EXPLORING THE IMPACT OF AUGMENTED REALITY AND VIRTUAL REALITY TECHNOLOGIES ON BUSINESS MODEL INNOVATION

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ETHICAL DECLARATION

I declare that this thesis is wholly my own work except where I have made explicit reference to the work of others. I have read the DBA guidelines and relevant institutional regulations and hereby declare that this thesis is in line with these requirements. I have discussed, agreed, and complied with whatever confidentiality or anonymity terms of reference were deemed appropriate by those participating in the research and dealt appropriately with any other ethical matters arising.

I have uploaded the entire thesis as one file to Turnitin on Moodle, examined my 'Similarity Report' by viewing the detail behind the overall 'Similarity Index', and have addressed any matches that exceed 3%. I have made every effort to minimise my overall 'Similarity Index' score and the number of matches occurring.

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Date: 31 March 2020

DEDICATION

This work is dedicated to my wonderful children Fiona, Phillip, and Ludwig; who enrich my life every day and who already have put “the most significant dent into my universe”.

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ABSTRACT

The entrepreneurial environment of the 21st century is becoming increasingly complex. Consequently, firms that strive to be successful in the long run need to employ new concepts to continuously reinvent themselves. Business model innovation (BMI) is such a concept. Furthermore, BMI can be impacted by the technologies augmented reality (AR) and virtual reality (VR). However, little is known about the effect of this impact. Therefore, this study's aim is to better understand the impact of AR/VR on BMI. The formal objective of the study is "*to explore the impact of AR and VR technologies on BMI*". To meet the research objective, the researcher constructs a theoretical research framework based on a business model (BM) and BMI literature review; designs and operationalises a phenomenologist, subjectivist, interpretivist research approach using a multiple case holistic "Type 3" case study design; and implements case data collection in form of semi-structured interviews in five companies that employed AR/VR for BMI. Case study data was collected between January and September 2019. The study indicates that AR/VR are well perceived. The technologies are used for short-term marketing benefits, to optimise company internal processes, and for the development of new products and services. However, working with AR/VR is challenging due to a low maturity level of the technology. Furthermore, BMI through AR/VR requires demanding decisions from management. The study further reveals that AR/VR are still young technologies that do not yet lead to new revenue streams, in most cases. However, research participants expect that the relevance of AR/VR will continue to grow in the future. The impact of AR/VR on BMI is a push in BM newness resulting in twofold consequences: it presents firms with new business opportunities, as well as with significant organisational challenges. Consequently, BMI efforts for AR/VR technology should be strategically guided.

Keywords: business model innovation, business models, augmented reality, virtual reality, case studies.

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Section One:

INTRODUCTION AND DBA RESEARCH OVERVIEW

1 Research Introduction

The aim of this research is to create a better understanding of the impact of augmented reality (AR) and virtual reality (VR) technologies on business model innovation (BMI). The formal objective of the study is to explore the impact of AR and VR technologies on BMI. AR and VR are 3D based technologies, e.g. “technologies … which operate with three-dimensional-data. The three dimensions are spatial coordinates”[1] (Astor *et al.*, 2013, p.10). The VR technology attempts to create visually realistic virtual 3d-experiences through specialised goggles which present 3d-simulations through interactive imaging. AR is a mezzanine-technology which combines the real and the virtual (Azuma, 1997) by enriching (augmenting) what an observer sees with digital information such as data or three-dimensional objects. This information can be shown in numerous ways, for example per smartphone, tablet computer, or specialised AR glasses.

This study was undertaken as part of a professional Doctorate in Business Administration (DBA) at Waterford Institute of Technology (WIT), Ireland. The researcher commenced the DBA program in October 2014. The WIT DBA program is divided in three phases. Phase 1 consists of five workshops for professional development and to build research expertise as a foundation for phases two and three. Phase 2 consists of writing four research papers (continuous paper series). In the researcher’s case, Paper 1, the Conceptual Paper, investigates the existing body of knowledge with respect to contemporary business model (BM) and BMI literature while reflecting on the impact of AR and VR technologies on BMI. A conceptual research framework is developed, and clear definitions of the BM and BMI concepts are given. Paper 2, the Methodology Paper, assures the scientific rigour of the study. The author derives a suitable research approach to achieve the research objective. Therefore, the paper reflects on the philosophical underpinnings of the research and justifies the research methodology chosen. Further, a roadmap how to operationalise the research is presented, and key issues are discussed. Paper 3, the Design Paper, offers a review of the research steps taken thus far and discusses initial learnings garnered from implementing a pre-pilot case study test run, two expert interviews, and a full pilot case study. Paper 4, the Findings Paper, describes five research cases in which AR or VR technology impact BMI. Case study data was collected between January and September 2019. Company background and research participant

[1] Translated from German by the author

descriptions are offered. An analysis of the findings arising from the case data is presented. Phase 3 of the DBA consists of the thesis write up and viva.

This introduction provides important background information to the study and essentially presents the reader with the research justification. The overall research context, the chosen research methodology, and detailed portrayals of the organisational contexts of the research case settings are introduced. This is followed by an outline of the overall thesis structure and synopses of the research papers. Findings and a discussion are presented in Section Three.

2 Research Context

2.1 The 21st Century – a Time of Change

The 21st century is the age of the "digital transformation". The creation of new markets and products have always been associated with risks (Venkataraman, 1997) and change has always been occurring (Chaston, 2000). However, business in the 21st century is becoming more and more complex and entrepreneurial (Sarasvathy, 2001). This is driven by the continuous emergence of new digital technologies (Kleber, 2016; Remane *et al.*, 2017). In this capacity, digitalisation[2] has already significantly impacted numerous industries, such as the recorded music industry (cf. Moreau, 2013), the motion picture industry (cf. Zhu, 2001), the consumer photo industry (cf. Weitzel, 2005), the taxi and hotel industry (Rayna and Striukova, 2016), as well as less prominent sectors, for example air-line marketing (cf. Jarach, 2002). In short, we live in a time of unprecedented global change (Brynjolfsson *et al.*, 2014).

Concrete examples of two technologies, which drive change – thereby offering significant opportunities in numerous industries – are AR and VR (Goldman Sachs, 2016; Ebert *et al.*, 2017). These technologies are at the technological centre of interest of this thesis. However, technology alone is "unlikely to produce sustainable profitability if business model configuration is not properly adapted to the competitive environment" (Teece, 2010, p.174). It is the BM, that links firms' performance and technology employment

[2] The author follows the differentiation of „digitisation" and "digitalisation" as proposed by (Brennen and Kreiss, 2014): digitisation is considered to be the process of digitising data by converting analogue data to digital data. Digitalisation refers to the phenomenon of increased usage of computer systems and digital technologies.

(Baden-Fuller and Haefliger, 2013). Therefore, the BM and BMI concepts are the second focal point of this thesis.

2.2 BMI, the New Frontier in BM Research

Companies may approach the commercialisation of new technologies through the development of BMs (Chesbrough, 2010; Brettel, 2015). The BM concept is a "stand-alone concept in its own right"(Baden-Fuller and Haefliger, 2013, p.419) and reaches "far beyond simple storytelling of how a firm does business" (Evans *et al.*, 2017, p.598). BMs are simplified but complete representations of how a given or planned company operates (Stähler, 2002) and what specific activities it engages in (Foss and Saebi, 2018). However, it is considerably more than just a building plan of a business: it should also be able to give insight into why a given business should exist (Stähler, 2016). As such, a BM "outlines the architecture of revenues, costs, and profits associated with the business enterprise delivering that value" (Teece, 2010, p.173). In this context, Foss and Saebi (2018, p.13) comment that "an architecture is not a list of the firm's mechanisms for creating, delivering, and capturing value, but a mapping of the functional relations among those mechanisms and the underlying activities".

From an analytical perspective, BMs are theoretical instruments (Osterwalder *et al.*, 2005). They are conceptual tools, which as a system illustrate "how the pieces of a business fit together" (Magretta, 2002, p.6). Said differently, BMs are blueprints describing how firms create and capture value (Timmers, 1998; De Reuver *et al.*, 2009) and go about their daily business (Osterwalder *et al.*, 2005). BMs themselves can become a source of competitive advantage (Magretta, 2002; Boons and Lüdeke-Freund, 2013; Bashir and Verma, 2017) and ultimately, the result may be that "a mediocre technology pursued within a great BM may be more valuable than a great technology exploited via a mediocre BM" (Chesbrough, 2010, p.354).

However, BMs are not static but dynamic in nature (De Reuver *et al.*, 2007). Therefore, companies who strive for sustainability must continuously reinvent their BMs (Sharma and Gutiérrez, 2010; Schaffer *et al.*, 2020). Brettel (2015) suggests that BMI might be created through the reconfiguration of BM components and BM design types. This, however, might be an oversimplification, as innovating a BM is significantly more than the mere development of a novel service or product (Frankenberger *et al.*, 2013). BMI can provide significant opportunities, especially during turbulent times (Giesen *et al.*, 2010). The age of the "digital transformation" is such a time – a time of accelerated economic growth and international turmoil. As a consequence, BMs "age faster than ever before" (Lindgardt and Ayers, 2014, p.2). BMI, however, is challenging (Euchner, 2016) – perhaps even more challenging than other innovation types (Snihur and Zott, 2013); such as product, process, service, or management innovations (Schallmo, 2013). Furthermore, BMI in practice is difficult to implement and risky (Euchner and Ganguly, 2014). As a result, many BMI efforts fail (Christensen *et al.*, 2016; Geissdoerfer *et al.*, 2018).

At least two fundamental dimensions for BMI exist: the degree of novelty of a new BM; and how new to an industry a BM is (Foss and Saebi, 2016). In either case, the challenge with new BMs is, that initial market and company-internal resistances need to be overcome. This can be exemplified by the online retailing business: "online retailing is now considered a legitimate business model; however, this was not always the case" (Snihur and Zott, 2013, p.10). Significant, initial market and stakeholder resistances had to be overcome. More generally speaking, BMI can refer to two fundamentally different ideas: BMI in the sense of inventing or introducing entirely new BMs (cf. Mitchell and Coles, 2003; Khanagha *et al.*, 2014; Christensen *et al.*, 2016), or BMI in the context of innovating an existing BM (cf. Santos *et al.*, 2009; Lindgardt and Ayers, 2014; Gassmann *et al.*, 2017). In the case of innovating an existing BM, the challenge arises that BMs are generally designed to resist change (Zott and Amit, 2010; Christensen *et al.*, 2016). This sends BMs down a path of a potentially predictable BM life cycle or journey (Morris *et al.*, 2015; Christensen *et al.*, 2016), thereby possibly failing to unlock the true potential benefits of active BMI.

BMI is a process (O Riordan *et al.*, 2014; Euchner and Ganguly, 2014) that describes either the alteration from one BM to another or the creation of completely new BMs (Geissdoerfer *et al.*, 2018), and may resemble other innovation processes (Frankenberger *et al.*, 2013). In this context, it is interesting to note, that innovation management processes themselves undergo change as well: traditional, linear processes such as the original Stage-Gate® process (cf. Cooper, 1983) no longer sufficiently support today's fast paced development cycles; instead they need to be updated to include dynamic concepts and feedback loops (Trott and Hartmann, 2009; Bers *et al.*, 2014; Sommer *et al.*, 2015). According to Bashir and Verma (2017, p.14) "the perks of business model innovation go beyond the product and process innovation ... [and] business model innovators will always outperform the product and process innovators".

The continuous rise of information and communication technologies results in the need for ever increasingly complex BMs (Osterwalder and Pigneur, 2004). However, neither BM development nor the impact of BMI have been exhaustively investigated (Wirtz *et al.*, 2016; Foss and Saebi, 2016). In brief, not just technology, but BMs for AR and VR must be innovative and continuously updated, as well. This innovation-process, however, needs to be managed, as a mal-fitting innovation-management-process may result in a lack of capturing value from innovation (Chesbrough, 2003). To sum it up, BMI is the next frontier for BM researchers, as it "represents a novel and more holistic form of organizational innovation" (Foss and Saebi, 2016, p.201).

2.3 The Impact of AR and VR Technology on BMI

BMs play a crucial role in capturing benefits from digital technology (Parida *et al.*, 2019). Consequently, emerging technological innovations and BMs are profoundly linked (Baden-Fuller and Haefliger, 2013) and BMI can be driven by emerging digital technologies, such as AR and VR (Euchner, 2016; Amit *et al.*, 2020). In this capacity, AR and VR technology can act as a trigger to initiate BMI (Casadesus-Masanell and Ricart, 2011) and BMI is an essential task when attempting to capture the benefits of technology driven transformation (Lambert and Davidson, 2013). As a matter of fact, technology development decisions are BM decisions (Baden-Fuller and Haefliger, 2013) and emerging digital technologies such as AR offer new BMI opportunities (Martinez *et al.*, 2019). As a result, BMI proficiency becomes particularly important in the context of emerging technologies (Amit *et al.*, 2020).

Jørgensen and Pedersen (2018) observe a growing list of AR/VR solutions that foster potential product and service improvements while reducing ecological footprints. For example, "augmented reality (AR) tools are poised to have great potential for organizations when it comes to complex processes in the field of industrial applications – like construction or maintenance in the automotive industry" (Jetter *et al.*, 2018, p.18). Corporations recognise these new possibilities, however, oftentimes it is challenging to use numerous new technologies at the same time (Rachinger *et al.*, 2019) – and a new technology usually needs to be integrated in pre-existing technology structures (Baden-Fuller and Haefliger, 2013). AR technology holds great potential to revolutionise the work process (Berkemeier *et al.*, 2019) and offers new ways of customer interaction (Ibarra *et al.*, 2018), for example in cultural heritage tourism, where the technology has gained increased attention by researchers (Cranmer, 2017).

BMs themselves may be shaped by technological innovations (Teece, 2006) and a new technology can foster BMI (Baden-Fuller and Haefliger, 2013). This is especially true in the high velocity environment of the internet, where BMs must be frequently altered to meet new challenges (Wirtz *et al.*, 2010). Consequently, BMI can become “a matter of corporate survival” (Zott and Amit, 2017, p.23). However, “it is ill-understood how changing market, technology and regulation conditions generally drive revisions in BMs” (De Reuver *et al.*, 2009, p.1). This observed gap between factual necessity and lived reality motivates the researcher to explore the impact of AR and VR technology on BMI.

2.4 Research Justification

The digital transformation forces companies to rethink their BMs (Ibarra *et al.*, 2018; Bouwman *et al.*, 2019) and firms need to build new BMs which are adapted to the new digital world (Zott and Amit, 2017). However, Parida *et al.* (2019, p.1) observe that “many research gaps remain in analyzing how industrial companies can leverage digitalization to transform their business models” and Rachinger *et al.* (2019) criticise the limited number of empirical insights into digitalisation in the context of BMs. Furthermore, only a very limited number of studies investigate what drives BMI (Snihur and Zott, 2020) and thus far “little attention has been paid to specific technological contexts” of BMI (Bouwman *et al.*, 2019, p.15). This case study deficit leaves businesses without guidance for understanding how to innovate their BMs (Evans *et al.*, 2017), which is problematic because once implemented (potentially inferior) BMs may resist change (Christensen *et al.*, 2016; Snihur and Zott, 2020). Lastly, Foss and Saebi (2018, p.17) observe that “relatively little is known empirically about where BMs come from, that is, the origination, *innovation* [emphasis added], dissemination, adoption, etc. of BMs” and point to a key issue in the BM and BMI literature landscape: the lack of cumulativeness caused by the lack of clarity in literature regarding the terms BM and BMI, as observed by numerous authors (e.g. Euchner, 2016; Foss and Saebi, 2016; Rayna and Striukova, 2016).

Given the comments above it becomes apparent, that more empirical studies on BMI are needed, as previously indicated by numerous scientists (e.g. Wirtz and Daiser, 2017;

Teece, 2018; Bouwman *et al.*, 2019; Berkemeier *et al.*, 2019; Amit *et al.*, 2020). The presented study – which explores the impact of AR and VR technologies on BMI – is such a study. The study is set in a concrete technological context (cf Bouwman *et al.*, 2019), namely AR and VR technology, and explores how/if the technology drives/impacts BMI (cf Snihur and Zott, 2020). The study also contributes to theory by offering clear and novel definitions of the concepts of BM and BMI. The author hopes that these definitions will support future efforts for increased literature cumulativeness.

2.5 Research Aim, Objective, and Research Questions

This research project is aimed at better understanding the impact of AR and VR technologies on BMI. The formal objective of the study is "*to explore the impact of augmented reality and virtual reality technologies on BMI*". To guide the research effort, research questions (RQs) were formulated. As the research progressed, research questions were reformulated, amended, dropped, and added. The final five research questions are summarised below, followed by detailed justifications per RQ.

RQ1: How are augmented reality and virtual reality technologies being applied by companies participating in the study?

RQ2: What are the anticipated effects of augmented reality and virtual reality technologies on business?

RQ3: What are the benefits of employing augmented reality and virtual reality technologies?

RQ4: What challenges do companies face, when implementing augmented reality and virtual reality projects?

RQ5: How can companies deploy and use augmented reality and virtual reality technologies for business model innovation?

2.5.1 RQ1: How are augmented reality and virtual reality technologies being applied by companies participating in the study?

AR and VR offer numerous new business opportunities and hold potential for the development of new applications. Examples are the fields of maintenance, assembly, training, and education (cf. Virtual Dimension Center, 2012; Sun and Tsai, 2012; Gavish *et al.*, 2015; Flug Revue, 2015; Zwettler, 2015; Westerfield *et al.*, 2015; Chen *et al.*, 2015); the area of marketing (cf. Runde, 2015; Scholz and Smith, 2016; Make, 2015); and the realm of remote collaboration (Oda *et al.*, 2015; Greenwald *et al.*, 2017). The aim of this research question is to describe the way companies apply AR and/or VR.

2.5.2 RQ2: What are the anticipated effects of augmented reality and virtual reality technologies on business?

BMI can be propelled by emerging digital innovations (Baden-Fuller and Haefliger, 2013; Euchner, 2016) and Deloitte (2017) suggests that companies should experiment with technologies such as AR. But where is this heading in praxis and what are the expectations of practitioners? The aim of this research question is to report how AR and VR technologies are expected to impact BMI according to people from practice.

2.5.3 RQ3: What are the benefits of employing augmented reality and virtual reality technologies?

Numerous authors predict a prosperous future for AR and VR technologies (cf. Kleber, 2016; Panetta, 2016; Digi-Capital LLC, 2016; Brohm *et al.*, 2017). Examples of companies who add AR or VR technology to their daily operations are the German rail and transport group (Bill Goodwin, 2015) and the furniture store IKEA (Demodern GmbH, 2017). However, technological innovations and BMs are profoundly linked (Baden-Fuller and Haefliger, 2013) and a mal-fitting innovation-management-process may result in a lack of capturing value from innovation (Chesbrough, 2003). Consequently, every new product effort should be amended by BMI efforts (Teece, 2010). The researcher would like to find out whether AR/VR technology employments are beneficial in the researched cases; and if so, what the benefits of these technology employments are? Therefore, the aim of this research question is to explore the benefits of employing AR/VR technology.

2.5.4 RQ4: What challenges do companies face, when implementing augmented reality and virtual reality projects?

New technologies always come along with new challenges. However, only few research projects address the challenges of BMI (Geissdoerfer *et al.*, 2018). Regarding the employment of AR/VR, Capgemini (2018, p.19) state “because the technology is new, it’s no surprise that organizations lack in-house AR/VR expertise. In fact, it is one of the top three barriers to growth identified by our respondents”. The aim of this research question is to get a deeper understanding of the challenges companies face, when implementing AR/VR projects.

2.5.5 RQ5: How can companies deploy and use augmented reality and virtual reality technologies for business model innovation?

Many of the world's top advisory and research firms identify AR and VR technologies to be a major strategic technology trend, offering numerous BMI opportunities (e.g. Gartner, Inc., 2016; Goldman Sachs, 2016; KPMG, 2017; Deloitte, 2017). However, it is not clear how this identified trend can be brought to praxis. Therefore, the aim of this RQ is to explore how companies deploy and use AR and/or VR to innovate their BMs.

3 The Research and the Researcher

The researcher is a Munich, Germany based entrepreneur in his mid-40s. His entrepreneurial focus centres on emerging digital technologies – such as AR and VR – and their application to new business opportunities. He graduated with a MSc Systems Engineering from Munich University of Applied Sciences, and BSc Electrical Engineering and Computer Sciences (second major) from the University of Wisconsin, US. He is the author of "Das 3D-Druck-Kompendium", a guide to 3d-printing for entrepreneurs, consultants and innovation drivers (Hagl, 2015). His passion and professional core functions are to consult customers on how to apply innovative technologies, as well as the conceptualisation and design of digital solutions and products.

In the past 25 years, the researcher has witnessed the fascinating developments of numerous digital companies such as Google, Apple, and Facebook; as well as Twitter, WhatsApp, Netflix, Spotify and so on. Inspired by these enormous successes, the researcher continuously strives to understand what makes these companies great and how similar successes can be accomplished. The reading of numerous mainstream books on entrepreneurship, as well as active networking, ultimately led the researcher to the WIT DBA program. He started the program with the vague notion of wanting to find out "how to make an idea or business successful" and arrived at the concept of BMI as a powerful tool to support entrepreneurs and managers.

A direct result of the researcher's learnings regarding BMI is the design of a novel BM for real estate distribution and the associated founding of the new company[3] ImmoPresenter 3D; a Proptech startup. The company was founded in September 2019. At its core is a solution combining VR and artificial intelligence. The envisioned system

[3] https://immopresenter3d.com/en/

aims to automate the decision-making processes of buyers and tenants in real estate sales and rentals. To achieve this, the unique and imminent strength of VR is employed, namely on the phenomenon of immersion.

4 Research Methodology and Philosophical Foundations

As previously stated, the formal objective of the study is "to explore the impact of AR and VR technologies on BMI". After clearly stating the research objective, a next critical step in the research process is the formulation of researchable research questions (Wellington *et al.*, 2005; Aslam and Emmanuel, 2010), as presented in Section 2.5. Having done that, the researcher next needs to think about his thinking (Johnson and Duberley, 2003), understand different research philosophies and research approaches (Jackson, 2013), take a philosophical position with regards to his perspective on the nature of reality (Creswell and Poth, 2017), decide on an adequate way for knowledge creation (Saunders, 2011), and reflect on his values regarding research choices (Saunders, 2011).

From an ontological perspective, the author is convinced that the social world is to a very large extent constructed in our minds by observing phenomena and attaching interpretations and meaning to them (phenomenological view). This conviction places the author in the ontological camp of subjectivism. Relating to the four paradigms for the analysis of social theory as proposed by Burrell and Morgan (1979), the author used to have a radical change view of society. Radical change plus subjectivism would have placed the researcher in the radical humanist paradigm. However, from experience the researcher observed, that technology driven changes he followed in the past had often unfolded significantly slower and much less revolutionary than he had anticipated. Consequently, he decided to adopt a regulatory view onto society. This however, is in line with the interpretive paradigm, rather than the radical humanist paradigm (Saunders, 2011). As a result, the author chooses to adopt an interpretive paradigm for this study, a wise decision, as it turned out. The epistemological consequence of the subjectivist approach to social sciences is an anti-positivistic[4] attitude towards knowledge-creation

[4] Anti-positivism is a synonymous expression for the epistemological stance of interpretivism (Bhattacherjee, 2012)

(cf. Burrell and Morgan, 1979). Hence, in summary, the research adopts a subjectivist, phenomenologist, interpretivist research philosophy.

After defining the researcher's philosophical stance, the qualitative research approach of case study research was selected as a suitable methodology. Generally speaking, case study research is a holistic, context-aware approach, considering multiple perspectives of the phenomenon under investigation (Hussy *et al.*, 2013). In this capacity, case study research is a suitable method of choice if the researcher wishes to investigate a contemporary phenomenon in its natural context (Yin, 2011), and strives to answer "how" or "why" questions (Yin, 2013). Both aspects hold true for this study. The study is aimed at the exploration of the contemporary phenomenon of the emerging technologies AR and VR; and strives to answer "how" questions. Therefore, this research is based on the case study research approach as outlined by Yin (2017). Yin (2017, p.48) formulates for formal case study research designs types. In the presented study, the researcher adopts a multiple-case holistic "Type 3" case study design. This means, that multiple AR and VR cases are analysed.

To sum it up, the researcher adopts a phenomenologist, subjectivist, interpretivist approach; using a multiple-case holistic "Type 3" case study design (cf. Yin, 2017, p.48). The case studies focus on business-to-business companies that have employed AR or VR technologies for BMI.

5 Organisational Context of the Research Cases

In order to get a view of the impact of AR/VR technologies on BMI, the researcher chooses five companies of different sizes and from different industries. Research cases were identified from a pre-existing company database of the researcher and via a rigorous process, namely a predefined structured online search (cf. Section 3.2 of Paper 2). The objective of the search is to specifically identify AR and VR applications/use cases. The researcher chose Germany as a geographical region for his research because Germany is quite active in the AR/VR field. Germany has an active AR/VR community[5] and is the European host of the "AWE" (augmented world expo) – the world's most prestigious AR/VR conference and expo held annually in Europe, Asia and the US (Messe München,

[5] for example XR Bavaria e.V. (https://xrbavaria.de)

2019). In 2019, the 5th International AR & VR Conference[6] was held in Munich, Germany, as well.

Overall, five companies are analysed, first individually (cf. Paper 4) and then on a cross case basis. For this, a structured online search (Google search) based on pre-defined key phrases was implemented. Key phrases were generated by combining the terms "augmented reality" and "virtual reality" with search key words identified from analysing the researcher's literature review implemented in Paper 1. All search activities and results were documented in detail to identify potentially interesting cases. The identified candidate cases were then entered into a database and assessed by the six case selection criteria[7] as designed in the Methodology Paper (Paper 2). Cases were selected non-randomly by the researcher's discretion. A brief overview of participating companies' details is provided in Table 1. Further company specifics are provided the sections below.

Table 1 – Participating company overview.

Company code	Number of employees	Number of years in operation	Brief case description
SteelCo	160.000	20, however, more than 100 when considering the company history prior to mergers.	Employing Head Mounted Augmented Reality for Spatial Measurement and Instant Project Visualisation
SportCo	15	5	Virtual Reality as Enabler for a Visionary New Product
TransportationCo	320,000	25, however, approximately 100 when considering the company history prior to mergers.	Personnel Recruiting with Virtual Reality
SanitaryCo	4	5	Sanitary Planning with Virtual Reality
SupplyCo	10,000	50	Using Augmented Reality to Assist Construction Workers

[6] http://arvrconference.com

[7] The six case selection criteria designed in the Methodology Paper are

1. a significant involvement of augmented reality and/or virtual reality technology;
2. the county of deployment must be or include Germany;
3. the case is completed, or passed a significant milestone, or has been aborted;
4. the case is relevant for business model innovation;
5. the case is applicable to business; and
6. the case is accessible.

The SteelCo case is included in the study because it promised to be interesting from the very beginning. The case received a lot of media attention and exemplifies how AR technology is used to increase the overall process efficiency of an established product from first customer contact to manufacturing. The SportCo case is included in the study because it offers the opportunity to understand how a startup uses VR technology to develop an entirely new consumer product. The TransportationCo case is included in the study because it demonstrates how a very large Corporation uses VR to innovate its recruitment process – a core challenge with strategic significance for TransportationCo. The SanitaryCo case is included in the study because it exemplifies how VR has arrived as an addition to a pre-existing design software solution. This addition enables SanitaryCo to innovate its sales process and arguably gain an innovative edge over its competitors. Lastly, the SupplyCo case is included in the study because it demonstrates that according to research participants AR technology has the potential to transform an entire company, as well as an entire industry.

5.1 Case 1 – SteelCo: Employing Head Mounted Augmented Reality for Spatial Measurement and Instant Project Visualisation

SteelCo is a diversified industrial group with a strong focus on steel processing. The annual turnover of SteelCo is in the EUR billions. The company has a history of more than 100 years. SteelCo is active in approximately 100 countries and the number of employees at SteelCo is 160,000. The company strives to innovate its product and service offering by digitalising company processes. SteelCo deployed a high-end augmented reality headset to help increase the overall process efficiency of an established product, from first customer contact to product manufacturing. A unique feature of this case is that the AR hardware employed was “hacked” in order to perform tasks, for which it hasn’t been originally designed. SteelCo’s solution is not a stand-alone solution but is integrated with pre-existing business processes and the sales cycle.

5.2 Case 2 – SportCo: Virtual Reality as Enabler for a Visionary New Product

SportCo is a five year old start-up focusing on new product development of their own hardware products and associated software, which are related to physical training, gaming, and physiotherapy. SportCo has 15 employees. The company develops a new VR-enabled sports device designed for VR. The product was conceived well before the commercial availability of high-performance VR hardware and software. Inspired by the market introduction of the Oculus Rift VR goggles, the founders decided to go ahead and launch the business. The product is successfully introduced to the market and it has won numerous design awards.

5.3 Case 3 – TransportationCo: Personnel Recruiting with Virtual Reality

TransportationCo is a leading logistics and mobility company in Germany with a history of more than 100 years. The number of employees in TransportationCo is 320,000 and its revenue in Germany is in the EUR billions. A core challenge for the company is the continuous staffing of several thousand open positions for hundreds of different job profiles. TransportationCo turned to VR to support the recruitment process of new personnel. For this, customised VR software was developed and 360-degree videos were shot at different job sites. The 360-degree videos are presented in VR for job candidates to see and experience different job settings.

5.4 Case 4 – SanitaryCo: Sanitary Planning with Virtual Reality

SanitaryCo specialises in modern sanitary, heating, and bath construction. SanitaryCo is a small business with four employees and was founded in 2015. The company uses a professional bathroom planning software to design projects for customers. A recent addition to this planning software is support for VR to present the designed and planned bathrooms. Thus, VR was deployed to support the design and sales process.

5.5 Case 5 – SupplyCo: Using Augmented Reality to Assist Construction Workers

SupplyCo is a large, internationally active manufacturer and supplier of scaffoldings, formwork systems, engineering services, and complementary products such as equipment rental or gear cleaning services. The company has a history of 50 years and its products are positioned in the premium segment. SupplyCo has approximately 10,000 employees and its annual revenue exceeds 1.5 billion EUR. SupplyCo develops an AR apps and cloud content management ecosystem to manage, distribute, and display AR content on construction sites. The AR content is aimed at supporting construction workers in setting up scaffoldings and formwork systems. Apps for tablets, smart phones, and selected AR headsets are available. The apps can be obtained from the publicly available app stores. Customer and product specific content can be downloaded after supplying login credentials. The apps are used by SupplyCo's employees, as well as by SupplyCo's customers. The needed 3D content is created in standard CAD software. A unique feature of SupplyCo's solution is that it is industry-neutral and could theoretically be transferred to other industries.

6 Structure of the Thesis

Overall, the thesis is structured as follows. Section One (this section) provides important background information to the study and presents the reader with the research justification. Furthermore, the overall research context, the chosen research methodology, and detailed portrayals of the organisational contexts of the research case settings are introduced. An integral part of the program is the writing of four research papers (continuous paper series). These papers are included in Section Two. Synopses of the research papers are offered in Section 7.

Section Three is dedicated to the detailed cross case analysis of the research case data. Further, research findings are discussed, conclusions drawn, contributions to theory and practice presented, recommendations for professional practice given, and research limitations talked about. The section closes with outlining further research opportunities and concluding remarks. Finally, in Section Four, extracts from the reflective log the researcher maintained over the course of the DBA program are presented.

7 Research Paper Series Synopses

7.1 Paper 1 – Exploring the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany. A conceptual framework.

Paper 1, the Conceptual Paper, reviews contemporary BM, BMI, and AR and VR related literature, and constructs a conceptual framework to explore the impact of AR and VR technologies on BMI in technology companies. The researcher observes that due to the ever-increasing complexity of the entrepreneurial environment paired with a wave of new digitally-based technological innovations, new concepts are needed to meet the challenges of the era of digitalisation.

In Section 2, the paper introduces the BM as a suitable candidate to be such a concept, and the following novel BM definition is derived from literature (e.g. Timmers, 1998; Hamel, 2001; Stähler, 2002; Osterwalder and Pigneur, 2002; Chesbrough and

Rosenbloom, 2002; Magretta, 2002; Osterwalder, 2004; Bouwman *et al.*, 2008; De Reuver *et al.*, 2009; Teece, 2010; Zott *et al.*, 2011; Al-Debei and Avison, 2010; Frankenberger *et al.*, 2013; Morris *et al.*, 2015; Foss and Saebi, 2016):

BMs are defined as simplified but complete, holistic and dynamic representations of how a company operates, comprised of four value-orientated elements namely: value proposition, value network, value creation mechanism, and value capture and finances; which when deployed at different firm levels can act in a business function capacity as a communication tool, a mediator between strategic objectives and technology, and/or a source of competitive advantage.

However, current BM concepts are too static. To overcome this limitation, the author further presents the topic of BMI – the next frontier in BM research – and conducts a BMI literature review (e.g. Mitchell and Coles, 2003; Hwang and Christensen, 2008; Zott and Amit, 2010; Sharma and Gutiérrez, 2010; Giesen *et al.*, 2010; Casadesus-Masanell and Ricart, 2011; Frankenberger *et al.*, 2013; Snihur and Zott, 2013; Baden-Fuller and Haefliger, 2013; Morris *et al.*, 2015; Foss and Saebi, 2016; Gassmann *et al.*, 2017), resulting in a novel definition of BMI, as presented below. Furthermore, the AR and VR technologies, and BMI opportunities enabled by them, are thoroughly investigated.

BMI is defined the continuous process of the creation of new business models or innovating any of the business model components or their interplay namely: value proposition, value network, value creation mechanism, value capture and finances; or innovating its business function capacity as a communication tool, mediator between strategic objectives and technology, and/or as a source of competitive advantage.

In Section 3, the author then presents the primary research questions and proposes a conceptual framework to explore the impact of AR and VR technologies on BMI. The paper contributes to literature by offering a clearer perspective of the BM concept and BMI with respect to AR and VR technologies as drivers for BMI. Most importantly, it adds to literature by constructing a novel conceptual framework to explore the impact of AR and VR on BMI in technology companies.

7.2 Paper 2 – Exploring the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany. A research approach.

Paper 2, the Methodology Paper, assures the scientific rigour of the study. The purpose of the paper is to design the research approach to achieve the research objective. Therefore, the paper reflects on the philosophical underpinnings of the research and justifies the research methodology chosen, in Section 2 of the paper. The researcher adopts a phenomenologist, subjectivist, interpretivist approach; using a multiple-case holistic "Type 3" case study design (cf. Yin, 2017, p.48). The proposed case studies will focus on business-to-business technology companies that have employed AR or VR technologies for BMI.

Section 3 of the paper is dedicated to the operationalisation of the research process and presents the documentation, data collection, data access, and data analysis strategies. Furthermore, the researcher discusses key issues regarding research timeline and ethical considerations. The paper then concludes with a summary in Section 4 and gives a brief outlook on the next research steps.

7.3 Paper 3 – Exploring the impact of augmented reality and virtual reality technologies on business model innovation in Germany. A research design.

Paper 3, the Design Paper, builds on the two previous papers (the Conceptual Paper and the Methodology Paper). The researcher offers a review of the research steps taken thus far, describes how the research operationalisation strategy worked in praxis; and discusses initial learnings garnered from the implementation of a pre-pilot case study test run, two expert interviews, a full pilot case study, and research log reflection.

