example information science, engineering, innovation management, or business development (Hoffmann et al., 2015, p. 245).

Its success in fields which are rather unrelated to design, can be explained by a closer look on its core characteristics:

- Design thinking is *user centred*

User-centricity is nowadays gaining importance for economic success and survival, 'as economies in the developed world shift from industrial manufacturing to knowledge work and service delivery' (Brown, 2008, p. 2). That causes once an expansion of the innovation terrain towards process, service and business model innovations and a growing importance of innovations which focus to meet user needs instead of mainly solving a technical problem. By centring users and their needs, design thinking emphasises the problem space. That contrasts the engineering way of thinking in solution spaces which holds the danger to solve problems, for which a solution can be developed instead of finding solutions for the actual problem (Meinel and von Thienen, 2016, p. 2).The application of design thinking in engineering disciplines may thus balance, complement and broaden the engineering approach to innovation and problem solving by guiding the focus also on the problem and the underlying user needs.

- Design thinking is for *'wicked' problems*

Design thinking particularly helps to solve 'wicked problems', which describe typical design problems. Design problems are characterised by their complexity which precludes their handling by means of rational decisions processes. Instead, designers address such problems by terminating complexity with means of suggesting a certain artefact which causes improvement but not truth or 'the optimum' (Berger, 2014, pp. 27–34). According to Rittel and Webber (1973) wicked problems share some common characteristics:

- Wicked problems are difficult to define. There is no definite formulation.
- Wicked problems have no stopping rule.
- Solutions to wicked problems are not true or false, but good or bad.
- There is no immediate or ultimate test for solutions.
- All attempts to solutions have effects that may not be reversible or forgettable.
- These problems have no clear solution, and perhaps not even a set of possible.
- solutions.
- Every wicked problem is essentially unique.
- Every wicked problem may be a symptom of another problem.
- There are multiple explanations for the wicked problem.
- The planner (policymaker) has no right to be wrong.

The concept of 'super wicked problems'(Peters, 2017, p. 388) adds further characteristics, which are that (1) time is running out, (2) there is no central authority or only a weak central authority to manage the Problem, (3) the same actors who cause the problem seem to solve it, and (4) the future is discounted radically so that contemporary solutions become less valuable (Peters, 2017, p. 388). In knowledge societies, problems become more and more complex and at the same time can no longer be evaluated solely by their technological efficiency, but – like design problems – by their social effectivity, which might require and justify solutions which are rationally and technologically not preferable (Berger, 2014, p. 35).

- Design thinking fosters *creative*, inventive solutions.

In order to do so, design thinking regards design as an iteration of divergent-convergent thinking (Heck, 2017, p. 29). Convergent thinking is part of every scholarly education (Hoffmann et al., 2015, p. 1746) and describes the development of conventional and 'correct' solutions and ideas (Hoffmann et al., 2015, p. 245). On the contrary, divergent thinking is the ability to develop inventive unconventional ideas in order to solve problems in an innovative and trailblazing way (Hoffmann et al., 2015, p. 245). The combination of both results in an interplay of choice creation and choice making (IDEO, no data). The double diamond design thinking process which is introduced in the following section especially emphasises this interplay.

F.1.1.2 The double diamond design thinking process

There are several process models for design thinking. It is a core principle in design thinking, that processes are not linear, but iterative (Hoffmann et al., 2015, p. 246). In 2004, the Design Council, a leading actor in the design thinking community, has defined a rather flexible process of four iterative steps which can be adapted to the specifics of different applications (Santos et al., 2017, p. 2): the double diamond design process (see Figure 63). Beside its flexibility, this design process is chosen for this research, because it best highlights the dualistic approach with regard to both the distinguishing between the problem and the solution space and the interplay between divergent and convergent thinking. In a nutshell, the double diamond process defines the problem and the solution space as two equally important working spaces (Przybilla et al., 2018, p. 17), which are each approached by a divergent exploration phase, in which 'choices are created' and a convergent step, in which 'choices are made' by means of synthesis (problem space) or selection (solution space) (IDEO, no data):

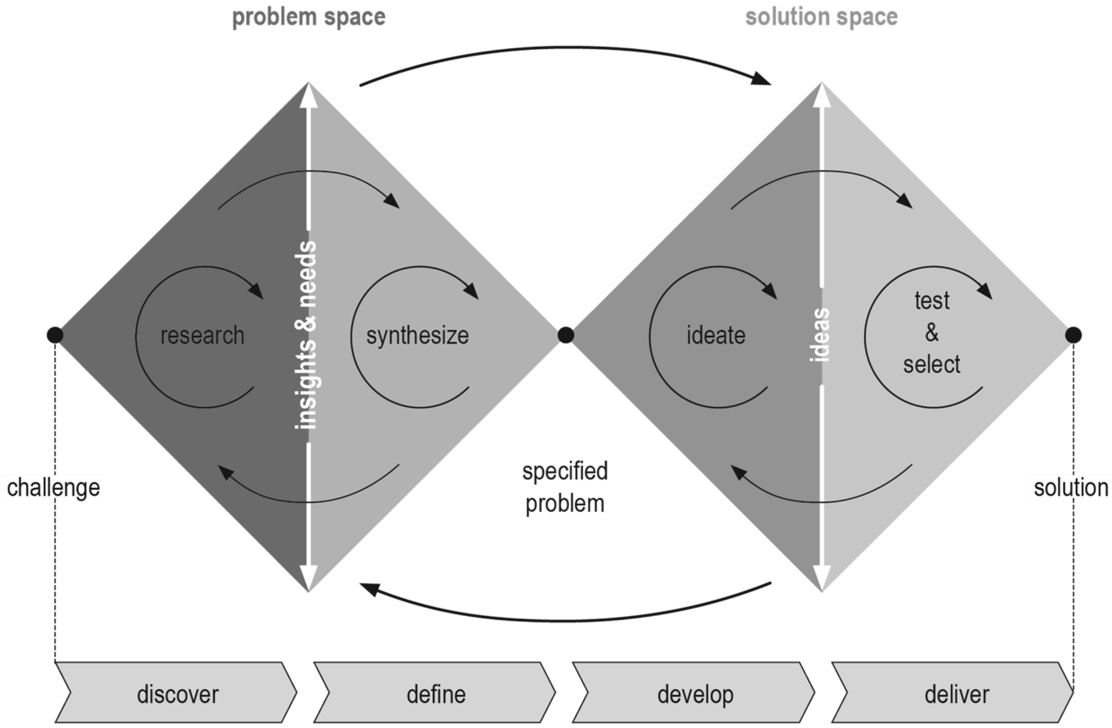


Figure 63: The iterative double diamond model of design thinking (own illustration)

Trigger for the design process is the statement of an identified – or assumed – general problem – also referred to as challenge – which initiates the exploration of the problem space. In this research step, divergent thinking is used to discover the problem space in order to find needs and develop a thorough understanding for the initially assumed problem (Przybilla et al., 2018, p. 17; Design Council, 2009). The second step describes the convergent phase in the problem space, which aims to define the concrete problem by synthesising. The resulting specific problem definition and understanding, is (1) the output of the problem space analysis and (2) the connection of the problem and the solution space and (3) the input for the solution space. Like in the problem space, the approach of the solution space starts with a divergent phase, in which ideas are to be developed. That is why this step is also referred to as ideation. The fourth process step test & select describes the convergent phase in the solution space which refers to the decision for and specification of a certain solution including corresponding testing, which in the end allows to deliver a solution.

Research phase – discover:

To 'discover' in the design thinking context has both a rational and empathic aspect (Grots and Pratschke, 2009, p. 19): The rational aspect refers to the systematic analysis of the problem field with its specific conditions and influencing factors, for example by means of objective analysis methods in order to gain a thorough understanding of the problem and its context. This analysis is known from other disciplines and may use objective analysis methods. What specifies the design thinking discover phase is the empathic analysis, which aims to understand the users and their needs by experiencing their user behaviour in context (Grots and Pratschke, 2009, p. 20): This user-centred analysis includes both attentive observations of and in the context, but also the active generation of information by means of dialogues and interaction (Grots and Pratschke, 2009, p. 20). The aim is to connect to users in order to determine and understand their implicit and explicit needs (Hoffmann et al., 2015, p. 249) and to detect details which may be relevant for the solution of the problem. The empathic analysis may be supported by methods which are related to ethnology (Meinel and von Thienen, 2016, p. 3). In both rational and empathic analysis, divergent thinking – meaning an unbiased open and free analysis which goes beyond the problem focus – is prerequisite. That is because relevant 'information and inspiration [for the specification and solution of problems] are often not found in, but next to the problem focus, in its background or environment' (Grots and Pratschke, 2009, p. 20, own translation). Such an unbiased and open research is extensive and thus often time-consuming and costly but allows to question the problem and to refine it or its focus if necessary.

Synthesis phase – define:

In this phase, findings from the first phase are synthetised. It includes in the first step the documentation and visualisation of all findings in order to link, condense and implicitly interpret findings. In the second synthesis step, findings are summarized and grouped in order to identify pattern, interrelations, and inconsistencies. By editing these findings, a condensed, communicable, and clear illustration of relevant findings is developed as basis for both the following process steps and a concrete, if necessary redefined, problem statement.

Ideation phase – develop:

This phase aims to generate the maximum quantity of ideas and may thus be best described as the creative step in the process. Beside the fact, that design thinking considers brainstorming as a process step (in which the method brainstorming may be applied), ideation is a typical idea generation process. That is why common rules, methods and procedures of idea generation including creativity techniques, find application in this phase. Divergent thinking is again a central element in this microprocess, which includes 'seeking inspiration from elsewhere' (Design Council, 2009).

Testing phase – deliver:

In this phase, different ideas are tested at small scale in order to identify working solutions and amongst these the one which is finally realized and 'delivered' (Design Council, 2009). Prototyping is a central element in this step to make ideas and solutions tangible. Prototypes are built for user evaluation. Depending on the project, the artefact and how far the development process proceeded, the level of abstraction and the chosen prototyping methods and models may vary: Especially for process and service prototyping unconventional prototypes like comics, storytelling or role-playing may be used. Final prototypes are then tested with or by the user to evaluate the solution with regard to the fulfilment of user needs and the ability of the solution to enthuse and inspire them.

F.1.2 Lead user theory

Von Hippel introduced the lead user method as new market research technique in 1986 (Hippel, 1986) to support the development of innovative products which satisfy future customer needs. He defines lead users as follows (Hippel, 1986, p. 796):

Definition: **Lead users**

(1) face needs that will be general in a marketplace – but face them months or years before the bulk of that marketplace encounters them, *and*

(2) are positioned to benefit significantly by obtaining a solution to their needs and so may innovate.

Adapted from further research of von Hippel (Hippel, Franke, and Prügl, 2009; Herstatt and Hippel, 1992). Schmidt (2019) presents characteristics, which are assigned to lead users (Schmidt, 2019, pp. 54–55):

Characteristics: **Lead users**

- create their own context-specific interim solutions,
- search for new impulses and inspiration to advance the interim solution, and
- aim to find a professional, working solution which performs better than their own interim solution.