The assessment of the collected pilot case study data leads the researcher to implement several amendments to the research design. Most notably, one research question is dropped, the remaining research questions are reformulated, and two new research questions are added. Furthermore, the researcher links research questions to praxis from experience. The research question modifications and link to praxis are included in Table 2. Furthermore, the technology scope under investigation is expanded, and the research focus widened, to not only include "technology companies".

Table 2 – Old and new research questions.

#	Old research question	New research question (as of end of Paper 3)	Link to praxis
Initial RQ1	What types of augmented reality and virtual reality technologies are German technology companies adopting for business model innovation?	(Dropped, refer to Section 3.3 for details)	Technology overview: hardware, software components, devices.
RQ1	How are augmented reality and virtual reality technologies being applied by German technology companies for business model innovation?	How are augmented reality and virtual reality technologies being applied by companies participating in the study?	What is going on, today? What can be / is AR/VR used for, today? (Identify use cases)
RQ2	What effects do augmented reality and virtual reality technologies have on business model innovation in German technology companies?	What are the anticipated effects of augmented reality and virtual reality technologies on business?	Where is this all going? (A preview into the future)
RQ3	How can German technology companies maximise the benefits of augmented reality and virtual reality technologies for business model innovation?	What are the benefits of employing augmented reality and virtual reality technologies?	How can who benefit from AR/VR? (Value proposition)
RQ4	n/a	What challenges do companies in Germany face, when implementing augmented reality and virtual reality projects?	What are the core challenges I have to address when introducing AR/VR into my company?
RQ5	n/a	How can companies in Germany deploy and use augmented reality and virtual reality technologies for business model innovation?	How do I get started? (Value creation mechanism) How do I successfully implement an AR/VR project? (Process/value creation mechanism)

7.4 Paper 4 – Exploring the impact of augmented reality and virtual reality technologies on business model innovation in Germany. Findings.

Paper 4, the Findings Paper, describes five research cases in which AR or VR technology impact BMI in companies. Furthermore, company background details and research participant descriptions are offered (see also Section 5 above). Lastly, an analysis of the findings arising from the case data is presented – chronologically and separately per case to do justice to the exploratory research approach. For the data analysis, the researcher follows a “think inside the box”, then “think outside the box” approach (cf. H. O’Connor and N. Gibson, 2003, p.66): first, data is analysed to answer the original research questions; then the data is skimmed for “surprises” and other unexpected and overarching themes or ideas. In Table 10 of Paper 4, the researcher presents a summary of how AR and VR impact BMI, as per the research objective. According to Creswell (2002), documents can be an important source of information in qualitative research. Hence the researcher kept the option open to include documents in the analysis, if interesting documents exist, are accessible, and contribute to the research (cf. Paper 2 Section 3.4.3). However, during research implementation, the researcher could not access documents he considered of valuable for analysis: in some cases, no documentation was available; in other cases, potentially interesting documents were classified and not provided to the researcher. Therefore, document analysis is excluded from the case data analysis.

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Section Two:

RESEARCH PAPER SERIES

PAPER 1: CONCEPTUAL PAPER

PAPER 1: “EXPLORING THE IMPACT OF AUGMENTED REALITY AND VIRTUAL REALITY TECHNOLOGIES ON BUSINESS MODEL INNOVATION IN TECHNOLOGY COMPANIES IN GERMANY. A CONCEPTUAL FRAMEWORK.”

Doctorate in Business Administration (DBA)

Participant Name: Richard Hagl 20068512
Supervisors: Dr Aidan Duane and Prof. Klaus Sailer

Date: 25 / 09 / 2017

RESEARCH PAPER SERIES

Paper 1:

CONCEPTUAL PAPER

"Exploring the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany. A conceptual framework."

ABSTRACT

Almost daily, new, digitally-based technological innovations emerge. Two prominent examples are augmented reality (AR) and virtual reality (VR). Innovation has long been identified as a key driver for competitive advantage, however, in today's fast-paced and globally-connected environment, technological innovation alone is not enough anymore. As a result, firms struggle to profit from digital innovations. Additional concepts are needed. Business model innovation (BMI) is such a concept. However, most entrepreneurs don't sufficiently understand what business models are, lack the skills to design appropriate models, and fail to innovate business models, as market conditions change. Furthermore, the business model concept is too static, remains vague, and concrete guidance from the academic world regarding business model innovation remains scarce. Hence, further business model innovation research is needed. This paper reviews contemporary business model, business model innovation, and augmented reality and virtual reality related literature, and constructs a conceptual framework to explore the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany. This paper contributes to literature by offering a clearer perspective of the business model concept and business model innovation with respect to augmented reality and virtual reality technologies as drivers for business model innovation. The planned study will contribute to praxis by developing a refined framework explaining the impact of augmented reality and virtual reality on business model innovation in technology companies. This refined framework will assist future research efforts and support entrepreneurs in the innovation of business models through emerging technologies, such as augmented reality and virtual reality.

ETHICAL DECLARATION

I declare that this submission is wholly my own work except where I have made explicit reference to the work of others. I have read the relevant notes, guidelines and procedures on conducting academic writing and research and hereby declare that this submission is in line with these requirements.

I have uploaded the entire submission as one file to Turnitin in Moodle, examined my “Match Overview” by viewing the detailed percentage listings and the overall “Similarity” score, and have addressed any matches that exceed 3%. I have made every effort to minimise my overall “Similarity” score and the number of matches occurring.

Name: *Richard Hagl*

Date: 25 September 2017

1 Introduction

Triggered by current developments in the US, a continuous stream of new, digitally-based technological innovations conquer the world, changing it fundamentally (Kleber, 2016). This phenomenon is part of the current mega-trend "digitalisation"[8] which has already significantly impacted numerous industries such as the recorded music industry (cf. Moreau, 2013), the motion picture industry (cf. Zhu, 2001), the consumer photo industry (cf. Weitzel, 2005), the taxi and hotel industry (Rayna and Striukova, 2016a), as well as less prominent sectors, for example air-line marketing (cf. Jarach, 2002). In short, we live in the age of the "digital transformation", a time of unprecedented global change (Brynjolfsson *et al.*, 2014).

Concrete examples of two technologies, with are expected to drive major change – thereby offering significant revenue opportunities – in numerous industries in the next few years, are augmented reality (AR) and virtual reality (VR) (Goldman Sachs, 2016; Ebert *et al.*, 2017). These technologies are at the technological centre of interest of the proposed study.

Companies may approach the commercialisation of new technologies through the development of business models (Chesbrough, 2010; Brettel, 2015). Business models can serve as communication tools (Magretta, 2002; Morris *et al.*, 2005) and "as a mediating construct between technology and economic value" (Chesbrough and Rosenbloom, 2002, p.532). To take things further, business models themselves can become a source of competitive advantage (Magretta, 2002; Boons and Lüdeke-Freund, 2013), as they are more difficult to imitate than product-, service-, or process-innovations (Schallmo, 2013). Ultimately, the result may be, that "a mediocre technology pursued within a great business model may be more valuable than a great technology exploited via a mediocre business model" (Chesbrough, 2010, p.354).

The continuous rise of information and communication technologies results in the need for ever increasingly complex business models (Osterwalder and Pigneur, 2004). However, neither business model development nor the impact of business model

[8] The author follows the differentiation of „digitisation" and "digitalisation" as proposed by Brennen and Kreiss (2014): digitisation is considered to be the process of digitising data by converting analogue data to digital data. Digitalisation refers to the phenomenon of increased usage of computer systems and digital technologies.

innovation have been exhaustively investigated (Wirtz *et al.*, 2016; Foss and Saebi, 2016). In brief, not just technology, but business models for augmented reality and virtual reality must be innovative and continuously updated, as well. This innovation-process, however, needs to be managed, as a mal-fitting innovation-management-process may result in a lack of capturing value from innovation (Chesbrough, 2003). Said differently, business model innovation is the next frontier for business model researchers, as it "represents a novel and more holistic form of organizational innovation" (Foss and Saebi, 2016, p.201).

Digital technologies, such as augmented reality and virtual reality, are drivers for business model innovation (Casadesus-Masanell and Ricart, 2011; Snihur and Zott, 2013) and business models themselves may be shaped by technological innovations (Teece, 2006). This is especially true in the high velocity environment of the internet, where business models must be frequently altered to meet new challenges (Wirtz *et al.*, 2010). However, "it is ill-understood how changing market, technology and regulation conditions generally drive revisions in business models" (De Reuver *et al.*, 2009, p.1).

This observed gap between factual necessity and lived reality motivates the author to investigate how the technologies of augmented reality and virtual reality are changing the business models of technology companies.

So far, business models which bring mobile augmented reality applications to commercial success aren't clearly defined (Bernardos and Casar, 2011) and according to van Kleef *et al.* (2010) there has been no real breakthrough for commercial augmented reality applications. This perception is likely to have changed with the release of the Nintendo's Pokemon GO smartphone game (cf. Niantic, Inc. *et al.*, 2016), which is possibly responsible for a significant surge in the company's stock value (Reuters, 2016), and continues to break records, for example becoming the fastest app in history to reach $ 500 million in revenue and the fastest game to reach $ 1 billion in revenue (Russell, 2017). Similarly, virtual reality is a fascinating new field likely to offer numerous benefits such as improved spatial understanding (Bowman and McMahan, 2007). According to neuro scientist Adam Gazzaley, virtual reality may very well be the next evolutionary step in information technology (Kleber, 2016). This is further supported by a survey conducted by Unity Technologies (2014), which concludes that architectural visualisation is entering a new era of innovation. As a result, design firms will profit commercially from these shifts in technology as new business opportunities emerge. However, as Visnjic *et al.*

(2016), as well as Zott *et al.* (2011) conclude, firms need to do more than just forge technology to appealing products and services: if they wish to fully realise the possible commercial potentials, they also need to design unique business models. Finding out how business models of technology companies are impacted by augmented reality and virtual reality technologies will be a valuable contribution to praxis of the planned research.

Despite an enormous market potential, very little is known about business model innovation for augmented reality and virtual reality. This observed gap is in line with Zott *et al.* (2011), who note that "academic research on business models seems to lag behind practice" (p.1022) and that "prior frameworks used in isolation cannot sufficiently address questions about total value creation" (p.1029). Helping close this gap is therefore expected to be valuable contribution to theory by the planned research.

In this paper, the author constructs from literature a theoretical framework to explore the impact of augmented reality and virtual reality technologies on business model innovation. Additional to deriving a theoretical framework, the proposed research empirically focusses on innovation of business models of technology companies, which is arguably impacted by the technologies augmented reality and virtual reality. The overall aim is to explore how augmented reality and virtual reality are impacting business model innovation in technology companies in Germany.

The remainder of this paper is structured as follows. Section 2 reviews the existing body of knowledge regarding business models, business model innovation, and the emerging impact of augmented reality and virtual reality technologies. Section 3 presents the primary research question before proposing and explaining the conceptual framework for the study. This section will also provide a brief overview of the proposed research methodology which will be described in greater detail in a subsequent paper. The paper concludes in Section 4 with a summary of the key aspects of the proposed study.

2 Literature Review

In this section, the author reviews the existing body of knowledge regarding business models, business model innovation, and the emerging impact of augmented reality and virtual reality technologies on business model innovation.

2.1 The Business Model Concept

Business models are simplified but complete representations of how a given or planned company operates (Stähler, 2002). However, it is considerably more than just a building plan of a business: it should also be able to give insight into why a given business should exist (Stähler, 2016). As such, a business model "outlines the architecture of revenues, costs, and profits associated with the business enterprise delivering that value" (Teece, 2010, p.173). From an analytical perspective, business models are theoretical instruments (Osterwalder *et al.*, 2005). They are conceptual tools, which as a system illustrate "how the pieces of a business fit together" (Magretta, 2002, p.6). Said differently, business models are an architecture for the flow of information, services, and products; and they describe revenue sources and benefits for the involved players (Timmers, 1998). Business models are blueprints describing how firms create and capture value (De Reuver *et al.*, 2009) and go about their daily business (Osterwalder *et al.*, 2005). An example of a business model as applied in praxis is shown in Table 1.

Table 1 – Example of the Business Model Canvas concept (Osterwalder and Pigneur, 2011) applied to the start-up ImmobilienChat GmbH (reproduced with permission of copyright holder)

<table>
<tr>
<td colspan="2" rowspan="2">Key partners
Service provider software development
Marketing agency
Call centre
External sales organisation</td>
<td colspan="2">Key activities
Portal development
Customer acquisition
Customer service optimisation
Continuous business modelling</td>
<td colspan="2" rowspan="2">Value proposition
Faster sales of property through new contacts, cross-market sales network, and increased portfolio
Direct access to property developer portfolios beyond qualified single contractors
Toolbox improve efficiency</td>
<td colspan="2">Customer relationship
Individually personally (key accounts)
Personally</td>
<td colspan="2" rowspan="2">Customer segments
Estate agents
Property developers (commercial and living)
Portfolio holder</td>
</tr>
<tr>
<td colspan="2">Key resources
Customer base and market leadership
ImmobilienChat portal
Support personal</td>
<td colspan="2">Channels
Direct sales
Phone and email
Online-marketing
ImmobilienChat portal
Existing network</td>
</tr>
<tr>
<td colspan="5">Cost structure
Start-Up and initial software development
Personnel costs (fix)
Consulting fees (variable)
Partner costs (variable, e.g. call centre)
Cooperation costs
Marketing and Sales
Organizational costs and rent</td>
<td colspan="5">Revenue streams
Monthly membership fees
Additional income through additional services and providing advertising space
Consulting and tailoring services (such as customer CRM integration)</td>
</tr>
</table>

Business models have only become a prominent and publicly discussed topic in recent years (Teece, 2010). While the term first appeared in the 1970s (Stähler, 2002), the concept became widely known and discussed with the rise of the Internet in the 1990s (Zott *et al.*, 2011). Realising that fast technological advances in combination with rapid growth in the e-business sector resulted in significant wealth creation opportunities (Amit and Zott, 2001), much of the initial work on business models attempted to answer the question how web-based firms could seize revenue streams (Nielsen and Lund, 2014).

Unfortunately, oftentimes these early business models failed to integrate sound business math, which resulted in the failure of many rather overoptimistically founded and funded companies (Magretta, 2002), and ultimately lead to the historic dot-com bubble, which reached its climax in the year 2000 (Kraay and Ventura, 2007). As a result, several authors contend, that the profit-formula should be a crucial element of the business model concept (Nielsen and Lund, 2014). However, the dot-com era, perhaps marking the beginning of the digitalisation age, did not only upset online entrepreneurs – it also devastated the business models of numerous industries (Teece, 2010). The effects of this development cannot be overseen: "half of the Fortune 500 companies from the year 2000 have disappeared: digital Darwinism is indeed in action we are already in the maelstrom" (Streibich, 2017, p.1). This emphasises the ever-increasing importance for entrepreneurs to understand how to design and innovate business models.

2.1.1 Functions of Business Models

Generally speaking, the business model is a "multifaceted concept" (Lambert and Davidson, 2013, p.669) and can be employed for several purposes. A literature review conducted by the author reveals that business models for technological innovations, such as augmented reality and virtual reality, likely may fulfil one or more of the following three functions:

1. communication tool
2. mediator between strategic objectives and technology
3. source of competitive advantage

An overview of business model functions and selected related articles is shown in Table 2.

Table 2 – Business model functions and related articles.

Business model function	Related articles (selection)
Communication tool	Magretta (2002) Osterwalder (2004) Morris *et al.* (2005) Al-Debei and Avison (2010) Nielsen and Lund (2014) Morris *et al.* (2015)
Mediator between strategic objectives and technology	Chesbrough and Rosenbloom (2002) Yuan and Zhang (2003) (Chesbrough, 2007a) Wang *et al.* (2009) Al-Debei and Avison (2011) Lüdeke-Freund (2013) Lambert and Davidson (2013)
Source of competitive advantage	Teece (2010) Zott *et al.* (2011) O Riordan *et al.* (2014) Morris *et al.* (2015) Foss and Saebi (2016)

2.1.2 Business Model Elements: The Value Domain

"At its heart, a business model performs two important functions: value creation and value capture" (Chesbrough, 2007a, p.12). Morris *et al.* (2005) describe business models as having strategic elements as well as being concerned with operational effectiveness. After analysing 30 business model definitions, they identify three principal business model categories. Zott *et al.* (2011) conclude that "the most prevalent component is related to the concept of value" (p.1037).

However, as the author discovered, the identification of *four* main elements is a common theme among business model scholars. Table 3 summarises the four business model elements identified by the author in an attempt to group similar components by column. The final row contains synthesised business model element descriptions as proposed by the author.

A potential insight from grouping the business model elements, as done in Table 3, is the observation, that there is a greater agreement regarding some business model elements than in respect to others.

Table 3 – Overview of the four business model elements grouped by author and synthesised descriptions

Author	Business model elements			
Hamel (2001)	core strategy	value network	strategic resources	customer interface
Stähler (2002)	value proposition	product or service	value architecture	revenue model
Osterwalder and Pigneur (2002)	product innovation	customer relationship	infrastructure management	financials
Bouwman *et al.* (2008)	technology domain	service domain	organization domain	financial domain
Hwang and Christensen (2008)	value proposition	processes	resources	profit formula
Al-Debei and Avison (2010)	value proposition	value network	value architecture	value finance
Frankenberger *et al.* (2013)	the what	the who	the how	the why
Brettel (2015)	value proposition	target customer	value creation	value capture
Rayna and Striukova (2016)	value proposition	value delivery	value creation	value capture
Synthesised descriptions (author's proposal)	*value proposition*	*value network*	*value creation mechanism*	*value capture and finances*

2.1.2.1 Value proposition

Here, authors mostly describe a value offering. Five out of nine scholars explicitly label the element "value proposition" (Stähler, 2002; Hwang and Christensen, 2008; Al-Debei and Avison, 2010; Brettel, 2015; Rayna and Striukova, 2016b). Further, the descriptions "product innovation" (Osterwalder and Pigneur, 2002)[9], "technology domain" (Bouwman *et al.*, 2008), and "the what" (Frankenberger *et al.*, 2013) in essence also describe a proposed value offering of a company. Hence the author argues, that the term "value proposition" is likely to be understood and accepted by most business model scholars and practitioners.

[9] Later, Osterwalder and Pigneur (2011) also use the term "value proposition" for general business model development

2.1.2.2 Value network

Regarding this element, there seems to be wide range of interpretations. A closer look reveals, that the majority of authors describe a relationship with their customer in this category (Stähler, 2002; Osterwalder and Pigneur, 2002; Frankenberger *et al.*, 2013; Brettel, 2015), or include the customer relationship aspect at least in part (Al-Debei and Avison, 2010; Rayna and Striukova, 2016b). However, a mere focus on the customer might be too limiting, as value can be exchanged between multiple stakeholders (Hamel, 2001; Al-Debei and Avison, 2010). Therefore, the author contends that the expression "value network" is a suitable summary term.

2.1.2.3 Value creation mechanism

In this case, the expressions "value architecture" (Stähler, 2002; Al-Debei and Avison, 2010) and "value creation" (Brettel, 2015; Rayna and Striukova, 2016b) are the leading expressions. All terms have in common, that the reviewed authors describe how the proposed value is created. This can be as simple as taking a detailed look at a company's resources and organisational structure, or by managing a complex network of partners. In all cases value is created. For the purpose of this paper, the author will summarise this element as the "value creation mechanism", noting that this needs to include the supporting infrastructure, e.g. organisational and administrative aspects, as well as the management of partners and suppliers.

2.1.2.4 Value capture and finances

Finally, the fourth element seems to be dominated by the question how a company captures profits. However, another important function, namely the firm's finances are also mentioned (Osterwalder and Pigneur, 2002; Bouwman *et al.*, 2008; Hwang and Christensen, 2008; Rayna and Striukova, 2016b). As previously noted, many companies failed in the dot-com rush, as they paid too little attention to the basics of business finances (Magretta, 2002). Hence the author will tag this element as "value capture and finances".

Simply identifying the primary elements of business models would fall short of noting that these elements are interdependent and interrelated, making the business model an overarching concept (Frankenberger *et al.*, 2013), which attempts to understand a given business holistically (Chesbrough and Rosenbloom, 2002; Nielsen and Lund, 2014). It is this holistic aspect, which makes the business model concept unique, leading some authors to observe or state that the business model can be considered a unit of analysis of its own (Stähler, 2002; Osterwalder *et al.*, 2005; Zott *et al.*, 2011; Frankenberger *et al.*, 2013).

2.1.3 Defining the Business Model

Given the findings presented above, in the context of this study, business models can be defined as: *simplified but complete, holistic and dynamic representations of how a company operates, comprised of four value-orientated elements namely: value proposition, value network, value creation mechanism, and value capture and finances; which when deployed at different firm levels can act in a business function capacity as a communication tool, a mediator between strategic objectives and technology, and/or a source of competitive advantage.*

2.2 Business Model Innovation (BMI)

Business models are not static, but have a dynamic nature (De Reuver *et al.*, 2007) and companies who strive for sustainability need to continuously reinvent their business models (Sharma and Gutiérrez, 2010). Furthermore "business model innovation can provide significant opportunities both during periods of rapid economic growth and at times of turmoil" (Giesen *et al.*, 2010, p.17). The age of the "digital transformation" is such a time – a time of accelerated economic growth, and international turmoil – in which "business models age faster than ever before" (Lindgardt and Ayers, 2014, p.2). At the same time, new digitally-based technological innovations coupled with innovative business models disrupt industry after industry (cf. Streibich, 2017). Hence, it is no surprise, that 54 per cent of CEOs surveyed in 2015 worldwide reported to worry about competition entering their markets (Christensen *et al.*, 2016), and that research conducted by the Boston Consulting Group in 2014 revealed that 94 per cent of the most innovative companies actively pursue business model innovation (Lindgardt and Ayers, 2014).

However, business model innovation is challenging (Euchner, 2016), perhaps even more challenging than other innovation types (Snihur and Zott, 2013); such as product, process, service, or management innovations (Schallmo, 2013). As a result, many business model innovation efforts fail (Christensen *et al.*, 2016). On the one hand, these failures might be caused by the application of business model concepts which are too static (Euchner, 2016;

Rayna and Striukova, 2016a). On the other hand, even innovative, fully-functional business models may fail to produce economic return for the initiator, if they don't successfully fend off more powerful imitators (Casadesus-Masanell and Ricart, 2011). As previously suggested by the "blue ocean strategy" idea (cf. Kim and Mauborgne, 2004), "almost any business model will perform brilliantly if a company is lucky enough to be the only one in a market" (Casadesus-Masanell and Ricart, 2011, p.4). On the opposing side, business models are likely to fail if surrounding market conditions and competitive settings are ignored. As a result, the strategic function of business model innovation is particularity promising for future research endeavours (Morris *et al.*, 2015), such as the planned research.

Lindgardt and Ayers (2014) define business model innovation as "the process of changing both the value that is promised to customers and how it is delivered to tap into new profit sources" (p.2), while Gassmann *et al.* (2017) derive their definition of business model innovation from the following business model definition: "the logic of the firm, the way it operates and how it creates and captures value for its stakeholders" (p.45). Accordingly, they conclude, that business model innovation "refers to a significant change of this logic" (p.45). Consequently, a first logical step towards business model innovation is a clear understanding of the business model concept itself (Foss and Saebi, 2016), as the author has done in Section 2.1.

Fourteen further business model innovation definitions are collected in table 3 of the Foss and Saebi (2016) paper (see Appendix A), not including their own definition of business model innovation, namely "designed, novel, nontrivial changes to the key elements of a firm's business model and/or the architecture linking these elements" (p.201).

At least two fundamental dimensions for business model innovation exist: the degree of novelty of a new business model; and how new to an industry a business model is (Foss and Saebi, 2016). In either case, the challenge with new business models is, that initial market and company-internal resistances need to be overcome. This can be exemplified by the online retailing business: "online retailing is now considered a legitimate business model; however, this was not always the case" (Snihur and Zott, 2013, p.10). Significant, initial market and stakeholder resistances had to be overcome.

More generally speaking, business model innovation can refer to two fundamentally different ideas: business model innovation in the sense of inventing or introducing entirely new business models (cf. Mitchell and Coles, 2003; Khanagha *et al.*, 2014; Christensen *et al.*, 2016), or business model innovation in the context of innovating an existing business model (cf. Santos *et al.*, 2009; Lindgardt and Ayers, 2014; Gassmann *et al.*, 2017). In the case of innovating an existing business model, the challenge arises that business models are generally designed to resist change (Zott and Amit, 2010; Christensen *et al.*, 2016). This sends business models down a path of a potentially predictable business model life cycle or journey (Morris *et al.*, 2015; Christensen *et al.*, 2016), thereby possibly failing to unlock the true potential benefits of active business model innovation. This is even more troubling, as continuous re-invention of an existing business is not optional these days, rather failing to do so will debatably lead to business failure (Frary, 2017; Kümmerlen, 2017).

Business model innovation is a process (O Riordan *et al.*, 2014) and may resemble other innovation processes (Frankenberger *et al.*, 2013). Brettel (2015) suggests that business model innovation might be created through the reconfiguration of business model components and business model design types. This, however, might be an oversimplification, as innovating a business model is significantly more than the mere development of a novel service or product (Frankenberger *et al.*, 2013).

Emerging technologies, such as augmented reality and virtual reality, can act as triggers to initiate business model innovation (Casadesus-Masanell and Ricart, 2011) and business model innovation is an essential task when attempting to capture the benefits of technology driven transformation (Lambert and Davidson, 2013). However, before entrepreneurs can go about innovating their business model, they need to comprehend what a business model actually is (Chesbrough, 2007a). In the next step, they need to develop an understanding when and how to perform business model change (Giesen *et al.*, 2010). Some authors therefore argue, that innovating business models should be approached similarly to other innovation methodologies, namely in a procedural manner (Frankenberger *et al.*, 2013; O Riordan *et al.*, 2014) and offer business model innovation frameworks (cf. Giesen *et al.*, 2010; Frankenberger *et al.*, 2013), business model classifications or templates (cf. Timmers, 1998; Gassmann *et al.*, 2013), design guides for business model development processes (cf. Simmert *et al.*, 2017), or outline the development of software tools to aid business model innovation (e.g. O Riordan *et al.*, 2014).

It is interesting to note, that innovation management processes themselves undergo change as well: traditional, linear processes such as the original Stage-Gate® process (cf. Cooper, 1983) may no longer sufficiently support today's fast paced development cycles; instead they likely will need to be updated to include dynamic concepts and feedback loops (Trott and Hartmann, 2009; Bers *et al.*, 2014; Sommer *et al.*, 2015). Given the author's previously derived definition of the business model concept (see p.43), three dimensions of potential business model innovation opportunities become apparent:

1. Innovating one or more of the four business model elements
2. Innovating the interplay of one or more of the four business model elements
3. Innovating the business function fulfilled by the business model

The author contends that the third aspect – innovating business model functions – is more complex to understand, than the first two innovation dimensions. Therefore, special attention is paid to this topic in the following section.

2.2.1 Innovating Business Model Functions

As the author showed previously, business models fulfil one or more of three fundamental functions (communication tool, mediator between strategic objectives and technology, source of competitive advantage). Hence, business model innovation may attempt to innovate one of more of these business model functions.

2.2.1.1 Communication tool

The business model can be used as a "focusing device for entrepreneurs and employees" (Morris *et al.*, 2005, p.734), as a way to explain to employees how a company works and what management expects (Magretta, 2002; Nielsen and Lund, 2014), and as a tool to aid management to structure, understand, adapt and implement their strategic objectives (Osterwalder, 2004; Nielsen and Lund, 2014). The importance of this function increases steadily. Why? Because in an increasingly complex and short-lived environment, firms have to continuously rework their business models (Chesbrough, 2007a; Giesen *et al.*, 2010), inform everyone in the firm about important changes in focus, and attempt to build new business models (Christensen *et al.*, 2016).

Business model innovation introduces a new “distinct type of innovation” (Snihur and Zott, 2013, p.26), which holds the potential for greater success than comparable innovation approaches (Simmert *et al.*, 2017). However, winning the approval of the necessary stakeholders for this type of innovation is particularly challenging (Snihur and Zott, 2013). Hence, the communication function of business models is a promising locus of investigation when exploring business model innovation for technological innovations, such as augmented reality and virtual reality.

2.2.1.2 Mediator between strategic objectives and technology

Business model innovation for emerging technological innovations must fulfil strategic functions (Pisano, 2015), which help managers or entrepreneurs to make sound decisions regarding the application of technological innovations and their accompanying business models (Morris *et al.*, 2015; Christensen *et al.*, 2016). Hence, business models can be viewed as “a mediating construct between technology and economic value” (Chesbrough and Rosenbloom, 2002, p.532). Business model scholars have recognised for some time, that technological innovations must be accompanied by business models (Chesbrough, 2007a; Al-Debei and Avison, 2011), because it is not merely the application itself, “but the business model behind the application that really determines the success” (Yuan and Zhang, 2003, p.1). Said differently, business models can act as crucial links between the technical domain and the economic domain (Lüdeke-Freund, 2013). Teece (2010) also highlights the importance of business models accompanying innovations by stating that “every new product development effort should be coupled with the development of a business model which defines its ‘go to market’ and ‘capturing value’ strategies” (p.183).

However, the role of technology in relation to business models is also a significant one, as it fundamentally influences which organizational structures are reasonable (Nielsen and Lund, 2014). Also, business models themselves can be moulded by technological innovation (Zott *et al.*, 2011). An example for this is mobile commerce (m-commerce), where a new technology requires specialised business models (for a m-commerce example see Yuan and Zhang, 2003) and the question of “how to build viable business models for m-commerce is becoming very important for both organizations and researchers" (Sharma and Gutiérrez, 2010, p.33).

In brief, the mediating function of the business model offers significant opportunities for business model innovation, especially in the context of emerging technological innovations.

2.2.1.3 Source of competitive advantage

In the past, business model scholars haven't paid enough attention to the role of the chosen business model and the link between technological innovation and competitive advantage (Baden-Fuller and Haefliger, 2013). However, "superior technology and products, excellent people, and good governance and leadership are unlikely to produce sustainable profitability if business model configuration is not properly adapted to the competitive environment" (Teece, 2010, p.174). Furthermore, the cost of new product developments have risen tremendously (Chesbrough, 2007a), while the expenses for communication and computing have been rapidly declining, thereby allowing for new ways to create and deliver value (Zott *et al.*, 2011; Snihur and Zott, 2013; Euchner, 2016). Ultimately, this leads scholars to agree, that – particularly in the field of information systems – technology does not lead to success by itself. One challenge, however, remains: developing a functioning business model alone doesn't automatically guarantee a competitive advantage, as the business model doesn't necessarily fend of imitators (Teece, 2010; Snihur and Zott, 2013). As a result, competitive measures must be strategically built into business models by design (Casadesus-Masanell and Ricart, 2011).

On the opportunity-side, business modelling is a way to outperform competition (Mitchell and Coles, 2003; Casadesus-Masanell and Ricart, 2011). As a result, competition has, in part, become a competition of business model innovation where the superior business model itself may become a source of competitive advantage (Zott *et al.*, 2011; Foss and Saebi, 2016). O Riordan *et al.* (2014) even observe that "legendary firms that shape their industry structures are in fact business-model innovators" (p.2). Failing to recognise this may result in failing to profit from innovations. This lesson learned is exemplified in the origins of the open innovation approach: after studying the innovation activities of the Xerox Corporation in the 1970s at the Palo Alto Research Center (PARC), Chesbrough (2003) concluded that Xerox had had a problem of capturing value from innovation. On the opportunity-side, companies can be successful with accomplishments of others (Chesbrough, 2004). As a consequence, Chesbrough (2004) proposes, that companies should open their innovation processes. Further, they should implement open business models (Chesbrough, 2007b). While Trott and Hartmann (2009) point out, that the open innovation idea "represents little more than the repackaging and representation of concepts and findings presented over the past forty years within the literature on innovation management" (p.715), they still observe that "Chesbrough has been very successful in popularising the notion of technology transfer and the need to share and exchange knowledge" (p.731).

Consequently, applying business model innovation to create and secure competitive advantage is a novel approach to inform business *strategy* and therefore offers a significant research opportunity (Morris *et al.*, 2015) – an opportunity seized by this paper.

2.2.2 Defining Business Model Innovation

To help mend the lack of clarity in literature regarding the term "business model innovation", as identified by business model innovation scholars (e.g. Euchner, 2016; Foss and Saebi, 2016; Rayna and Striukova, 2016a), the following definition of business model innovation is derived by integrating the findings above with the author's definition of the business model concept:

In the context of this study, business model innovation is defined as: *the continuous process of the creation of new business models or innovating any of the business model components or their interplay namely: value proposition, value network, value creation mechanism, value capture and finances; or innovating its business function capacity as a communication tool, mediator between strategic objectives and technology, and/or as a source of competitive advantage*.

2.3 Augmented Reality and Virtual Reality Technologies

A prominent subset of current technological innovations is a group of technologies that are 3d-based: 3d-products, 3d-technologies, and 3d-services are "products, technologies, and services which operate with three-dimensional-data. The three dimensions are spatial coordinates"[10] (Astor *et al.*, 2013, p.10). The author is particularly interested in the

[10] Translated from German by the author

following groups of 3d-based technologies: computer generated images (CGI)[11], virtual reality, augmented reality[12], and 3d-printing (3DP). Brief definitions of these technologies are given in Table 4.

For the purpose of this study, however, the scope of technologies is delimited to augmented reality and virtual reality. The reason for this is, that the conceptual and technical requirements for 3d-printing (e.g. the 3d-modelling requirements, processes, and tools) differ significantly from those of computer generated images, augmented reality, and virtual reality (Wiedemann, 2015). Second, augmented reality and virtual reality have roots in visual communication science (Portman *et al.*, 2015) and can be considered logical evolutionary next steps in the progression of computer generated images, hence making augmented reality and virtual reality mere subsets of CGI. However, from a technical and practical perspective, augmented reality and virtual reality are very closely related: 3d-modelling principles, modelling requirements, development processes, and software tools are very similar (Wiedemann, 2015).

Table 4 – Definitions of 3d-based technologies.

Term	Definition
Virtual reality (VR)	Virtual reality is a technology which attempts to create visually realistic virtual 3d-experiences. This is achieved through specialised goggles which present 3d-simulations through interactive imaging. Interactive in this case means, that the field of view ("what the user sees") is updated as the user moves his head too look around in a virtual environment. If equipped with further tracking systems, it is even possible for the user to move around in this virtual environment. Spatial sound and other technologies may enhance this experience even more.
Augmented reality (AR)	Augmented reality is a mezzanine-technology which combines the real and the virtual (Azuma, 1997). Augmented reality "enriches" (augments) what an observer sees, with digital information such as data or three-dimensional objects. This information can be shown via numerous ways such as a smartphone or tablet computer, a transparent screen-overlay, head-up-display technology, or specialised augmented reality glasses.
Mixed Reality (MR)	Mixed Reality is closely related/nearly identical to the concept of augmented reality. Some manufacturers, such as Microsoft Corp., differentiate between augmented reality and mixed reality, the difference being that mixed reality additionally provides for interaction with the environmental surroundings via an inside-out tracking approach, which does not require external tracking devices. For example, the Microsoft HoloLens mixed reality glasses, allow for the interaction of a virtual object with a physically present, haptic object (example: a virtual cup can be virtually placed onto a physically present table). For the purpose of this paper, however, this distinction is not necessary and not further mentioned.

[11] Including animations in the sense of moving images
[12] No refinement or detailed distinction between the terms "augmented reality" and "mixed reality" is made in this paper. See also Table 4 for further explanations.

From a practical perspective, it is not known whether one technology is advantageous over the other (Krichenbauer *et al.*, 2017). While in the past, the challenges posed by augmented reality applications were considered much greater than the challenges posed by virtual reality (Van Krevelen and Poelman, 2007), it can be now expected that, as early as by the year 2019, augmented reality might become a part of virtual reality – a scenario referred to as "dual use" (Ebert *et al.*, 2017, p.64). This idea can be underlined by the following example which shows that the technical and conceptual border between augmented reality and virtual reality cannot be clearly drawn. Let's consider a smart-phone-based[13] virtual reality application which utilises the front-facing camera of the phone. Operating in this mode is called "camera pass through". Adding information to the camera image shown in the smart-phone-based virtual reality application now actually results in an *augmented* reality experience on a *virtual* reality set-up. An example of a product employing this concept is the smartphone-based mixed reality headset "Bridge" (Occipital, Inc., 2017).

As explained, the technical and conceptual border between augmented reality and virtual reality cannot be clearly drawn. Thus, the technological focus of the proposed research is centred on both, augmented reality and virtual reality technologies.

2.3.1 Augmented Reality and Virtual Reality: Business Model Innovation Drivers

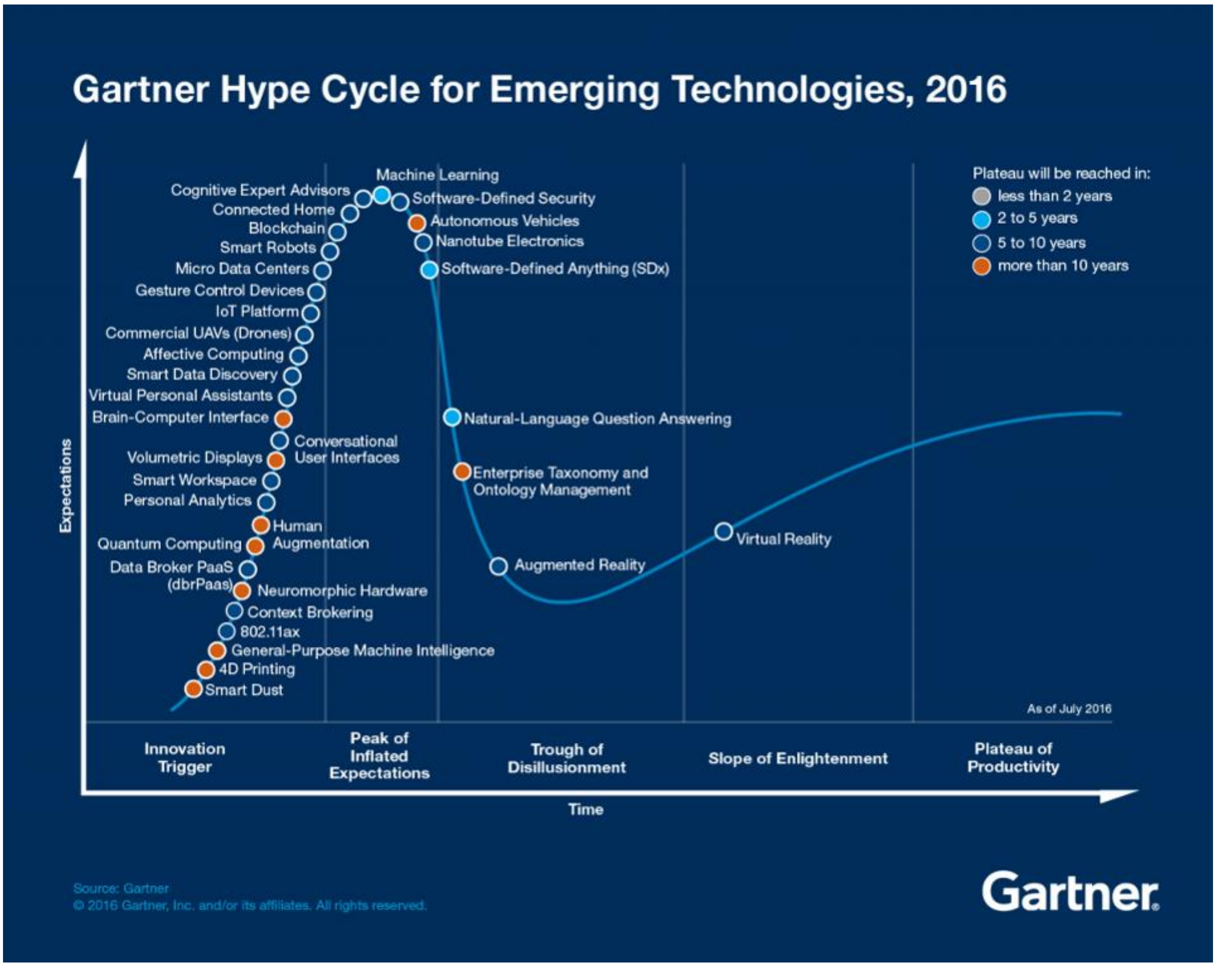
Emerging technological innovations and business models are profoundly linked (Baden-Fuller and Haefliger, 2013) and business model innovation can be driven by emerging digital technologies, such as augmented reality and virtual reality (Euchner, 2016). Ivan Sutherland introduced the idea of a three-dimensional display that presents "the user with a perspective image which changes as he moves" (Sutherland, 1968, p.757) as early as 1968 and thereby created the "first augmented reality system, which is also the first virtual reality system" (Arth *et al.*, 2015, p.2). However, it is today, almost fifty years later, that the world's leading[14] research and advisory company Gartner places augmented reality and virtual reality on their top ten strategic technology trends (Panetta, 2016) and concludes, that "transparently immersive technologies identified within this theme are at or over the Peak of Inflated Expectations, … and they are now poised to achieve real

[13] Prominent examples of smart-phone-based virtual reality headsets are the Samsung Gear VR (Samsung Electronics Co., Ltd., 2016) and Google Cardboard (Google, 2016)
[14] According to Gartner (http://www.gartner.com/technology/about.jsp)

productivity” (Walker, 2016, p.1). The Gartner hype cycle for emerging technologies 2016 is shown in Figure 1.

Put in numbers, augmented reality and virtual reality are expected to offer significant income opportunities in the next few years: combined, the optimistically forecasted annual revenue for augmented reality and virtual reality is as high as $120 billion by the year 2020 (Digi-Capital LLC, 2016). A more conservative prediction expects the market volume to jump from three billion dollars in 2016 to 40 billion by 2020 (SuperData LLC, 2017), which still is “almost double the commonly cited revenues for mobile and tablet combined in 2016” (Unity Technologies, 2016, p.4). Equity researchers Goldman Sachs (2016) expect revenue opportunities valued at $80 billion by 2025 in their base case.

Figure 1 – Gartner hype cycle for emerging technologies 2016 (Gartner, Inc., 2016).



These forecasts are founded on the assessment, that augmented reality and virtual reality have now reached a sufficient level of technological readiness (Ebert *et al.*, 2017), “offering more opportunity than ever before to create compelling AR experiences”

(Billinghurst *et al.*, 2015, p.3). While arguably gaming is the most obvious case for augmented reality and virtual reality, the potential applications for augmented reality and virtual reality seem endless and range through various industries, as well as numerous areas of private life (Brohm *et al.*, 2017).

The technologies are broadly seen as potential new training systems for maintenance and assembly tasks (Gavish *et al.*, 2015) and can assist during all steps of the manufacturing process (Virtual Dimension Center, 2012). The company Airbus, for example, uses an augmented reality display to aid airplane assembly (Flug Revue, 2015) and research conducted by Westerfield *et al.* (2015) even indicates, that "using an intelligent AR tutor can significantly improve learning compared to more traditional AR training" (p.157). An example of a potential future maintenance case is the „AR Maintenance System" research project conducted by the University of Bremen, which has the aim to employ augmented reality to assist the maintenance of wind turbines by providing service technicians with detailed information, as well as taking over documentation tasks (Zwettler, 2015).

Similarly, augmented reality and virtual reality promise to be beneficial for education and teaching purposes, for example by facilitating students with a virtual training platform of an injection moulding machine (Sun and Tsai, 2012), by putting students in situations or places that couldn't otherwise be accessed or visited (Greenwald *et al.*, 2017), by producing high levels of enjoyment during the learning process (cf. Harley *et al.*, 2016), or by improving learning motivation, student creativity, and the teaching of creative design (Wei *et al.*, 2015). Literature to date hasn't produced evidence yet, that augmented reality applications which support medical learning provide value (Barsom *et al.*, 2016). However, Chen *et al.* (2015) developed an augmented reality based surgical navigation system and were able to show that the system was accurate enough to meet clinical requirements.

Another area of interest is the field of marketing (Runde, 2015). As a matter of fact, many of the world's largest companies have already incorporated augmented reality and virtual reality into their marketing strategies (Scholz and Smith, 2016): "innovative marketers can now leverage augmented reality to craft immersive brand experiences, create more interactive advertising, and enable consumers to experience products and spaces in novel ways." (Scholz and Smith, 2016, p.2). Examples are an augmented reality colouring book by The Walt Disney Company (Make, 2015) and a virtual reality headset which can be folded from a McDonalds happy meal packaging (Radio Hamburg, 2016).

A study by McMahon *et al.* (2015) showed, that augmented reality navigation proved to be a more effective navigation solution than paper maps and online maps, such as Google Maps, for students with intellectual disability. Jung *et al.* (2016) discovered, that "entertainment experience from VR and AR can lead to enhanced overall tourist experience" (p.11). For destination marketing practitioners, attraction theme parks are a potential market for augmented reality applications (Jung *et al.*, 2015).

Employing augmented reality and virtual reality for remote collaboration also offers novel opportunities: who can a user interact with (e.g. remote people) and how can be interacted (Greenwald *et al.*, 2017). A concrete use case for remote collaboration is remote assistance, where a remote expert can "create and manipulate virtual replicas of physical objects in the local environment to refer to parts of those physical objects and to indicate actions on them" (Oda *et al.*, 2015, p.405). Air New Zealand is taking this approach even further: Microsoft's head mounted display HoloLens is tested to support the cabin crew by displaying passenger details, or even attempting to interpret passengers' body language (Air New Zealand, 2017).

Further promising fields are psychological research, where virtual reality offers unprecedented chances to study human behaviour (Diemer *et al.*, 2015), military training via an augmented reality first-person shooting solution (cf. Zhu *et al.*, 2015), city planning for energy production (Santana *et al.*, 2017), and virtual showrooms and product configurators – as pioneered by car manufacturer Audi (cf. Janssen, 2015) and furniture manufacturer IKEA (cf. Demodern GmbH, 2017).

Industry insiders identify new opportunities driven by virtual reality for journalism (cf. Albrand, 2015), and established television transmitters, such as ABC News, already introduced virtual reality to their reporting service offering (Förtsch, 2015). New start-ups also try to secure the emerging markets of virtual reality broadcasting (e.g. Jaunt Inc., 2017; NextVR, 2017) or virtual reality arcades (e.g. Virtual Area, 2017; Hologate, 2017; Playspace, VR, 2017).

Finally, virtual reality is a suitable new tool for teaching and research in architecture (Portman *et al.*, 2015) and virtual reality real estate presentation applications range from hotels presenting their room offering (e.g. Shangri-La Hotels and Resorts, 2016) to self-serviceable platforms targeting real estate agents (e.g. Transported, 2017).

In this section, the author reviewed the existing body of knowledge reading business models, business model innovation, and reflected on the emerging technologies augmented reality and virtual reality. Further, current business model innovation opportunities offered by these technologies were described. In the next section, the author presents the primary research question and constructs a theoretical framework to explore what impact augmented reality and virtual reality have on business model innovation.

3 Conceptual Framework

This section defines the primary research question before proposing and explaining the conceptual framework for the study. This section will also provide a brief overview of the proposed research methodology which will be described in greater detail in a subsequent paper.

3.1 Research Objective and Research Questions (RQ)

The formal objective of the proposed study is "*to explore the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany*". The purpose of this conceptual paper is to investigate the existing body of knowledge with respect to contemporary business model and business model innovation literature, while reflecting on the impact of the emerging technologies augmented reality and virtual reality on business model innovation, in order to develop an appropriate conceptual framework for the study. Therefore, this paper reviews contemporary business model, business model innovation, and augmented reality and virtual reality literature, and constructs a conceptual framework as discussed in the next section.

The overall aim is to explore how augmented reality and virtual reality are impacting business model innovation in technology companies in Germany. Accounting for the sought-after business model innovation outcomes – innovating an existing business model or creating new business models – the resulting primary research questions therefore are:

3.1.1 Research Questions

RQ1: What types of augmented reality and virtual reality technologies are German technology companies adopting for business model innovation?

RQ2: How are augmented reality and virtual reality technologies being applied by German technology companies for business model innovation?

RQ3: What effects do augmented reality and virtual reality technologies have on business model innovation in German technology companies?

RQ4: How can German technology companies maximise the benefits of augmented reality and virtual reality technologies for business model innovation?

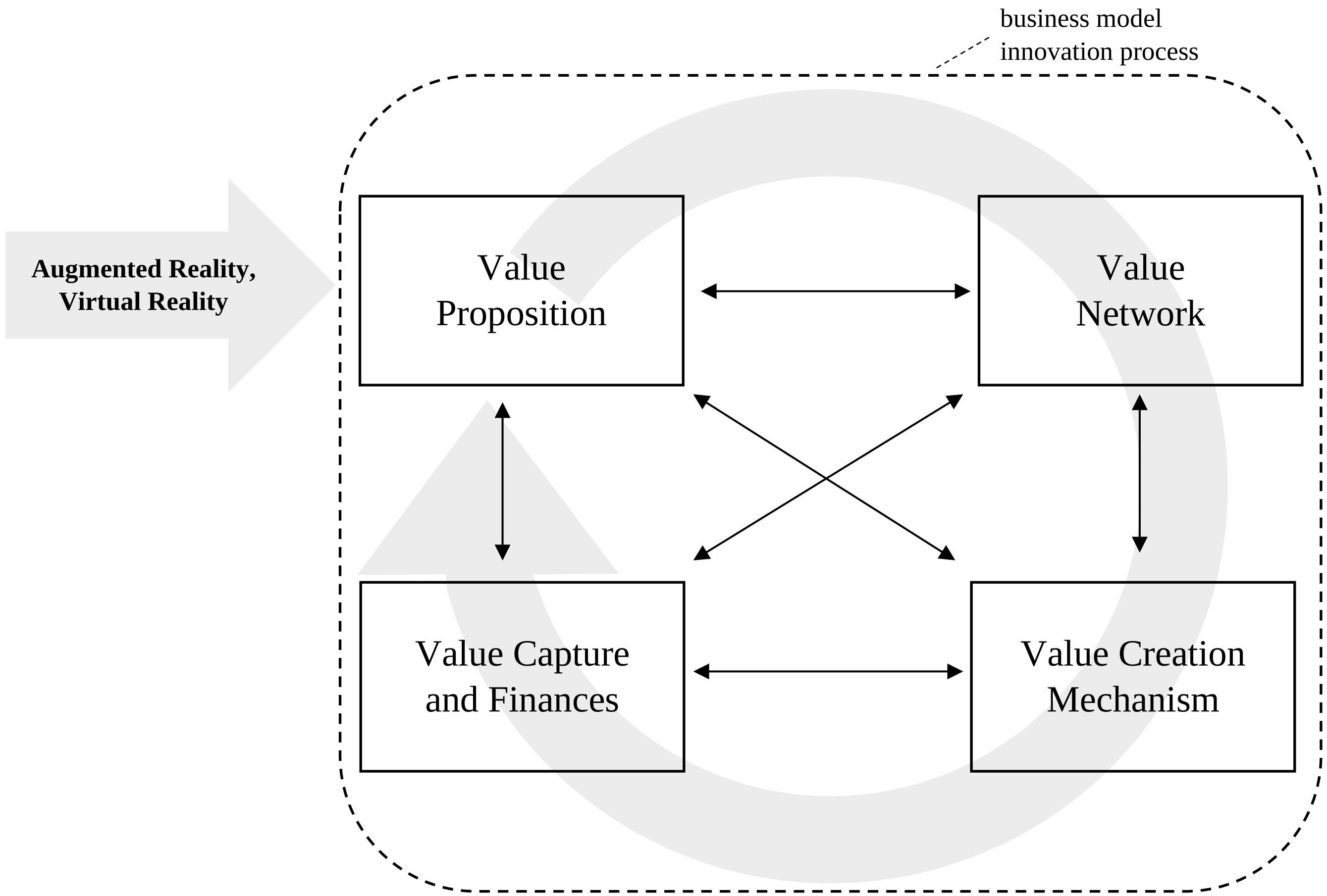
3.2 Conceptual Framework to Explore the Impact of Augmented Reality and Virtual Reality on Business Model Innovation

This paper proposes a conceptual framework to explore the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany. The resulting conceptual framework is presented in Figure 2.

To better understand the framework, the reader is directed to start at the right-hand side of Figure 2. There, the key findings of the business model and business model innovation literature review are summarised and amended by the final objective of the business model innovation process: the innovation of an existing business model or the creation of an entirely new business model. The left-hand side of Figure 2 presents an arrow labelled "augmented reality, virtual reality" indicating that these technologies offer new, potential business opportunities and therefore act as motivators to start the business model innovation process. At the centre of Figure 2, the business model value domains identified in literature are shown. They are connected by double-headed arrows, indicating that the business model is an inter-connected concept. Finally, a circular arrow in the background demonstrates that business model innovation is a continuous, dynamic process. Arguably, the first step in business model innovation can be the search for a new or improved value proposition, followed by the subsequent steps, as shown.

The planned research adopts a subjectivist, phenomenologist, interpretivist research approach; using multiple case studies of German business-to-business technology companies who (plan to) employ augmented reality and/or virtual reality to innovate their existing business models, or to create new business models, underpinned by multiple data collection approaches. The research methodology will be presented in a subsequent paper.

Figure 2 – Proposed conceptual framework to explore the impact of augmented reality and virtual reality on business model innovation in technology companies. (adapted from Chesbrough and Rosenbloom, 2002; Morris *et al.*, 2005; Al-Debei and Avison, 2010; Lüdeke-Freund, 2013)



Business model
- Simplified but complete representation of how a company operates
- Holistic approach

Business model elements
- Value based
- Interconnected

Business model functions
- Communication tool
- Mediator between strategic objectives and technology
- Source of competitive advantage

Business model innovation process
- Continuous
- Dynamic

Business model innovation outcomes
- Innovated business model
- New business model

4 Summary

Due to the ever-increasing complexity of the entrepreneurial environment paired with a wave of new digitally-based technological innovations, new concepts are needed to meet the challenges of the era of digitalisation.

In Section 2, this paper introduces the business model as a suitable candidate to be such a concept, and a novel business model definition is derived from literature. However, current business model concepts are too static. To overcome this limitation, the author further presents the topic of business model innovation – the next frontier in business model research – and conducts a business model innovation literature review, resulting in a novel definition of business model innovation. Further, the technologies augmented reality and virtual reality, and business model innovation opportunities through them, are investigated.

In Section 3 the author then presents the primary research questions and proposes a conceptual framework to explore the impact of augmented reality and virtual reality technologies on business model innovation.

This paper contributes to literature by offering clear definitions of the business model concept, as well as business model innovation, and by reflecting on these concepts in respect to augmented reality and virtual reality technologies. Most importantly, it adds to literature by constructing a novel conceptual framework to explore the impact of augmented reality and virtual reality on business model innovation in technology companies.

The planned study will contribute to praxis by developing a refined framework explaining the impact of augmented reality and virtual reality on business model innovation in technology companies. This refined framework will assist future research efforts and support entrepreneurs in the innovation of business models through emerging technologies, such as augmented reality and virtual reality. Despite an enormous market potential, very little is known about business model innovation through emerging digital technologies. Helping close this gap, will be a valuable contribution to theory.

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6 Appendix A

Table 5 – Business model innovation definitions table taken from Foss and Saebi (2016, p.210)

Selected Definitions of Business Model Innovation (Ordered Chronologically)

Authors	Definitions
Mitchell and Coles (2004a: 17)	"By business model innovation, we mean business model replacements that provide product or service offerings to customers and end users that were not previously available. We also refer to the process of developing these novel replacements as business model innovation."
Markides (2006: 20)	"Business model innovation is the discovery of a fundamentally different business model in an existing business."
Santos et al. (2009: 14)	"Business model innovation is a reconfiguration of activities in the existing business model of a firm that is new to the product service market in which the firm competes."
Aspara et al. (2010: 47)	"Initiatives to create novel value by challenging existing industry-specific business models, roles and relations in certain geographical market areas."
Gambardella and McGahan (2010: 263)	"Business-model innovation occurs when a firm adopts a novel approach to commercializing its underlying assets."
Yunus et al. (2010: 312)	"Business model innovation is about generating new sources of profit by finding novel value proposition/value constellation combinations."
Sorescu et al. (2011: S7)	"As a change beyond current practice in one or more elements of a retailing business model (i.e., retailing format, activities, and governance) and their interdependencies, thereby modifying the retailer's organizing logic for value creation and appropriation."
Amit and Zott (2012)	Innovate business model by redefining (a) content (adding new activities), (b) structure (linking activities differently), and (c) governance (changing parties that do the activities).
Bucherer et al. (2012: 184)	"We define business model innovation as a process that deliberately changes the core elements of a firm and its business logic."
Abdelkafi et al. (2013: 13)	"A business model innovation happens when the company modifies or improves at least one of the value dimensions."
Aspara et al. (2013: 460)	*Corporate business model transformation* is defined as "a change in the perceived logic of how value is created by the corporation, when it comes to the value-creating links among the corporation's portfolio of businesses, from one point of time to another."
Berglund and Sandström (2013: 276)	"A BMI can thus be thought of as the introduction of a new business model aimed to create commercial value."
Casadesus-Masanell and Zhu (2013: 464)	"At root, business model innovation refers to the search for new logics of the firm and new ways to create and capture value for its stakeholders; it focuses primarily on finding new ways to generate revenues and define value propositions for customers, suppliers, and partners."
Khanagha et al. (2014: 324)	"Business model innovation activities can range from incremental changes in individual components of business models, extension of the existing business model, introduction of parallel business models, right through to disruption of the business model, which may potentially entail replacing the existing model with a fundamentally different one."

RESEARCHER REFLECTIONS TO PAPER 1

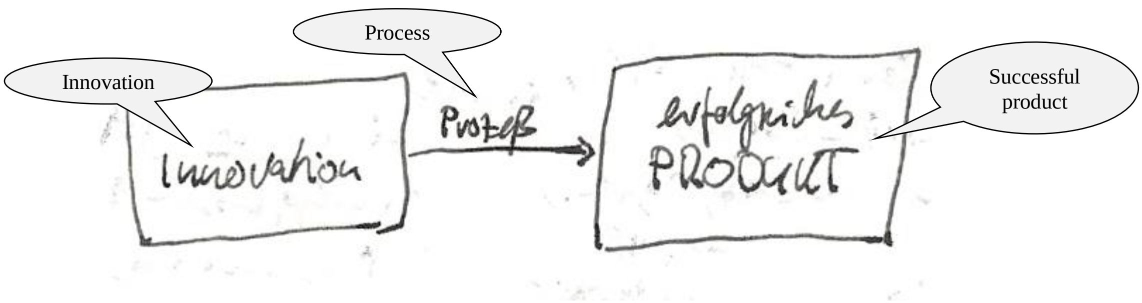
The first paper in the paper series is the Conceptual Paper. In this paper, a review of critical literature is presented to provide the theoretical foundation for aims and objectives of the thesis. The review needs to include state-of-the-art research of the chosen field, as well as seminal work.

For the researcher, this paper proved to be very challenging. From a high level perspective, the researcher struggled to adopt "business school like thinking". To him, being a trained engineer, social science concepts felt "unconvincing and soft", at the time. He asked himself questions like "where are the *hard* facts; where is *solid* proof?" His scepticism was further fuelled by the fact that a fellow student chose "business schools in a crises" as a research topic. The student presented numerous particulars regarding how business schools worldwide are failing to equip the students with the skills they need for practice. On top of being sceptical, perhaps even somewhat haughty, the researcher had started the DBA program with an admittedly naïve onset. In his research rationale, the researcher writes in November 2014 the following.

> "While Osterwalder and Pigneur (2002, p.76) find that "new business models are constantly emerging in electronic commerce" and introduce a new e-business model ontology, no concrete process exists regarding how to derive such business models, when planning is not an option due to uncertainty."

The original plan, so to say, was to develop an approach to manage dynamic innovation processes in the midst of new technologies, emerging markets, and further entrepreneurial aspects. Ideally, the result would be a simple process entrepreneurs can follow to build up a successful enterprise, as depicted in Figure 1 (explanations added in form of bubbles).

Figure 1 – Research rationale thoughts (researcher's log entry October 26, 2014).



This simplistic thinking paired with an overly complex, multidimensional setup (new technologies, emerging markets, and further entrepreneurial aspects) was the perfect recipe for disaster, as the researcher would painfully learn. On this path, the researcher reviewed numerous literature streams he ended up not using; for example effectuation theory, a thinking structure designed to aid entrepreneurs in early phases of their businesses (Society for Effectual Action, 2011), which was first formulated by Saras Sarasvathy (2001) in the year 2001; and produced what feels like an “endless number of theoretical frameworks”. Ultimately, the researcher worked on the Conceptual Paper from January 2016 until arriving at the final version as included in this thesis in September 2017. Looking back, the researcher is glad that he was forced to rethink his theoretical foundations until they were solid and strong. Once developed, the research framework guided and carried the researcher throughout the entire study.

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PAPER 2: METHODOLOGY

PREFACE TO PAPER 2

The second paper in the paper series is the Methodology Paper. In this paper, the research design and its planned operationalisation is presented. While writing the Methodology Paper, the researcher pushed forward in parallel with other tasks such as obtaining clearance from the ethics office and clarifying the legality of emailing or calling companies to ask for research participation. Furthermore, the researcher reflected further on the detailed wording of the research questions and discussed them with his supervisor. On February 28, 2018 Dr Duane writes in an email the following.

> "There is a big difference between GERMAN technology companies (i.e. they are German owned) and technology companies in Germany (i.e. any technology company operating in Germany). I assume you intend the latter?"

This clarification exemplifies one of many occasions where not being a native English speaker posed an additional challenge for the researcher. In his mind, this is exactly what the research questions were about, however, he then realised that this is not what the research questions state. On the same day he notes the following in his research log regarding the feedback of Dr Duane.

> "Yes, I want to focus on technology *companies that are operating* in Germany. Hence, when looking at the cases, I have to precisely look at where the case is deployed."

A second modification of the RQs is, that the researcher decided to drop the term "for business model innovation" from RQ1 and RQ2. The reason for this is, that at that time recent reports suggested that AR and VR have gained more momentum (Goldman Sachs, 2016) and that an upturn in the market is possible (Ebert *et al.*, 2017).; however, the actual pace of change remained unclear. Therefore, in the initial stage of this study it was imperative to first understand what is going on in practice before attempting to identify or propose any changes to the status quo. The RQ updates are summarised in Table 1. Later on, the research questions were to change yet again after the implementation of the pilot case study, which is presented in Paper 3 of the paper series.

Table 1 – Comparing research question updates between Paper 1 and Paper 2.

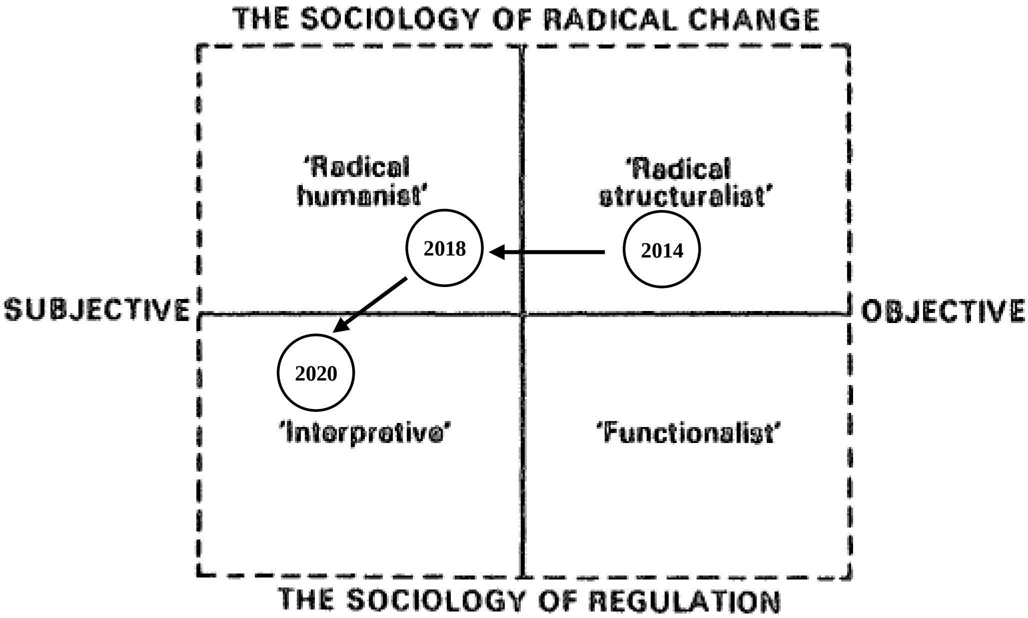
	Paper 1 wording	Paper 2 wording	Explanation (from Paper 2)
RQ1	What types of augmented reality and virtual reality technologies are German technology companies adopting for business model innovation?	What types of augmented reality and virtual reality technologies are technology companies in Germany adopting?	This RQ aims to identify the types of AR and VR technologies being deployed by technology companies in Germany.
RQ2	How are augmented reality and virtual reality technologies being applied by German technology companies for business model innovation?	How are augmented reality and virtual reality technologies being applied by technology companies in Germany?	This RQ aims to describe the specific manner in which technology companies in Germany employ AR and VR.
RQ3	What effects do augmented reality and virtual reality technologies have on business model innovation in German technology companies?	What impact does augmented reality and virtual reality technologies have on business model innovation in technology companies in Germany?	The aim of this RQ is to describe how AR and VR impact business model innovation in technology companies in Germany.
RQ4	How can German technology companies maximise the benefits of augmented reality and virtual reality technologies for business model innovation?	How can technology companies in Germany maximise the benefits of augmented reality and virtual reality technologies for business model innovation?	The purpose of this RQ is to identify the steps that technology companies in Germany can take, to maximise the benefits of AR and VR for BMI.

For the researcher, writing the Methodology Paper was quite an interesting, mind opening, and even enjoyable experience. Diving into research philosophy and learning about the scientific method as explained by Bhattacherjee (2012) solidified the researcher's comprehension of what science really is, for the first time in his life.

Following Holden and Lynch (2004) who state that in order to form a philosophical position, researchers first need to make basic assumptions regarding the nature of science, as well as the nature of society; the researcher thought about how adequate knowledge can be created (epistemology), reflected on his perspective on the nature of reality (ontology), and explored his values (axiology) and personal beliefs about human nature. Finally, combining the philosophy of science with theory of society, as proposed by Burrell and Morgan (1979), truly changed the researcher's view onto the world, for two reasons. One, his initial scepticism toward social science disintegrated and the researcher began to acknowledge that qualitative "non-engineering-like" approaches can produce valuable and valid knowledge.

Second, when taking philosophical position in the paradigm topology matrix developed by Burrell and Morgan (1979), the researcher observed a second fundamental shift in his view onto the world. Considering the theory of society dimension, the author generally confessed to a view of society of radical change. He believed that the social world – particularly politics, and business – are full of imperfections, chaotic structures, and dysfunctionalities; and that many of these unsatisfying, rigid structures should be changed: fundamentally, quickly, and radically. However, from experience the researcher deduced that technologically-driven changes unfold significantly slower and are much less revolutionary, than he had predicted and expected in the past. Therefore, he decided that taking a regulatory view of society is a more useful approach for the study. Looking onto the world today, the researcher believes that choosing the interpretive paradigm was not only prudent for the study, but that an interpretivist philosophy is a better approach to life than the paradigms previously adopted by the researcher. In essence, the researcher's worldview transformed from the radical structuralist paradigm to the interpretive paradigm via the radical humanist paradigm throughout the DBA journey, as illustrated in Figure 1. When he commenced his research project in October of 2014, the researcher viewed the world from the radical structuralist paradigm. After completion of Paper 2 in May 2018, the researcher accepted qualitative approaches as valid and adequate for the creation of knowledge, but kept his radical change view onto society, hence confessing to the radical humanist paradigm. He chose the interpretive paradigm for the study, perhaps out of caution and intuition; and of course also because his supervisor recommended it. At time of writing, March 2020, the researcher has switched his worldview to the interpretive paradigm, not only for the research study, but more fundamentally as his personal worldview.

Figure 1 – The researcher's paradigm journey (adapted from Burrell and Morgan, 1979, p.22)



The second major section of Paper 2 is research operationalisation. Here, the researcher was in his full element. Being a Systems Engineer and technology designer, the researcher enjoys structuring projects and developing plans for project implementation. The textbook *Case Study Research and Applications: Design and Methods* by Yin (2017) proved to be an excellent read and guided the researcher in all operationalising steps, from case study candidate identification and case access negotiation to data collection and data analysis strategies. The outcome of the Paper 2 examination was also significantly more enjoyable than the Paper 1 experience. The paper was immediately recommended and commended on by the examiners.

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PAPER 2: "EXPLORING THE IMPACT OF AUGMENTED REALITY AND VIRTUAL REALITY TECHNOLOGIES ON BUSINESS MODEL INNOVATION IN TECHNOLOGY COMPANIES IN GERMANY. A RESEARCH APPROACH."

Doctorate in Business Administration (DBA)

Participant Name: Richard Hagl 20068512
Supervisor: Dr. Aidan Duane

Date: 21 / 05 / 2018

RESEARCH PAPER SERIES

Paper 2:

METHODOLOGY PAPER

"Exploring the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany. A research approach."

ABSTRACT

Due to the ever-increasing complexity of the modern entrepreneurial environment; paired with a wave of newly-emerging, digitally-based technological innovations; companies need to develop new concepts to meet the entrepreneurial challenges of the 21st century. Business model innovation is such a concept. Business models are not static and need to continuously be innovated. Furthermore, they are impacted by emerging technologies such as augmented reality and virtual reality. However, little is known about the impact of augmented reality and virtual reality on business model innovation. Therefore, the overall research aim is to better understand the impact of augmented reality and virtual reality technologies on business model innovation in technology companies. The formal objective of the proposed study is "*to explore the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany*". In this methodology paper, the author reflects on the philosophical underpinnings of the planned research, justifies the chosen research methodology, and presents the research operationalisation strategy. To meet the research objective, the study adopts a phenomenologist, subjectivist, interpretivist approach; using a multiple-case holistic "Type 3" case study design. The proposed case studies will focus on business-to-business technology companies in Germany who have employed augmented reality and/or virtual reality technologies for business model innovation. The next research steps are obtaining ethical clearance from the academic review board, and the implementation of a pilot case study to test the data collection methods and the qualitative data analysis strategy outlined in this paper.