As a result, lead user

- find and connect to other experts in that field that inspire them in solving the problem.
- gather knowledge and experience about both the problem and (working and not working) solutions.

Based in these characteristics, Schmidt reinterprets the lead user meth-od as research methodology (Schmidt, 2019, p. 57): He defines the product as the artefact to be developed and the market as the available knowledge and in particular that in the problem field. For him, lead users are ‘cutting edge persons or organisations that are very advanced and outstanding in the field of [the re-search topic]’ (Schmidt, 2019, p. 57). In addition, they have an extraordinarily high need for the artefact in their application domain and comprehensive knowledge and experience about potential solutions.

Because of the above characteristics, the integration of lead users and their expertise in development and/or innovation processes can be very beneficial for companies which innovate and develop new products. The lead user method thus provides the following four steps which assist companies to find suitable lead users (Lüthje and Herstatt, 2004; Churchill, Hippel and Sonnack, 2009; Wagner and Piller, 2011): project preparation, trend and need analysis, lead user identification and a lead user workshop. For the LD²M, the third step, lead user identification, is relevant. There are two search strategies, which are mainly recommended for lead user identification: screening and pyramiding (see Figure 64).

Screening is a popular search approach, by which subjects with desired attributes are identified within a defined sample with means of a parallel, ‘undirected’ search process: In the first step, the sample is defined, in which the subjects are expected to be found and searched. In the second step, every subject within the sample is tested for the desired attributes (Hippel, Franke and Prügl, 2008, p. 2). Since the findings from each subject do not influence the testing, it can be conducted in parallel (Hippel, Franke and Prügl, 2008, p. 4). After screening all subjects, the ones which fit the desired attributes best, are chosen. Because the search for potential subjects is limited to members of the sample, sampling is the decisive factor for successful lead user identification via screening (Schmidt, 2019, p. 58). Sampling and thus successful screening presuppose that it is disclosed and known where subjects with desired attributes can be found. As the number of subjects in a sample grows and/or desired attributes are rarely distributed, screening becomes a very inefficient search technique (Hippel, Franke and Prügl, 2008, p. 2). That is why for the identification of lead users who are a rare and highly distributed species, pyramiding as 'directed' and open-ended search approach is often favoured.

Pyramiding is based in the idea 'that people with a strong interest in a topic or field tend to know people more expert than themselves.' (Hippel, Franke and Prügl, 2008, p. 1). It is a sequential search approach, which allows learning from each search sequence (Hippel, Franke and Prügl, 2008, p. 4): The search process is started with the identification of a known subject, which is expected to meet the desired attributes best. This person is then asked to recommend an even more advanced person, meaning someone who knows even more about the topic of interest and/or has more of that attribute than the person themselves (Hippel, Franke and Prügl, 2008, p. 2). The following search is conducted by means of the snowball principle, meaning that each recommended subject is asked to appoint someone even more advanced. By using the knowledge about fellow experts and networks of each subject, this search technique allows guiding through social networks in a very directed way towards subjects with the desired attributes (Schmidt, 2019, p. 58). Especially, pyramiding has the potential to identify subjects out of the searcher's range of contacts and expectations. Schmidt (2019, p. 59) found, that after a certain number of search sequences, a 'group of recommended experts' developed, because the questioned subjects all recommended the same group of experts or some members of this group. He conducted an additional screening search to validate if the found peer group represented a local or global maximum. The result showed, that the identified 'group of recommended experts' with means of pyramiding factually represent the peer group with subjects which best met the desired attributes at a global scale and may thus in addition be regarded as an abortion criterion for pyramiding.

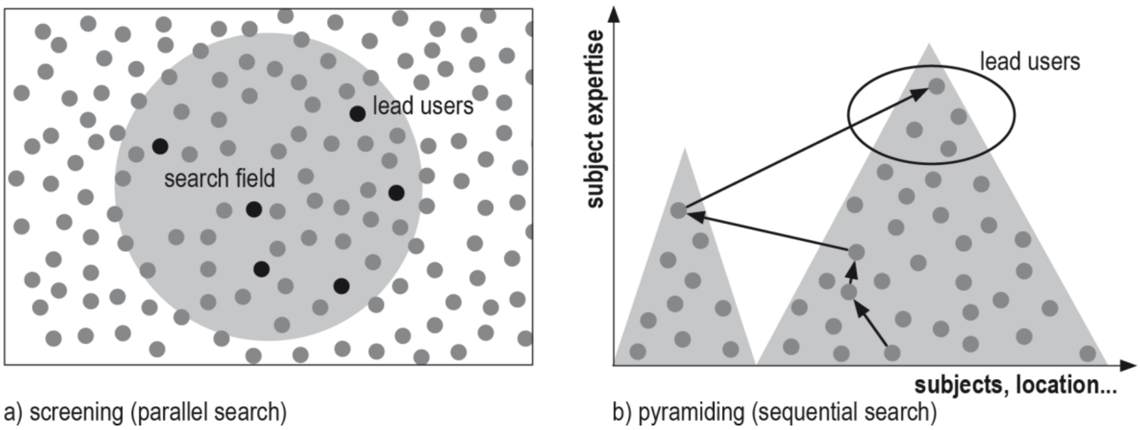


Figure 64: Contrasting the lead user identification principles of screening and pyramiding (Schmidt, 2019, p. 58)

F.1.3 Analogy reasoning theory

With regard to human cognition, '[a]nalogy is considered as a fundamental component of creativity and a beneficial method for idea generation' (Han et al., 2017, p. 1). It is an established means of problem solving not only in art but also in science (Han et al., 2017, p. 11) which can be described as follows:

> An **analogy** is defined as the likeness of relations of different sources and targets: A is related to B like C is related to D.

With regard to innovations, the potential of analogy was first used for product design problems but is nowadays also applied to solving business and/or strategy problems: For example, analogy is commonly used in cross-innovation (Hoffmann et al., 2015), for idea generation by means of patent research (Tiefel, 2008) or for business model development (Han et al., 2017). Analogy may support both the generation of creative ideas and the understanding of a concept (Han et al., 2017, p. 13). Analogy technique may be defined as follows:

> **Analogy reasoning** describes the application of knowledge from a well-known base domain) and to a less-known target domain (Han et al., 2017, p. 13).

In order to conduct analogy reasoning, a system of relations concerning central properties is transferred from a base to a target situation. An analogy is created, if similarities between the systems of relations in the base and target domain are identified. (Casakin and Goldschmidt, 1999, p. 154).

In practice, reason by analogy may be conducted by the following steps (based on Winkelhofer, 2006, p. 159):

(1) Describe the problem (including definition, and if necessary, refinement and abstraction)

(2) Search for and collect far and near analogies, even if they appear bizarre

(3) Assess and select analogies

(4) Analyse the structure, functionality, and the context of selected analogies

(5) Transfer the analogies to the problem in order to develop approaches to solving the problem

(6) Evaluate and advance the found solution(s).

F.1.4 The concept of levelled matrix-structured interrelation analysis

The author (Theissen, 2018) has developed a three-levelled matrix-structured interrelation analysis concept. The concept proposes to organize extensive sets of interrelated factor at different levels with an escalating degree of specificity. This is exemplified in the propagative Context Factor Approach (proCoFa) for context factors (level 3), which are grouped in more generic categories (level 2), which themselves are classified in different clusters (level 1). The levelled organisation of a voluminous set of interrelated factors has several advantages for a subsequent interrelation analysis: First and most important, by switching between and combining different levels as shown in Figure 65 it allows to describe interrelations at the level of maximum explanatory power. Second, the complexity, extent of, and effort for an interrelation analysis can be customized. Third, by conducting the interrelation analysis at different levels of specificity, findings at each corresponding scale of investigation are gathered which enhances the output of the analysis.

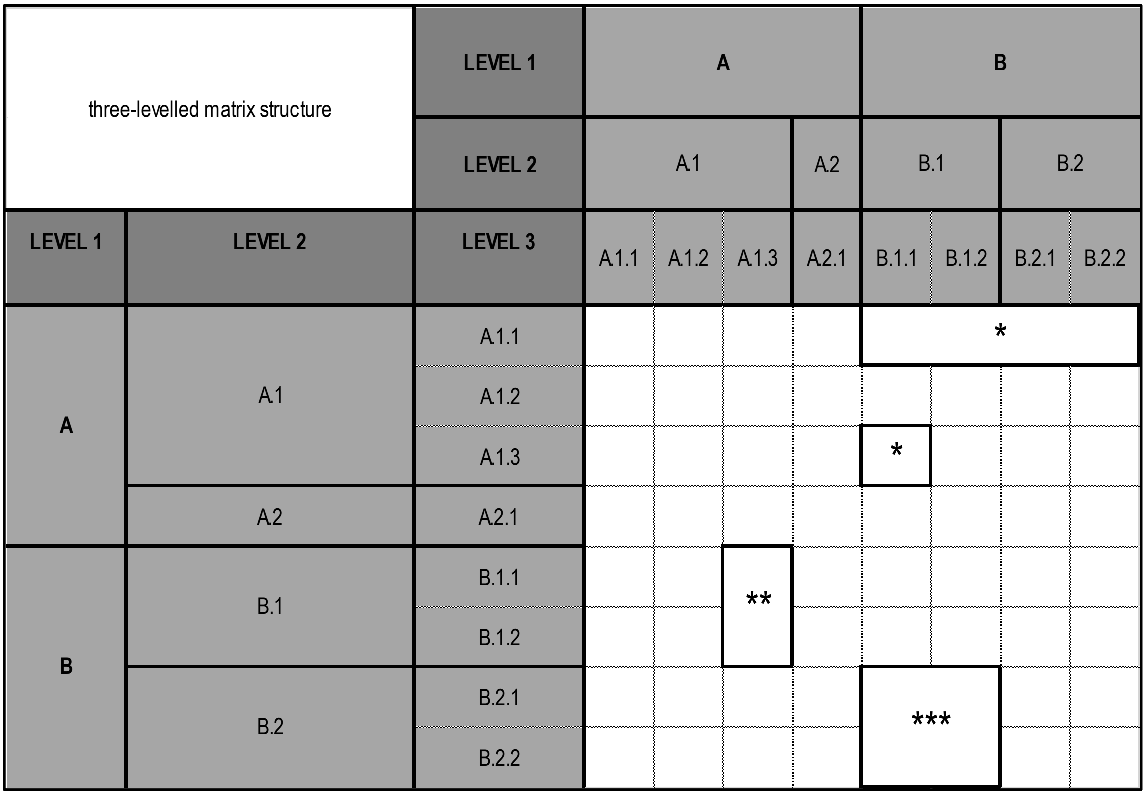


Figure 65: Three-levelled, matrix-structured interrelation analysis (based on Theissen, 2018)

The entirety of multi-criteria (decision) analysis methods may be used for such a levelled matrix-structured interrelation analysis. However, the author recommends the choice of a non-numerical scale for qualitative performance analysis as it is conducted in this study. That is because non-numerical scales obviate the indication that scores are mathematically exploitable scores with quantitative informative value. Among non-numerical scales, directed (like a (+/-)-scale) and undirected scales (like a *-scale) can be distinguished, which are both suitable to display the strength of a relation: A *-scale may for example distinguish light (*), moderate (**) and strong (***) relations, while the (+/-)-scale reaching from --- to +++ allows to evaluate both a positive and negative light, moderate and strong impact. It has to be noted, that the choice for a directed scale like (+/-) or an undirected scale like a *-scale mainly depends on the way the elements are defined, which the following example shows: If the elements are labelled ‘relational risk’ and ‘membership policy’, only the strength of impact of an IOC measure like for example the membership policy can be evaluated. A *-scale is appropriate. However, if the elements are defined as ‘relational risk reduction’ and ‘open membership policy’, not just the strength but also the conduciveness can be evaluated which makes a directed scale like (+/-) appropriate. That is why in the definition phase of the matrix items, one consistent way of defining elements should be aspired.

F.2 Checklists

F.2.1 Checklist for the functional system analysis

Table 8: Checklist (1) – functional analysis

Subject-matter	**Questions**	***Examples***	**Notes**
Normative analysis – What shall the system do?			
IOCS's objective (generic)	What shall the overall purpose and objective of the IOCS be (generic)? How shall the IOCS contribute to solve the determined problem?	*knowledge diffusion; standard development; resource management and/or economization*	The objective of an IOCS is defined at a rather generic level. If an IOCS already exists, its objective is generally formally defined in its statutes.
Design tool's scope of application (specific)	Which system function shall be influenced by the IOC-setting, which is developed with the LD²M?	*IOCA; number or constellation of actors; reputation*	The scope of application refers to the design tool. In this thesis, the scope of application is the enhancement of IOCA, yet other scopes can be defined.
Specification of target parameters (specific)	Which output shall be generated by means of the designed set of measures?	*more trust, efficiency, exchange; more participants, a broader variety of actors, new/vertical actors;*	The desired results are defined, which shall be achieved by the designed set of IOC-measures. That is why very specific – and if possible verifiable – parameters should be chosen. However, the nature of IOC makes it often impossible to define quantifiable parameters.
Descriptive analysis – What is the system doing?			
Status-quo functions (generic and specific)	If an IOCS already exists: What is the overall function which is conducted by the IOCS	*knowledge exchange, peer reviewing, strategic alignment, collaborative development, expert workshops*	It is especially important to identify existing discrepancies between the above defined purpose and its actually conducted function
	Which (sub-) functions are conducted in the IOCS?		
Status-quo inputs (specific)	Which inputs trigger IOC(A) and especially the proceeding of (sub-) functions most?	*certain actor (groups) or activities, structures, regulations, laws, funding, tooling, codes of conduct, policies, cultures*	
Status quo outputs (specific)	Which outputs are generated by the (sub-) functions?	*faster knowledge diffusion, industry alignment, faster development cycles, collaboration at eye level*	

F.2.2 Checklists for the structural system analysis

Table 9: Checklist (2a) – Analysis of the IOCS structure

Subject matter	Attributes	Functions	Assets	Relations	Controllable?	Notes
Description						
System and its elements	*Properties of the subject matter*	*Activities which are conducted by the subject matter*	*Assets which a subject matter brings into the IOCS*	*Common description of the type(s) of relations, if appropriate. Detailed analysis in Code of practice (2b).*	*If possible, judge if the subject matter or some of its characteristics in the sphere of control of the IOCS or beyond?*	*Record additional information if necessary* *Note:* *Not each subject matter might show all features*
System level						
IOCS						The boundary has to be defined as additional element for the system
Component level						
Actor (groups)						Actors can be grouped based on attributes, functions, assets, or other suitable characteristics like behaviour, cultural or industry similarities
Hard institutions						Like policies, laws, funding
Soft institutions						Behavioural pattern, codes of conduct, cultural influences, and habits

Table 10: Checklist (2b) – Analysis of IOCS component interrelations

Inter-relations	**Actor (group) 1**	**Actor (group) 2**	**Institution (group) 1**	**Institution (group) 2**	**…**	**System**
Actor (group) 1	*loyal**	*distrustful**	*beneficial**	*disadvanta-geous**		
Actor (group) 2	*cooperative**					
Institution (group)1	*supports**					
Institution (group) 2	*opposes to**					
…						
System						

**examples of interrelations*

F.2.3 Checklist for hierarchical system analysis

Table 11: Checklist (3) – Analysis of IOCS external influences

Subject matter	**Attributes**	**Functions**	**Assets**	**Relations**	**Controllable?**	**Notes**
Description						
Supra-system and its elements	*RELEVANT properties of the subject matter*	*RELEVANT activities which are conducted by the subject matter*	*RELEVANT assets which a subject matter brings into the IOCS*	*RELVANT relation to and/or influence on the system (IOCS)*	*In most cases, external influences are uncontrollable. Highlight if it is controllable!*	*Not each subject matter might show all characteristics*
Supra-system						
Supra-system						The precise definition of the supra-system(s) may or may not be applicable
Supra-system's components						
Actor (groups)						Only characteristics, which are relevant for the description of influence, are regarded
Hard institutions						
Soft institutions						

F.3 Codes of practice

Table 12: Code of practice for the IAM application

<u>General recommendation:</u> **Make use of the levelled interrelation analysis (see Appendix F.1.4) – choose the lowest level of detail for interrelation assessment and only move to a higher level of detail if additional informative value is generated**		
Code of practice I – IAM without information on the base IOCS		
step 1	Transfer the STM (outcome of the second phase of the LD^{2}M) to segment A2	
step 2	Assess the mutual interrelations and -dependencies between the institutions in segment A1	
step 3	Assess the influence of the target IOCS's elements on the effectiveness and impact of institutions in segment B2.	
step 4	Assess the effect of the institutions on the different elements of the target IOCS in segment B1	
step 5	Evaluate the potential of the chosen institutions to contribute to the objectives of the design tool and their effect with regard to the defined target parameters in segment C.	
Code of practice II – IAM with information on the base IOCS		
	Alternative I (Assessment in the target domain only)	*Alternative II (Assessment in the base and the target IOCS)*
step 1	Transfer the STM of the TARGET IOCS (outcome of the problem space analysis) to segment A2	
step 2	Assess the mutual interrelations and -dependencies between the institutions in segment A1	
Step 3a		Assess the influence of the target IOCS's attributes and components on the effectiveness and impact of institutions in segment B2 with regard to effects experienced or expected in the BASE IOCS.
Step 3b		Assess the effect of the institutions on the different attributes and components of the IOCS in B1 with regard to the BASE IOCS.
step 3c	Describe the main effect of each relative attribute in segment D1 and assess potential impacts on each institution and element in the IOCS in segment D2.	
step 4	Describe the dominant effect or impact of the relative attributes for both the IOCS measures and (if relevant) for the target IOCS's attributes and components in segment E	
step 5a	Assess the influence of the target IOCS's attributes and components on the effectiveness and impact of institutions in segment B1.	Reassess the data in B1 under consideration of the findings in D1, D2 and E in order to define the influence of the TARGET IOCS's attributes and components on the effectiveness and impact of institutions.

Step 5b	Assess the effect of the institutions on the different attributes and components of the target IOCS in segment B2	Reassess the data in B2 under consideration of the findings in D1, D2 and E in order to define the effect of the institutions on the different attributes and components of the TARGET IOCS.
Step 6	Evaluate the potential of the chosen institutions to contribute to the objectives of the design tool and their expected effect on the defined target parameters in segment C.	

Table 13: Code of practice for the LD²M

LD²M	**Code of practice**
step 1	Define the objective and purpose of the LD²M application.
step 2	Define the user (team) for the LD²M according to 7.3 (referred to as (LD²M-user(s)).
step 3a	Identify lead user as insider knowledge source by pyramiding (see Appendix F.1.2). **Starting point**: Any actor in the (potential) IOCS under consideration, if there is a choice, the actor who is expected to best meet the lead user characteristics is preferred (see characteristics under 7.2.1.2). **Abort criterion**: All questioned actors recommend the same group of experts or some members of this group (see Appendix F.1.2).
step 3b	Gather and explicate insider knowledge from lead users by using (1) conversation with and observation of the lead user in the IOCS, (2) free interviews and discussions in order to match perceptions and understanding between LD²M-user(s) and the lead user, and (3) complementing guided interviews based on the checklists corresponding to each concept of system theory (see Appendix F.2.) In order to conduct a nonbiased, discover phase, means (a) and (b) are preferred for the first cycle, while (c) is the primary tool in iteration cycles.
step 3c	Complement information about the IOCS – especially on external and structural influences – by additional methods and knowledge sources of your choice.
	conduct (partial) iteration cycles of 3a-3c until the outcome of the discover-phase is satisfactory.
step 4a	Synthesize the explicated knowledge by means of (1) the provided checklists (see Appendix F.2) for structuring and pattern identification, and (2) the STM (see Appendix F.2) in order to illustrate the outcome and detected interrelations and specifics.
step 4b	Complement the process of synthesizing by additional methods and techniques of your choice.
	conduct (partial) iteration cycles of 3a-4b until the outcome of the definition-phase is satisfactory.
step 5	Refine problem statement if necessary.
step 6a	Generate ideas for institutions by analogy reasoning by using (1) primary knowledge and (2) secondary knowledge. If possible, include IOC-context information (see Chapter Appendix F.1.3). Adjust the process to your time frame.

step 6b	Complement the process of idea generation by additional methods and techniques of your choice.
	conduct (partial) iteration cycles of 6a-6b until the outcome of idea generation is satisfactory.
step 7a	Define a set of institutions which shall be assessed.
step 7b	Assess the set of institutions in the IAM. Complement the assessment by additional methods and techniques of your choice.
	conduct (partial) iteration cycles of 6a-7b until the outcome is satisfactory with regard to the following abort criterion: **Abort criterion**: A set of institutions ‘sufficiently’ enhances the IOCS with regard to the defined purpose and objective of the LD²M The minimum value for sufficiency in this context is, that the expected improvement of the IOC process justifies the expenses (meaning time, effort, and costs) of conducting the LD²M. The maximum value in this context is reached if the expected further advancement of the IOC process cannot justify the expenses of additional review cycles within the LD²M anymore (according to requ (5) under 7.1).
step 8	Select a set of institutions **Selection criterion**: The set of institutions which – in comparison to the other sets under consideration – is expected to create the best positive total with regard to reduction of (perceived) relational risk (or the under step 1 defined purpose respectively) (according to requ (4) under 7.1).
step 9	Implement the set of institutions in the IOCS and observe and record the effects, especially with regard to the reduction of perceived relational risk (or the under step 1 defined alternative purpose respectively).

F.4 Expert validation

F.4.1 Interviews

The anonymized interview transcripts are digitally stored in accordance with common rules of good scientific practice for ten years at

Professur für Virtuelle Produktentwicklung

Institut für Maschinenelemente und Maschinenkonstruktion

Technische Universität Dresden

under supervision of my doctoral advisor

Prof. Dr.-Ing. Kristin PaetzoldByhain

where they are available upon request.