Keywords: business model innovation, augmented reality, virtual reality, emerging technologies.

ETHICAL DECLARATION

I declare that this submission is wholly my own work except where I have made explicit reference to the work of others. I have read the relevant notes, guidelines and procedures on conducting academic writing and research and hereby declare that this submission is in line with these requirements.

I have uploaded the entire submission as one file to Turnitin in Moodle, examined my "Match Overview" by viewing the detailed percentage listings and the overall "Similarity" score, and have addressed any matches that exceed 3%. I have made every effort to minimise my overall "Similarity" score and the number of matches occurring.

Name: *Richard Hagl*

Date: 21 May 2018

1 Introduction

The creation of new markets and products have always been associated with downside risks (Venkataraman, 1997), and continuous change has always been occurring (Chaston, 2000). However, business in the 21st century is becoming increasingly complex, and entrepreneurial (Sarasvathy, 2001). Furthermore, a continuous stream of new, digitally-based technological innovations are fundamentally changing the world (Kleber, 2016). As a result, the 21st century is the age of the "digital transformation", a time of unprecedented global change (Brynjolfsson *et al.*, 2014; Streibich, 2017).

Two prominent examples of contemporary digitally-based technological innovations are augmented reality (AR) and virtual reality (VR). These technologies are expected to offer significant revenue opportunities in numerous industries in the next few years (Ebert *et al.*, 2017; Deloitte, 2017). However, new technologies – such as augmented reality and virtual reality – oftentimes have no obvious business case (Chesbrough, 2010), initially; and it is unclear how business models can be innovated through these technologies.

As previously stated in Paper 1, the overall research aim is to better understand the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany. The theory underpinning the planned study was outlined in Paper 1, along with the conceptual framework which is also included in Appendix A. The purpose of this methodology paper is to design the research approach to achieve the research objective. Therefore, this paper reflects on the philosophical underpinnings of the planned research and justifies the research methodology chosen. Further, the author presents a roadmap of how to operationalise the research and discusses key issues regarding data access, data collection, research time line, and ethical considerations.

The researcher adopts a phenomenologist, subjectivist, interpretivist approach; using a multiple-case holistic "Type 3" case study design (cf. Yin, 2017, p.48). The proposed case studies will focus on business-to-business technology companies in Germany who have employed augmented reality and/or virtual reality technologies for business model innovation.

The rest of this paper is structured as follows. The next section (Section 2) presents the reasoning behind the chosen research questions; reflects on research philosophy and takes philosophical position; and concludes with presenting the chosen research approach. Section 3 is dedicated to the operationalisation of the research process and presents the documentation, data collection, data access, and data analysis strategies, amongst other related topics. The paper then concludes with a summary in Section 4 and gives a brief outlook on the next research steps.

2 Research Design

This section presents the research objective and discusses the reasoning behind the chosen research questions. The section also reflects on the philosophical underpinnings of the planned study. Furthermore, the author elaborates on the chosen research methodology.

2.1 Research Objective and Research Questions

The formal objective of the proposed study is:

"*to explore the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany*".

After clearly stating the research objective, a next critical step in the research process is the formulation of researchable research questions (RQs) (Wellington *et al.*, 2005; Aslam and Emmanuel, 2010). The primary research questions for the planned study are as follows:

2.1.1 RQ1: What types of augmented reality and virtual reality technologies are technology companies in Germany adopting?

To date, numerous kinds of augmented reality and virtual reality hardware and software solutions exist on the market (cf. RealityTechnologies.com, 2018), and new systems are being released or announced, almost daily (cf. TechCrunch, 2018). However, it is unknown which technology will prove to be superior over the other (Krichenbauer *et al.*, 2017) and, possibly, augmented reality might even become a part of virtual reality (Ebert *et al.*, 2017), or vice versa. Therefore, this research questions aims to identify the types of augmented reality and virtual reality technologies being deployed by technology companies in Germany.

2.1.2 RQ2: How are augmented reality and virtual reality technologies being applied by technology companies in Germany?

It is claimed that augmented reality and virtual reality offer numerous new business opportunities and potential for the development of new applications. For example in the fields of maintenance, assembly, training, and education (cf. Virtual Dimension Center, 2012; Sun and Tsai, 2012; Gavish *et al.*, 2015; Flug Revue, 2015; Zwettler, 2015; Westerfield *et al.*, 2015; Chen *et al.*, 2015); in the area of marketing (cf. Runde, 2015; Scholz and Smith, 2016; Make, 2015); or in the realm of remote collaboration (Oda *et al.*, 2015; Greenwald *et al.*, 2017). Hence, it is the aim of this research question, to describe the specific manner in which technology companies in Germany employ augmented reality and virtual reality.

2.1.3 RQ3: What impact does augmented reality and virtual reality technologies have on business model innovation in technology companies in Germany?

Oftentimes, business models and business model innovation are propelled by emerging digital innovations (Baden-Fuller and Haefliger, 2013; Euchner, 2016). Deloitte (2017, p.6) suggest that

> "enterprises should experiment enthusiastically but pragmatically with possible applications. Aside from marketing opportunities (such as the ability to place an AR-generated animated company logo anywhere or to superimpose a branded mask on a user's face), there are also possibilities for AR to assist with sales, technical guidance and aftermarket support".

While numerous authors predict a prosperous future for augmented reality and virtual reality technologies (cf. Kleber, 2016; Panetta, 2016; Digi-Capital LLC, 2016; Brohm *et al.*, 2017), thus far business models that lead augmented reality applications to success aren't yet defined (Bernardos and Casar, 2011), and commercial breakthroughs are yet to come (van Kleef *et al.*, 2010; Bastian, 2017). Examples of companies who are employing augmented reality or virtual reality technologies to their daily operations are the German rail and transport group who employs virtual reality as part of their recruiting strategy (Bill Goodwin, 2015; Innoactive GmbH, 2016); or the furniture store IKEA, who employs virtual reality to create a virtual showroom (Demodern GmbH, 2017), and augmented reality to support customers with the furnishing of their living rooms (Lehnert, 2017). However, the impact of augmented reality and virtual reality on business model innovation of these companies in particular, or businesses in general, remains vague. Therefore, it is the aim of this research question to describe how augmented reality and virtual reality impact business model innovation in technology companies in Germany.

2.1.4 RQ4: How can technology companies in Germany maximise the benefits of augmented reality and virtual reality technologies for business model innovation?

Many of the world's top advisory and research firms identify augmented reality and virtual reality technologies to be a major strategic technology trend, offering numerous business model innovation opportunities (e.g. Gartner, Inc., 2016; Goldman Sachs, 2016; Digi-Capital LLC, 2016; KPMG, 2017; Deloitte, 2017). Ebert *et al.* (2017) expect, that this trend will unfold in two steps: initially, augmented reality and virtual reality will be employed to optimise existing value chains (e.g. for cost reduction, increased quality, and emotionalization of products); a later phase will belong to the establishment of entirely new business models. Very little is known about the unfolding of this predicted later phase. Therefore, the purpose of this question is to identify the steps that technology companies in Germany can take, to maximise the benefits of augmented reality and virtual reality for business model innovation.

2.2 Research Philosophy

Johnson and Duberley (2003) encourage management researchers to think more about their thinking. Thus, prior to embarking on a research endeavour, it is essential that the researcher understands different research philosophies and research approaches (Jackson, 2013). The importance of this cannot be underestimated, because paradigm assumptions result in significant consequences regarding research implementation and interpretation of collected data (Evered and Louis, 1981; Guba and Lincoln, 1994). In the next sections, the author follows the encouragement by Johnson and Duberley (2003) and reflects on philosophy behind science.

2.2.1 The Scientific Method

Performing scientifically meaningful research requires the researcher to follow the scientific method, which is a "standardized set of techniques for building scientific knowledge," (Bhattacherjee, 2012, p.5). The scientific method rests on four fundamental assumptions:

1. replicability (others need to be able to repeat and replicate the performed research),
2. precision (concepts must be defined precisely enough, that they can be used by others),
3. falsifiability (theories need to be formulated such that they could potentially be rejected, if they were false, that is); and,
4. parsimony (the idea, that the simpler the explanation, the better) (Bhattacherjee, 2012).

Generally speaking, investigating a phenomenon can be approached in two ways: deductively and inductively (Saunders, 2011). Deductive research strives to empirically test concepts previously derived from theory (theory-testing approach), while inductive research attempts to propose new theory based on observed data (theory-building approach) (Bhattacherjee, 2012; Hussy *et al.*, 2013). The major differences between the approaches are summarised in Table 1.

Table 1 – Major differences between deductive and inductive approaches to research (Source: Saunders, 2011, p.127)

Deduction emphasises	Induction emphasises
• scientific principles • moving from theory to data • the need to explain causal relationships between variables • the collection of quantitative data • the application of controls to ensure validity of data • the operationalisation of concepts to ensure clarity of definition • a highly structured approach • researcher independence of what is being researched • the necessity to select samples of sufficient size in order to generalise conclusions	• gaining an understanding of the meanings humans attach to events • a close understanding of the research context • the collection of qualitative data • a more flexible structure to permit changes of research emphasis as the research progresses • a realisation that the researcher is part of the research process • less concern with the need to generalise

However, "not only is it perfectly possible to combine deduction and induction within the same piece of research, but also … it is often advantageous to do so" (Saunders, 2011, p.127). Walliman (2017) even concludes that combining inductive and deductive reasoning with experience is the foundation of modern scientific research. Thus, to form a philosophical position, researchers first need to make basic assumptions regarding the nature of science, as well as the nature of society (Holden and Lynch, 2004).

2.2.2 The Nature of (Social) Science

Saunders (2011) identifies three main angles to approach the topic of scientific research philosophy; namely ontology, epistemology, and axiology. Similarly, Morgan and Smircich (1980, p.491) state that "all approaches to social science are based on interrelated sets of assumptions regarding ontology, human nature, and epistemology".

2.2.2.1 Ontology

Ontology refers to the researcher's philosophical perspective on the nature of reality (Creswell and Poth, 2017). Here, a major question is, whether scientific theories are representations of mental concepts created by the human mind; or whether they reflect an external, absolute, and independent reality (Kilduff *et al.*, 2011). An objective perspective would argue the latter, hereby assuming, that social entities exist autonomously of social actors (Saunders, 2011). On the other end of the spectrum, a purely subjective researcher likely views social phenomena as constructed by the human mind and strives to understand the meanings that individuals give these observed phenomena (Saunders, 2011). However, viewing these philosophical perspectives onto reality as mere opposites might be an oversimplification: "researchers may be both objective and subjective … over the course of studying a research question" (Tashakkori and Teddlie, 1998, p.25), as proposed by pragmatists.

2.2.2.2 Epistemology

Epistemology is "the theory or science of the method or grounds of knowledge" (Webster's Unabridged 1913 Dictionary, 2016, p.4617); hence epistemology is concerned with the nature of knowledge itself (Holden and Lynch, 2004). This branch of philosophy attempts to answer the question what is considered adequate knowledge in an area of research (Saunders, 2011). This question is particularly pressing for research in the realm of social sciences, because it reflects on the roles of human subjects, the researcher's influence, and focusses on social phenomena (Walliman, 2017) – all aspects which are mostly deemed insignificant in the natural sciences (Bhattacherjee, 2012). Depending on the researcher's ontological position, two main knowledge-creating epistemological approaches may be taken: a positivistic or interpretivist approach (Walliman, 2017).

Following the tradition of the natural sciences, positivists assume that the world around us is real, that "a truth" exists, and that this truth can be revealed by a step by step process of reduction, hypothesis formulation, and testing; ultimately resulting in the deduction of definite, law-like theories (Saunders, 2011; Walliman, 2017). However, this restricts (positivistic) science to the measurable, and the observable, which then excludes human emotion or thought (Bhattacherjee, 2012).

Interpretivists, on the other hand, consider the social world to be relevant, and too complex and too dynamic to be reduced to discrete, universally valid, and rigid principles (Saunders, 2011). Interpretivists believe that it is important for the researchers to comprehend differences in the interpretation of events of individuals (Burrell and Morgan, 1979; Saunders, 2011). Therefore "subjectivists focus on the meaning of social phenomena rather than its measurement" (Holden and Lynch, 2004, p.11).

A strict positivist does not consider studying social phenomena a worthwhile effort (Bhattacherjee, 2012), while strict interpretivists see no point in solely categorising phenomena in cause and effect (Holden and Lynch, 2004). This conflict may never be settled (Walliman, 2017). As a result, coordination between these disparate camps requires skilled moderation (Kilduff *et al.*, 2011). A comparison of the research philosophies of positivism and interpretivism is shown in Table 2.

Table 2 – A comparison of the research philosophies positivism and interpretivism (adapted from Pathirage *et al.*, 2008, p.6; Saunders, 2011, p.119; Walliman, 2017, p.22)

Issue	**Positivist**	**Interpretivist**
Philosophical basis	Realism: the world exists and is knowable as it really is.	Idealism: the world exists but different people construe it in very different ways.
The role of research	To discover universal laws and generalizations.	To reveal different interpretations of the world as made by people.
Role of researcher	Neutral observer. Independent.	Part of the research process. Is part of what is being observed.
Theoretical approach	Rational, using inductive and scientific methods and value free data. Hypotheses and deduction.	Subjective, using inductive methods and value laden data. Gathering of rich data from which ideas are induced.

Issue	Positivist	Interpretivist
Methods	Experiments or mathematical models and quantitative analysis to validate, reject or refine hypotheses.	Surveys and observations with qualitative analysis to seek meaningful relationships and the consequences of their interactions. Analysis of language and meaning.
Analysis of society	Search for order. Society is governed by a uniform set of values and made possible only by acceptance of these values.	Search for dynamics. Multitude of values leading to complex interactions. Society made possible by negotiation.
Ontology	One reality exists, knowable within probability. Social entities exist independent of social actors. Researcher is external, objective.	Multiple, socially constructed realities. Researcher is part of the phenomenon. Reality is subjective and can change.
Epistemology	Objectivity is important; Researcher manipulates and observes in dispassionate, objective manner.	Interactive link between researcher and participants; values are made explicit; creating findings.
Units of analysis	Should be reduced to the simplest terms.	May include the complexity of "whole" situation.
Human interest	Should be irrelevant.	Are the main drivers of the science.
Generalisation through	Statistical probability.	Theoretical abstraction.
Common data collection techniques	Highly structured. Quantitative, but can use qualitative. Large numbers of samples selected randomly.	Small samples, in-depth investigations, qualitative.

2.2.2.3 Axiology and Human Nature

For philosophy, axiology is a relatively recent discipline (Hart, 1971). It is part of the theory of values, or value theory (Schroeder, 2016). In social sciences, axiology is concerned with the roles of the researchers' values regarding research choices (Saunders, 2011). As shown above, the researchers' view onto the world is shaped by their ontological and epistemological assumptions. This world view is further influenced by their beliefs about human nature, "whether or not the researcher perceives man as the controller or as the controlled" (Holden and Lynch, 2004, p.6).

Wellington *et al.* (2005, p.103) explain, that these beliefs are basically concerned with the ability of humans to act in the world:

> "Do people initiate action and make choices or do they respond in a mechanistic way to their environment and the things that happen to them? Do they act voluntarily and of their free will, or is their behaviour determined by innate instinctual forces or by external conditions and

> forces? For researchers, who are themselves human beings, this is an interesting area because whatever they decide inevitably applies to them as well as to their research populations.”

This belief (concerning human nature) is further individually biased by personal, axiological positions, such as political or religious views; and personal circumstances, such as age, gender, race, and so forth (Holmes, 2014). Consequently, a researcher’s choice of philosophical approach also reveals some of the researcher’s values and beliefs (Saunders, 2011).

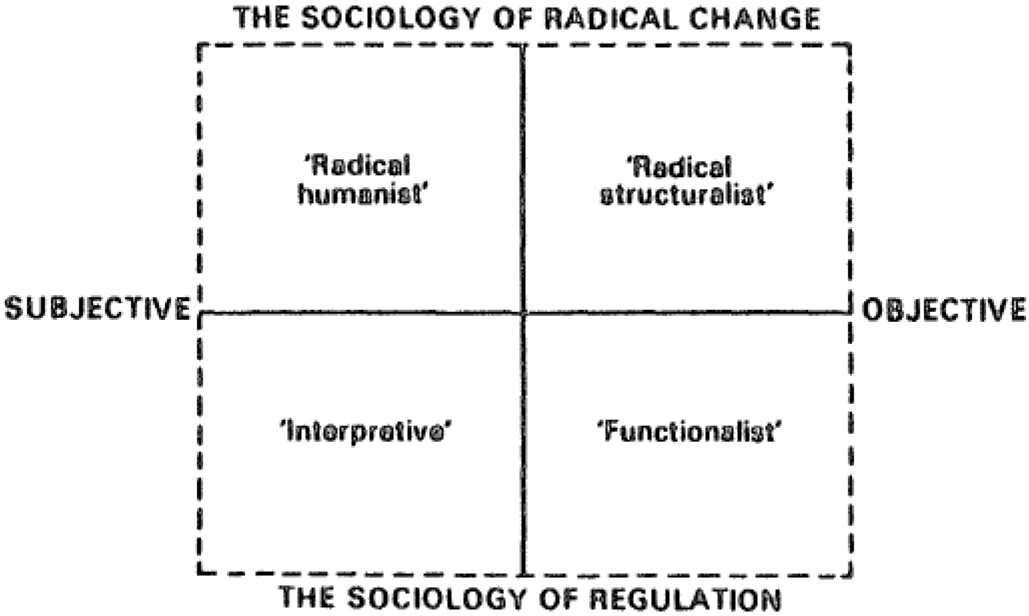
2.2.3 The Nature of Society

Thus far, the author has reviewed the two major, opposing philosophical traditions of positivism and interpretivism. In essence, these opposite views onto reality and knowledge-creation are modern continuations of the ancient conflict of Plato's concept of reality vs. Aristotle’s concept of reality (Hirschberger, 1980). However, Burrell and Morgan (1979, p.1) propose that “all theories of organisation are based upon a philosophy of science *and* a theory of society”; thus introducing a second, central dimension for the analysis of social life and organisations. This new dimension is spanned over a second axis with the opposing termini of “regulatory or radical change” (Holden and Lynch, 2004, p.3).

The sociology of regulation perspective assumes that society tends toward unity, cohesion, and stability (attempting to maintain the status quo); while a radical change perspective views society as deeply conflicted, oppressive and constraining (Goles and Hirschheim, 2000). Said differently, this represents the order-conflict debate, which is lead around effects that stabilise social order, versus effects or approaches that favour social change (Rollag, nd). Burrell and Morgan (1979, p.11) argue, that this debate “has met a premature death” and is an essentially important aspect when analysing the nature of social science.

Having identified two different dimensional assumptions regarding the nature of social science, namely positivism and interpretivism; and two differing assumptions regarding the nature of society, namely regulation versus radical change; Burrell and Morgan (1979) form a typology-matrix of four differing, mutually exclusive research paradigms as outlined in Figure 1.

Figure 1 – Four paradigms for the analysis of social theory (Source: Burrell and Morgan, 1979, p.22)



The radical humanist paradigm is comprised of a radical change view of society, combined with a subjective philosophy. Consequently, a radical humanist "adopts a critical perspective on organisational life" (Saunders, 2011, p.121), thereby being interested in phenomena surrounding social interactions. Thus, it is likely, a radical humanist will perform research with the aim to propose how fundamental changes can be implemented by looking at social actors.

The radical structuralist paradigm is comprised of a radical change view of society, combined with an objective philosophical stance. Like the radical humanist, the radical structuralist is interested in finding out how to change the way things are done. However, the chosen approach is objectivistic (Bhattacherjee, 2012), primarily focussing "on structural relationships within a realist social world" (Burrell and Morgan, 1979, p.34).

The interpretive paradigm is comprised of a regulatory view of society, combined with a subjective philosophy. The interpretivist seeks to understand the world, by striving to understand the meaning social actors give to a phenomenon and perceives reality as being created by individuals through an evolving, ordered process (Burrell and Morgan, 1979).

The functionalist paradigm is comprised of a regulatory view of society, combined with an objective philosophy. Like the interpretivist, the functionalist view on society is less critical and attempts to propose improvements, rather than revolution (Saunders, 2011).

As objectivist, the epistemological approach to knowledge-creation follows the tradition of the natural sciences (positivism), and likely is concerned with explanations and problem solving (Saunders, 2011). In the past, most social science research has been performed adopting this paradigm (Goles and Hirschheim, 2000; Bhattacherjee, 2012).

2.2.4 Taking Position: Philosophical Underpinnings of the Proposed Study

With reference to the two dimensions proposed by Burrell and Morgan (1979), "radical change" and "regulation", the author generally confesses to a view of society of radical change. I believe that the social world – particularly politics, and business – are full of imperfections, chaotic structures, and dysfunctionalities; and that many of these unsatisfying, rigid structures should be changed: fundamentally, quickly, and radically. Influenced by work such as "Homo Deus: A brief history of tomorrow" (Harari, 2016), and "The second machine age: Work, progress, and prosperity in a time of brilliant technologies" (Brynjolfsson and McAfee, 2014); I further believe, that the 21st century is a time in which the pace of change accelerates – driven by technological innovations, and an ever more interconnected world.

From an ontological perspective, the author is convinced that the social world, as we perceive it, is to a very large extend constructed in our minds. We do this by observing phenomena and then attaching interpretations and meanings to them (phenomenological view). I believe that entrepreneurial opportunities can be created, rather than discovered. I contend that whether a technological innovation finds extensive employment, or not, ultimately is a *choice* made by humans. This choice, in turn, is primarily influenced by the perceived importance[1] that social actors give to the new technology and associated phenomena. This conviction places the author in the ontological camp of subjectivism.

Linking back to the paradigm-matrix of Figure 1, radical change plus subjectivism places the author in the radical humanist paradigm. However, oftentimes – and contrary to my own beliefs and postulations – technologically-driven changes unfold significantly slower and are much less revolutionary, than I may have predicted and expected. Similarly and in the context of this study, a slower than expected growth is occurring in the augmented

[1] In his professional career, the author has observed numerous times, that management did not further pursue a promising, new technological approach, despite initial, quantifiable successes and opposing expert predictions, and recommendation. These choices, in turn, have then lead to self-fulfilling-prophecy-like results. Further, interpretations are mere snapshots in time. What might "sound like a good idea" at one point in time, may turn out to appear as a "rather poor idea", at a later point in time; and vice versa.

reality and virtual reality industry as acknowledged by Bastian (2017). These “order-preserving-forces” perhaps indicate, that taking a regulatory view of society is a more useful approach for the planned study.

As previously stated, it is the overall research aim to better understand the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany. Recent reports still suggest that augmented reality and virtual reality technologies have gained more momentum (Goldman Sachs, 2016), and an upturn in the market is possible (Ebert *et al.*, 2017), however, the actual pace of change remains unclear. Therefore, in the initial stages of this study, it is imperative to understand what is going on in practice as a practical and insightful first step (as indicated by RQs 1 and 2), before attempting to propose any changes to the status quo. This however, is in line with the interpretive paradigm, rather than the radical humanist paradigm (Saunders, 2011). As a result, the author chooses to adopt an interpretive paradigm for the purpose of this study. The epistemological consequence of the subjectivist approach to social sciences is an anti-positivistic attitude towards knowledge-creation (cf. Burrell and Morgan, 1979).

In summary, the planned research adopts a subjectivist, phenomenologist, interpretivist research philosophy.

2.3 Research Methodology

Thus far, the author has discussed how the underlying philosophical assumptions significantly impact the researcher’s choice of a suitable methodology. This strengthens the researchers’ position regarding the proposed research implementation process (Jackson, 2013) and helps improve the outcomes of the planned research (Snape and Spencer, 2003). Holden and Lynch (2004, p.6) define methodology as “the researcher’s tool-kit – it represents all the means available to social scientists to investigate phenomena”. Saunders (2011, p.4) uses “the term methods, to refer to techniques and procedures used to obtain and analyse data ... In contrast, the term methodology refers to the theory of how research should be undertaken”. Thus, having identified my philosophical stance as being interpretive in Section 2.2.4, the author notes that “in its approach to social science, it tends to be *nominalist, anti-positivist, voluntarist and ideographic*” (Burrell and Morgan, 1979, p.28).

The term nominalist relates to the opinion, formulated by philosopher and theologist Johannes Roscelin, that general ideas and universally valid concepts exist in name only (Webster's Unabridged 1913 Dictionary, 2016). According to Burrell and Morgan (1979, p.4), "the nominalist position revolves around the assumption that the social world external to individual cognition is made up off nothing more than names, concepts and labels which are used to structure reality". As such, the nominalist approach aims to obtain phenomenological insights, rather than attempting to build on positivistic science (Holden and Lynch, 2004). Anti-positivism is a synonymous expression for the epistemological stance of interpretivism (Bhattacherjee, 2012), as explained in Section 2.2.2.2. Anti-positivism employs qualitative methods such as participant observation, or interviews (Bhattacherjee, 2012). Voluntarism refers to an assumption in regards to human nature (see Section 2.2.2.3), postulating that humans can act independently and by freewill (Morgan and Smircich, 1980). Finally, the ideographic approach opposes the nomothetic approach and aims at highlighting the individual's interpretation of a phenomena, rather than striving to deduct law-like statements about social life (Burrell and Morgan, 1979) by utilising quantitative methods. The ideographic approach analyses "subjective accounts generated through inside situations and involving oneself in the everyday flow of life" (Pathirage *et al.*, 2008, p.7).

2.3.1 Choice of Methodology

As described in the previous section, the author's philosophical positioning in the interpretive paradigm lends itself to an anti-positivist approach to knowledge creation. Consequently, the author contends, that a qualitative research approach is well suited for reaching the research objective. Remenyi and Williams (1998) offer a table in which research tactics and their philosophical bases are put into relation. This table is aimed at assisting researchers in choosing suitable research approaches (Holden and Lynch, 2004). It is presented in Table 3. It presents the case study research methodology as an appropriate candidate for a subjectivist research approach. In his foreword, Yin (2017, p.xxiii) takes this point even further by stating:

> "An opposing perspective, however, suggests that case study research may be separate from qualitative research. Case studies may need to follow their own customized research procedures in identifying and defining the case to be studied, along with numerous other procedures as discussed in the chapters of this book."

Table 3 – Research tactics and their philosophical bases (Source: Remenyi and Williams, 1998).

Research approaches	Objectivism	Subjectivism
Action research		Strictly interpretivist
Case studies	Have scope to be either	Have scope to be either
Ethnographic		Strictly interpretivist
Field experiments	Have scope to be either	Have scope to be either
Focus groups		Mostly interpretivist
Forecasting research	Strictly positivistic with some room for interpretation	
Futures research	Have scope to be either	
Game or role playing		Strictly interpretivist
In-depth surveys		Mostly interpretivist
Laboratory experiments	Strictly positivistic with some room for interpretation	
Large-scale surveys	Strictly positivistic with some room for interpretation	
Participant-observer		Strictly interpretivist
Scenario research		Mostly interpretivist
Simulation and stochastic modelling	Strictly positivistic with some room for interpretation	

Figure 4: Research Tactics and Their Philosophical Bases

Source: Remenyi et al. (1998)

Generally speaking, case study research is a holistic, context-aware approach, considering multiple perspectives of the phenomenon under investigation (Hussy *et al.*, 2013). Case study research is a suitable method of choice if the researcher wishes to investigate a contemporary phenomenon in its natural context (Yin, 2011), and strives to answer "how" or "why" questions (Yin, 2013). For this study, these two aspects hold true: the planned study is aimed at the exploration of the contemporary phenomenon of the emerging technologies augmented reality, and virtual reality; and strives to answer "how" questions. Therefore, this research will be based on the case study research approach as outlined by Yin (2017).

2.3.2 Case Study Research Design

Yin (2017, p.xxi) suggests that there is a significant difference between "non-research case studies" which are popular in studies of nature, and "case study research", which adheres to the scientific method, as defined in Section 2.2.1. This study aligns with "case study research", and thus, the fundamental scientific assumptions of replicability, precision, falsifiability, and parsimony (cf. Bhattacherjee, 2012) have to be addressed. The researcher's strategy how to meet these requirements is summarised in Table 4.

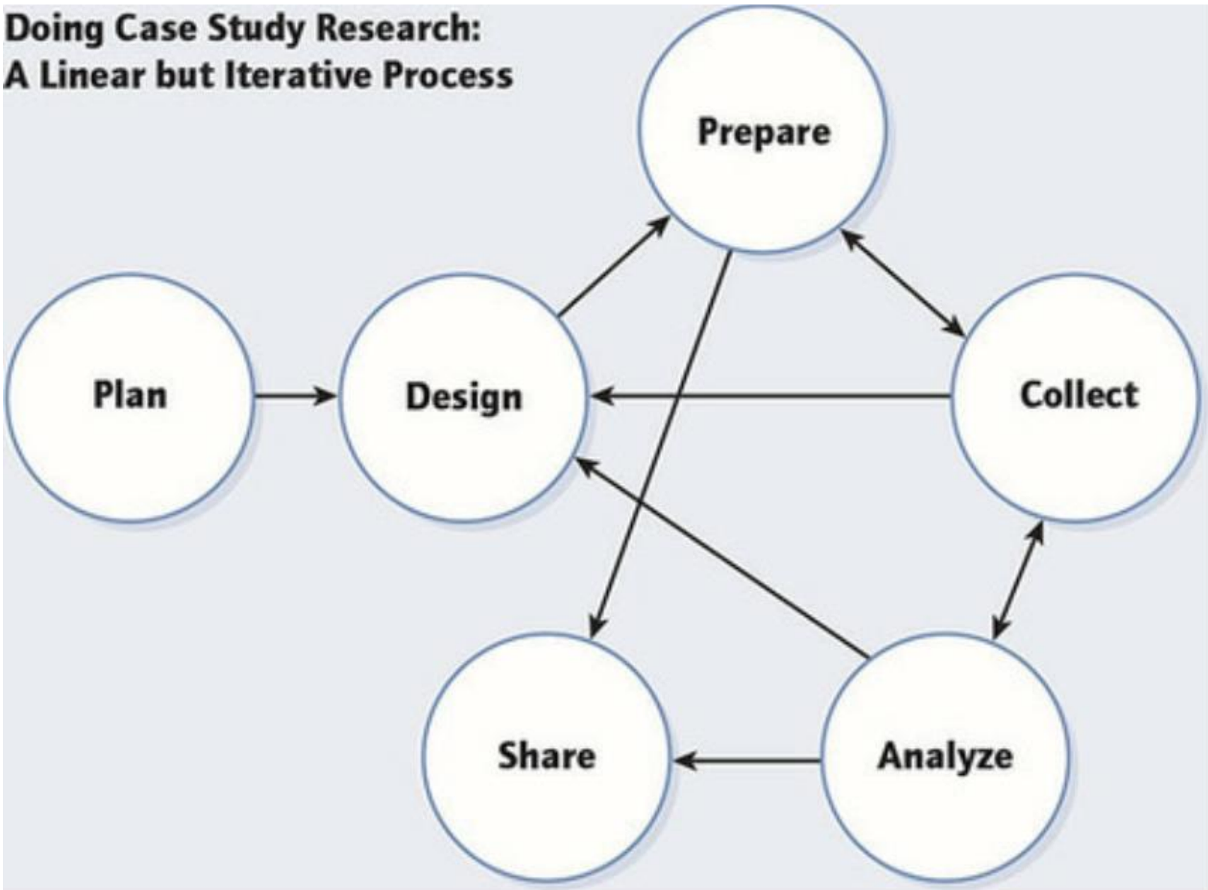
Table 4 – Assumptions underlying the scientific method and strategy for meeting the implied requirements.

Scientific assumption	**Implied requirement**	**Strategy**
Replicability	The study can be repeated by others.	The researcher will create a detailed case study log and database (see Section 3.1), documenting all steps, observations, decisions and conclusions.
Precision	Concepts are defined precisely.	All concepts and procedures will be defined and documented in detail (see Section 3, as well as appendices and case study database).
Falsifiability	Theories can be rejected, if they turn out to be false.	The planned research is of exploratory nature. Hence, as indicated by Bhattacherjee (2012), the researcher is primarily striving to scope out the phenomenon of interest, and to generate initial ideas and hunches; rather than formulating "hard" theory. However, should observations made throughout the research lend themselves for theorising, these will be worded carefully as ideas for further research, which can be rejected if necessary.
Parsimony	Choose the simplest explanation.	As mentioned above, the study is primarily focussing on exploring, rather than explaining. Any potential explanation attempts will be monitored for simplicity and challenged by rival explanations.

The author would like to point out, that particularly the points "falsifiability" and "parsimony" may not be applicable to the proposed research project, as it is and interpretive piece of work. As observed by Stahl (2014), it can even be questioned, whether interpretive research requires an empirical basis at all.

Yin (2017, p.3) describes performing case study research as a linear but iterative process with the goal "to design good case studies and to collect, present, and analyze data fairly" as presented in Figure 2.

Figure 2 – Case Study research process (Source: Yin, 2017, p.2).



The initial design and preparation of the planned case study are part of this paper. Data collection results, and analysis of the collected data will be presented in two subsequent papers. For the design of a case study, Yin (2017, p.24) proposes four steps:

1. define the case(s) to be studied;
2. develop theory, propositions, and related issues to guide the anticipated case study and generalise its findings;
3. identify the case study design (single or multiple, holistic or embedded cases);
4. test the design against four criteria for maintaining the quality of a case study.

2.3.2.1 Case Definition

This component of the case study design deals with the identification of the case to be studied. It needs to take into account the aspects of defining the case and bounding the case (Yin, 2017).

2.3.2.1.1 Defining the Case / Unit of Analysis

It is important that the researcher understands the chosen unit of analysis as it shapes the types of data, as well as the data collection approach (Bhattacherjee, 2012). Bhattacherjee (2012, p.9) further observe that:

> "One of the first decisions in any social science research is the unit of analysis of a scientific study. The unit of analysis refers to the person, collective, or object that is the target of the investigation. Typical unit of analysis include individuals, groups, organizations, countries, technologies, objects, and such."

This is well in line with Yin (2017, p.29), who identifies numerous case study entities, including "small groups such as families", "citizen participation", "communities", "decisions", "programs", "organizational learning", "schools", "social movements", and "disaster recovery efforts", as appropriate units of analysis.

Given that the aim of this study is to better understand the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany, the author defines augmented reality and virtual reality application *cases* to be "the case", e.g. the unit of analysis. More specifically, the author is interested in finding example cases, in which an augmented reality or virtual reality technology was deployed, to then learn what impact this deployment had on business model innovation in the technology company. Examples of cases could be the employment of augmented reality or virtual reality to innovate the marketing or training process in a company (typically, this could be done in form of a project, which means, that a given company may actually have more than one suitable case for investigation); or the creation of an entirely new firm (e.g. start-up).

2.3.2.1.2 Bounding the Case

Once researchers have defined what the case is (cases need to be real-world phenomena with concrete manifestations), they also need to define what the case is not (Yin, 2017). Figure 3 presents some possible case units, including "projects" as units of analysis – the anticipated entity of research for the planned study. Table 5 elaborates further on the selection criteria of candidate projects.

Figure 3 – Illustrative cases for case studies (Source: Yin, 2017, p.32).