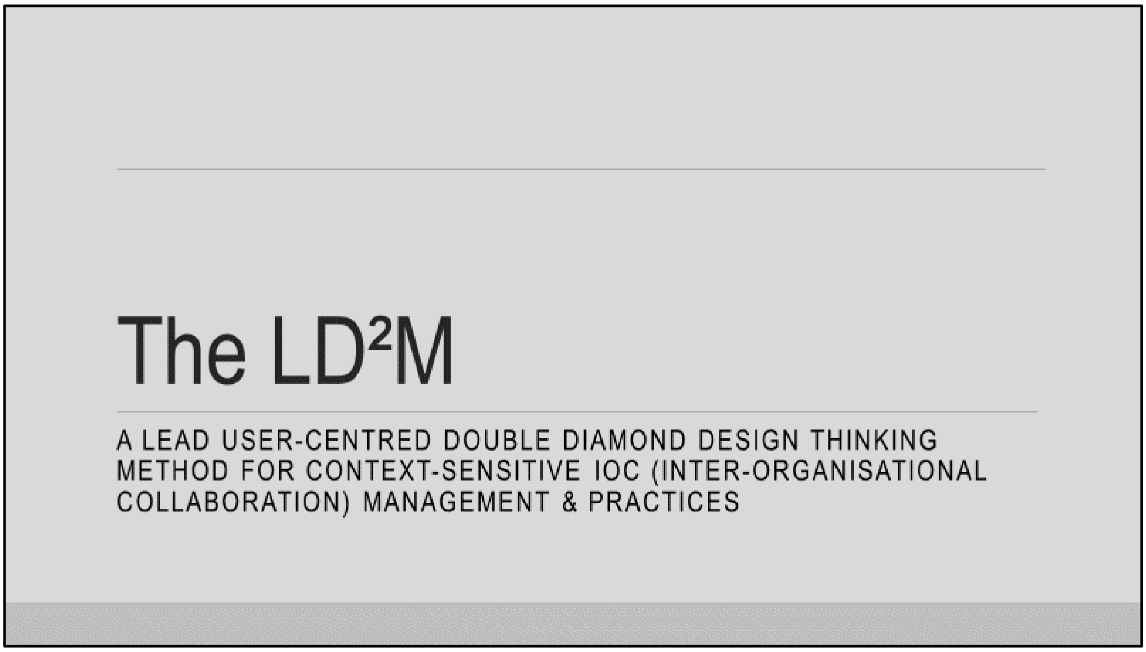
Interview 11: personal phone interview by Natalie Theissen at 16 March 2022

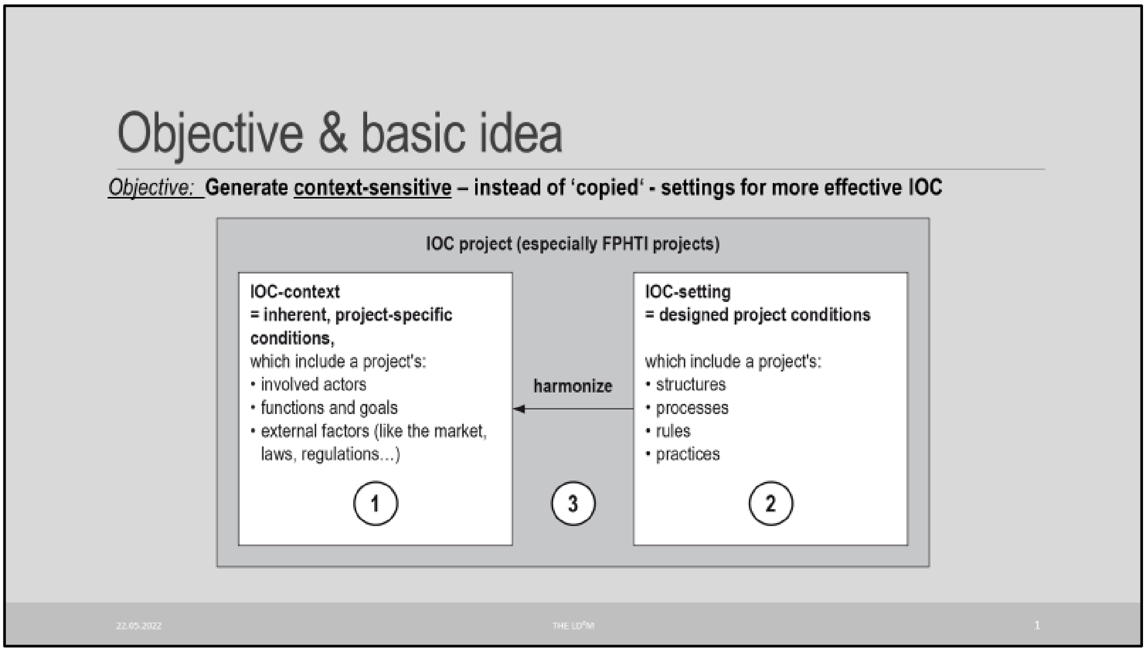
Interview 12: personal phone interview by Natalie Theissen at 12 April 2022

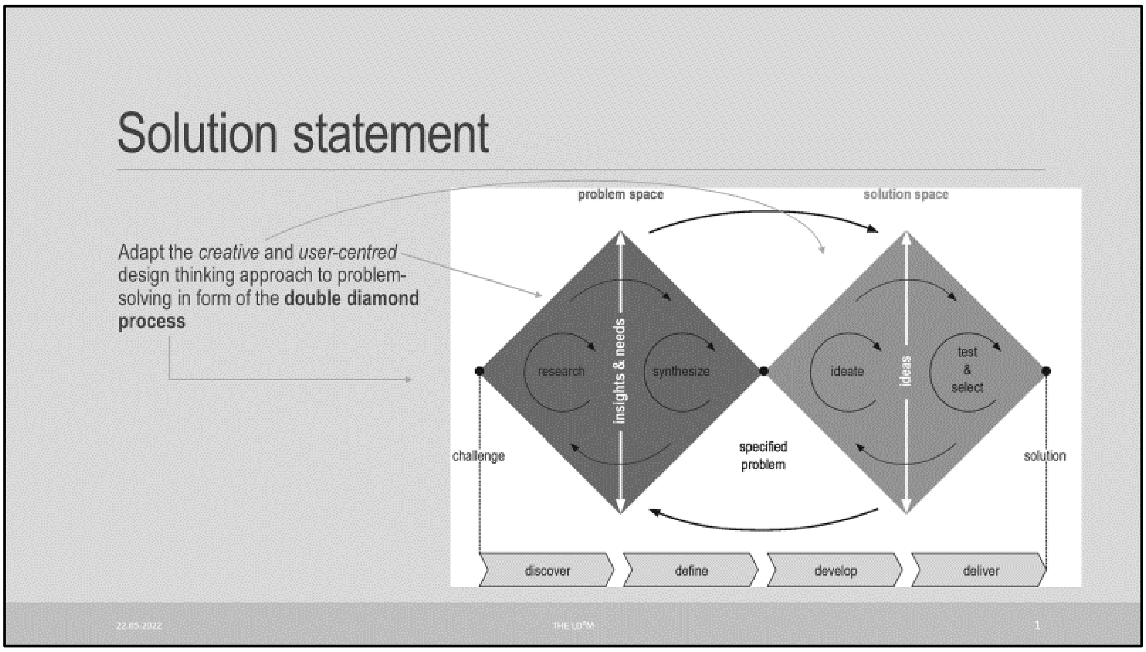
Interview 13: personal phone interview by Natalie Theissen at 27 April 2022

F.4.2 Presentation

The following power point presentation was used in expert interviews to introduce the LD²M as basis for discussion and evaluation.

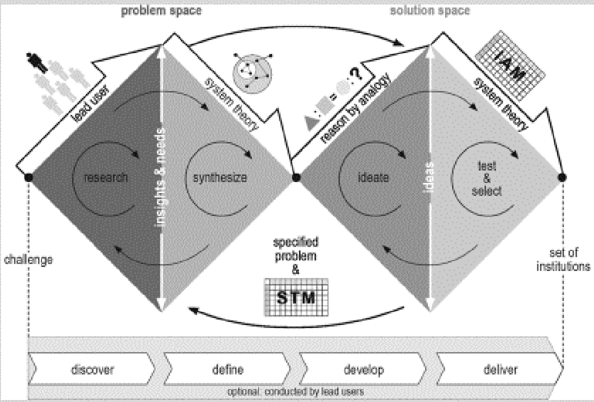



Objective & basic idea
Objective: Generate context-sensitive – instead of 'copied' - settings for more effective IOC
IOC project (especially FPHTI projects)
IOC-context
= inherent, project-specific conditions,
which include a project's:
• involved actors
• functions and goals
• external factors (like the market, laws, regulations…)
1
harmonize
3
IOC-setting
= designed project conditions
which include a project's:
• structures
• processes
• rules
• practices
2


Solution statement
Adapt the creative and user-centred design thinking approach to problem-solving in form of the double diamond process
problem space
solution space
research
synthesize
insights & needs
ideate
ideas
test & select
challenge
specified problem
solution
discover
define
develop
deliver

The LD²M

In a nutshell



Step 1: Discover

Discover the IOC setting by means of **lead user inquiry → FIND NEEDS**

Step 2: Define

Define the IOC setting with its specifics by developing a **system model** of the IOC context

Step 3: Develop

Develop potential solutions by means of **analogy reasoning**

Step 4: Deliver

Select a particular solution which best suits the IOC under consideration by means of an **impact assessment matrix**

22.05.2022 THE LD²M 2

Before you beginn:

Define the team which will conduct the LD²M.

Ideally the team comprises

1. …representatives of different needs and perspectives within the IOC project,
2. …experienced IOC actors with good reputation and networks, and/or
3. …lead users (meaning cutting-edge actors in the IOC project with regard to IOC activity).

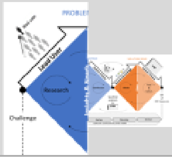
BE AWARE:

The lead users in the LD²M team are not to be confused with the under step 1 inquired lead users, who provide insights to the IOC context and thus take the function of ‚knowledge sources', but do not actively conduct the LD²M!

22.05.2022 THE LD²M 1

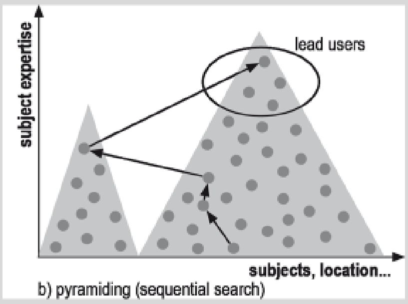
The LD²M

step 1



Aim: **Exploration of the IOC context and its actors using LEAD USER KNOWLEDGE**

Gather insights by means of conversations, observations, discussions and interviews with lead users (= cutting-edge IOC actors, known from new product development [1]), most efficiently by pyramiding (meaning to use lead user recommendations)



b) pyramiding (sequential search)

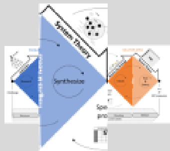
Pyramiding is based on Eric von Hippel's view, "that people with a strong interest in a topic or field tend to know people more expert than themselves."[1]

[1]Hippel, Eric von, Nikolaus Franke, and Reinhard Prügl (2006). *"Efficient identification of leading-edge expertise: Screening vs. pyramiding"*. In: *Portland International Conference on Management of Engineering and Technology* 2.c, pp. 884–897.

22.05.2022 THE LD²M 3

The LD²M

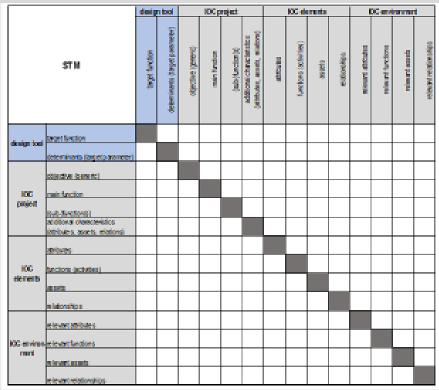
step 2



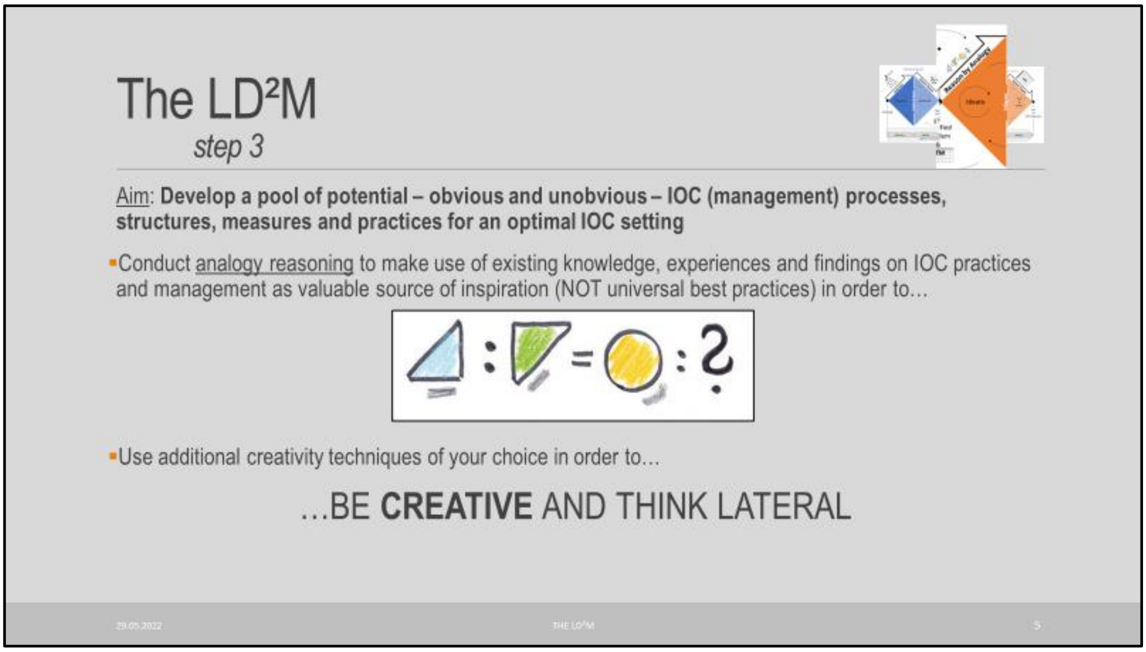
Aim: **Model the specific IOC project based on the insights gained in step 1**

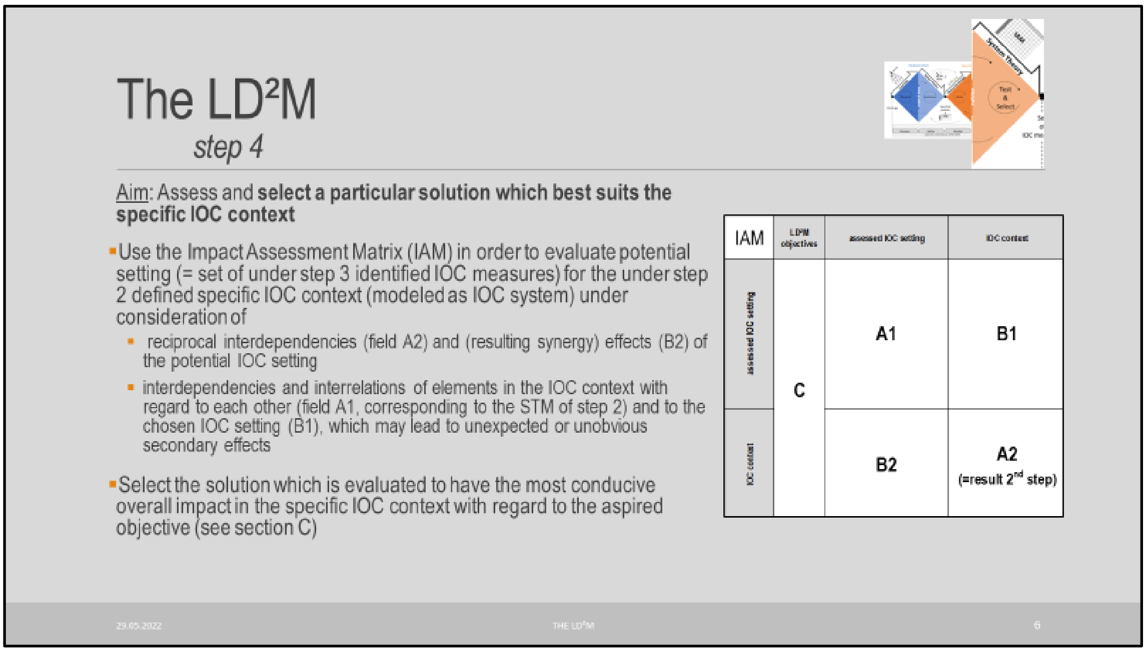
- Regard the IOC context as system and describe its
  - (1) *Functions* (**what does** the system do? **What shall** the system do?),
  - (2) *Structures* (which **elements** (including their characteristics and interrelations) affect the IOC project and
  - (3) *Environment* (which **external (pre-set) factors** affect the IOC setting?)

  (This process is guided by checklists (see appendix, slides 7 to 10)
- Illustrate and condense the results in the matrix ("STM) shown on the right



29.05.2022 THE LD²M 4


The LD²M
step 3
Aim: Develop a pool of potential – obvious and unobvious – IOC (management) processes, structures, measures and practices for an optimal IOC setting
Conduct analogy reasoning to make use of existing knowledge, experiences and findings on IOC practices and management as valuable source of inspiration (NOT universal best practices) in order to…
Use additional creativity techniques of your choice in order to…
…BE CREATIVE AND THINK LATERAL
29.05.2022
THE LD²M
5


The LD²M
step 4
Aim: Assess and select a particular solution which best suits the specific IOC context
Use the Impact Assessment Matrix (IAM) in order to evaluate potential setting (= set of under step 3 identified IOC measures) for the under step 2 defined specific IOC context (modeled as IOC system) under consideration of
reciprocal interdependencies (field A2) and (resulting synergy) effects (B2) of the potential IOC setting
interdependencies and interrelations of elements in the IOC context with regard to each other (field A1, corresponding to the STM of step 2) and to the chosen IOC setting (B1), which may lead to unexpected or unobvious secondary effects
Select the solution which is evaluated to have the most conducive overall impact in the specific IOC context with regard to the aspired objective (see section C)
IAM
LD²M objectives
assessed IOC setting
IOC context
assessed IOC setting
IOC context
C
A1
B1
B2
A2
(=result 2nd step)
29.05.2022
THE LD²M
6

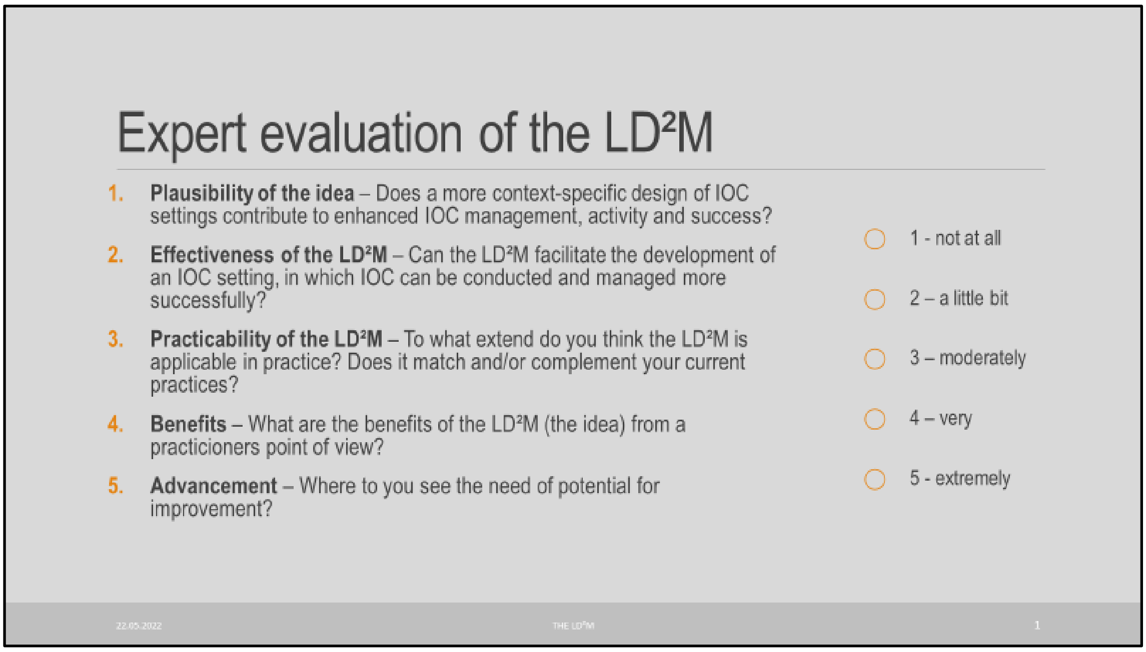


Figure 66: Presentation for expert interviews

G IAM demonstrator analysis

The coding system of the interrelation analysis of 3GPP (see Appendix E) is applied, according to which an element may determine (D), require (R), support (S), hinder or obviate (H) or affect (A), positively affect (P) or negatively affect (N) another element. For some elements, mutual interdependence (M) is used to describe the interrelation. For reasons of presentability, the strength of a perceived interrelation is expressed by the prefixes H-, M-, L-, which each represent a high, moderate, or low perceived strength.