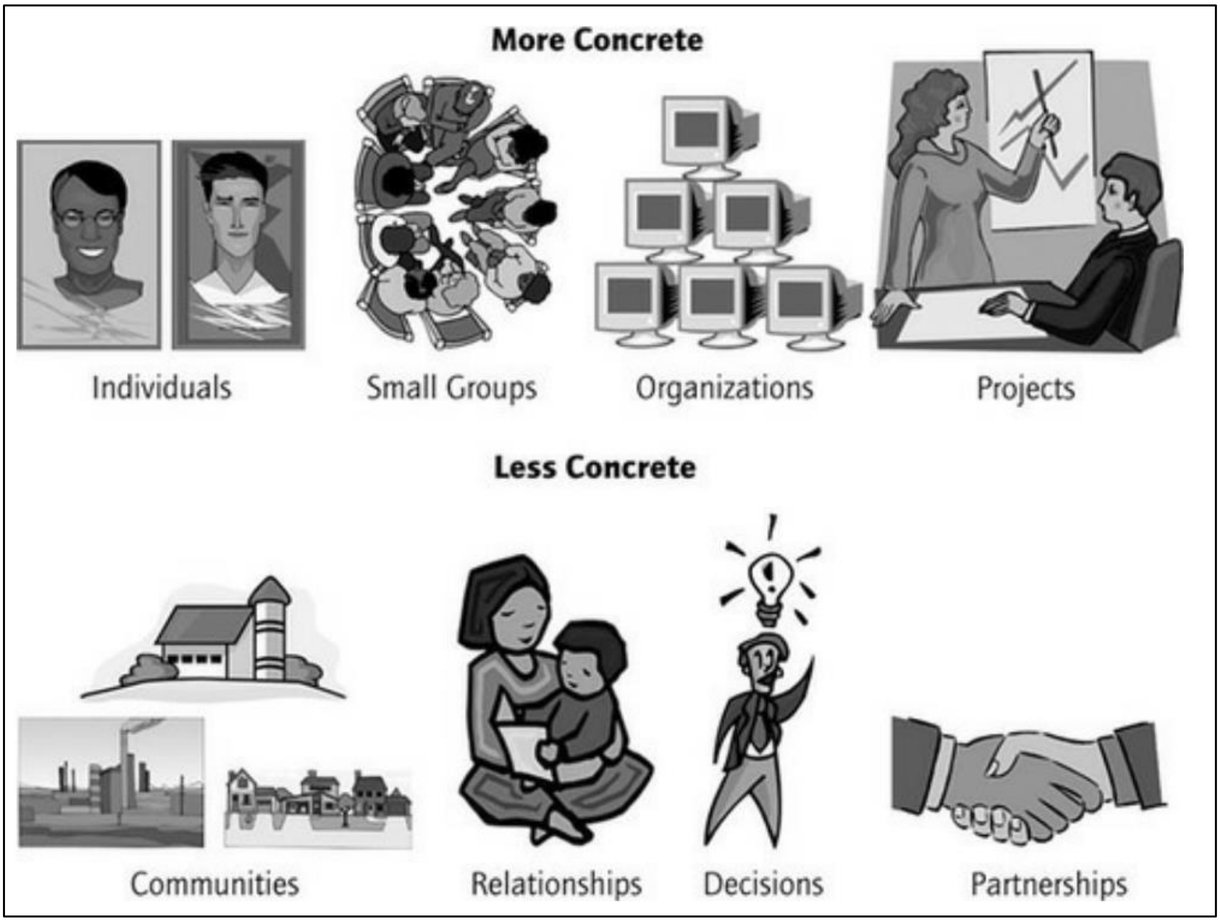


Table 5 – Criteria for pre-selecting candidate cases/candidate projects[2].

Criteria	Explanation
Significant involvement of augmented reality and/or virtual reality technology.	The research aims to explore the impact the technologies augmented reality and virtual reality have (on business model innovation). Hence, the employment of augmented reality technologies must be central to, or significant for, the project or case. See Table 14 in Appendix B for AR/VR technology dimensions to help the identification and decision for inclusion process.
County of deployment must be or include Germany.	The research is focussed on the impact of business model innovation on technology companies in Germany. Hence, only cases which were deployed in Germany, or by German technology companies, are considered. The deployment does not necessarily have to be exclusive to Germany.
Case is completed, or passed a significant milestone, or has been aborted.	Cases must be complete (or must have passed a significant enough milestone) such that conclusions regarding the impact of the case can be drawn, or at least discussed. An aborted project may also be considered, as “no result might also be a result”.
Case is relevant for business model innovation.	The research is centred on the topic of business model innovation and the impact of augmented reality and virtual reality technologies on business model innovation. Hence, the project needs to have an impact on the existing business model of the entity employing the technology or be part of the creation of a new business model.

[2] “Candidate projects” meaning that identified projects are recognised to be possible loci of investigation, however, these candidates may or may not be included in the final research.

Criteria	Explanation
Applicable to business.	The research focusses on business model innovation, hence business models, hence it focuses on business. Therefore, only cases which are arguably relevant for business are included. Criteria here include the following: the employing entity needs to be a non-governmental organisation (including free-lancers) and should be striving for profit[3].
Access issues and access estimation.	Cases can only be researched if they are accessible. If, for some reason, it is clear from the beginning, that access to the case participants and stake holders is "impossible", the case is not included into the data base. The same is true for cases which are deemed morally questionable or illegal.

2.3.2.2 Theory Underpinning the Study

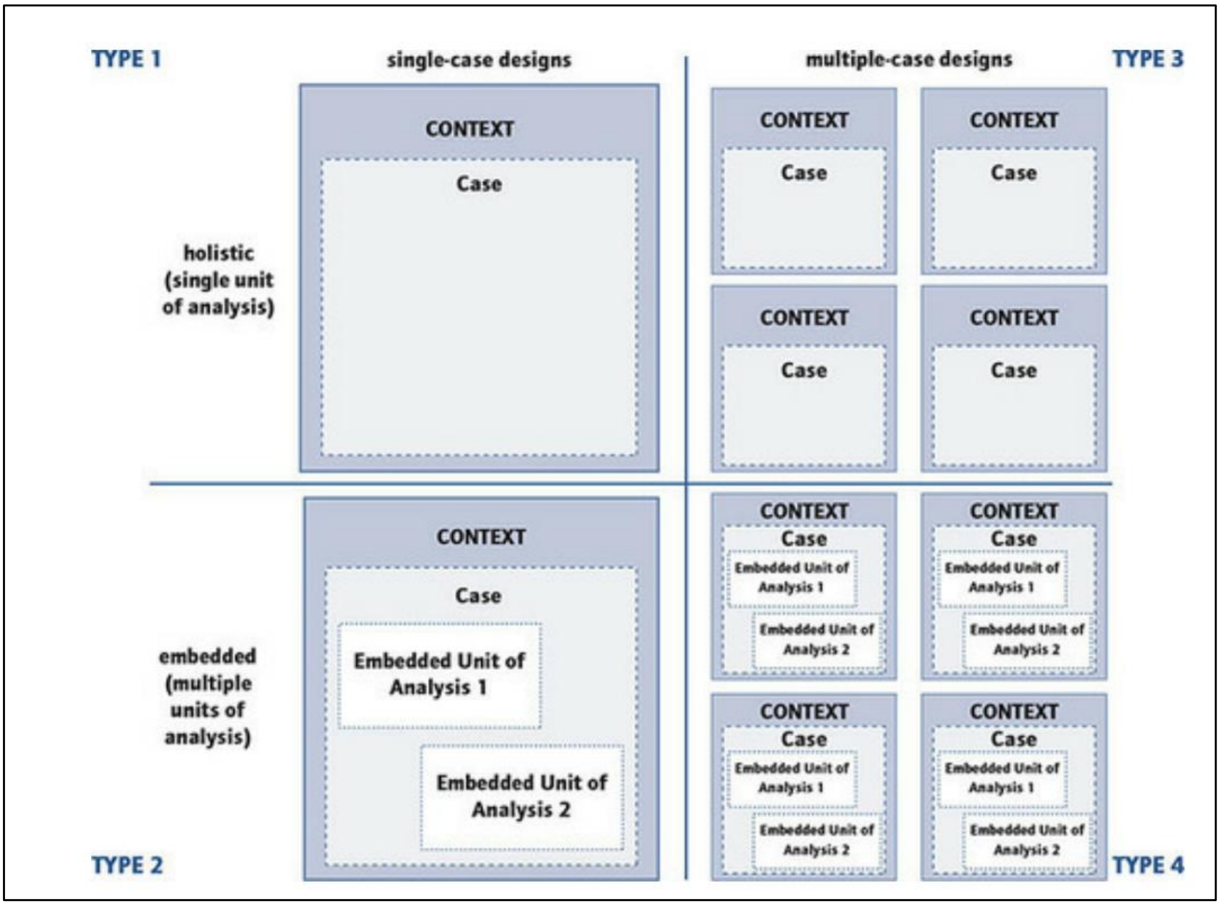
The author conducted a thorough literature review in Paper 1 which led to the development of a conceptual framework which in included in Appendix A. This conceptual framework was then used to formulate the research objective and four research questions, which are also underpinned by theory, as discussed previously in Section 2.1.

2.3.2.3 Case Study Design Type

Perhaps one of the most novel contributions of Yin's work is the formulation of four formal case study research designs as summarised in the two-by-two matrix in Figure 4. This research adopts a multiple-case holistic "Type 3" case study design. This means, that multiple augmented reality and/or virtual reality projects fulfilling the criteria of Table 5 above will be investigated and analysed.

[3] The author recognises, that non-profit organisations, as well as governmental organisations, may use business models. However, limiting the study to profit orientated organisations better defines the research endeavour and increases the likely quality and contribution of the outcome.

Figure 4 – Basic types of designs for case studies (Source: Yin, 2017, p.48).



2.3.2.4 Case Study Quality

To fulfil scientific standards, four tactics to test for, and improve the quality of the research design are proposed by Yin (2017, pp.42, 43):

1. construct validity,
2. internal validity,
3. external validity, and
4. reliability.

Construct validity refers to the concept of defining appropriate operational measures for the study (Yin, 2017). The author will address this by offering concise definitions of concepts, as demonstrated in Table 5 above, thought the entire research project (see Section 3). Furthermore, multiple sources of evidence will be collected and referenced wherever possible. Lastly, key informants will have the opportunity to review the case study data collected through them.

Internal validity refers to the concept of showing causal relationships between measures; however, this aspect is not applicable to exploratory studies (Yin, 2017), such as this one. Therefore, the author will not further discuss internal validity, here.

External validity refers to the concept of exhibiting how to generalise a study's findings. The author addresses this by basing the research on a literature review (refer to Paper 1) and a conceptual framework (refer to Appendix A). The author also developed research questions in Section 2.1; and will apply a replication logic as suggested by Yin (2017), by employing a multiple-case study design as explained previously in Section 2.3.2.3

Reliability refers to the concept of disclosing how the steps of the study can be repeated by an external researcher. The author will address this by maintaining a detailed case study log as a chain of evidence, by creating a case study database, and by designing case study protocols.

In this section, the author reflected on the research philosophy underpinning the planned study, took philosophical stance, and argued for the employment of a multiple-case study design to meet the research objective. The next section is dedicated to operationalising the chosen research methodology.

3 Research Operationalisation

Noting that "conducting scientific research … requires two sets of skills – theoretical and methodological" (Bhattacherjee, 2012), this section is dedicated to operationalising the research approach by deriving a plan of how to put the research effort into practise. Yin (2017, p.26) notes that "a research design is more than a work plan. The design's main purpose is to avoid the situation in which the evidence does not address the research questions." To address this challenge, the author follows the following research operationalisation approach and steps:

1. create and maintain a case study log and database (research documentation);
2. identify cases/project candidates from a pre-existing database and an online research;
3. contact stakeholders and select cases according to critical requirements;
4. define the unit of observation, and prepare data collection by designing study protocols;

5. begin the preparation of a data analysis strategy;
6. reflect on further considerations such as ethical issues and potential challenges; and
7. prepare a pilot case study.

3.1 The Case Study Log and Database

In order to ensure the reliability of the case study, the author followed the recommendation by Yin (2017) and installed a case study database. The case study database consists of the components outlined in Table 6.

Table 6 – Case study database components and purpose.

Component	Description	Purpose
"BMI Case Study Database" folder	The main folder (file based) used to organise and collect data for the case study. The folder is hosted on "Dropbox", a hosted file sharing and storage solution (cf. Dropbox, 2018).	Collect and organise digital files and documents. External researchers may request access to the Dropbox folder.
Case Study Log	A Microsoft Word document containing a log which is maintained throughout the research. Further, observations, ideas, and other useful information and notes are collected here.	A chronological documentation of performed steps and events.
Case Study Database Mind Map	A FreeMind based mind map. The mind mapping software is available for free at http://freemind.sourceforge.net (cf. FreeMind, 2016)	A mind map used to dynamically develop and organise the case study.
Redmine project management system	Redmine is a web-based project management application with numerous functionalities such as issue tracking and much more (cf. Redmine, 2018).	Track important issues and tasks regarding the case study. Particularly, the communication with companies who are potential research participants is documented and logged here. Issue references are marked with square brackets, a hash-tag, and the issue ID. Example "[#4377]". External researchers may request access to the Redmine project[4].
Zotero library	Zotero is a cloud based, free, open-source research tool which helps researchers in the organisation, analysis, and sharing their research (zotero.org, 2018).	This designated library is used to organise parts of the research data. External researchers may request access to the Zotero library[5].

[4] Redmine project URL: https://pm.phaenom.com/projects/case-study-exploring-the-impact-of-augmented-reality-and-virtual-reality-technologies-on-business-mo/issues

[5] Zotero library URL: https://www.zotero.org/groups/2110785/case_study_exploring_the_impact_of_augmented_reality_and_virtual_reality_technologies_on_business_model_innovation

3.2 Case Study Candidate Identification

Companies are searched for in two ways: one, by skimming though the lists of companies and cases already known to the author, and second, by conducting a structured online research.

3.2.1 Existing Database of Companies

The author has collected a database of companies and cases over the past few years. Mostly, these are stored in Zotero and in a market research documents[6], digitally. The approach is to organise, and further analyse and categorise this pre-existing database with the goal to "randomly" identify potential cases of interest.

3.2.2 Google AR/VR Case Search

To support the case study research, case study researchers may create customised research "instruments"; such as "surveys, questionnaires, and examinations administered to individuals who have insight into the research situation" (Hancock and Algozzine, 2006, p.52). To aid the initial case identification, the author creates an online search design as detailed below.

3.2.2.1 Overview

The objective is to specifically identify augmented reality and virtual reality applications/use cases in Germany. The approach is to perform a structured online research (Google search). The collected data is entered into a project management tool[7].

3.2.2.2 Search Design

The search involves the following steps:

1. Build key phrases for the search;
2. document search activities and note newly emerging key words;
3. pre-select cases by criteria as specified and make notes on decision reasoning;
4. enter pre-selected cases and associated company details into the project management system and note any additional observations or ideas;
5. build key phrases from search notes (cf. step 2);

[6] Digital files in Microsoft Word (docx), Microsoft Excel (xlsx), or Portable Document Format (PDF) format.

[7] The initial case identification will be performed within the company of the author. Access restrictions may apply.

6. pre-select and enter new cases and companies into the project management system.

3.2.2.2.1 Build Key Phrases

Initially, the terms "augmented reality", and "virtual reality" are combined with the search key words collected in Table 7 to build key phrases. These initial key words have been identified from literature[8] (see Appendix C for further details).

Table 7 – Initial AR/VR use case keywords used.

Keyword	German Translation	Comment
advertising	Werbung	
arcades	~~Arkaden~~	This keyword is excluded in German, because the direct translation is not useful.
architecture	Architektur	
assembly	Montage	
assistance	Hilfe	
broadcasting	Rundfunk-	
collaboration	Zusammenarbeit	
configurators	Konfiguratoren	
disability	Behinderung	
documentation	Dokumentation	
education	Bildung	
enjoyment	Vergnügen	
entertainment	Unterhaltung	
experiences	Erfahrungen	
gaming	Spiele	
information	Information	
journalism	Journalismus	
learning	Lernen	
maintenance	Instandhaltung	
manufacturing	Produktion	
marketing	Marketing	
medical	Medizin	
navigation	Navigation	
planning	Planung	
presentations	Präsentationen	

[8] The term "military" has been excluded from the searches at the author's discretion.

Keyword	German Translation	Comment
psychology	Psychologie	
real estate	Immobilien	
showrooms	Ausstellungsräume	
support	Unterstützung	
teaching	Lehren	
television	Fernsehen	
tourism	Tourismus	
training	Ausbildung	
virtual replicas	~~virtuelle Replikate~~	This keyword is excluded in German, because the direct translation is not useful.

3.2.2.2.2 Document Search Activities

Then, a Google search is performed on the key phrases. Searches are performed on a desktop computer from an IP address based in Germany. All searches are performed in English and German. The key phrases are entered without quotes in the search field on www.google.de, and the search results are documented in a table per search query, as specified in Table 8. The used search log template is provided in Appendix D. Newly arising, interesting key words are noted down separately during the research and are added to the search queries. The results analysis is limited to the first ten Google search results, plus Google ad results, additionally, if present; and excluding all other Google results such as image search results, video results, and scientific articles results. This limitation is done to reduce the overall research time according to the time available. Duplicate results from previous queries are noted and not included twice.

Table 8 – Search documentation criteria.

Criteria	Explanation
Search result	The result as returned by Google.
Decision for inclusion and reasoning	Indicator whether the entry results in inclusion into the case candidate database. Interesting companies are captured separately (own Redmine ID). “No” = not included “Company” = interesting company “Case” = interesting case “Duplicate” = Duplicate entry, already captured somewhere else.
Redmine references	References to the project management database.

3.2.2.2.3 Pre-Select Cases

In the next step, after performing the case search, cases are quickly pre-selected according to the criteria previously explained in Table 5 (page 99). Notes are made on the reasoning behind the selection of a given case.

3.2.2.2.4 Enter Pre-Selected Cases into Database

Pre-selected cases and associated company details are entered into the project management system as elaborated on in further detail in Table 9, and additional observations or ideas are noted.

Table 9 – Data collected during AR/VR case online search.

Collected data	Description	Related Redmine Field[9]
Case name	A short, descriptive case name.	"Projekt"
Case ID	Automatically created internal Redmine number.	Issue ID
Case description	A brief description of the case (two to three sentences, see also Table 10 for key data aspects).	"Beschreibung"
References to involved companies[10]	A referencing feature of Redmine: links to other issues are created.	"Zugehörige Tickets"
Contact persons (if identifiable)	A list of possible contact persons is added to the custom field "Vorgehensweise".	"Vorgehensweise"
Date added (system automatic)	All activity is time-tracked by the system automatically.	
URLs to the cases	Links to online resources regarding the case are added to the case description.	"Beschreibung"

Table 10 lists key data to support the description of research case candidates.

Table 10 – Key data for selecting and describing an AR/VR case.

Key data	Explanation
Application/purpose	What problem or new solution did the application solve or address?
Stake holders	Who are the players involved? Participating companies and targeted audience.
Technological dimension	What hardware, software, content, and delivery methods were employed (see Table 14 in Appendix B)?

[9] Technical note: the custom-made tracker type "Vorgang" is used.

[10] Each company will be entered into the project management system individually, and hence will have its own ID/Redmine number.

3.2.2.2.5 Round Two of Searches

See steps 4 and 5 above (e.g. build more key phrases and capture new cases).

3.2.2.3 Case Search Limitations

The author is aware, that likely many potentially interesting cases are not revealed through the online search. Reasons for this may be products or services, which are under development but not released to the public, yet (secrecy issues); or augmented reality or virtual reality applications which are developed solely for companies internal, proprietary purposes.

3.3 Negotiating Access and Selection of Cases

After the identification of potential cases and projects, the next important step and challenge is gaining access to the case (Saunders, 2011). Identifying and getting access to the right kind of data sources is crucial, as the choice of interview partners directly impacts the quality of information obtained (Hancock and Algozzine, 2006). The criteria describing suitable cases and projects have been outlined in Section 2.3.2.1, however, the author notes, that the term “project” itself refers to a socially constructed concept, which – as the author contends – cannot be investigated directly. Hence, the author will gather data from involved individuals, who can be considered to represent the case, project, and involved companies, appropriately. Depending on the case, “involved individuals” likely are a company’s management team who can assess the impact of the employed technologies onto the business model; as well as senior technicians, who can assess the implications of working with augmented reality or virtual reality from a technical perspective. For start-ups, likely the founding team will be considered. Furthermore, customers or users of a new, augmented reality or virtual reality powered solution or service might also be considered as sources for relevant data.

3.3.1 Approaching Companies

Companies associated with identified potential research case are contacted via email, phone, or social media[11], depending on the contact information available or revealed by the online search. The legality of this has been confirmed by a legal counsel (see Appendix E). A letter template for reaching out to companies is provided in Appendix F.

[11] E.g. via a message on LinkedIn (cf. LinkedIn, 2018) or XING (cf. Xing, 2018)

3.3.2 Selecting Companies and Cases

After reaching out to the companies, the first step will be a phone call, clarifying the appropriateness of the case. The purpose of this phone call is to fulfil a "screening-function"; and:

- to confirm, that the identified case is a good fit for the case study research project;
- to make sure, that the researcher is in contact with the right person, e.g. that his contact is capable, knowledgeable, and authorised to provide the researcher with the necessary back-ground information, and access to case participants;
- to substantiate the company's interest and ability in supporting the research project;
- to ensure (repeated) access to the relevant players;
- to assure trust and confidentiality between the researcher and the research participants;
- to clarify all necessary organisational issues;
- to agree on next steps and a potential time line;
- and ultimately, to decide whether to include the identified case in the research project.

Each phone call will be prepared. Preparation includes finding a quiet place for the phone call, reviewing company and case candidate details, and arranging all necessary documents for the call. After implementation of the call, it will be post-processed immediately. This includes noting any additional observations, updating the case study database and log, and summarising the next planned steps. Furthermore, prior to making a final decision on case inclusion and sending a follow-up email to the candidate, the researcher will implement a 24 hour pause – e.g. "sleep over it" – with the aim to improve the decision quality. A guide to facilitate the initial phone call to company candidates is provided in Appendix G in form of a mind map.

3.4 Data Collection Strategy

Collecting data for a case study research project is not a trivial task (Yin, 2017), and researchers need to identify the types of data which address their research questions best (Creswell, 2002). Creswell (2002) categorises the types of qualitative data (units of observation) that can be collected into four general classes:

1. Observations,
2. interviews and questionnaires,
3. documents,
4. audio-visual materials.

Furthermore, an integral part of any qualitative research project is the recording of data (Lofland and Lofland, 2006). For data collected through observations or interviews, this is commonly done by preparing data collection protocols (Creswell, 2002; Yin, 2011). In the next sections, an overview of the types of collected data (e.g. the units of analysis) and the associated documentation strategy is given:

3.4.1 Observations

Making observations is the method of collecting information by watching people and places at research sites (Creswell, 2002). Furthermore, observations are any hints and clues the researcher detects throughout the research implementation or qualitative data analysis process (Yin, 2017). During document analysis, for example, this includes "worrying whether the originator of the document intended any important messages between the lines" (Yin, 2017, p.84).

Initially, it is not planned to conduct observations in a formal manner; however, the researcher will note down all observations made during the research in form of field notes throughout the entire research process. These field notes are made, for example, while performing online research, during visits to research sites, and while scanning and skimming through collected data. These observations will be added to the case study log chronologically and assigned with the custom build Microsoft Word format "$Observation (general)". This formatting is then indexed via the "table of figures" feature offered by Microsoft Word, resulting in a summary overview of all observations. If it turns out that it is helpful to group certain types of observations, then this will be achieved by adding additional Microsoft Word formatting types and indexing these, individually.

3.4.2 Interviews and Questionnaires

Qualitative data may be collected through open-ended questions collected in interviews or questionnaires (Creswell, 2002). Various types of qualitative interviews exist, including structured interviews, unstructured or semi-structured interviews, and group interviews (Myers and Newman, 2007), however, "the main types of generated data in qualitative research are in-depth interviews and group discussions" (Ritchie et al., 2013).

Questionnaires are an interesting, time-saving option; however, the researcher feels that this would distance him too much from the research participants. As a result, important information might be missed; consequently, questionnaires are not part of the initial data collection strategy. Semi-structured interviews, on the other hand, are of particular interest to the researcher, as they are "capable of disclosing important and often hidden facets of human and organizational behaviour" (Qu and Dumay, 2011, p.246). Conducting semi-structured interviews with key players of the selected case will be the primary source of data for this study.

3.4.2.1 Interview Strategy and Protocol Design

In this section, the overall interview strategy and steps surrounding the interview implementation; as well as the initial design of the interview protocol are presented.

3.4.2.1.1 The Interview Process

Overall, the author has designed an interview process, which consists of three steps:

1. interview preparation,
2. interview implementation, and
3. interview post-processing.

The interview preparation is composed of the following steps:

1. review interview participant: be familiar with whom you talk to;
2. review the case/project in detail: be familiar with the case in as much detail as possible;
3. print of a copy of the interview guide (perhaps bring an extra copy, just in case);
4. pack extra materials for taking notes (pen and additional paper);
5. pack holder to place the phone in such a way, that it can record the conversation well.

The interview process will include the following steps:

1. begin the meeting/getting together with casual small talk with the interviewee;
2. continuously observe the surroundings for any unexpected, relevant observations;
3. set up interview documents and recording device:
   a. set the phone (which is used as a recording device) to flight mode,
   b. prepare the two stacks of paper – one, the interview guide, where checkmarks can be made when a topic has been talked about; second, a blank paper for notes and observations cross-referenced to the interview questions;
4. start recording as early as possible: record the opening words; the participant's consent and approval of recording; as well as the explanation of the next steps.

Thirdly, the interview post-processing will cover the following steps:

1. note personal observations and feelings directly after the interview;
2. transcribe the interview into English[12] text;
3. perform the manual qualitative data analysis.

3.4.2.1.2 Semi-Structured Interview Protocol Design

The interview guide is designed around the four research questions as presented in Section 2.1. Furthermore, the conceptual framework (see Appendix A) is used to guide the formulation of details in the interview questions. The desired outcome is the creation of a document which guides the interview process.

As noted by Yin (2017), case study research is a suitable method of choice if the researcher strives to answer "how" or "why" questions. RQ2 and RQ4 are formulated as "how" questions. RQ1 and RQ3, on the other hand, are formulated as "what" questions; however, "some types of "what" questions are exploratory" and "this type of question is a justifiable rationale for conducting an exploratory study" (Yin, 2017, p.10). Following the recommendation by Creswell (2002), the interview guide is started with a header to collect meta information, such as a brief case description; date, time, and place of the interview; and name of the interviewee, role of the interviewee, and name of the interviewer. Further, all questions will be formulated open-ended, as proposed by Creswell (2002). Lastly, a reminding sentence regarding the overall research aim is added

[12] Interviews held in German will be translated directly into English during the transcription process.

to the header of the interview guide document; and room for notes is reserved on the form. All interviews will be audio recorded, as recommended by Yin (2017). The interview protocol is provided in Appendix H.

3.4.3 Documents

In qualitative research, documents can be an important source of information (Creswell, 2002). Documents studied by the researcher may include "material extracted from the Internet, private and public records, physical evidence, and instruments created by the researcher" (Hancock and Algozzine, 2006, p.51).

At this point in time, the researcher plans to primarily examine information obtained from the Internet during the case identification phase, as outlined in Section 3.2. For the most part, this information consists of case descriptions, marketing information, and company background information. This data will be analysed for usefulness as the research progresses. Furthermore, as the research evolves, the researcher will monitor and probe for access to further, potentially interesting document sources; as it is unclear whether these documents exist at all, and if they do exist, whether the researcher will be able to gain access to these documents.

3.4.4 Audio-Visual Materials

Audio-visual materials are sounds or images which enrich the researchers' comprehension of the investigated phenomenon (Creswell, 2002). For this study, the author will treat these materials analogously to documents, as explained in Section 3.4.3. He will monitor the usefulness of such data as the research project progresses.

3.4.5 Addressing Challenges During Qualitative Interviews

The qualitative interview is a strong tool for researchers, however, qualitative interviews also pose numerous difficulties and potential pitfalls (Myers and Newman, 2007). To help circumnavigate the challenges, the researcher considers some of the potential issues as summarised by Myers and Newman (2007). An overview of potential risks and how these will be addressed by the researcher is given in Table 11.

Table 11 – Potential problems and pitfalls during qualitative interviews (adapted from Myers and Newman, 2007, pp.4, 5); and how they will be addressed by the researcher.

Potential pitfall	**Description** (Source: Myers and Newman, 2007, pp.4, 5)	**Addressing the issue in the study**
Artificiality of the interview	The qualitative interview involves interrogating someone who is a complete stranger; it involves asking subjects to give or to create opinions under time pressure.	The researcher will attempt to ensure, that the interview setting is comfortable and undisturbed, and that the interviewee has scheduled sufficient time for the interview. Furthermore, the researcher will take ample time during the initial warm-up phase for small-talk to facilitate a warm and competent setting.
Lack of trust	As the interviewer is a complete stranger, there is likely to be a concern on the part of the interviewee with regard to how much the interviewer can be trusted. This means that the interviewee may choose not to divulge information that he or she considers to be "sensitive". If this is potentially important information for the research, the data gathering remains incomplete.	Prior to the interview, e.g. beginning during case selection phase, the researcher will strive to create a relationship of trust. This will be achieved by discussing and disclosing any potential conflicts of interest, by being transparent in respect to the researcher's professional role, and by signing non-disclosure documents as needed.
Lack of time	The lack of time for the interview may mean that the data gathering is incomplete. However, it can also lead to the opposite problem – of subjects creating opinions under time pressure (when these opinions were never really held strongly to start with). In this case more data are gathered but the data gathered are not entirely reliable.	The researcher will attempt to avoid situation of time pressure, entirely. Access and time-restrictions will also be discussed and arranged during the initial contact phase.
Level of entry	The level at which the researcher enters the organization is crucial (Buchanan, Boddy, & McCalman, 1988). For example, if a researcher enters at a lower level, it may prove difficult if not impossible to interview senior managers at a later date.	Prior to conducting any interviews, the researcher will attempt to identify the relevant players and stakeholders, he wishes to talk to. Thereafter, he will derive an interview order and overall strategy.
Elite bias	A researcher may interview only certain people of high status (key informants) and therefore fail to gain an understanding of the broader situation.	Similar to the point above: the researcher will attempt to identify the relevant players and stakeholders, and include the "right" people, rather than the "most important" ones.
Hawthorne effects	Qualitative interviews are intrusive and can potentially change the situation. The interviewer is not an invisible, neutral entity; rather, the interviewer is part of the interactions they seek to study and influences those interactions (Fontana & Frey, 2000). The researcher may intrude upon the social setting and potentially interfere with peoples' behaviour.	The researcher will remain aware of this issue, however, as this study is centred around interviewing and "hidden" data collection (e.g. from non-human sources, such as document and the Internet), the author considers this a minor challenge.
Constructing knowledge	Naïve interviewers may think that they are like sponges, simply soaking up data that	This is of particular importance for the researcher, as he is a trained business

Potential pitfall	Description (Source: Myers and Newman, 2007, pp.4, 5)	Addressing the issue in the study
	is already there. They may not realise that, as well as gathering data, they are also actively constructing knowledge.	consulting. Consequently, he will continuously remind himself of the researchers listening role as indicate by Yin (2017).
Ambiguity of language	The meaning of our words is often ambiguous, and it is not always clear that subjects fully understand the questions.	The interview protocol, as well as probing questions will be used to ensure that the interviewees understand the researcher's questions. The author is experienced in dealing with this challenge.
Interviews can go wrong	Interviews are fraught with fears, problems and pitfalls. It is possible for an interviewer to offend or unintentionally insult an interviewee, in which case the interview might be abandoned altogether.	The researcher will be polite, professional and cautious in his communication. Furthermore, he is prepared to abort a session or case, should an interview "go wrong" after all.

3.5 Data Analysis Strategy

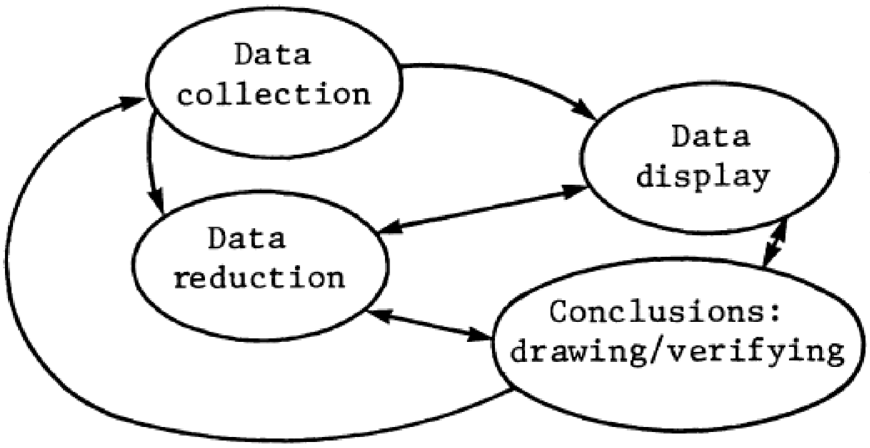
Examining case study evidence is one of the most crucial stages in the research process (Leech and Onwuegbuzie, 2008). However, analysing case study data is also one of the least developed parts in case study research, therefore posing a key challenge which needs to be considered prior to data collection (Yin, 2017). The planned research is of exploratory nature. It is aimed at better understanding the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany. When moving towards theory development grounded in empiricism, employing inductive methodologies is a suitable approach (Glaser *et al.*, 1968). This holds particularly true for research projects which strive to discover initial concepts for the purpose of guiding further theory building (Gioia *et al.*, 2013). The planned study is such a research project.

Generally speaking, there are two main inductive tactics: grounded theory, and analytic induction (Bansal and Roth, 2000). Analytic induction is the preferred approach of the author because is explicitly facilitates the use of pre-existing theory (Bansal and Roth, 2000). Following a general inductive approach "provides an easily used and systematic set of procedures for analyzing qualitative data that can produce reliable and valid findings" (Thomas, 2006, p.237). This analysis approach allows for new findings to emerge from raw data without being restricted by methodological structures (Thomas, 2006; Hussy *et al.*, 2013). According to Thomas (2006), data analysis by analytic induction is composed of three main steps:

1. summarise and reduce (the extensive amount of) raw data;
2. establish connections between the research objective and the overall findings extracted from the analysed raw data; and finally,
3. develop an underlying theory or model.

Furthermore, Miles and Huberman (1984, p.23) elaborate that these three data analysis steps are an iterative process which "consists of three concurrent flows of activity: data reduction, data display, and conclusion-drawing/verification". This concept is depicted in Figure 5.

Figure 5 – Components of data analysis as a flow model (Source: Miles and Huberman, 1984, p.23).



Creswell (2002) formulates a guide of six commonly taken steps in qualitative data analysis. Creswell (2002, p.237) also comments, that "these steps are not always taken in sequence". For the planned study, the researcher will follow the six-step outline proposed by Creswell (2002). An overview of the qualitative data analysis strategy is given in Table 12.

Table 12 – Summary of the researcher's qualitative data analysis strategy (adapted from Creswell, 2002).