DEMONSTRATOR **IAM for FPHTI IOCSs** **read:** **"column item is interrelated to line item"** **D = determines/influences** **P = positively affects** **N = negatively affects** **R = requires** **M = mutual interdependent** **S = supports/causes/enables** **H = hinders/obviates** **L-/M-/H- = low/moderate/high effect**	Effect assessment of relative attributes	enhance collaborative activity	perceived relational risk reduction	institutional trust	efficiency and effectiveness of IOC	membership policy	organisational structure	role of the IOCS	roles of the actors	(working) processes	data management system	mechanism of consensus	mechanism of economic participation	mechanism of moderation	mechanism of targeted activity	mechanism of corporate IOCS culture	mechanism of the critical mass	mechanism of informal exchange	mechanism of political capital	mechanism of progress	GP 'Knowing the value of the number'	GP 'Let the market rule the game'	GP 'No-loser policy'
membership policy			L-A	L-A	H-A			L-D	L-D				H-D										
organisational structure		M-A	M-A	H-A				L-M	L-M	M-D								M-P	L-P				
role of the IOCS	has to create more stability	M-A	H-A	L-A		L-D	M-M		L-D	L-D		L-P	L-D		M-D						L-D	M-D	L-D
roles of the actors		M-A		M-A			M-M			M-D		L-P		M-D							L-D		
(working) processes		H-A	M-A	H-A			M-A		L-M			M-P	L-D	M-R	M-S		L-D				L-S		
data management system		L-A	L-A	H-A						L-D													
mechanism of consensus	more difficult to conduct	H-A	M-A	M-A			L-D	L-D		M-D				M-R		M-A	H-R	H-R		H-R	H-R		H-S
mechanism of economic participation	NOT APPLICABLE	L-A	L-A	M-A		H-A				L-D	L-D							L-N				M-S	
mechanism of moderation	especially important	H-A	L-A	H-A			L-R		L-R	M-R		H-S			M-S	H-S	M-S	H-P	M-R	M-P	H-S	H-S	H-S
mechanism of targeted activity		M-A	L-A	H-A						L-D										H-P		M-S	
mechanism of corporate IOCS culture	rather poorly developed	H-P	L-A	M-A								L-S		M-S				M-P	M-S	M-P	H-D	H-D	H-D
mechanism of the critical mass	difficult to build	L-A	M-A	L-A								H-S		M-R		M-S		M-S		M-N	H-D		
mechanism of informal exchange	especially important	H-A										H-S		H-R		H-S	H-S		M-S	M-N			M-S
mechanism of political capital	especially important											H-S				L-P	M-S			L-P			
mechanism of progress		L-A	L-S	L-S								M-S		M-S	M-S		L-S	M-P				M-R	
GP 'Knowing the value of the number'	less internalized and established	M-P				H-D		M-D		M-D		M-S	M-P	H-R		H-D	H-M	M-P		M-N		L-D	M-D
GP 'Let the market rule the game'		L-A				L-D	M-D	H-D				L-S			H-P	H-D				L-P			
GP 'No-loser policy'			L-S							L-D		M-S		H-R		H-D		M-P	M-S	M-N			

Figure 67: IAM demonstrator segment A1 (values according to Segment A1 of 3GPP interrelation analysis, see Figure 56)

DEMONSTRATOR IAM for FPHTI IOCSs read: "column item is interrelated to line item" D = determines/influences P = positively affects N = negatively affects R = requires M = mutual interdependent S = supports/causes/enables H = hinders/obviates L-/M-/H- = low/moderate/high effect	objective (technological innovation)	function (joint problem solving)	sf 1 (high attractivity)	sf 2 (perceived relational risk reduction)	sf 3 (institutional trust)	sf 4 (foster knowledge exchange)	boundary (both way permeable)	coopetitive	voluntary	a 'social piano'	large number of actors	high diversity of actors	highly dynamic actor composition	inter-organizational r&d activity	horizontals (competitors)	verticals	external factors - not given
objective (technological innovation)		H-D	M-S					M-R			M-D	M-D	M-D				
function (joint problem solving)	H-M		M-S				H-D	M-R			H-P						
subfunction (sf) 1 (high attractivity)											H-P		M-P			M-P	
sf 2 (perceived relational risk reduction)	H-S	H-S	H-S			L-S		M-P		H-P					H-P	M-P	
sf 3 (institutional trust)	M-S	M-S	M-S	H-S		L-S				L-P					M-P		
sf 4 (foster knowledge exchange)	H-S	H-S	M-S						L-P					H-S			
boundary which is permeable in both ways	M-S	H-S	M-S	H-H		L-H		M-S	H-D	H-N	H-S	H-S	H-S		M-N	L-P	
coopetitive	H-S	H-S	L-H	M-H		M-A				H-N							
voluntary	L-H	L-H	M-S	L-H		M-H	H-R			M-N	M-M	M-M	M-M				
social pathway	H-H	H-H	M-H	H-H		H-H								M-N			
large number of actors	H-S	H-S	M-S	H-H		L-H				H-N		L-P		M-S	L-P		
high diversity of actors	L-S	L-S	M-S	H-H	L-R	M-H		M-P		M-N	L-S		L-S		M-P		
highly dynamic actor composition	M-H	M-H		H-H	M-R	M-N				M-N	L-R	L-R		M-N			
inter-organizational r&d activity	H-P	H-P	M-P			M-P		M-D									
horizontals (competitors)	M-S	M-S		M-H				H-P		M-N							
verticals	M-S	M-S	M-S	L-S		L-S	M-R	M-P		M-P	L-P	M-P			M-P		
external factors - not given in assessment																	

Figure 68: IAM demonstrator segment A2

DEMONSTRATOR
IAM for FPHTI IOCSs
read:
"column item is interrelated to line item"
D = determines/influences
P = positively affects
N = negatively affects
R = requires
M = mutual interdependent
S = supports/causes/enables
H = hinders/obviates

L-/M-/H- = low/moderate/high effect

	objective (technological innovation)	function (joint problem solving)	sf 1 (high attractivity)	sf 2 (perceived relational risk reduction)	sf 3 (institutional trust)	sf 4 (foster knowledge exchange)	boundary (both way permeable)	coopetitive	voluntary	a 'social piano'	large number of actors	high diversity of actors	highly dynamic actor composition	inter-organizational r&d activity	horizontals (competitors)	verticals	external factors - not given
membership policy	L-S	M-S	H-S	M-H		L-H	H-S		H-D	M-N	M-S	M-S	M-S		M-A	M-A	
organisational structure	L-S	L-S	L-S		M-S	H-S			M-P					M-A			
role of the IOCS	L-S	L-S	L-S		M-S	H-S			L-P					L-A			
roles of the actors	L-S	L-S	L-S		M-S	H-S			L-P								
(working) processes	M-P	H-P	M-P		M-P	H-P			M-P					L-A			
data management system	L-H	L-H	L-H		L-H	L-H											
mechanism of consensus	H-S	H-S	H-S	M-S	M-S	L-H				H-P	L-R						
mechanism of economic participation			M-A		L-S									M-A			
mechanism of moderation	H-S	H-S		M-S		H-S			M-R	H-P				M-F			
mechanism of targeted activity	L-S	L-S	M-S			H-S			L-P	L-P				M-A			
mechanism of corporate IOCS culture	L-S	L-S	H-S	H-S		M-S		L-P	H-P	H-P				H-F		M-P	
mechanism of the critical mass	M-S	M-S				L-H				M-P					M-P	M-P	
mechanism of informal exchange	M-S	M-S		M-S		M-S		M-P	M-P	H-P				H-F			
mechanism of political capital				M-S		L-S				M-P							
mechanism of progress	M-S	M-S	L-S			M-S			M-P	L-P							
GP 'Knowing the value of the number'	M-S	M-S	M-S	L-S				L-P		H-P	M-S	M-S			H-P	M.P	
GP 'Let the market rule the game'	L-S	L-S	H-S	M-H				M-A						M-R		M-P	
GP 'No-loser policy'	M-S	M-S	H-S	L-S				L-P		H-P					H-P	L-P	

Figure 69: revised IAM demonstrator segment B1

DEMONSTRATOR IAM for FPHTI IOCSs read: "column item is interrelated to line item" D = determines/influences P = positively affects N = negatively affects R = requires M = mutual interdependent S = supports/causes/enables H = hinders/obviates L-/M-/H- = low/moderate/high effect	membership policy	organisational structure	role of the IOCS	roles of the actors	(working) processes	data management system	mechanism of consensus	mechanism of economic participation	mechanism of moderation	mechanism of targeted activity	mechanism of corporate IOCS culture	mechanism of the critical mass	mechanism of informal exchange	mechanism of political capital	mechanism of progress	GP 'Knowing the value of the number'	GP 'Let the market rule the game'	GP 'No-loser policy'
objective (technological innovation)	M-D		L-D				M-R	H-D	L-R						L-D			
function (joint problem solving)	H-D		M-D				M-R		M-R							H-R		M-R
subfunction (sf) 1 (high attractivity)	M-D	L-D	L-D	L-D	L-D		H-R	M-D	M-D	M-D	H-R					H-R	H-R	H-R
sf 2 (perceived relational risk reduction)				L-D	M-D		H-P	L-D	M-S		H-R	L-R	M-R	H-R		M-R		M-R
sf 3 (institutional trust)		L-D	M-D		M-D	L-D	L-R	M-R			M-R	M-R				M-R		M-R
sf 4 (foster knowledge exchange)		M-D	M-D	M-D	H-D	M-D			M-R	H-R			M-R		M-R		M-R	
boundary which is permeable in both ways	H-R							M-R	H-R		H-R		M-R					
coopetitive					L-R		H-A	H-R	H-R		M-R	L-R	H-R		M-R	M-R	L-R	L-R
voluntary	H-R		L-D	L-D	L-D		H-R	M-R	M-R			M-R			H-R	M-D	H-D	M-D
social pathway	H-N				M-R		M-R		H-R		H-R		H-R	H-R				H-R
large number of actors		L-D			M-D		M-N	L-R	H-R	L-R	M-R	H-P	M-R	L-N	L-R	L-R		L-R
high diversity of actors				L-D	M-D		M-S	L-N	H-R	L-R	M-R	M-P	M-R				L-S	
highly dynamic actor composition							M-N		M-R		H-R		M-R	L-R	M-N			
inter-organizational r&d activity				L-D	L-D	L-D		M-D		M-D					M-D			
horizontals (competitors)							M-N	H-R	H-R		L-R		M-R		M-R	H-R	M-R	H-R
verticals	M-R				L-D		H-P	L-N			M-R	H-P	M-R		M-P	M-R		
external factors - not given in assessment																		