Research step	Aspects, purpose, and details	Application to this study
Prepare and organise the data for analysis	Create a strategy on how to organise the data. Transcribe the data. Hand/manual analysis versus computer aided analysis.	The data organisation strategy has been defined in Section 3.1. After the interviews, data will be transcribed to text. German interviews will be translated. The author prefers a (semi-)manual qualitative data analysis approach. See Section 3.5.1 for more information.
Explore and code the data	Get a general sense of the data. Code the data.	The author follows the indication by Yin (2017, p.167) "whether using computer-assisted software or not, one starting point for any analysis is to "play" with your data". After the initial data exploration phase, the data will be encoded. Refer to Section 3.5.2 for more information.
Use codes to build descriptions and themes	Description development refers to the process of describing people, events, or places in great detail. The aim is to form a deep understanding of the phenomenon under investigation. Formulating themes refers to the qualitative data analysis practise of aggregating codes to develop core ideas.	The approach for description and theme building will be further detailed during the data collection process, particularly in the pilot case study phase.
Represent and report findings	Representing findings in different ways, such as tables, hierarchical diagrams, maps, or figures is a key step in presenting research results. Findings are commonly reported in form of a narrative discussion with the aim to summarise the key insights the study revealed.	The representation of the findings will be conceptualised and reported in a subsequent paper.
Interpret findings	Interpretation of findings is the researcher's attempt at making sense of the collected data and reflecting on the meaning of the phenomenon investigated.	The interpretation of the findings will be presented in a subsequent paper.
Implement strategies to validate the accuracy of the findings	Strategies to validate the accuracy of the findings are strategies aimed at increasing the credibility and trustworthiness of the research and drawn conclusions.	The researcher will adhere to the three common quality approaches of triangulation, member checking, and auditing. Refer to Section 3.5.3 for more information.

3.5.1 Semi-Manual Qualitative Data Analysis

Numerous software tools, which can aid the qualitative data analysis process, exist. However, it can be preferable to perform the qualitative data analysis by hand, for example, if the researcher wants to be closer to the data and is analysing a relatively small data base – smaller being fewer than 500 pages of single-spaced text (Creswell, 2002).

Creswell (2002, p.238) estimates, that “a 30-minute interview will often result in about 20 pages of single-spaced transcription”. The author expects to investigate approximately seven cases, thereby conducting 30-minute interviews with two to three stakeholders. This very rough estimate results in approximately 420 pages of transcribed text[13]. Even when adding field notes and additional observations and records, the expected text database will remain relatively small.

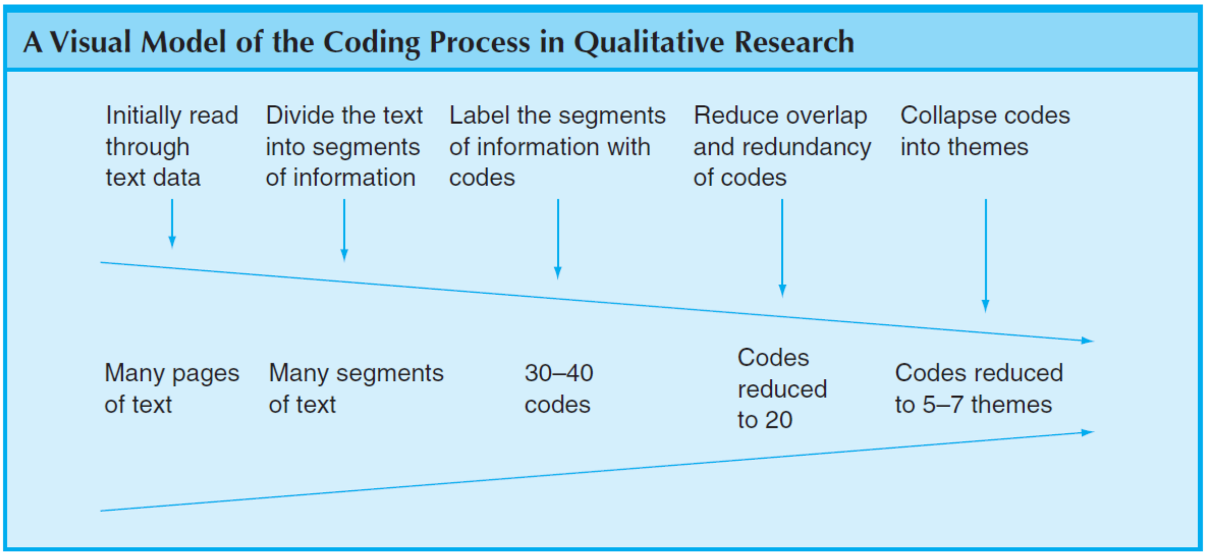
The author, however, is an experienced user of computers, particularly of the spread sheet software Microsoft Excel. He plans to employ this software to aid the data organisation and qualitative data analysis steps such as attaching codes to segments of text or counting the number of times a code or theme appears. The author feels that this “semi-manual” approach to qualitative data analysis combines “the best of both worlds”: the number-crunching ability of computers without imposing predetermined restrictions caused by qualitative data analysis software designs.

3.5.2 Data Encoding

“Coding is the process of segmenting and labelling text to form descriptions and broad themes in the data” (Creswell, 2002, p.243). There is no formal way for coding data (Yin, 2017). However, Creswell (2002) offers a visual model to guide the qualitative data analysis process. This visual model is depicted in Figure 6. The researcher will follow this coding process.

[13] 7 cases x 3 interviews = 21 interviews. 21 x 20 pages = 420 pages of transcribed text.

Figure 6 – A visual model for the coding process in qualitative research (Source: Creswell, 2002, p.244)



Furthermore, one way to draw conclusions from prioritised, reduced, and organised data is a "think inside the box", then "think outside the box" approach (H. O'Connor and N. Gibson, 2003, p.66). Concretely, this means that data is first analysed for answering the original research questions. Then the data is skimmed for "surprises" and other unexpected themes or ideas. Discovered connections are documented, described, challenged, and finally concluded. The drawing of potential conclusions is a continual process throughout the entire qualitative data analysis process (Creswell, 2002) and will be documented throughout the entire research in the case study database.

3.5.3 Triangulation, Member Checking, and Auditing

Researchers typically use the three quality-enhancing strategies triangulation, member checking, and auditing (Creswell, 2002). Triangulation is the notion of collecting evidence from different data sources, such as different individuals, different types of sources, and from different cases (Yin, 2017). For this research, the author will collect data from semi-structured interviews conducted with different individuals in different companies, as well as from field notes and other observational notes made during the research process; for example while conducting the online searches (cf. Section 3.2.2). Furthermore, after examining the results of the individual case studies, the researcher will follow the recommendation by Yin (2017) and thereafter conduct a cross-case synthesis.

Member checking refers to the process of asking research participants to review the account of events as given by the researcher (Creswell, 2002). The author plans to send accounts of the conducted interviews to selected interviewees, asking them to comment on the accuracy of the researcher's descriptions and interpretations.

Lastly, auditing refers to the action of involving an external reviewer to evaluate the quality of the study regarding its strengths and weaknesses (Creswell, 2002). An auditing process is inherent to the planned research project, as it is supervised and examined by an academic counsel.

3.6 Further Considerations

3.6.1 Ethical Considerations

Independent of the research approach, ethical aspects must be identified and preserved. When conducting research in the field of management-studies, one might be inclined to assume, that ethical considerations are a minor issue, especially if compared to disciplines like medicine or chemistry, where incautious or negligent behaviour may result in physical harm for humans or the environment. However, Bell and Bryman (2007) point out that researchers in this field face a whole unique set of ethical challenges, ranging from "power relations" over "conflicts of interest and affiliation bias" to "wrongdoing". Further, "management researchers face increasing pressure to protect the confidentiality and anonymity of research participants in order to avoid harmful effects" (Bell and Bryman, 2007, p.69).

3.6.1.1 Reflecting on IEEE Code of Ethics and IEEE Code of Conduct

The author, a trained engineer, considers the IEEE code of ethics (IEEE, nd) as well as the IEEE code of conduct (IEEE, 2014) well formulated guidelines for general professional and ethical behaviour. Some central elements of the two IEEE codes referenced above, which the author considers most relevant for the planned study, are reflected upon below:

3.6.1.1.1 <u>Safety, Health, and Welfare of the Public</u>

Particularly technology projects have the potential to impact the environment or society as a whole. While it is unlikely that the researcher will find himself in a situation "threatening mankind", he will observe carefully the impact of the studied cases in respect to safety, health, and welfare of the public; and disclose any potential observations to the individuals responsible.

3.6.1.1.2 Avoid Injury to Others, their Property, Reputation, or Employment

First and foremost, the author will make sure that no harm – neither physical nor psychological – will be caused to research participants. This will be done by adhering to safety-instructions where applicable and taking part in safety-courses where available. Further, the researcher will also be very cautious in regard to not harming the reputation of research participants and companies. This will, for example, be ensured by making transcripts, meeting logs, and observations available for review for and approval by research participants.

3.6.1.1.3 Be Respectful: Act in a Professional Manner and Treat Persons Fairly

Clearly, all communication and actions will be respectful, non-discriminating, and of professional grade, as customary in service-orientated business consulting.

3.6.1.1.4 Be Respectful of the Privacy of Others

All personal information will be collected and stored only within the legal bounds of the most recent privacy laws; and will be protected from unauthorised access. During the evaluation process all presented data and outcomes will be anonymised as much as necessary, so that no harmful links back to the source of data or insight can be made.

A particular point of concern might be the (unintended or unnecessary) disclosure of confidential intellectual property, know how, or other industry secrets by a research participant. Therefore, the researcher will be ready to sign any acceptable[14] non-disclosure agreement provided by the research participants' firms; and disclose all data included into the study for review and approval by research participants.

3.6.1.1.5 Conflict of Interest

Another significant challenge for the author in particular is the fact, that he is an entrepreneur in the field of augmented reality and virtual reality. Hence, additional to any potentially required non-disclosure agreements, he will disclose his professional status and discuss any implications with the research participants prior to conducting the study of the individual case. Furthermore, he will keep all communication and critical research data separate from my business. In the case that the author's business IT systems are used to support the research, the researcher will ensure that access to these systems and data is restricted. During the research, the researcher will refrain from actively pursuing business

[14] If no satisfying agreement can be derived, the case will not be included in the study.

interests in the case companies. In the event, that a participating company signals business interests, he will direct it to another CEO at Phaenom, and will not get involved in any business topics, until research completion. Any conflicts of interest will be monitored closely. The author will make any conflicts of interest transparent to the affected parties and strive for the best possible resolution. If doubts remain, the case will be excluded from the study.

3.6.1.1.6 Be Honest and Realistic in Stating Claims

The researcher is aware, that certain over-expectations might be interpreted into claims and statements by the researcher, due to his researching role and professional status. The researcher, however, knows that he is a novice to science and a newcomer to case study research. Therefore, he will monitor his claims and statements especially carefully.

3.6.1.1.7 Reject Bribery

Should the situation arise, any bribery in any form will be rejected.

3.6.1.1.8 Credit Properly the Contributions of Others

All research participants and supporters will be credited properly, unless otherwise desired by the research participant. Credit may also be included anonymously.

3.6.1.1.9 Comply with Applicable Laws

Applicable laws will be honoured and, if in doubt, double-checked with a legal counsel (for an example see Appendix E). Particularly, data protection laws are respected.

3.6.1.1.10 Participant Consent

All potential candidates who might be part of the research project will be informed about the research project and asked for their participation. It will be made sure, that participants who join the project at a later stage will be informed as well. The participation will be entirely voluntary and no one who chooses not to participate will suffer disadvantages from his/her choice or be retaliated against. Further, participants will be encouraged to give feedback to the researcher at any time. The participating companies' consent will be documented in the initial email and phone communication. The individual participants' consents (e.g. interviewees) will be captured verbally at the beginning of each interview. The researcher refrains from written consent agreements as not to unnecessarily hinder the research process. This is well in line with German legal regulations (freedom of contract).

3.6.2 Potential Challenges

3.6.2.1 Researcher Bias

The researcher is an active entrepreneur focussing on the employment of the technologies augmented reality and virtual reality. On the upside, this entrepreneurial orientation fuels his continued interest in these technologies and their potential impact on business model innovation. However, there is a certain risk, that this has a biasing impact on the author's interpretation of any findings. For example, he already believes, that augmented reality and virtual reality do have a significant impact on business model innovation in technology companies in Germany (and should therefore be employed much more intensively). However, in theory, the findings might contradict this believe, or even indicate, that augmented reality and virtual reality don't impact business model innovation at all. Consequently, the researcher will continuously remind himself of this potential pitfall. Furthermore, he will discuss his collected data and drawn conclusions with scientific peers whenever possible. Table 13 gives an overview of potential bias challenges per research question along with the author's strategy how to deal with these issues.

Table 13 – Research questions, researcher bias, and strategy addressing the issue.

Research question	Potential bias	Strategy addressing the issue
RQ1: What types of augmented reality and virtual reality technologies are technology companies in Germany adopting?	The researcher is familiar with a set of technologies, which he believes to be good, perhaps even superior choices. This may blind him to recognising cases which employ an augmented reality or virtual reality technology the researcher is unfamiliar with.	To some extent, identifying new technologies (new to the author) might be one of the most interesting aspects of this research. Hence, the author will keep an open mind for new technology discoveries. Furthermore, he will include colleagues who are technology experts, whenever an "unknown" technologies is discovered.
RQ2: How are augmented reality and virtual reality technologies being applied by technology companies in Germany?	As a computer scientist and systems engineer, the researcher has his own opinion how augmented reality and virtual reality could be applied.	The researcher will continuously remind himself, that his research quest is "to learn and listen", rather than to "teach and propose". Particularly during the data analysis phase, he will follow research methods rigorously and refrain from jumping to early conclusions.
RQ3: What impact does augmented reality and virtual reality technologies have on business model innovation in	Due to the researcher's entrepreneurial interests, he might be inclined to postulate, that there is (a significant) impact of augmented reality and virtual	Keep an open mind, including to being open to the possibility, that the findings might indicate, that augmented reality and virtual reality don't impact business model innovation at all. Discuss collected

Research question	Potential bias	Strategy addressing the issue
technology companies in Germany?	reality on business model innovation.	data and conclusions with scientific peers whenever possible.
RQ4: How can technology companies in Germany maximise the benefits of augmented reality and virtual reality technologies for business model innovation?	Similar to RQ2, the researcher might already have an entrepreneurial opinion on how to do this. Furthermore, the researcher might be inclined to assume, that there are benefits, which may not be the case (similar issue to RQ3 bias challenges).	Keep an open mind, including to being open to the possibility, that the findings might indicate, that augmented reality and virtual reality don't deliver benefits at all, for business model innovation. Furthermore, strive to gather insights from interviewees, thereby resisting to inject the researcher's own expectations.

3.6.2.2 Distrust and Conflict of Interest

For this research project, the researcher needs access to company personnel and potentially sensitive data. Besides the "usual challenges", the researcher might appear "particularly suspicious" to case candidate companies, as he pursues visible business interests. The result may be distrust in the researcher's direction, conflicting interests (e.g. if a competitive situation were to arise between the researched company and the researcher's business), and an overlap of agendas (e.g. performing research vs. acquisition of a new client). These issues have already be addressed in Sections 3.6.1.1.4 and 3.6.1.1.5 and will additionally be monitored in detail, and discussed transparently with case candidate companies. If in doubt, cases will be excluded from the study.

3.7 Pilot

Yin (2017) recommends to conduct a pilot case study prior to embarking on the overall case research endeavour. The pilot case study can help the researcher to refine the data collection strategy "with respect to both the content of the data and the procedures to be followed" (Yin, 2017, p.106). Following the recommendation by (Yin, 2017, p.107), the author will select a suitable pilot considering the selection criteria convenience, access, and geographic proximity. Further, the author will attempt to identify a company, who is particularity willing to talk to the author repeatedly. This may be a company with whom the author has already worked with. The anticipated outcome of the pilot case study is a pilot case study report, which documents the learnings made during the pilot study, summarises the changes made to the case study protocol and data analysis strategy, and provided insights for both, the researcher and the company participating in the pilot case study.

In this section, the author presented the research operationalisation strategy in detail. Further, he considered additional aspects, such as ethical issues and potential challenges. In the next section the author gives a summary of the paper and presents a brief preview on the next planned steps.

4 Summary

The 21st century is the age of the "digital transformation" – a time of unprecedented global change. In order to address the new order of magnitude of complexity in the entrepreneurial environment, companies must develop new concepts; such as business model innovation. However, as the term business model innovation indicates, business models are not static and need to continuously be innovated. Furthermore, newly-emerging, digitally-based technological innovations, such as augmented reality and virtual reality, are drivers for the innovation of business models.

The planned research is aimed at better understanding the impact of augmented reality and virtual reality technologies on business model innovation in technology companies. The formal objective of the proposed study is "*to explore the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany*".

This methodology paper reflects on the philosophical underpinnings of the planned research, justifies the chosen research methodology, and presents the research operationalisation approach. To meet the research objective, the researcher adopts a phenomenologist, subjectivist, interpretivist approach; using a multiple-case holistic "Type 3" case study design. Data will be collected primarily through implementation of semi-structured interviews, and observations made by the researcher.

The next research steps are obtaining ethical clearance from the academic review board, and the implementation of a pilot case study to test the data collection methods and qualitative data analysis strategy. The results of the pilot case study will be used to refine the research instruments. These results, as well as initial findings, will be reported in a subsequent paper.

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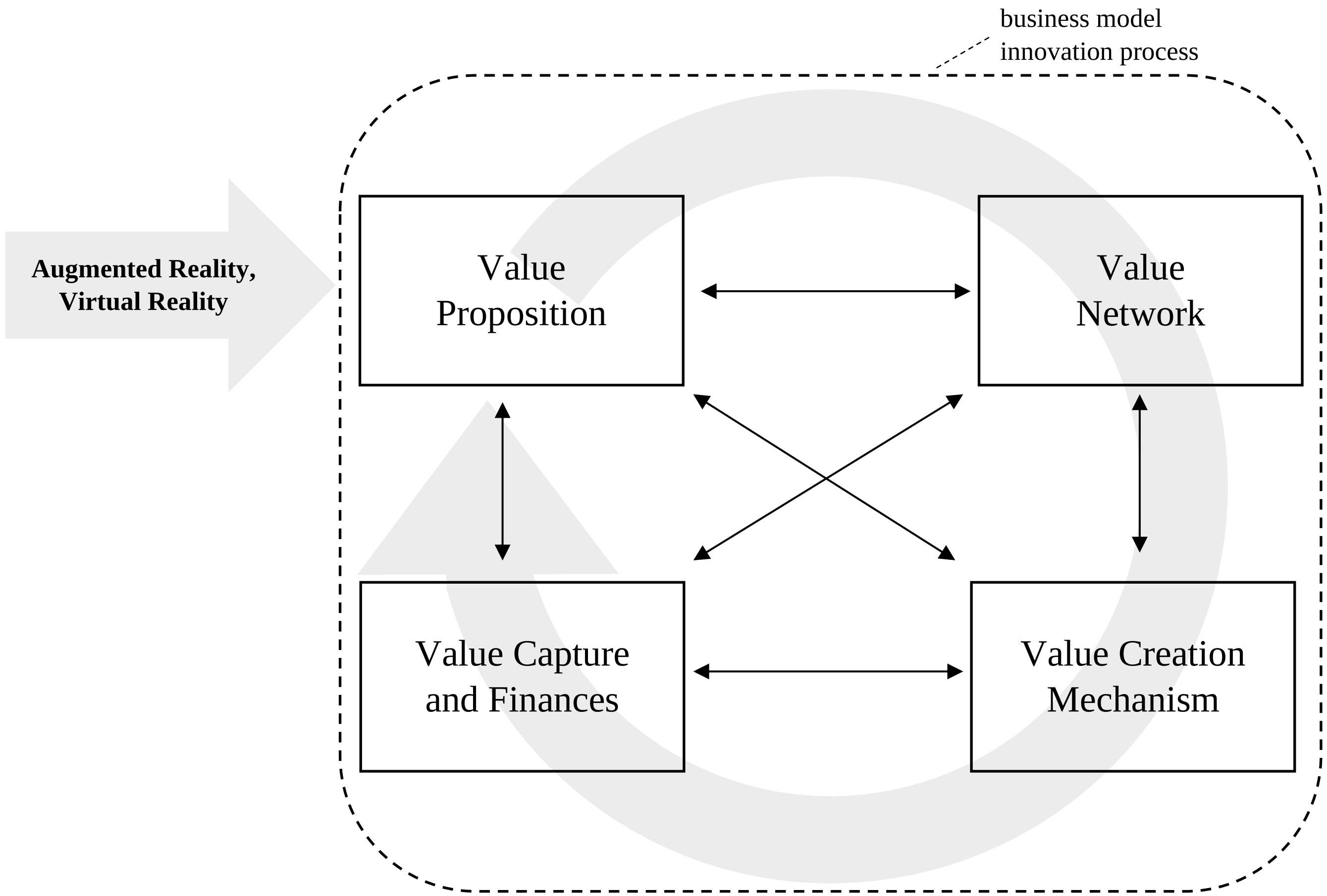
Appendix A Conceptual Framework to Explore the Impact of Augmented Reality and Virtual Reality on Business Model Innovation

As part of a previous conceptual paper, the author developed a conceptual framework to explore the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany. The conceptual framework is presented in Figure 7.

To better understand the framework, the reader is directed to start at the right-hand side of Figure 7. There, the key findings of the business model, and business model innovation literature review are summarised and amended by the final objective of the business model innovation process: the innovation of an existing business model, or the creation of an entirely new business model. The left-hand side of Figure 7 presents an arrow labelled “augmented reality, virtual reality” indicating that these technologies offer new, potential business opportunities and therefore act as motivators to start the business model innovation process. At the centre of Figure 7, the business model value domains identified in literature are shown. They are connected by double-headed arrows, indicating that the business model is an inter-connected concept. Finally, a circular arrow in the background demonstrates that business model innovation is a continuous, dynamic process. Arguably, the first step in business model innovation can be the search for a new or improved value proposition, followed by the subsequent steps, as shown.

Figure 7 – Proposed conceptual framework to explore the impact of augmented reality and virtual reality on business model innovation in technology companies. (adapted from Chesbrough and Rosenbloom, 2002; Morris *et al.*, 2005; Al-Debei and Avison, 2010; Lüdeke-Freund, 2013)



Business model
- Simplified but complete representation of how a company operates
- Holistic approach

Business model elements
- Value based
- Interconnected

Business model functions
- Communication tool
- Mediator between strategic objectives and technology
- Source of competitive advantage

Business model innovation process
- Continuous
- Dynamic

Business model innovation outcomes
- Innovated business model
- New business model

Appendix B Four Technological Dimensions of an AR/VR Case

Table 14 – Four technological dimensions of an AR/VR case.

Technological dimension	**Description**	**Examples**
Hardware	Hardware is used to present and interact with content. Hardware may also be used to create content.	Virtual reality googles; smart glasses, smart phones; accessories (e.g. data gloves). (360-degree) cameras; scanners, spatial microphones.
Software	Software solutions are needed to present and interact with digital content.	Hardware-specific operating systems; (game) engines and frameworks; applications.
Content	All hardware and software efforts ultimately revolve around presenting and interacting[1] with some kind of content.	(3d-) content can be created by 3d-artist; 3d-cameras; scanners; and by automation (e.g. data import).
Infrastructure	Once an application and content are created, they need to be delivered to the user/consumer.	Manual installation; app stores; web services; proprietary solutions.

[1] The author considers the possible *creation* of content through/in the virtual space as part of content interaction.

Appendix C AR/VR Use Cases Analysis of Chapter "Augmented Reality and Virtual Reality: Business Model Innovation Drivers"

The following is an excerpt of a chapter from the author's conceptual paper on business model innovation. Case relevant key words have been highlighted:

> While arguably gaming is the most obvious case for augmented reality and virtual reality, the potential applications for augmented reality and virtual reality seem endless and range through various industries, as well as numerous areas of private life (Brohm *et al.*, 2017).
> The technologies are broadly seen as potential new training systems for maintenance and assembly tasks (Gavish *et al.*, 2015) and can assist during all steps of the manufacturing process (Virtual Dimension Center, 2012). The company Airbus, for example, uses an augmented reality display to aid airplane assembly (Flug Revue, 2015) and research conducted by Westerfield *et al.* (2015) even indicates, that "using an intelligent AR tutor can significantly improve learning compared to more traditional AR training" (p.157). An example of a potential future maintenance case is the „AR Maintenance System" research project conducted by the University of Bremen, which has the aim to employ augmented reality to assist the maintenance of wind turbines by providing service technicians with detailed information, as well as taking over documentation tasks (Zwettler, 2015).
> Similarly, augmented reality and virtual reality promise to be beneficial for education and teaching purposes, for example by facilitating students with a virtual training platform of an injection moulding machine (Sun and Tsai, 2012), by putting students in situations or places that couldn't otherwise be accessed or visited (Greenwald *et al.*, 2017), by producing high levels of enjoyment during the learning process (cf. Harley *et al.*, 2016), or by improving learning motivation, student creativity, and the teaching of creative design (Wei *et al.*, 2015). Literature to date hasn't produced evidence yet, that augmented reality applications which support medical learning provide value (Barsom *et al.*, 2016). However, Chen *et al* (2015) developed an augmented reality based surgical navigation system and were able to show that the system was accurate enough to meet clinical requirements.
> Another area of interest is the field of marketing (Runde, 2015). As a matter of fact, many of the world's largest companies have already incorporated augmented reality and virtual reality into their marketing strategies (Scholz and Smith, 2016): "innovative marketers can now leverage augmented reality to craft immersive brand experiences, create more interactive advertising, and enable consumers to experience products and spaces in novel ways." (Scholz and Smith, 2016, p.2). ...
> A study by McMahon *et al.* (2015) showed, that augmented reality navigation proved to be a more effective navigation solution than paper maps and online maps, such as Google Maps, for students with intellectual disability. Jung et al. (2016) discovered, that "entertainment experience from VR and AR can lead to enhanced overall tourist experience" (p.11). For destination marketing practitioners, attraction theme parks are a potential market for augmented reality applications (Jung *et al.*, 2015).

Employing augmented reality and virtual reality for remote collaboration also offers novel opportunities: who can a user interact with (e.g. remote people) and how can be interacted (Greenwald *et al.*, 2017). A concrete use case for remote collaboration is remote assistance, where a remote expert can "create and manipulate virtual replicas of physical objects in the local environment to refer to parts of those physical objects and to indicate actions on them" (Oda *et al.*, 2015, p.405). Air New Zealand is taking this approach even further: Microsoft's head mounted display HoloLens is tested to support the cabin crew by displaying passenger details, or even attempting to interpret passengers' body language (Air New Zealand, 2017).

Further promising fields are psychological research, where virtual reality offers unprecedented chances to study human behaviour (Diemer *et al.*, 2015), military training via an augmented reality first-person shooting solution (cf. Zhu *et al.*, 2015), city planning for energy production (Santana *et al.*, 2017), and virtual showrooms and product configurators – as pioneered by car manufacturer Audi (cf. Janssen, 2015) and furniture manufacturer IKEA (cf. Demodern GmbH, 2017).

Industry insiders identify new opportunities driven by virtual reality for journalism (cf. Albrand, 2015), and established television transmitters, such as ABC News, already introduced virtual reality to their reporting service offering (Förtsch, 2015). New start-ups also try to secure the emerging markets of virtual reality broadcasting (e.g. Jaunt Inc., 2017; NextVR, 2017) or virtual reality arcades (e.g. Virtual Area, 2017; Hologate, 2017; Playspace, VR, 2017).

Finally, virtual reality is a suitable new tool for teaching and research in architecture (Portman *et al.*, 2015) and virtual reality real estate presentation applications range from hotels presenting their room offering (e.g. Shangri-La Hotels and Resorts, 2016) to self-serviceable platforms targeting real estate agents (e.g. Transported, 2017).

Appendix D AR/VR Case Search Log Template

Overview

In this log, the performed online research as designed in the "ARVR Case Search Design" document is being documented.

Notes

- <List observations here>
- …

Searches

Search "<insert key phrase here>"

Search result	Decision for inclusion and reasoning	Redmine references

Search "<insert key phrase here>"

Search result	Decision for inclusion and reasoning	Redmine references

…

Appendix E Legal Note on Approaching Companies

Initial query by the author (2018-02-10)

Folgende Rechtsfrage(n) haben Sie gestellt:
Sehr geehrte Rechtsanwälte,
bitte senden Sie mir ein unverbindliches Preisangebot zur Beantwortung folgender Rechtsfrage(n):
Ich bin Doktorand und möchte Unternehmen für mein Forschungsvorhaben kontaktieren.
Bei der Kontaktaufnahme geht es darum, zu erfragen, ob die vorab im Internet identifizierten Unternehmen bereit sind, an meiner Studie teilzunehmen.
Darf ich online-identifizierte und durch meine Forschungskriterien qualifizierte Unternehmen per Email anschreiben oder anrufen?
Beste Grüße,
Richard Hagl

Response from Lawyer (2018-02-11)

-----Ursprüngliche Nachricht-----
Von: Deutsche Anwaltshotline [mailto:ebs@deutsche-anwaltshotline.de],Gesendet: Sonntag, 11. Februar 2018 15:24; An: richard@hagl.net
Betreff: Antwort auf Ihre Rechtsfrage Nr. 247291
…
Sehr geehrter Herr Hagl,
Sie können Unternehmen grundsätzlich problemlos per Email kontaktieren mit Bitte, an einer Studie teilzunehmen. Eine unverlangte Kontaktaufnahme per Email oder Telefon ist erst einmal nur im Rahmen von Werbeanrufen und Werbeemail, die ohne vorherige Einwilligung des Empfängers, ergehen, unzulässig.
Die einmalige Anfrage, an einer wissenschaftlichen Studie teilzunehmen, stellt aber keine Werbung (Absatzförderungsmaßnahme) dar und ist damit nicht verboten.
Etwas anderes ergibt sich erst dann, wenn es nicht bei einer einmaligen Anfrage bleibt, sondern in belästigender Art und Weise erfolgt. Das wäre dann der Fall, wenn beispielsweise per automatisch generierter mail, permanent Emails an den Empfänger gesendet werden.
Es macht daher auf jeden Fall Sinn, unter Ihre Emailanfrage einen Informationszusatz zu setzen, mit der Angabe, dass es sich bei dieser Email nicht um eine Werbeemail handelt, diese Email auch nur einmalig erfolgt und wenn der Empfänger keine weiteren Email erhalten möchte, keine weiteren Schritte notwendig sind, da Sie die Empfängerdaten bei Nichtrückmeldung umgehend löschen werden.
Für weitere Rückfrage stehe ich Ihnen gerne zur Verfügung.
Mit freundlichen Grüßen
Dierk Straeter

Appendix F Letter to Companies

The following is a letter template which will be used to contact companies in order to negotiate access. This letter may be tailored in each instance, individually.

German (this is the version used)

Sehr geehrte Damen und Herren [oder direkter Ansprechpartner],
mein Name ist Richard Hagl. Ich bin Doktorand und Forscher für das Thema Geschäftsmodelle und die Technologien Augmented Reality (AR) und Virtual Reality (VR). Für mein Forschungsvorhaben suche ich (bereits vorausgewählte) Unternehmen, die bereit sind an einer Studie teilzunehmen.
Sicherlich fragen Sie sich, warum Sie an einer Studie teilnehmen sollten. Neben „idealistischen" Aspekten, z.B. dem Stärken des Wissenschafts- und Wirtschaftsstandortes Europa, entstehen für Sie und Ihr Unternehmen weitere, konkrete Vorteile: Zum einen teile ich Ihnen die Ergebnisse meiner Forschungsarbeit knapp und präzise, verständlich aufbereitet und auf Deutsch noch vor Veröffentlichung mit. Darüber hinaus können Sie – wenn Sie wollen – eine kostenfreie, telefonische Beratung mit mir wahrnehmen. In dem Beratungsgespräch vertiefen wir dann individuell die Forschungsergebnisse und ihre Anwendbarkeit auf Ihr Unternehmen oder Business Case.
Zum Vorhaben: in meiner Forschungsarbeit interessiere ich mich dafür, welche Auswirkungen die Technologien AR und VR auf heutige Unternehmen haben. Konkret suche ich Unternehmen, die bereits ein AR oder VR Projekt realisiert haben und bereit sind, Ihre Erfahrungen mit mir zu teilen.
[individually refer to the identified project here]
Zum Schluss möchte ich Ihnen noch garantieren, dass ich in meiner Arbeit höchste, wissenschaftliche, professionelle und ethische Ansprüche erfüllen werde. Selbstverständlich werden keinerlei personenbezogenen Daten oder vertrauliche Projekt-Details veröffentlicht oder an unbefugte Dritte weitergegeben (es sei denn, dass Sie dies, z.B. aus Marketinggründen, explizit wünschen). Gerne unterzeichne ich auch Ihre Geheimhaltungsvereinbarung, wenn Sie dies wünschen.
Im nächsten Schritt schlage ich vor, dass wir kurz telefonieren und ich Ihnen weitere Details zu dem Forschungsvorhaben und Ihrer Involvierung erläutere. Über Ihre, hoffentlich positive, Rückmeldung freue ich mich schon jetzt sehr!
Herzliche Grüße,
Ihr Richard Hagl

English (for reference only)

To whom it may concern [or direct contact person],
My name is Richard Hagl. I am a doctoral student and researcher on business models and the technologies augmented reality (AR) and virtual reality (VR). For my research project, I am looking for (already preselected) companies who are willing to participate in a study.
Surely, you are wondering why you should take part in a study. Besides "idealistic" aspects, e.g. strengthening Europe as a location for science

and industry, you and your company will benefit from further, concrete advantages: Firstly, I will share the results of my research with you prior to publication in a concise, precise, comprehensible fashion, edited in German. In addition, you can – if you so desire – consult with me via telephone, free of charge. In this counselling session, we will individually discuss the research results and their applicability to your company or business case.

About the project: In my research, I am interested in the effects of the technologies AR and VR onto today's businesses. Specifically, I am looking for companies who have already realised an AR or VR project and are willing to share their experiences with me.

[individually refer to the identified project here]

Finally, I want to assure you that my work will adhere to highest scientific, professional, and ethical standards. Of course, no personal information or confidential project details will be published or disclosed to unauthorized third parties (unless you explicitly would like me to, for example for marketing reasons).

In the next step I propose that we have a short phone call in which I'll explain further details about the research project and your involvement.