Figure 70: revised IAM demonstrator segment B2

DEMONSTRATOR IAM for FPHTI IOCSs read: "column item is interrelated to line item" D = determines/influences P = positively affects N = negatively affects R = requires M = mutual interdependent S = supports/causes/enables H = hinders/obviates L-/M-/H- = low/moderate/high effect	no compass delegates	no corporate IOCS culture established	no formation heritage	no reputation	smaller number of actors	lower diversity of actors	higher relative dynamics	less patent affine setting
external factors - not given								
verticals	L-N	M-N		M-N				
horizontals (competitors)	M-N	H-N	H-N		M-N			
inter-organizational r&d activity		M-N		M-N	L-N		M-N	
highly dynamic actor composition				L-P				
high diversity of actors				M-N				
large number of actors				M-N				
a 'social piano'	H-N	H-N			M-P	M-P	M-N	
voluntary	L-N	M-N		H-N				
coopetitive	M-N	H-N			L-N	M-N		
boundary (both way permeable)								
sf 4 (foster knowledge exchange)	M-N	H-H			M-F	L-F	M-N	
sf 3 (institutional trust)		H-H		M-H				
sf 2 (perceived relational risk reduction)	H-R	H-R			M-F	L-F	H-H	
sf 1 (high attractivity)	L-N	M-N		H-R	H-R			
function (joint problem solving)	M-N	H-N		M-N	M-A	M-N	M-N	
objective (technological innovation)	H-N	M-N		M-N			M-N	
GP 'No-loser policy'	H-N	H-N	M-N	H-R	H-R		H-R	
GP 'Let the market rule the game'	H-N	H-N	M-N	H-R				
GP 'Knowing the value of the number'	H-N	H-N	M-N	H-R	M-R		H-R	
mechanism of progress	L-N		L-A		M-P	M-P		
mechanism of political capital		M-H	M-H		L-F	L-F	L-H	
mechanism of informal exchange	M-R	H-R				M-F	H-R	
mechanism of the critical mass	L-N	L-N			M-N			
mechanism of corporate IOCS culture	H-N	H-N	M-N		M-F	M-F	M-N	
mechanism of targeted activity	L-N				L-P	M-P	L-N	
mechanism of moderation	H-R	H-R	M-R		M-F	L-F	M-R	
mechanism of economic participation								H-N
mechanism of consensus	H-N	H-N	M-N		M-F		M-H	
data management system			M-F		L-D			
(working) processes	L-N	M-N	M-A		L-F		L-H	
roles of the actors	M-H	L-H	M-A	M-D	L-F			
role of the IOCS	M-N		M-N	M-D	L-D			
organisational structure			M-F		L-F		L-N	
membership policy			M-F	H-D	L-F			
efficiency and effectiveness of IOC	H-N	H-N			H-P		H-N	
institutional trust		L-N						
perceived relational risk reduction	H-N	H-N			H-P	M-P	H-N	
enhance collaborative activity								
Effect assessment of relative attributes	↓ sociocultural robustness	↓ sociocultural robustness	↓ rational robustness	↓attractivity	↓robustness to abuse, ↓ alternatives to alliance		↓ rel. trust, ↑ rel. risk	

Figure 71: IAM demonstrator segments D1 and D2

DEMONSTRATOR **IAM for FPHTI IOCSs** **read:** **"column item is interrelated to line item"** **D = determines/influences** **P = positively affects** **N = negatively affects** **R = requires** **M = mutual interdependent** **S = supports/causes/enables** **H = hinders/obviates** **L-/M-/H- = low/moderate/high effect**	Effect assessment of relative attributes	enhance collaborative activity	perceived relational risk reduction	institutional trust	efficiency and effectiveness of IOC
membership policy			L-A	L-A	H-A
organisational structure		M-A	M-A	H-A	
role of the IOCS	has to create more stability	M-A	H-A	L-A	
roles of the actors		M-A		M-A	
(working) processes		H-A	M-A	H-A	
data management system		L-A	L-A	H-A	
mechanism of consensus	more difficult to conduct	H-A	M-A	M-A	
mechanism of economic participation	NOT APPLICABLE	L-A	L-A	M-A	
mechanism of moderation	especially important	H-A	L-A	H-A	
mechanism of targeted activity		M-A	L-A	H-A	
mechanism of corporate IOCS culture	rather poorly developed	H-P	L-A	M-A	
mechanism of the critical mass	difficult to build	L-A	M-A	L-A	
mechanism of informal exchange	especially important	H-A			
mechanism of political capital	especially important				
mechanism of progress		L-A	L-S	L-S	
GP 'Knowing the value of the number'	less internalized and established	M-P			
GP 'Let the market rule the game'		L-A			
GP 'No-loser policy'			L-S		
objective (technological innovation)					
function (joint problem solving)					
subfunction (sf) 1 (high attractivity)					
sf 2 (perceived relational risk reduction)					
sf 3 (institutional trust)					
sf 4 (foster knowledge exchange)					
boundary which is permeable in both ways					
coopetitive			M-N		M-D
voluntary					M-D
social pathway			H-N		H-N
large number of actors			H-N		L-N
high diversity of actors			H-A		L-N
highly dynamic actor composition			H-N		H-N
inter-organizational r&d activity					
horizontals (competitors)					
verticals					
external factors - not given in assessment					
no compass delegates	↓ sociocultural robustness		H-N		H-N
no corporate IOCS culture established	↓ sociocultural robustness		H-N	L-N	H-N
no formation heritage	↓ rational robustness				
no reputation	↓attractivity				
smaller number of actors	↓robustness to abuse, ↓ alternatives to alliance		H-P		H-P
lower diversity of actors			M-P		
higher relative dynamics	↓ rel. trust, ↑ rel. risk		H-N		H-N
less patent affine setting					

Figure 72: IAM demonstrator segments C and E

Table 14: Assessing the applicability of 3GPP's institutions for FPHTI IOCSs

Institution	**Assessment**	**Suggestions for adaption**	**RC**
Recommendation codes (RC): 0 = adoption; 1/2 = adaption with minor/moderate modifications; 3= no adaption			
membership policy	The membership policy has to compensate for the less established reputation of FPHTI IOCSs compared to 3GPP and has thus to put special emphasis on providing alluring conditions in order to attractive all relevant players.	Based on a thorough analysis of the economic and industrial background of relevant actors, which shall be attracted, the membership policy and the mechanism of economic participation should be aligned and focused to their needs and means. This should include the implementation of different types of memberships if actor diversity makes this necessary.	1
organisational structure	The member-driven, group-structured, self-organised 'platform' organisation of 3GPP is a good fundament to conduct satisfying and effective IOCA		0
role of the IOCS	The role of the IOCS can be regarded as an institution which can be used and adapted to compensate for the missing sociocultural robustness in FPHTI IOCSs due to their younger age and smaller size compared to 3GPP	A shift towards a higher degree of intervention may be considered (see the following section). However, this should not be the first means of choice and cannot be generally suggested but requires a detailed analysis of a specific IOCS, because an adaption of the IOCS's role results in an irreversible and fundamental different characteristic of the complete IOCS and its conception, which puts all other institutions into question. Especially, it significantly affects the actor's (perception of) (self-)efficacy.	1
roles of the actors	The role of the actors is an institution which can be adapted to compensate for the missing sociocultural robustness in FPHTI IOCSs due to their younger age and smaller size compared to 3GPP	The adaption of roles is a moderate and reversible means to (temporarily) compensate for power imbalances and may thus be considered. This may include the introduction of certain sub-roles or different types of roles (for example based on an actor's role in the market), which enables the implementation of quotes in processes and/or for the mechanism of consensus.	2
(working) processes	Processes are regarded as one of the most potential institutions for the compensation of missing sociocultural robustness in FPHTI IOCSs due to their younger age and smaller size compared to 3GPP	Processes are a powerful and suggested approach to create additional robustness and stability for IOC. For example, the implementation of quota systems for certain working steps, the initiation of activities and/or decision taking which afford the integration of or cooperation between different types of roles is an effective yet little fundamental means to prevent abuse and manipulation of the institutions by one (dominant) group of actors with common interests.	2
data management system	The data management system at 3GPP seems to be a little effective formation heritage.	FPHTI IOCSs should choose a data management system which meets the present standard of document identification, traceability, and user-friendliness.	3

mechanism of consensus	The mechanism of consensus, especially of a 100% consensus, is perceived as fundamental and irreplaceable basis for IOC in voluntary IOCSs.	It is highly suggested for FPHTI IOCSs to adapt or even adopt the consensus mechanism of 3GPP.	0
mechanism of economic participation	The mechanism of economic participation is strongly built on the high – and rather unique – patent affinity in 3GPP's core sector ICT.	Although the installation of a mechanism of economic participation is essential for IOC and the basis for knowledge exchange, FPHTI IOCSs should develop an own mechanism, which suits the IPR and/or economic participation culture of an IOC projects core sector(s). This may indicate another form of IPR-based participation (like open source at W3C) or even a mechanism, which is not build around IPR.	3
mechanism of moderation	The mechanism of moderation is perceived as decisive for IOC at 3GPP. However, this mechanism becomes even more important for IOC and the functionality of all other institutions which require sociocultural interaction in IOCSs if an IOCS has no compass delegates, no common culture, and/or a highly dynamic actor composition.	For FPHTI IOCSs, the mechanism of moderation may be the most decisive institution for successful IOC. It has to and can compensate for the relatively low robustness and relational and institutional trust in FPHTI IOCSs compared to 3GPP. However, this requires designating good moderators, meaning highly respected and accepted delegates who have a strong ability to reveal true incentives, emotions and motives of fellow actors in order to provide a basis for IOC and the effectiveness of other institutions. That is why an FPHTI IOCS should promote the importance of the function of a moderator in order to both gain capable candidates and support a responsible voting behaviour.	0
mechanism of targeted activity	The mechanism of targeted activity is highly recommended to stay focused and limit the sources for potential conflicts and discontentment.		0
mechanism of corporate IOCS culture	3GPP has a long established, commonly interpreted and by compass delegates advocated IOCS culture.	The mechanism is much weaker in younger IOCSs. That is why FPHTI IOCSs have to put much more emphasis and effort in the implementation and development of a corporate culture, which may include a more concrete definition of 'Dos and Don'ts' with regard to sociocultural behaviour, regularly feedback sessions with an open discussion of apparently deviant behaviour and the expectations on an IOCS culture in order to promote the development of one concerted cultural identity.	1
mechanism of the critical mass	The mechanism of the critical mass mandatorily accompanies the mechanism of consensus. However, in IOCSs with fewer actors, the mechanism is less robust to abuse and manipulation and at the same time restricted to fewer alternatives, which may make the process to build critical mass more difficult.	The mechanism of the critical mass naturally develops if the mechanism of consensus is adapted or adopted. However, in FPHTI IOCSs the moderator will play a much more pivotal and directing role for the process of critical mass development. In addition, it might be necessary to enhance the robustness against abuse and manipulation, for example by quote systems.	2