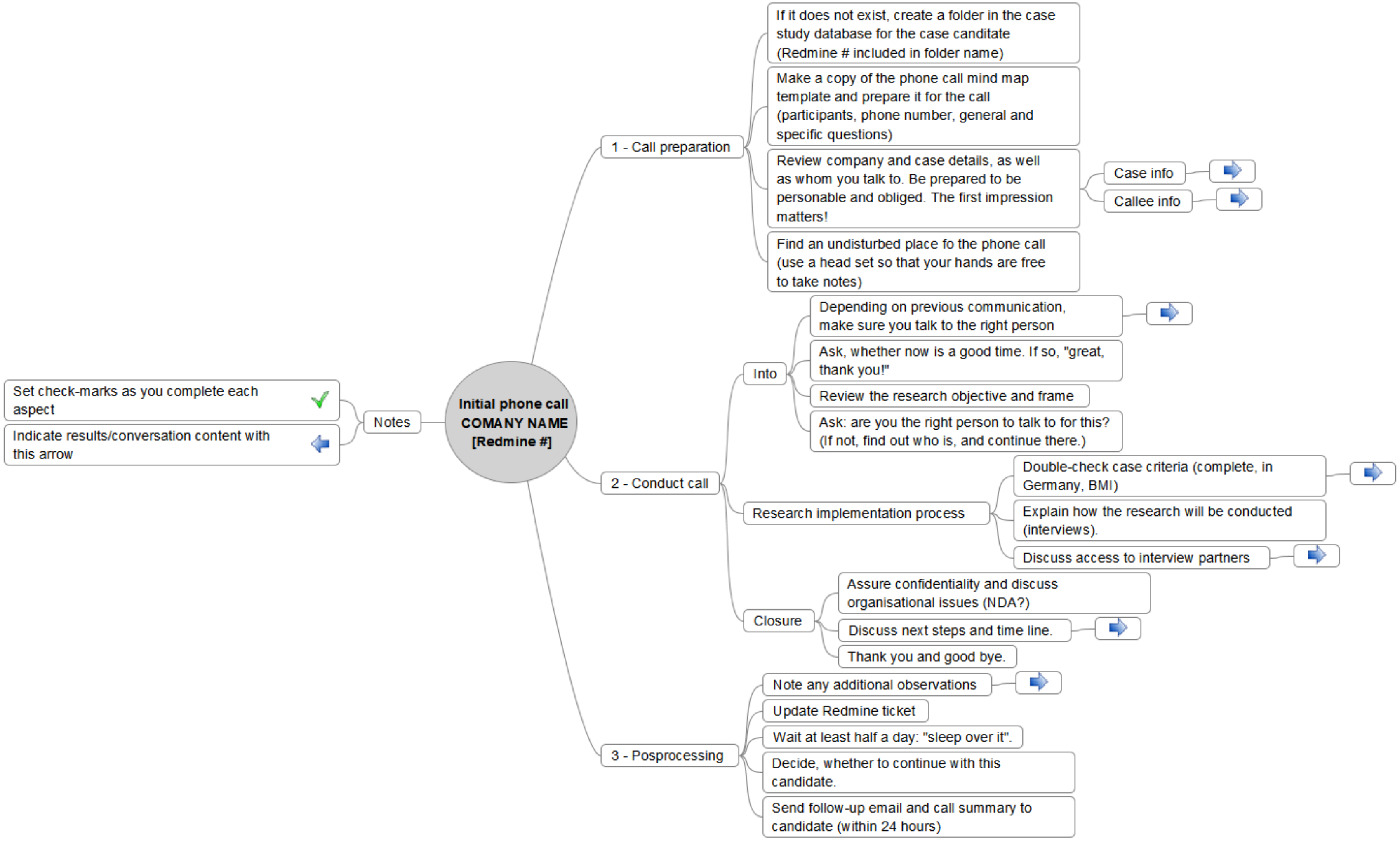
I am looking forward to your hopefully positive feedback!

Sincerely yours,

Richard Hagl

Appendix G Initial Phone Call Protocol

Figure 8 – Template mind map for initial phone call to company candidates.



Appendix H Interview Protocol

Interview Guide

Meta information

Case ID: Case description:

Date: Time:

Location:

Interviewee: Role of interviewee:

Interviewer: Richard Hagl

Research aim: to better understand the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany.

Questions

Room for short notes

(longer notes on separate paper)

Opening

[setup and start the recording]

1. First of all, I would like to thank you very much for this opportunity to learn about your case! As you have noticed, our conversation is being recorded. The recoding will only be used to aid the researcher's memory on the conversation and will not be used for any other purpose. Is the recording OK for you?
   [→ Answer needs to be "yes"]

2. Also, thank you for participating in this research project. As you know, participation is entirely voluntary. You can also change your mind at any point in time. Do you have questions regarding research participation?
   [→ Make sure that participation is agreed verbally]

3. Offer a brief summary of the research project.
   [better understand the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany]

4. Explain the interview format and expected duration.
   [casual conversation, questions are guiding questions only; I am interested in *your* perceptions, thoughts, interpretations; expected duration approximately 30 minutes]

5. Before we start, are there any other up-front issues such as confidentiality?
   [make sure all organisational issues are take care of]

Research aim: to better understand the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany.

Questions

Room for short notes
(longer notes on separate paper)

Main Interview

Warm-up

6. OK, let's get started! Can you please describe the case briefly?

7. What would you say is the most remarkable aspect of your project?

RQ1: What types of augmented reality and virtual reality technologies are German technology companies adopting for business model innovation?

8. What types of technologies were employed for the case?

    a. Software

    b. Hardware

    c. Infrastucture

    d. Other/anything else?

Research aim: to better understand the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany.

Questions

Room for short notes

(longer notes on separate paper)

RQ2: How are augmented reality and virtual reality technologies being applied by German technology companies for business model innovation?

9. How were the technologies applied?

10. [BMI outcomes:] Were the technologies used to drive a change within the existing organisation or product, or was it employed for a new organisation (such as a start-up) or to create a new product?

11. [BM functions:] employment of the technologies

    a. [Create a competitive advantage:] How would you say, did the employment of AR/VR impact your company's competitive positioning?

    b. [Mediate between strategic objectives and technology:] Can you describe the relation between your company's strategic objectives and your project?

    c. [Communication tool:] How was this project communicated to your company's stakeholders?

RQ3: What effects do augmented reality and virtual reality technologies have on business model innovation in German technology companies?

12. What would you say was the impact of this case onto the company?

13. Would you consider the employment of AR/VR to have been beneficial to the company or project? If so, how did the company benefit?

Research aim: to better understand the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany.

Questions

Room for short notes
(longer notes on separate paper)

RQ4: How can German technology companies maximise the benefits of augmented reality and virtual reality technologies for business model innovation?

14. Would you do this project again?

15. If you could start over, what would you do differently?

16. [BMI as a process:] What are your future plans regarding the work with AR/VR?

17. [BM elements (loosely investigate the AR/VR employment per BM element)]

    a. [Value proposition] What new value did the AR/VR employment offer? Form whom was this value offered?

    b. [Value network] Who all (including players outside of your company) benefited from the AR/VR employment? In what way?

    c. [Value creation mechanism] How was the project implemented?

    d. [Value capture and finances] How was this project financed? How did your company capture value from this project?

Research aim: to better understand the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany.

Questions

Room for short notes
(longer notes on separate paper)

Additional topics

18. Are you familiar with the term business model?

19. If, yes, what would you say a business model is?

20. Do you know whether your company is actively involved in business modelling?

Closing

21. Do you have any further questions or comments?

22. May I contact you again if I have further questions (via phone, email, or if needed, in person)?

23. Is there anyone else you think I should talk to?

24. Is there any other informational material you think I should have a look at?

25. Ask to be shown around / get a case demo, if possible.

26. Lastly, thank you very much for participating! As mentioned, in the next step the interview audio recording will be converted to text for further analysis. You will receive a copy of the text, as well as any conclusions I draw from statements. It would be great if you can review these documents and correct any misrepresentations or misinterpretations you find. The recording now ends [stop recording].

PAPER 3: RESEARCH DESIGN

PREFACE TO PAPER 3

The third paper in the paper series is the Research Design Paper. This paper builds directly on Paper 2. In this paper, the conceptualised research operationalisation is tested, and the research design amended, as necessary. Yin (2017) recommends to conduct a pilot case study prior to embarking on the overall case research endeavour. The pilot case study can help the researcher refine the data collection strategy "with respect to both the content of the data and the procedures to be followed" (Yin, 2017, p.106). Following this recommendation by Yin (2017), the author implemented a full pilot case study in May 2018.

Following the case candidate selection criteria developed in Paper 2 and elaborated on in Table 5 of Paper 2, the researcher identified six promising case candidates. Despite the fact that the researcher had spoken to the selected case candidate contacts in person regarding his research, previously, only half of the contacts responded to the researcher's enquiry. Still, the researcher was able to win – what he considered particularly interesting – a startup business (company B) as a (first) pilot case study participant. However, as it would turn out later, the selected company wasn't a fruitful choice and the pilot case study had to be repeated (company C). Table 1 offers an overview of the case candidate selection criteria applied to the companies B and C. Overall, cases were selected non-randomly by the researcher's discretion. Details on the research participants and research participant selection are presented in Table 2.

Table 1 – Case candidate selection criteria applied to companies B and C.

Selection criteria	Pilot attempt 1 (Berlin-based startup, referred to as "company B" in Paper 3)	Pilot (referred to as "company C" in Paper 3)
Significant involvement of augmented reality and/or virtual reality technology.	The startup's product is based on VR technology. Without VR, the company would not exist.	The 360-degree photo tours are integrated into the sales- and presentation-processes of company C. Significant effort has been undertaken to integrate the technology into pre-existing processes and software tools.
County of deployment must be or include Germany.	The company is based in Berlin, Germany and serves customers in Germany.	The company is based in Germany and primarily serves customers in Germany.
Case is completed, or passed a significant milestone, or has been aborted.	A first product has been developed and introduced to market.	As stated above, significant effort has been exerted to integrate the solution. 360-degree images and the option to view them on a VR headset are offered on a regular basis.

Selection criteria	Pilot attempt 1 (Berlin-based startup, referred to as "company B" in Paper 3)	Pilot (referred to as "company C" in Paper 3)
Case is relevant for business model innovation.	VR collaboration has the potential to impact the BMs of numerous companies. Furthermore, the creation of a startup with a new BM represents BMI in itself.	The VR employment adds to and impacts numerous details in the BM of company C, as further explained in Paper 3.
Applicable to business.	The company and product operate on a B2B basis.	VR is used on a B2C basis and according to company C helps company C to increase its profit.
Access issues and access estimation.	Access was successfully established.	Access was successfully established

Table 2 – Research participant selection details (pilot case study and expert interviews).

Research participant	Company and role	Participant selection details
EXP1	CEO of company A	EXP1 is a co-founder of company B and a technology enthusiast who has been pioneering VR since the late 1990s in a large automotive corporation. The researcher believes EXP1 to be a perfect choice for the study for two reason. One, EXP1 is able to reveal deep understanding of the workings and strategic objectives of company A; and two, as a seasoned expert, EXP1 can offer deep VR knowledge, entrepreneurial insights, and industry experience.
EXP2	CTO at company A	EXP2 has studied business administration, however, out of personal interest he preferers to work in the technical domain. EXP2 has experience in numerous technical areas, such as back-end development, front-end development, application programming interface development, cloud infrastructure, and machine learning. As CTO at company A, his responsibility is the technology design of the VR solution. In this capacity, he is a well fit choice for the presented study, as he can disclose many VR technology related specifics and offer deep expertise on VR technology and related systems.
Realtor1	Realtor at company B	Realtor1 is a young, female business professional who works as a real estate agent for company C in full-time employment. Her daily business is to consult customers who wish to sell their real estate object, as well as to manage the real estate object sales process. This includes maintaining the online listings, communicating with potential interested clients, meeting clients for touring real estate properties, as well as creating the content for the 360° virtual tours, on site. Given Realtor1's first-hand experience with the VR solution of company B, she is a well fit choice for the presented study, because she can give detailed reports on VR technology employment. Furthermore, Realtor1 "lives" the full sales process of real estate properties and can position the VR employment and its effects and impacts well into the overall company context.

Research participant	Company and role	Participant selection details
CTO2	CTO at company B	CTO2's official job title is "Head Product & Digital Innovation". In this function, he is the first point of contact for innovative ideas in company C. Further, he is responsible for product innovations, the integration of new technologies, and rollout of new tools such as the technology case under investigation. He is a full-time employee for company C for more than seven years. His academic background is in entrepreneurship and management. Given CTO2's expertise and role in company B, he is a very good choice for the presented study, because they can directly report on how the VR project came about, how the technology integration works, and what company B's future plans with the technology are. The researcher knows, that CTO2 is in direct contact with top management at company B and has knowledge regarding company B's strategic objectives.

The initially chosen company B is a Berlin-based startup, which was established in the year 2017. The company has been seed-funded by an entrepreneurial investment firm, that focuses on emerging digital markets, and holds majority shares of the startup. At the core of the company lies the development of an innovative VR software solution for industry collaboration. Furthermore, the startup offers AR and VR software development as a service (agency model). Since its establishment, the relatively small business was able to develop an impressive product which, as the author sees it, can be considered one of the most sophisticated available on the VR collaboration market, at the time.

The researcher was able to conduct two interviews on site. One with the chief executive officer (CEO), and the second interview with the chief technology officer (CTO). During the initial access negotiations, the researcher had only been informed of the opportunity to talk to the CEO. After arrival at the site, he was surprised to find out that the CTO had been briefed, as well. Prudently, the researcher had brought extra copies of all documents such as the interview guide and the consent form. A slightly odd situation arose, when both participants (CEO, CTO) sat down in the meeting room at the same time. However, the author was able to explain, that his research had been designed for the implementation of individual interviews. After clarification, the interviews were conducted individually, back to back, first with the CEO, then with the CTO. The interview implementations went very well, and the interview preparations – as outlined in the Methodology Paper – proved to be very valuable and functional.

While interesting findings arose from the two implemented interviews (cf. Paper 3), and operational aspects of the research design were tested successfully; the core problem with the chosen company turned out to be that the researcher could not truly investigate the technology impact aspect on BMI. However, this is the core objective of the study. Being a startup that develops a new VR product, the two research participants could "only" disclose how they *believe* that their product will impact their customers' BMs. These predictions, however, are expectations of the interviewees, perhaps even hopes, rather than sufficiently tangible observations for the study's objective. BMI can refer to two fundamentally different ideas: BMI in the sense of inventing or introducing entirely new BM (cf. Mitchell and Coles, 2003; Khanagha *et al.*, 2014; Christensen *et al.*, 2016), or BMI in the context of innovating an existing BM (cf. Santos *et al.*, 2009; Lindgardt and Ayers, 2014; Gassmann *et al.*, 2017). Arguably, the researched startup strives to introduce an entirely new BM. In this setting, the only discovered impact of AR/VR technology on the startup itself is, that "AR and VR are the very reason why our business exists" (CTO). To sum it up, the researcher decided to repeat the full pilot case study in the context of an established business that employed AR or VR technology within a pre-existing BM. The interviews of the initial pilot attempt are included in Paper 3 as expert interviews; CEO as EXP1 and CTO as EXP2.

The implementation of the expert interviews and the pilot case study led to two significant amendments of the overall study. One, the term "technology companies" was removed from the research aim, objective, questions, and overall research project title. Second, the initial RQ1 was dropped, the remaining research questions were amended, and two new research questions were added. Regarding the term "technology companies" the researcher had been re-evaluating its value for quite some time. On March 24, 2018 the researcher notes in his log the following.

> "Another topic is the formulation and justification of the research questions, which is rather challenging, as so much is unknown at this point. I think I really need to dive into the company identification analysis as fast as possible to get a clear picture of who is doing what with augmented reality and virtual reality. As a matter of fact, a deep market expertise will likely become a new, extremely valuable asset for me as a researcher, as well as an entrepreneur. As a note: Ebert *et al.* (2017) offer numerous interesting examples and links to further potential use cases. Furthermore, I just realised, that I struggle with the term "technology company". This is a central part of the research questions and becomes extremely relevant now, when I select cases and associated companies. This needs clarification."

In the Conceptual Paper, the researcher introduced his research motivation as follows:

> "Digital technologies, such as augmented reality and virtual reality, are drivers for business model innovation (Casadesus-Masanell and Ricart, 2011; Snihur and Zott, 2013) and business models themselves may be shaped by technological innovations (Teece, 2006). This is especially true in the high velocity environment of the internet, where business models must be frequently altered to meet new challenges (Wirtz *et al.*, 2010). However, "it is ill-understood how changing market, technology and regulation conditions generally drive revisions in business models" (De Reuver *et al.*, 2009, p.1).
>
> This observed gap between factual necessity and lived reality motivates the author to investigate how the technologies of augmented reality and virtual reality are changing the business models of *technology companies* [emphasis added]."

Consequently, the researcher formulated his research aim, objective, and research questions to include the expression "in technology companies". However, while further progressing in the research, the researcher struggled with deciding, whether a given company associated with a research case should be considered a "technology company", or just a "technology-enabled firm", or was perhaps about to become a technology company. For example, the pilot case study company C (large real estate company) employs numerous different software solutions to facilitate the organisation's processes. This includes the development of its own software, as well as programming software for the integration of third-party tools, such as the researched VR solution. Does this make company C a technology company, or is it about to become one since the developed IT solutions could be offered to other real estate companies in the future, or is it "merely" a software enabled real estate firm? This is a decision that the researcher cannot possibly make from a first look onto the company without knowing its overarching future strategic objectives. Furthermore, the researcher identified several interesting research cases which fit the six case selection criteria as designed in the Methodology Paper (see also Table 1 above), where he does not consider the associated company a technology company – for example the later included SanitaryCo case (SanitaryCo is a small business that specialises in modern sanitary, heating, and bath construction). This left the author with one of two options: either amend the research design by a concise definition of what a technology company is and exclude companies not fitting this definition – or remove this limitation. The author contends that limiting case selection in this manner does not add substantial value to the research, excludes research cases worth investigating, and causes undesirable case access issues. Gaining access to the right interview partners is crucial as it directly impacts the quality of case data information obtained (Hancock and Algozzine, 2006). However, case access can be challenging (Saunders, 2011). This is something that the researcher painfully experienced first hand. The researcher had initiated promising communication with almost 30 companies. Along the way, however, some companies suddenly stopped responding entirely, despite the fact that the researcher had already verbal agreements for research participation. Other interesting cases had to be given up on, because the legal department would not grant access by external researchers. One core issue, that the researcher observed, is that companies are apparently overrun by research participation requests. At the end of the day, the researcher decided to remove the expression "in technology companies" from the research aim, objective, questions, and overall research project title.

A valuable feedback from the Paper 2 examiners is the suggestion to reassess the original RQ1 in the context of the research design as developed in Paper 2. The feedback states as follows.

> "Suggest you reassess how you address RQ1 in the context of the proposed research design, and if it is essential to the study– will this require a substantial number of cases? It is more readily apparent how the other research questions can be addressed within the multiple case study approach, being How and What questions."

The researcher's research design encompasses a relatively small data set. However, RQ1 lends itself more to a *quantitative* data collection approach, which would require a larger data set. As stated by Hancock and Algozzine (2006, p.52), case study researchers may create customised research "instruments"; such as "surveys, questionnaires, and examinations administered to individuals who have insight into the research situation". However, given the DBA time constraints, and the researcher's limited resources to execute the study, the researcher followed the examiners' recommendation and dropped RQ1.

Later on, the researcher received clear feedback on Paper 3. The examiners expressed concerns regarding the formulation of the research questions and requested amendments to them, such as dropping the BMI reference from RQ2 to RQ4. The researcher adopted those changes. The examiner feedback is included below.

> “Major Issues
> Consider dropping the term BMI from RQ2 to RQ4. … Reconsider the themes under RQ3 and in particular 4.4.1 and 4.4.2 to remove the focus on individual industries ie drop the theme around real-estate tourism.”

During the analysis of the pilot case data two new themes emerged which had not been addressed by the RQs, thus far. First, the theme of challenges which need to be mastered when introducing the new technology emerged. Second, details in respect to how to deploy and use the new technology were revealed by the research participants. In respect to challenges (new RQ4), pilot study interviewees reported numerous challenges including technical challenges, challenges related to getting humans on board, challenges posed by a high need for explanation of AR/VR technology, and a problematic slow market development. These pilot case data observations were further supported by an investment guide published by Capgemini (2018). Reflecting on this investment guide, the researcher notes in his research case study log as follows.

> “2018-09-28 (Friday)
> Researchers notes:
> [10:39h] … Another interesting thought appeared during the data analysis: do I need to add an additional research question addressing the challenges companies have with the implementation of AR/VR projects? For example, it was interesting to see, that the Realtor1 encountered some challenges when using the hardware and software to create the 360° photos; however, these challenges arose from side issues, such as malfunctioning tripod, or lack of Internet connectivity.
>
> These thoughts are further supported by Capgemini (2018):
> “Because the technology is new, it’s no surprise that organizations lack in-house AR/VR expertise. In fact, it is one of the top three barriers to growth identified by our respondents” (Capgemini, 2018, p.19).”

In respect to AR/VR technology deployment (new RQ5), pilot study interviewees explain the process how VR technology was identified, introduced, and then deployed companywide in company C. Given the researcher’s experience it became instantly obvious, that the described approach constitutes one of many ways how a company can get started with AR/VR. In this context, Capgemini (2018) summarises “for organizations, the major brakes on progress will be technological integration, data readiness, *the inability to identify use cases* [emphasis added], talent, and general awareness” (Capgemini, 2018, p.23). Ultimately, the researcher formulated two new research questions. The new RQ4 is aimed at exploring what challenges companies face when implementing AR/VR projects. The new RQ5 is aimed at exploring how companies can deploy a (first) AR/VR project. The researcher was also working on the preparation of a technology and BMI workshop for a customer, at the same time. This workshop is aimed at decision-makers in industry, who plan to employ AR or VR technology in their business (for the first time) but struggle to find an entry point. While reflecting on the workshop, the researcher realised, that the workshop agenda asked for by the customer can be formulated as questions, which are almost analogous to the research questions as (re)formulated by the researcher. This link to praxis further encouraged the researcher to reformulate the research questions, and to add the two new research questions. An overview of the original RQs, the reformulated RQs, and a link to practical application is given in Table 3 of Paper 3 and presented below as Table 3.

Table 3 – Old and new research questions, and link to praxis.

#	Old research question	New research question	Link to praxis
Initial RQ1	What types of augmented reality and virtual reality technologies are German technology companies adopting for business model innovation?	(Dropped, refer also to Section of Paper 3 for further details)	Technology overview: hardware, software components, devices.
RQ1	How are augmented reality and virtual reality technologies being applied by German technology companies for business model innovation?	How are augmented reality and virtual reality technologies being applied by companies participating in the study?	What is going on, today? What can be / is AR/VR used for, today? (Identify use cases)
RQ2	What effects do augmented reality and virtual reality technologies have on business model innovation in German technology companies?	What are the anticipated effects of augmented reality and virtual reality technologies on business?	Where is this all going? (A preview into the future)
RQ3	How can German technology companies maximise the benefits of augmented reality and virtual reality technologies for business model innovation?	What are the benefits of employing augmented reality and virtual reality technologies?	How can who benefit from AR/VR? (Value proposition)
RQ4	n/a	What challenges do companies face, when implementing augmented reality and virtual reality projects?	What are the core challenges I have to address when introducing AR/VR into my company?
RQ5	n/a	How can companies deploy and use augmented reality and virtual reality technologies for business model innovation?	How do I get started? (Value creation mechanism) How do I successfully implement an AR/VR project? (Process/value creation mechanism)

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PAPER 3: “EXPLORING THE IMPACT OF AUGMENTED REALITY AND VIRTUAL REALITY TECHNOLOGIES ON BUSINESS MODEL INNOVATION IN GERMANY. A RESEARCH DESIGN.”

Doctorate in Business Administration (DBA)

Participant Name: Richard Hagl 20068512

Supervisor: Dr Aidan Duane

Date: 02 / 12 / 2018

RESEARCH PAPER SERIES

Paper 3:

DESIGN PAPER

"Exploring the impact of augmented reality and virtual reality technologies on business model innovation in Germany. A research design."

ABSTRACT

The 21st century is the age of the "digital transformation" – a time of unprecedented global change. To address the magnitude of this complexity in the entrepreneurial environment, this study proposes that companies must engage with business model innovation. As the term business model innovation indicates, business models are not static and need to continuously be innovated. Furthermore, newly-emerging, digitally-based technological innovations, such as augmented reality and virtual reality, are new drivers for the innovation of business models. This study aims to develop a better understanding of the impact of augmented reality and virtual reality technologies on business model innovation. The formal objective of the proposed study is "to explore the impact of augmented reality and virtual reality technologies on business model innovation in Germany". This Paper builds on two previous papers (a Conceptual Paper and a Methodology Paper). In this Design Paper, the author offers a review of the research steps taken thus far; discusses initial learnings garnered from the implementation of a pre-pilot case study test run, two expert interviews, a full pilot case study, and research log reflection. The assessment of the collected pilot case study data leads the researcher to implement several amendments to the research design. Most notably, one research question is dropped, the remaining research questions are reformulated, and two new research questions are added. Further, the technology scope under investigation is expanded, and the research focus widened, to not only include "technology companies".

Keywords: business model innovation, augmented reality, virtual reality, emerging technologies.

ETHICAL DECLARATION

I declare that this submission is wholly my own work except where I have made explicit reference to the work of others. I have read the relevant notes, guidelines and procedures on conducting academic writing and research and hereby declare that this submission is in line with these requirements.

I have uploaded the entire submission as one file to Turnitin in Moodle, examined my "Match Overview" by viewing the detailed percentage listings and the overall "Similarity" score, and have addressed any matches that exceed 3%. I have made every effort to minimise my overall "Similarity" score and the number of matches occurring.

Name: *Richard Hagl*

Date: 02 Dezember 2018

1 Introduction

The 21st century is a time of unprecedented global change (Harari, 2016). This global change is driven by an ever more interconnected world; and by continuously-emerging, digitally-based technological innovations (Brynjolfsson and McAfee, 2014), such as augmented reality (AR) and virtual reality (VR). Entrepreneurs who strive to reap the benefits of the entrepreneurial opportunities associated with this change – as well as managers, who strive to circumnavigate the significant risks associated with this rapid change – need to identify and apply new strategies to deal with the new challenges of the 21st century (Streibich, 2017).

This study proposes that business model innovation (BMI) is a suitable approach to meet this unparalleled period of entrepreneurial turmoil and opportunity. The overall aim of the study is to better understand the impact of augmented reality and virtual reality technologies on business model innovation. The theory underpinning the study is outlined in the Conceptual Paper (Paper 1), along with a conceptual framework developed for this study which is provided again in Appendix A for clarification.

The Methodology Paper (Paper 2) reflects on the philosophical underpinnings of the study and justifies the research methodology chosen – a phenomenologist, subjectivist, interpretivist research approach; using a multiple-case holistic "Type 3" case study design (cf. Yin, 2017, p.48). Further, the author presents a roadmap of how to operationalise the research, and discusses key issues regarding data access, data collection, and ethical considerations.

The purpose of this Design Paper (Paper 3) is to discuss the author's initial learnings garnered from implementing a pre-pilot case study test run, conducting two expert interviews, and executing a full pilot case study. The Design Paper also discusses the theoretical insights gained from feedback from the WIT Ethics Committee, examiner commentary, and the author's personal reflections.

The rest of this paper is structured as follows. In Section 2 the author offers a brief overview of the research thus far. In Section 3 the author describes how the research operationalisation strategy worked in praxis and summarises modifications performed for the main study. Section 4 discusses the researcher's findings. The paper concludes in Section 4 with a summary of the paper and an outline of the next steps in this study.

2 A Brief Research Overview

In Section 2, the author gives a brief overview of the research project in its current state, thereby revisiting the research aim, research objective, and research purpose and contributions. Further, the research questions as well as the research framework derived from the theory are included for reference. The research is conducted as part of a doctoral programme (DBA) facilitated by Waterford Institute of Technology (WIT). The formal title of this project is "Exploring the impact of augmented reality and virtual reality technologies on business model innovation in Germany."

2.1 Project Titles and Associated Papers

An integral part of the programme is the writing of four research papers (continuous paper series) which are then compiled into the doctoral thesis. The papers are structured as follows:

1. Paper 1 (Conceptual Paper):
   "Exploring the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany. A conceptual framework."
2. Paper 2 (Methodology Paper):
   "Exploring the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany. A research approach."
3. Paper 3 (Design Paper) (this paper)
   "Exploring the impact of augmented reality and virtual reality technologies on business model innovation in Germany. A research design."
4. Paper 4 (forthcoming)

2.2 Research Contributions

Overall, the research contributes to the literature by reflecting on the business model concept and business model innovation in respect of augmented reality and virtual reality technologies. Furthermore, it adds to literature by constructing a conceptual framework to explore the impact of augmented reality and virtual reality on business model innovation in companies[1], which will assist future research efforts and support entrepreneurs in the innovation of business models.

Digital technological innovations such as augmented reality and virtual reality reshape business models (Teece, 2006) and drive business model innovation (Casadesus-Masanell and Ricart, 2011). However, "it is ill-understood how changing market, technology and regulation conditions generally drive revisions in business models" (De Reuver *et al.*, 2009, p.1). Helping close this gap is a valuable contribution to theory, aligning it closer to practice.

2.3 Research Aim, Objective, Questions, and Conceptual Framework

The study is aimed at better understanding the impact of augmented reality and virtual reality technologies on business model innovation. The formal objective of the proposed study is "*to explore the impact of augmented reality and virtual reality technologies on business model innovation in Germany*".

To guide the research effort, a conceptual framework was developed (see Appendix A); and four research questions were formulated, initially. After conducting the full pilot case study, one research question has been dropped (initial RQ1, for more details see Section 3.3) and the remaining research questions were amended. Further, two more research questions were added. For further information on the amended and added research questions see Section 4.1.

The amended and new research questions are presented below:

RQ1: How are augmented reality and virtual reality technologies being applied by companies in Germany, today?

RQ2: What are the anticipated effects of augmented reality and virtual reality technologies on business in Germany?

RQ3: What are the benefits of employing augmented reality and virtual reality technologies in Germany?

[1] The author recognises, that business model innovation may be performed outside of companies, as well; however, the research is aimed at business model innovation in established businesses. This will be assumed implicitly, from now on, and the term "companies" will therefore not necessarily be included.

RQ4: What challenges do companies in Germany face, when implementing augmented reality and virtual reality projects?

RQ5: How can companies in Germany deploy and use augmented reality and virtual reality technologies for business model innovation?

In this section, the author gave a brief overview of the research project, its aim, objective, contributions, research questions, and conceptual framework. In the next section, the researcher reports on his efforts to test the research design as developed in the Methodology Paper.

3 Testing and Amending the Research Design

In this section, the author reports on testing the research design as conceptualised in the Methodology Paper, and briefly summarises modifications made to the research design.

3.1 Update Ethics Procedures

The Ethics Committee provided the researcher with valuable feedback regarding many operational details to improve the scientific standard of the study. Following the committee's advice, the researcher created the following documents:

1. An information sheet explaining the background and details of the study.
2. A confidentially statement signed by the researcher, explaining what data is collected, how the data is used; and guaranteeing the research participants a high level of professional confidentiality.
3. A participant consent form.
4. A confidentiality statement for research assistants[2].

All documents were created in German, as the research sample/target is German; English translations of these documents were created. The general information sheet is provided in Appendix B for reference. The remaining documents are available from the researcher upon request.

On May 29, 2018, the Ethics Committee indicated, that the researcher has now met the ethical requirements to the committee's satisfaction. The approval letter by the Ethics Committee is included in Appendix C for reference.

[2] Note: this document has been created after submission to the Ethics Committee

3.2 Clarifying Interpretive (vs. Positivist) Case Design

The examiner commentary provided the author with valuable feedback and recommendations on his previous submission of the Methodology Paper (Paper 2). In this section, the author follows a recommendation stated in the examiner commentary, and further clarifies the philosophical positioning of the study.

In the Methodology Paper, the author reflects in depth on the research philosophy underpinning the study. This is an important step for any researcher as it helps improve the outcomes of research projects (Snape and Spencer, 2003). As previously stated, the author chooses a multiple-case holistic "Type 3" case study design (cf. Yin, 2017, p.48), as outlined by Yin (2017). The examiners, however, pointed out, that "Yin has been observed as a positivist leaning case author". This observation can be detected in Yin's work, as well: for example, Yin (2017, p.42,43) proposes four tactics to test for, and improve the quality of research designs; namely "construct validity", "internal validity", "external validity", and "reliability". Particularly the points "internal validity" and "external validity" indicate a strong emphasis on a positivistic attitude towards knowledge creation. This preference, however, may not be best suitable for the implementation and interpretation of interpretive case study research (Klein and Myers, 1999; Stahl, 2014); such as the author's study, which is of exploratory nature.

The author is aware, that Yin (2017) himself touches on this issue, as well (notes were made in the Methodology Paper, accordingly). However, Stahl (2014) takes this issue significantly further, and questions, whether interpretive research requires an empirical basis at all. Stahl (2014, p.2) considers interpretive researchers to be "storytellers who construct arguments to help their audience understand a particular point"; who are not saying that they are reporting facts, rather that they are presenting the "interpretations of other people's interpretations" (Stahl, 2014, p.2). Following alternative implementation, and quality assessment criteria for interpretive case study research may help enrich the variety of research in the field of information systems (IS) sciences (Klein and Myers, 1999). Therefore, the authors Klein and Myers (1999) propose an interdependent set of seven principles to aid the implementation, and quality evaluation of interpretive research in information systems research.

Noting that "empiricism is so deeply ingrained in IS research that it is hardly ever questioned" (Stahl, 2014, p.4), the author would like to briefly revisit the question, what exactly interpretive research is. Based on the research epistemology classifications proposed by Chua (1986) into positivist, interpretive, and critical; Klein and Myers (1999) offer three definitions of types of research approaches in information systems research. Their definition of interpretive research in IS states:

> "IS research can be classified as interpretive if it is assumed that our knowledge of reality is gained only through social constructions such a language, consciousness, shared meanings, documents, tools, and other artifacts. Interpretive research does not predefine dependent and independent variables, but focuses on the complexity of human sense making as the situation emerges (Kaplan and Maxwell 1994); it attempts to understand phenomena through the meanings that people assign to them (Boland 1985, 1991; Deetz 1996; Orlikowski and Baroudi 1991). Interpretive methods of research in IS are "aimed at producing an understanding of the context of the information system, and the process whereby the information system influences and is influenced by the context". (Walsham 1993, pp. 4-5)" (Klein and Myers, 1999, p.3).

The author's research is aimed at better understanding a contemporary information systems phenomenon (the emergence of the technologies augmented reality and virtual reality), and its impact on business model innovation, at a very early stage. The epistemological approach is based on the interpretive research paradigm (cf. Burrell and Morgan, 1979). Hence, the author contends that his study clearly falls under the research type – namely interpretive IS research – as defined by Klein and Myers (1999, p.3), and just presented above.

Having further clarified the interpretive nature of the case study, the author would like to take the advice by Klein and Myers (1999), and make the reader aware, that the principles for interpretive field research, as developed by Klein and Myers (1999), will be considered throughout the further research process. The author contends that this will be another interesting aspect of the study, as the work by Klein and Myers (1999) is of conceptual nature (Klein and Myers, 1999). Applying their principles to praxis may turn up novel insights into interpretive case study research methodology. The summary table of the interpretive field research principles by Klein and Myers (1999, p.72) is included in Appendix D, for reference.

3.3 Reassessment of Research Questions One

A second, very valuable feedback from the examiners is the suggestion to reassess RQ1 in the context of the proposed research design. The researcher's current research design encompasses a relatively small data set – it is planned to analyse approximately five to seven individual cases. RQ1 however, lends itself to a more quantitative data collection approach, which would require a larger data set. As stated by Hancock and Algozzine (2006, p.52), case study researchers may create customised research "instruments"; such as "surveys, questionnaires, and examinations administered to individuals who have insight into the research situation". However, given the current DBA time constraints, and the researcher's limited resources to execute the study, the author follows the examiners' recommendation has dropped RQ1.

Question eight of the interview guide[3] was aimed at addressing RQ1 and it has been used for the pilot case study. While conducting the pre-pilot test run, the expert interviews, and the full pilot case study, the researcher observed that question eight from the interview guide served particularly well as an "ice breaker" question. Therefore, this question will remain in the interview guide, whilst serving a new intention.