mechanism of informal exchange	The mechanism of informal exchange is the basis for technological excellence from expert pooling and for the disclosure of true incentives and motives for compromising. However, at 3GPP this mechanism requires rather little 'official' guidance any more due to the high continuity of (compass) delegates and their concerted welcoming and integrating attitude towards newcomers.	The mechanism of informal exchange is pivotal for consensus-based IOC. That is why FPHTI IOCSs should put much emphasis into the guidance and promotion of informal exchange, for example by arranging social get-togethers and/or informal side-meetings between certain (groups of) actors. For the latter, the moderator again plays an important role if informal meetings are not fixed in general rules or procedures.	1
mechanism of political capital	The mechanism of political capital is a social effect which naturally evolves around sociocultural interaction with a concerted code of conduct, especially if actors and their goal attainment is interdependent of other actors.	FPHTI IOCSs should foster and accentuate the value of political capital. It is again the moderator who has a decisive role because he or she has to publicly pinpoint deviant behaviour without inappropriately showing the malefactor up. In addition, regularly implemented feedback sessions as suggested for the development of a corporate IOCS culture may help to make actors more sensitive to the value of fellow actors with a high political capital for effective IOC.	1
mechanism of progress	The mechanism of progress is a market-induced mechanism in IOCSs which aim to satisfy market demands and highly supports the give-and-take which is necessary in order to build a critical mass and/or find consensus.	As FPHTI IOCSs aim to solve a concrete problem in the market, they are highly suggested to make use of this 'natural mechanism' in order to foster decisions and the willingness to compromise among its actors.	0
GP 'Let the market rule the game'	This GP is the basis for strict targeted activity and a lean scope of intervention which is both prerequisite if a broad variety of actors shall be attracted.	The adoption of this GP is highly suggested in order to both avoid anti-trust issues and to provide an IOC-setting which is acceptable and attractive for as many actors as possible regardless of their objectives because it does not curtail their economic independence and activity. An FPHTI IOCSs should realize this GP by clearly restricting the scope of intervention and the range of IOC activity to the minimum which is necessary to jointly reach the common goal.	0
GP 'Knowing the value of the number'	The two GPs are both essential in IOCSs which aim to develop one concerted solution with few – or best no – competing alternative solutions for the same problem.	An FPHTI IOCS always evolves because of a certain necessity or at least advantage to jointly innovate – may it be for economic and/or technology reasons. In either case, it has to be a main objective of the IOCs and its actors to bring and keep all relevant players in the IOCS, which is displayed by these GP. However, their intensity and interpretation might vary for different (FPHTI) IOCSs depending on their objectives and problem to be solved.	1
GP 'No-loser policy'			1

H Multi-scale typology of factors of effective IOC

Kozuch and Sienkiewicz-Malyjurek, (2016, 2016a) have researched on key factors at for effective IOC in the public sector. As a result, they developed the below presented multi-scale typology of factors which affect IOC, in which they differentiate if factors have a determining of influencing effect on IOC (Kozuch and Sienkiewicz-Malyjurek, (2016, pp. 106, see). Although the typology is founded in their research on the public sector, it may provide a comprehensive and substantiated orientation on potential key factors due to its rather universal and holistic character.

Table 15: Multi scale typology of factors of effective IOC according to Kozuch and Sienkiewicz-Malyjurek (2016, pp. 106)

Type	Factor
Factors of external environments	• governmental policy (central, regional, and local) • legal regulations • development of social problems and needs • national/regional culture • social conditions in the region • economic conditions in the region (e.g. employment, recession, inflation, budget deficit)
Factors related to organisation characteristics	• regulations in particular organisations • organisational, professional and social culture in individual organisations • leadership with organisational and communication skills • team building • resources of individual organisations (finance, time, physical space, • materials, equipment, working tools, appropriately skilled personnel) • type and structure of collaborative tasks • structure of working groups (heterogeneity, size) • common ground of collaboration (vocabulary, values of interests, understanding of working practices and group norms) • collaborative technologies (e.g. communication technologies, information systems) • adaptability to changing work requirements • flexibility and openness to changing circumstances of collaboration • organisation of work in individual organisations • organisational structure of individual institutions
Factors related to people characteristics	• experience in inter-organisational collaboration • professional competence of the employees from individual organisations • conflicts between personnel from individual organisations • informal connections between personnel from individual organisations • personality of the chiefs of individual organisations • friendship between personnel from individual organisations • respect between personnel from individual organisations • commitment (willingness to cooperate) of particular organisations to collaboration • trust between personnel from individual organisations • understanding between personnel from individual organisations

Instruments of inter-organisational collaboration	• professional and informal communication between personnel • from individual organisations • communication in inter-organisational working teams • coordination of inter-organisational working teams • coordination of working in individual organisations • incentives to inter-organisational collaboration • organisation of collaborative work (e.g. time pressured, competitive, rapidly changing, stable etc.) • level of shared inter-organisational knowledge • learning processes between organisations • joint trainings • error management in individual organisations • knowledge management in individual organisations
Relational factors	• close links between organisations • conflicts between organisations • expectations of collaborating organisations • constraints in inter-organisational collaboration • shared mission, vision and goals • interest in collaboration in fellow partners • ability to compromise between organisations • self-interest of individual organisations from collaboration • specialization of collaborating organisations • interdependence of the particular organisations • inter-organisational trust • equitable contributions to collaboration of each willing organisations • uncertainty conditions of collaborative work • time of inter-organisational collaboration (time limits, cycles of collaboration) • iteration of inter-organisational collaboration • roles of particular organisations in collaboration • balance between dependence and autonomy • inclusiveness to collaboration of needed organisations • demands of collaborative tasks • performance of inter-organisational collaboration • support within collaborating organisations • management of inter-organisational collaboration (styles, transparency of decisions and guidance e.g.) • joint decision-making by organisations

I Quality criteria framework for multi-method DSR research

The validation of this research is based on the quality criteria framework of Gerber, Tuckerand and Hofer (2018): Based on Martensson & Martensson (2007, p. 13). They have introduced a set of quality criteria which is especially developed to evaluate DSR artefacts in business and management research. As such, it specifically accounts for the method pluralism which is often inherent to business and management research problems and is especially suitable for the evaluation of artefacts in multi-method environments (Gerber, Tuckerand and Hofer, 2018, p. 16). Gerber at al.'s quality research framework is presented in Figure 73.

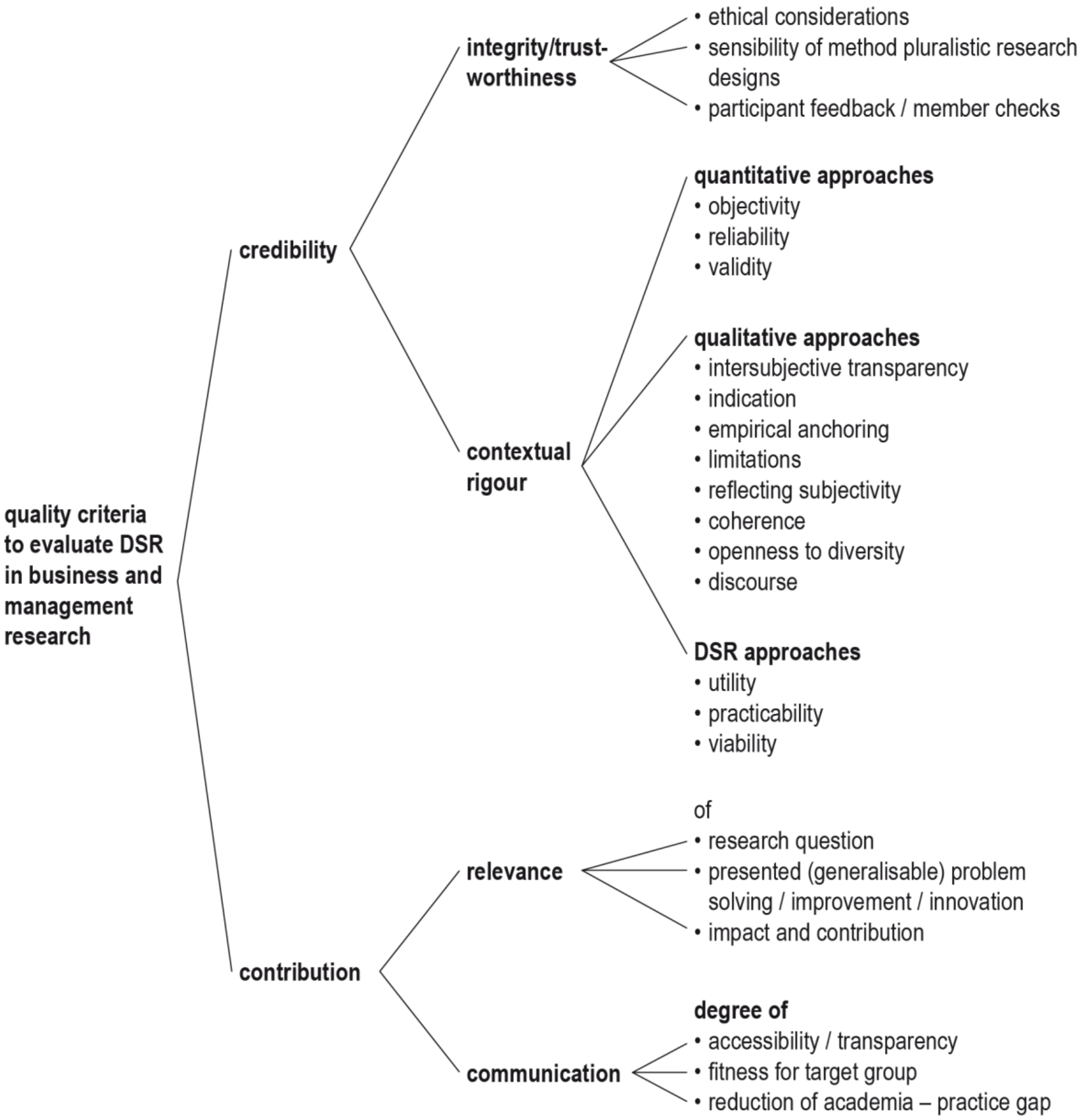


Figure 73: Gerber, Tuckerand and Hofer's (2007) quality criteria framework for DSR in Business and Management Research

It is a holistic validation approach, which allows to conduct a comprehensive validation of both the entire research approach and its different components with the therein applied methods. Because of this specific focus, validation of Gerber et al.'s quality criteria framework is still in progress (Gerber, Tuckerand. and Hofer, 2018). That is why the application of this framework for this research is accompanied by an extensive literature review on quality criteria in order to assess the qualification, appropriateness and integrity of the chosen validation criteria: Especially Martensson has conducted much more research on multidisciplinary quality criteria, including the development of a detailed research quality model (Martensson et al, 2016), that is based on his findings from 2007 (Martensson and Martensson, 2007), which he validated in international empirical studies among senior researchers (Martensson et al, 2019): The face validity attested Martensson's research quality model an overall validity and comprehensiveness, although some aspects have been evaluated to be less important. As Martensson's model and Gerber et al.'s framework shows a high overall consistency and correspondence of relevant elements, Martennson's validation also indicates the quality of Gerber et al.'s quality criteria framework with regard to content. The two approaches can easily be combined, which is used in this study to provide a tailored validation concept: It complements Gerber et al.'s framework by some quality criteria of Martennson et al (2016) and exchanges the generic quality criteria for qualitative approaches by specific criteria for case studies and grounded theory research.