3.4 Removal of the Term "technology companies" from the Research Aim, Objective, and Questions

In the Conceptual Paper (Paper 1, p.4), the researcher introduced his research motivation as follows:

> "Digital technologies, such as augmented reality and virtual reality, are drivers for business model innovation (Casadesus-Masanell and Ricart, 2011; Snihur and Zott, 2013) and business models themselves may be shaped by technological innovations (Teece, 2006). This is especially true in the high velocity environment of the internet, where business models must be frequently altered to meet new challenges (Wirtz *et al.*, 2010). However, "it is ill-understood how changing market, technology and regulation conditions generally drive revisions in business models" (De Reuver *et al.*, 2009, p.1).
>
> This observed gap between factual necessity and lived reality motivates the author to investigate how the technologies of augmented reality and virtual reality are changing the business models of *technology companies* [emphasis added]."

Consequently, the researcher formulated his research aim, objective, and research questions to include the expression "in technology companies". However, while further progressing in the research, the researcher made two observations. First, after identifying interesting cases, the author struggled with deciding, whether the company associated

[3] Interview Guide V.1.2.

with the case should be considered a "technology company", or just a "technology-enabled firm", or was perhaps about to become a technology company. Second, the researcher identified several interesting research cases (including the pilot case), which fit the six case selection criteria[4] as designed in the Methodology Paper (Paper 2).

This left the author with one of two options: either amend the research design by a concise definition of what a technology company is or remove this limitation. The author contends that limiting case selection in this manner does not add substantial value to the research, excludes research cases worth investigating, and causes undesirable case access issues. Therefore, the expression "in technology companies" has been removed from the research aim, objective, and research questions.

3.5 The Case Study Log in Action

Yin (2017) recommends that researchers install a case study database. The author has followed this recommendation. An important component of the case study database is a case study log, which the author has maintained since February 2018. Thus far, the log covers well over 100 pages, 57 of which are filled solely with daily log entries[5]. While keeping the log, the author notes down not just events chronologically, but also observations he considers insightful. The log learnings can be grouped as organisational observations and general observations regarding the case study log itself; and insights considered valuable for the overall research outcome by the author.

Regarding general observations, the first thing noted by the researcher is, that keeping a case study log is indeed an extremely helpful research tool; relevant not only for other researchers who wish to retrace the steps taken by the researcher, but also for the author himself. Particularly the digital format proves to be a more suitable approach for scientific research than the initial pen-and-paper approach pursued by the author.

Research relevant insights gained from maintaining the case study log are presented in context throughout this paper.

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[4] The six case selection criteria designed in the Methodology Paper are a significant involvement of augmented reality and/or virtual reality technology; the county of deployment must be or include Germany; the case is completed, or passed a significant milestone, or has been aborted; the case is relevant for business model innovation; the case is applicable to business; and the case is accessible.

[5] As of October 9th, 2018. The rest of the pages contain introductory texts; tables of contents; figures, and notes; and appendices.

3.6 New Encoding Schemes for Research Participants and Participating Companies

As described in Paper 2, the author logs all case relevant communication and events in an online project management system. This online management system assigns a unique identifier (ID) to each task. An example of such an ID is “#770001”. While these IDs are used by the researcher internally to reference cases (example “#770001”), and case study participants (example “#770001A”), he realises that these IDs might be confusing. Hence, the researcher uses a more accessible coding system in the research write-up, as shown in Table 1 (encoding scheme for companies) and Table 2 (encoding scheme for research participants). References to company and research participants names have been removed for confidentiality.

Table 1 – Encoding scheme for, and description of participating companies.

Participating company code	Company description	Internal case ID	Real name
A	A Munich-based IT business focusing on software and prototype development for AR/VR. The researcher is a shareholder in this company.	#770007	(removed for privacy)
B	A Berlin-based start-up that develops a virtual reality conferencing solution.	#770001	(removed for privacy)
C	A large real estate company with focus on privately used real estate projects.	#770010	(removed for privacy)

Table 2 – Encoding scheme for research participants and expert interview partners, company association, and Redmine reference.

Research Participant Code	Associated Company Code	Internal participant ID	Comments	Real name
Developer1	A	#770007A	See also Section 3.7	(removed for privacy)
EXP1	B	#770001A	See Section 3.8.1	(removed for privacy)
EXP2	B	#770001B	See Section 3.8.2	(removed for privacy)
Realtor1	C	#770010A	See Section 3.9.4	(removed for privacy)
CTO2	C	#770010B	See Section 3.9.5	(removed for privacy)

3.7 Pre-pilot Case Study Test Run

Prior to embarking on the full pilot case study research, the author decided to conduct a pre-pilot case study test run. The purpose of the pre-pilot case study test run was to make sure that the interview preparation and implementation *process* operates as intended; that the recording process works; that the recording will be audible; that the interview questions can be understood by a research participant; and that the interview length is appropriate.

The test run was conducted with an employee and shareholder of one of the businesses owned by the researcher, encoded as “Company A”. The test interviewee (also referred to as “Developer1”) is an experienced augmented reality and virtual reality senior developer who has been involved in numerous augmented reality and virtual reality projects, thereby working for various clients in the past five years. For the pre-pilot test run, the interviewee chose a completed virtual reality case which had been created and rolled out for a client in the past year.

Before starting the interview, the interviewee gave feedback on the documents he had received upfront. He commented, that the documents provided clarity on the research project and its aims. Developer1 commented on a personal note, that he would be interested in the research results, which would consequently further encourage him to take part in such a study. Emphasising to potential further case study participants, that they will receive insights into the research results is therefore used as an incentive for research participation when contacting companies, initially.

The interview recording process with the researcher’s smart phone worked well. The interview length was 27 minutes, which is just about the amount of time (30 minutes) the researcher had anticipated per interview. The quality of the resulting audio recording was good, and it is suitable for further processing. The interviewee understood the questions as prepared in the interview guide[6] well. The author noted, however, that some of the questions did not seem particularly well fitting for a company, that is an AR/VR expert. Therefore, the researcher concluded, that it might be prudent to look for companies that are not experts for the technologies augmented reality and virtual reality, but who employed augmented reality or virtual reality to innovate an aspect of an augmented

[6] Interview Guide V.1.2 DE

reality/virtual reality-technology-unrelated business. This observation was further confirmed during two expert interviews (see Section 3.8 for more details).

The recorded data was not analysed by the researcher, since the pre-pilot test run was merely aimed at testing the overall setup and procedural durability. The researcher decided after the pre-pilot case study test run, that the interview guide is adequate for the pilot case study. Perhaps the main benefit of conducting this pre-pilot test was of a psychological nature: the researcher's confidence increased significantly, and he felt well prepared for the full pilot case studies.

3.8 Two Expert Interviews

The researcher conducted two interviews with experts in the field of augmented reality and virtual reality technology. Both experts work at the same company, which the researcher will refer to as company B. Company B is a Berlin-based start-up, which was established in the year 2017. The company has been seed-funded by an entrepreneurial investment firm, whose focus lies on emerging digital markets, and holds majority shares of the start-up. At the core of company B lies the development of an innovative virtual reality software solution for industry collaboration. Furthermore, the start-up offers augmented reality and virtual reality software development as a service (agency model). Since its establishment, the relatively small business was able to develop an impressive product which, as the author sees it, can be considered one of the most sophisticated available on the virtual reality collaboration market today. The researcher was able to conduct two interviews on site. One with the chief executive officer (EXP1), and the second interview with the chief technology officer (EXP2).

3.8.1 Interview Partner EXP1

EXP1 is CEO and co-founder of the start-up company B. He is an enthusiastic technology expert, who holds a bachelor's degree in computer sciences, and a master's degree in business administration; and has previously worked with several tech companies. EXP1 has been pioneering virtual reality technologies as early as during the late 1990s in a large automotive corporation.

3.8.2 Interview Partner EXP2

EXP2 is CTO at the start-up. EXP2 has studied business administration, however, out of personal interest he preferers to work in the technical domain. EXP2 has experience in numerous technical areas, such as back-end development, front-end development, application programming interface development, cloud infrastructure, and machine learning. His responsibility is the technology design.

3.8.3 General Observations

The researcher travelled from Munich to Berlin and arrived on site just in time. Company B is located in the heart of Berlin. The site was "fashionable", and the researcher could sense a spirit of innovation and contentment. Right off the bat, he encountered a somewhat uncomfortable situation, because he had to ask, whether it is okay to talk to one person at a time, rather than with two interviewees simultaneously, as expected by the interview participants. After this issue had been resolved, the researcher conducted two interviews, one with each interviewee, as described above. The meeting room provided by the research participants' company was quiet and suitable.

The researcher was prepared to take notes during the interview, however, this seemed neither to be particularly necessary, nor helpful, as taking notes during the interview process threatened to distract the interviewee, as well as the interviewer. After interview completion, the researcher went back to his hotel room and noted down his thoughts and feelings, immediately, as follows[7]:

> "Observations from conducting expert interviews:
>
> On-site surprise: I had (and took) the opportunity to conduct two interviews.
>
> The interview guide worked well, in general; however, whenever a question was difficult to communicate, immediate discomfort could be observed in the interviewee.
>
> Overall challenge: the questions seem to be more fitting for a case within a company, that is not an AR/VR provider. The pilot case was an AR/VR start-up. Consequently, for the main study I will attempt to focus on established companies, that implemented an AR/VR case to innovate an established business or case.
>
> Clearly, I could observe a gap between "yes, I know what business models are" and the lacking ability to formulate what a business model is (same held true for the pre-pilot test run with company A).
>
> Interesting discrepancy in perception of the business focus: the CTO (EXP2) felt that the company was an agency, a service provider for augmented reality and virtual reality, whose focus is primarily on

[7] Extract from researcher's Case Study Log V.18, log entry 2018-05-16

> creating revenue though billable services (billable hours). He felt, that this, perhaps, should have been more the initial focus of the company. The CEO (EXP2) felt that the focus is the development of their product. Offering services is a mere, temporary consequence of a slower-than-expected evolving market.
>
> Interview recording times: CEO: 38 minutes; CTO: 42 minutes."

Insights gained from the two expert interviews are integrated and presented in Section 4.

3.9 Conducting the Full Pilot Case Study

As recommended by Yin (2017), the author conducted a full pilot case study in order to test and refine the conceptualised data collection strategy. In this section, the author reports on the learnings made from the implementation of the full pilot case study.

3.9.1 Case Identification and Description

On an unexpected occasion, the researcher was talking to a real estate agent at the end of March 2018 (Realtor1, see also Section 3.9.4), from whom he learned, that it is now common practice in the real estate industry to present 360° photographs of properties, which are for sale. These 360° photographs are most often not presented via a virtual reality headset; rather, numerous images are combined and linked together. The result is a virtual tour which can be taken in a web browser[8].

The turnkey solution referred to by Realtor1, who works as a realtor for company C (see also Section 3.9.3) is offered by the company "Ogulo" (cf. Ogulo GmbH, 2018). The company Ogulo is based in Berlin and specialises in creating technology for the creation and presentation of virtual reality tours for real estate. A screenshot of the browser-based version of the tour is presented in Figure 1. Examples of browser-based virtual tours can be found directly on the homepage of Ogulo[9].

[8] A virtual reality view is offered, as well. The solution is also available on smart phones.
[9] https://ogulo.de

Figure 1 – Web browser view of an Ogulo 360° virtual tour.

During the conversation with the real estate agent, a further interesting detail emerged: the realtor explained, that the solution offered detailed data on what potential clients were looking at, while taking the virtual online tour. This was exemplified by a case in which an interested client virtually visited the living room of a house of interest, for a duration of almost 45 minutes. Therefore, the realtor concluded, that "the client has already planned out the entire room in its head. Clearly, the client had to be seriously interested. Consequently, the following price negotiations were done harder". In the researcher's mind, the most interesting observation here is, that new kinds of meta-data can be collected when employing new, digitally-based technologies, such as augmented reality and virtual reality. This aspect is further discussed in Section 4.4.3. Intrigued by the degree of sophistication and daily application of the 360° virtual tours in a large real estate company (company C), the researcher decided to explore the impact of the technology in company C as a pilot case.

3.9.2 Discussion on Case Inclusion and Boundary

The pilot case described above lends itself to re-open the discussion on what virtual reality really is. The author has offered definitions for virtual reality, augmented reality, and mixed reality in his Conceptual Paper (Paper 1); however, these definitions are very technology-, and human-experience focussed. Particularly from a business model innovation perspective, the researcher decided to rethink these definitions and allow for less technology-heavy cases to be include (e.g. the pilot case study). From a technological viewpoint, creating 360° virtual tours in a web browser, is much less sophisticated than developing a fully-immersive virtual reality experience. However, numerous businesses (cf. Immoviewer, 2018; Ogulo GmbH, 2018; Matterport, Inc., 2018) seem to bet exactly on this “technologically-less-ambitious” business model. An augmented reality example of a company that seems to thrive well[10] on a “low-hanging-fruit approach” to employing the augmented reality technology is the company INDE, who offers interactive, large-scale augmented reality installations to “inspire, entertain, inform and educate” (INDE, 2018). The author contends that these business examples might be particularly interesting, as they are less focused on leading-edge technology; and seem to be primarily centred on an innovative approach to business modelling, thereby potentially underlining the observation previously made by O Riordan *et al.* (2014, p.2), that “legendary firms that shape their industry structures are in fact business-model innovators”; rather than technology leaders.

3.9.3 Company C

Company C is a large real estate company with focus on privately used real estate objects[11]. Company C has brokered around 100,000 real estate units since the company was founded, employs over 700 qualified and permanent employees, and prioritises the employment of innovative technologies as a means to accelerate the company’s growth.

3.9.4 Interview Partner Realtor1

Realtor1 is a young, female business professional who works as a real estate agent for company C in full-time employment. Her daily business is to consult customers who wish to sell their real estate object, as well as to manage the real estate object sales process. This includes maintaining the online listings, communicating with potential interested clients, meeting clients for touring real estate properties, as well as creating the content for the 360° virtual tours, on site.

3.9.5 Interview Partner CTO2

CTO2’s official job title is “Head Product & Digital Innovation”. In this function, he is the first point of contact for innovative ideas in company C. Further, he is responsible for

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[10] The author is fully aware, that it is nearly impossible to judge how well a business is doing from visiting its website. However, the company is in business since 2011, and it presents numerous international references for its product installations. Furthermore, the company's individual success is not at the centre of interest, here; rather the researcher strives to exemplify this “technologically-less-ambitious business approach”.

[11] “Privately used real estate objects” refers to real estate objects, which are used by private individuals, rather than real estate properties, which are used for commercial purposes.

product innovations, the integration of new technologies, and rollout of new tools such as the technology case under investigation. He is a full-time employee for company C for more than seven years. His academic background is in entrepreneurship and management.

Insights gained from the pilot case study are presented in Section 4.

3.10 Updated Interview Guide

As previously reported in the sections regarding the pre-pilot case study test run (Section 3.7), the expert interviews[12] (Section 3.8), and the full pilot case study (Section 3.9), the interview guide as designed in Paper 2 worked generally well. However, the author also identified issues for improvement.

First, the author shortened the general introduction, and opening questions; however, a new question regarding the interviewees background and role in the company and project was added, as the researcher had noticed, that this information was missing for the case description write-up and needed to be obtained, afterwards. Second, the interview guide questions were reworded to ask about business model innovation as indirectly, as possible; and to facilitate both business model innovation outcome possibilities, namely a case in which a pre-existing business model was innovated or the case where an entirely new business model has been created. Thirdly, the two new research questions were integrated and expanded upon with sub-questions. Lastly, the interview guide questions were matched section by section with the initial findings from the pilot case study, and direct questions or probing hints linking to the research findings were worked in. The revised interview guide is provided in Appendix E.

In this section, the author reported on testing the research design as conceptualised in the Methodology Paper and presented the consequential adaptations made to the research design. In the next section, the author presents initial findings and insights gained from the research thus far.

[12] The interview guide (version 1.2) was also used in the expert interviews.

4 Data and Initial Findings

In this section, the author reports on the analysis of the pilot case study data. Further, the findings which arose from the pilot study, the expert interviews, and the observations made by the researcher during the research thus far, are discussed.

4.1 Data Analysis Overview, Amended Research Questions, and a Link to Praxis

For the data analysis, the author follows a “think inside the box”, then “think outside the box” approach (cf. H. O’Connor and N. Gibson, 2003, p.66): first, data is analysed for answering the original research questions; then the data is skimmed for “surprises” and other unexpected and overarching themes or ideas.

The two conducted pilot case study interviews resulted in transcribed text of 3353 words for Realtor1 and 3272 words for CTO2. After numerous times of reading the text, 117 descriptive statements were extracted into a Microsoft Excel spreadsheet for further analysis. Over the course of several days, the descriptive themes were further reduced to 52 themes, then 13 codes, which were finally collapsed to the six codes presented below (code counts are given in parentheses following the codes):

1. Increase sales efficiency (37)
2. Support imagination (18)
3. Impact on BMI (17)
4. Strengthen corporate image (14)
5. Master challenges (13)
6. Deployment and usage (11)

During this iterative process of analysing, reducing, and encoding the data, the researcher realised that two new themes emerged, which had not been addressed by the research questions, yet. Firstly, the theme of challenges which need to be mastered when introducing the new technology emerged; and secondly, details in respect to how to deploy and use the new technology were explained. Ultimately, this let the researcher to formulate two new research questions, which are elaborated on in further detail in Section 4.5 and Section 4.6, respectively. Further, as previously recommended by the examiner commentary, all research questions were revisited and reworded as a consequence of reflecting on them in the light of the pilot case study findings, expert interview insights, and personal reflections.

Coincidentally, the researcher was also working on the preparation of a technology and business model innovation workshop for a customer, at the same time. This workshop is aimed at decision-makers in industry, who plan to employ augmented reality or virtual reality technology in their business (for the first time) but struggle to find an entry point. While reflecting on the workshop, the researcher realised, that the workshop agenda asked for by the customer can be formulated as questions, which are almost analogous to the research questions as (re)formulated by the researcher. The researcher's reflection on the topic as documented in the case study log is included in Appendix F for reference.

This link to praxis further encouraged the researcher to reformulate the research questions, and to add the two new research questions. An overview of the original research questions, the reformulated research questions, and a link to practical application is given in Table 3. Details on, and the reasoning behind reformulating and adding research questions are presented in the following sections.

Table 3 – Old and new research questions, and link to praxis.

#	Old research question	New research question	Link to praxis
Initial RQ1	What types of augmented reality and virtual reality technologies are German technology companies adopting for business model innovation?	(Dropped, refer to Section 3.3 for details)	Technology overview: hardware, software components, devices.
RQ1	How are augmented reality and virtual reality technologies being applied by German technology companies for business model innovation?	How are augmented reality and virtual reality technologies being applied by companies in Germany, today?	What is going on, today? What can be / is AR/VR used for, today? (Identify use cases)
RQ2	What effects do augmented reality and virtual reality technologies have on business model innovation in German technology companies?	What are the anticipated effects of augmented reality and virtual reality technologies on business in Germany?	Where is this all going? (A preview into the future)
RQ3	How can German technology companies maximise the benefits of augmented reality and virtual reality technologies for business model innovation?	What are the benefits of employing augmented reality and virtual reality technologies in Germany?	How can who benefit from AR/VR? (Value proposition)
RQ4	n/a	What challenges do companies in Germany face, when implementing	What are the core challenges I have to address when introducing

#	Old research question	New research question	Link to praxis
		augmented reality and virtual reality projects?	AR/VR into my company?
RQ5	n/a	How can companies in Germany deploy and use augmented reality and virtual reality technologies for business model innovation?	How do I get started? (Value creation mechanism) How do I successfully implement an AR/VR project? (Process/value creation mechanism)

4.2 RQ1: How are augmented reality and virtual reality technologies being applied by companies in Germany, today?

The aim of this research question is to describe the specific manner in which companies in Germany employ augmented reality and virtual reality, today. The researcher's initial findings are presented below.

4.2.1 New Service Offering for Customers

CTO2 reported, that company C is using the virtual tour as a new service offering for their customer. CTO2 states:

> "Good. I mean, we're always looking for new ways, of course, how to simplify our services for the end customer and make them [the ways] more efficient, and of course the topic of Ogulo is a good example, where the prospective buyer can get an impression based on this 360-degree tour that goes well beyond the classic photo and perhaps even makes a visit [on site] unnecessary ..." (CTO2)
>
> „Gut. Ich meine wir suchen immer wieder natürlich nach neuen Wegen, wie wir unsere Services halt in Richtung des Endkunden vereinfachen und auch effizienter gestalten können und da ist natürlich das Ogulo-Thema ein schönes Beispiel, das der Kaufinteressent sich auf Basis dieser 360-Grad-Besichtigung schon einen Eindruck verschaffen kann der deutlich über das klassische Foto halt hinausgeht und gegebenenfalls auch eine Besichtigung überflüssig macht …" (CTO2)

Realtor1 revealed, that some customers directly ask whether this type of virtual online tour was available. In summary, augmented reality and virtual reality technologies can be used to offer new services to customers, perhaps even services already expected by today's customers.

4.2.2 Strengthen the Corporate Image: Being Perceived as Innovative and Trustworthy

While CTO2 categorised the project to be primarily a marketing gimmick, he also conceded that it helped position company C as a technologically innovative pioneer, which is an important support for the brand. He further elaborated, that being perceived as innovative and trustworthy is important, particularly in the real estate industry in Germany, where brokers have to fight for sellers (clients who are selling their house or plot of land), rather than for buyers.

> "I think in the end you're not fighting for the buyer, or in very few cases nowadays, but for the seller, who you have to win. ... But I believe that the seller who selects a broker selects him from the point of view of who he will sell most successfully with. And of course, he sees what a real estate agent uses, 360-degree tours, that, that, that, that, that, that; and so of course that fuels confidence in the seller to do it with realtor x rather than with realtor y who doesn't use it ..." (CTO2)
>
> „Ich glaube, letztendlich kämpft man ja nicht um den Käufer oder in den wenigsten Fällen heutzutage, sondern um den Verkäufer, den muss man gewinnen. ... Ich glaube aber der Verkäufer, der einen Makler auswählt, wählt den nach Gesichtspunkten dahingehend aus, mit wem er am erfolgreichsten verkaufen wird. Und der sieht natürlich was so ein Makler alles einsetzt, 360-Grad-Touren, das, das, das, das, das; und somit schürt das natürlich Vertrauen in den Verkäufer, lieber mit dem Rechten das zu machen als mit dem Linken, der es nicht nutzt …" (CTO2)

EXP2 of company B also mentioned, that for some clients "innovativeness in itself" provides value. He described cases, in which companies presented augmented reality or virtual reality applications with the objective to be perceived as innovative by their partners and employees. Said differently, the mere fact that the company presented augmented reality or virtual reality technologies was considered to have a positive effect on marketing, branding, public relations, and in-selling (e.g. marketing activities which are targeted towards stakeholders and players *inside* the organisation). Lastly, Realtor1 stated, that some clients are simply excited about today's technological possibilities which sheds a positive light onto company C and concludes: "company C is ahead by a nose and that's good".

4.2.3 Present Real Estate Properties More Accurately and Support Imagination

According to Realtor1, the key benefit of employing the 360° virtual tour technologies is, that real estate properties can be presented online much better. Further, Realtor1 reported a new benefit of 360° photographs to be, that these images cannot be manipulated by the realtors. She elaborated, that to date, it is common practice for realtors to take pictures that show the real estate property in the best possible light, and that these images are post-processed intensively. This can lead to a disappointment in customers who plan to buy or rent a property, because expectations gained from viewing images are not met when on site. On the contrary, 360° photographs are not post-processed, digitally, and reveal a 360° view of the entire surrounding. Therefore, interested clients gain a much more realistic view of what the property really looks like and hence their expectations are met much more accurately.

> "So, many [visitors] stand in the object and say, "ah yes cool, it really looks like it did in the tour". … In the past, when you only had the photos, which are often, to be honest, always heavily post-processed by the brokerage firms, and that's just not possible on this tour." (Realtor1)
>
> „Also viele [Besucher] stehen im Objekt und sagen, ah ja cool, das sieht ja wirklich so aus wie in der Tour. … Also früher hatte man ja immer nur die Fotos, die ja häufig, das muss man ja auch ehrlich sagen, von den Maklerfirmen immer stark bearbeitet werden und das ist halt bei dieser Tour einfach nicht möglich.“ (Realtor1)

Looking into the future, CTO2 imagines that virtual reality goggles will be used, to show potential buyers what a real estate object needy of renovations will look like once the modernisation efforts are completed. This will not only support the imaginative power of customers, but also holds the potential to increase the attractiveness of an offered property.

> "I can imagine very well that even with renovations or conversion-needy real estate objects one can show with goggles what it will look like after the modernisation, in order to simply boost the attractiveness of the real estate, despite the fact, that the project is not finished yet." (CTO2)
>
> „Ich kann mir sehr gut vorstellen das eben auch bei Renovierungs- oder umbaubedürftigen Immobilien man eben da schon mit VR-Brillen zeigen kann wie es einmal nach der Modernisierung ausschaut, um einfach die Attraktivität der Immobilie, obwohl sie es heute noch nicht ist, hochzupuschen.“ (CTO2)

4.2.4 Win the Trust of Employees

In company C, the virtual tour was one of the first digital innovation projects, according to CTO2. Further he reported, that this project was perceived very well and received very good feedback from the realtors. He assesses, that this project had a positive contribution on employees' perception on digital technologies. According to CTO2, the project was well suited to present the introduction of new digital solutions in a positive light: "you [the employee] don't need to be afraid of innovation, on the contrary, it is perceived as good and helpful" (CTO2). The researcher, too, observed, that Realtor1 spoke of the new technology only in positive terms. This perhaps indicates, that the employment of virtual reality technology may have a positive contribution on employees' perception of innovative technologies, in general.

4.2.5 Digital Assistance, Changed Business Processes, and a New Agency Business Model

From the expert interviews, three dominant themes emerged. According to the interviewees, augmented reality and virtual reality technologies were employed in the areas of digital assistance, to change business processes, and to support new agency business models (e.g. AR/VR software development as a service).

For example, augmented reality is employed to aid customer support, or as an innovative new maintenance tool, in both cases with the objective to increase the efficiency of business processes. The aspect of fundamentally changing business processes was exemplified by a virtual reality collaboration product, which is used for design reviews; and to reduce travel costs, by eliminating some or all travel needs. According to the interviewees, employing virtual reality enables instant feedback of project stakeholders, and hence helps in making decisions earlier, and in avoiding mistakes (see it, before you build it). Again, this results in cost savings and faster development cycles. All three areas are still in very early stages, according to the experts. As a consequence, company B morphed from a product-orientated start-up to a software agency. As such, the business focuses on tailoring their virtual reality collaboration software to individual clients' needs, on the development of augmented reality and virtual reality software prototypes, and on the employment of the technologies to emotionalise brands.

4.2.6 AR/VR as a Strategic Step Towards the Digital Transformation

From a strategic perspective, CTO2 explained that he believes, that the Digital Transformation will have a significant impact on the real estate business. Hence, company C needs to prepare for a time, where perhaps up to 80% of real estate sales might be handled digitally. He considers projects like this 360° virtual tour as a good sub-step towards the Digital Transformation.

> "I believe that the company has to prepare itself for the day where the added value of a real estate agent or where competitors are in the market, where online competitors are in the market, who want to take a bite out of the services of a human real estate agent and I believe we have to prepare ourselves for this time with many such services and tools, such digital tools, when more and more business takes place digitally vs. by human beings and this [the virtual tour] is just an exemplary product on the way there and maybe it is really so that in 10 years 50 percent of all real estate and the sales will be handled to 80 percent digitally." (CTO2)

> "Also ich glaube dass das Unternehmen sich schon für den Tag vorbereiten muss wo der Mehrwert eines Maklers oder wo Wettbewerber im Markt sind, Online-Wettbewerber im Markt sind, die an den Services eines menschlichen Maklers dran rum beißen und ich glaube wir müssen uns mit ganz vielen solchen Services und Tools, solchen digitalen halt auf diese Zeit vorbereiten, wo mehr und mehr digital erfolgt vs. durch den Mensch und das ist halt ein beispielhaftes Produkt auf dem Weg dahin und vielleicht ist es tatsächlich mal so das in 10 Jahren 50 Prozent aller Immobilien und die Verkäufe zu 80 Prozent digital abgewickelt werden." (CTO2)

4.3 RQ2: What are the anticipated effects of augmented reality and virtual reality technologies on business in Germany?

The aim of this research question is to describe how augmented reality and virtual reality technologies impact business model innovation in Germany. Originally, when formulating this research question, the researcher had assumed that augmented reality and virtual reality were already impacting business model innovation in Germany, significantly. However, this assumption is not reflected by the researcher's findings, thus far. To the contrary, during the pilot case study the researcher found, that the interviewees reported the impact to be of little significance (see Section 4.3.1 below). However, both interview partners, as well as the two experts the researcher spoke to (cf. Section 3.8), were optimistic regarding the future development and impact of augmented reality and virtual technology. It is this observation (the *reported* effects on business model innovation, today versus the *anticipated* effects), that let the author to the addition of the word “anticipated” in the research question.

4.3.1 No Significant Impact in the Pilot Case Study Company, to Date

When asked about the significance of the project for company C, Realtor1 stated:

> “Well, in the end it's "only us brokers" who work with it. Sure, it [the technology] has an impact in the sense that the company hopes for more turnover through it, sure. But I think that this will come to light in the long run. Well, I don't think it's a factor that has become so noticeable in the last year since we have Ogulo[13].” (Realtor1)

> “Also, letztendlich sind es ja “nur wir Makler” die damit arbeiten. Klar, es wirkt sich in dem Sinne aus das die Firma sich mehr Umsatz dadurch erhofft, klar. Aber ich glaube das wird sich erst auf lange Sicht zeigen. Also, ich glaube nicht das das irgendwie jetzt ein Faktor ist den man jetzt im letzten Jahr, wo wir Ogulo haben, sich das so bemerkbar gemacht hat.” (Realtor1)

Similarly, CTO2 indicated that company C “certainly benefited from the implementation [of the project]”, however, that this isn’t measurable in key figures. Further, CTO2 termed the project primarily to be “a nice marketing project” which didn’t really change much in the business processes of company C, so far.

4.3.2 AR/VR Expected to Have an Effect on Business Model Innovation in the Future

During the expert interviews, both interviewees, EXP1, and EXP2, reported to see augmented reality and virtual reality technologies as a very promising, soon-to-be lucrative industry, with great growth potential. Case study interviewee CTO2 also expressed the opinion, that virtual technology can have an impact on business models, particularly impacting the way real estate objects are visited in the future. Further, CTO2 stated, that he could very well see this technology development to pose a threat to realtors’ jobs in the next 10 to 15 years:

> “Well, I think that such a technology can have an impact on the business model particularly if you develop it further – in that the role of the broker can be replaced in parts by technology. Let’s assume customers want, so what's the benefit of a realtor? The realtor welcomes the interested parties, explains to them in a flowery way what a great object this [real estate object] is, shows them around, and, and, and; that with a hundred of interested parties and in the end, the realtor filters out who wants to actually buy it [the property]. I believe such a technology,

[13] Ogulo is the turnkey virtual walk-through solution employed by company C (cf. Ogulo GmbH, 2018)

> perhaps also with VR goggles in the future or whatever, can partially replace the on-site inspection to a certain extent at, least in a first phase. And that would mean that there is less work to be done for the broker, which could mean that this would have an influence on the personnel structure, because the seller says well, the [seller himself] doesn't have to do that much anymore. ... And that the better the technologies get, the more the pose a threat to the realtors' job in the next 10, 15 years." (CTO2)

> "Also, ich glaube das so eine Technologie und auch wenn man das weiterentwickelt, einen Einfluss auf das Geschäftsmodell haben kann – dahingehend, dass die Rolle des Maklers ein bisschen durch Technologien ersetzt werden kann. Und zwar angenommen Kunden möchten, also was ist der Vorteil des Maklers? Das der den Interessenten an die Hand nimmt, denen ganz blumig erklärt was das für ein tolles Objekt ist, eine Vor-Ort-Besichtigung macht und, und, und; das mit hundert Interessenten und am Ende filtert sich heraus wer es kaufen will. Ich glaube so eine Technologie, vielleicht auch mit einer VR-Brille zukünftig oder was auch immer, kann in Teilen mal die Vor-Ort-Besichtigung zu einem gewissen Maß zu mindestens in einer ersten Phase ersetzen. Und das würde bedeuten das es weniger Aufwand bei unserem Makler gibt, das könnte bedeuten das das einen Einfluss auf Personalstrukturen hat, weil der Verkäufer sagt na ja, so viel muss der [der Verkäufer selbst] gar nicht mehr machen. … Und dass, umso besser die Technologien werden, der Job des Maklers auf die nächsten 10, 15 Jahre gefährdet sein kann." (CTO2)

Thus far, the researcher observes, that the effects of augmented reality and virtual technologies on business model innovation in Germany appears to be marginal, at this point in time; however, he also observes, that expectations for future developments are high (see also Section 4.5.3, which discusses the slow market development speed). A predicted compound annual growth rate of 98.8% during the coming years (forecast until 2021) (cf. IDC, 2017) further indicate, that the AR/VR industry is being pushed forward, and industry observers such as Karsten Baumgartl are certain that "AR is not new, but it is definitely ripe" (Baumgartl, 2018, p.1). Therefore, the researcher contends that updating the research question with an "attempt to look into a possible future" by asking interviewees about the expectations will reveal valuable insights.

4.4 RQ3: What are the benefits of employing augmented reality and virtual reality technologies in Germany?

The aim of this research question is to explore how companies in Germany can benefit from the employment augmented reality and virtual reality technologies. The researcher's initial findings are presented below.

4.4.1 Increased Efficiency

An increase in sales efficiency is the most dominant theme identified in the pilot case study data analysis. As a matter of fact, according to CTO2 increasing sales process efficiency was an initial motivation to initialise the project (cf. Section 4.2.1). The efficiency of the sales process in real estate is increased through the 360° virtual tour in several ways. For example, employing the technology enables more accurate real estate property presentations resulting in better-met customer expectations, as explained in Section 4.2.3. This in turn results in higher lead quality (Realtor1) and increased decision-readiness in clients (CTO2).

Further, avoiding "real estate sightseeing tourism", as Realtor1 termed it, reduces the total number of fruitless inspections (Realtor1), which in turn preserves internal resources (CTO2). Real estate sightseeing tourism arose as a surprising – and somewhat humorous – point: Realtor1 explained, that a significant number of potential clients turn out to be scam. These people pretend to be prospective buyers, however, all that they are really interested in is getting inside the real estate object, out of pure curiosity. Realtor1 reported, that employing the 360° virtual tours noticeably reduces the number of dubious visits. This is not only saving time for realtors, but is also beneficial for many property sellers, who can be disturbed by unnecessary visits. Upon further investigation, the researcher discovered, that real estate sightseeing tourism is an industry-known problem addressed by numerous realtors (e.g. Kischkel Immobilien, 2013; Dittmann, 2017; HHImmobilien, 2017). The author reasons, that the ability to display objects with a high degree of detail on the Internet may hold both, unexpected benefits and new threats. For example, presenting the photographic details may assist burglars in identifying empty buildings or valuable items in properties for sale; a danger perhaps comparable to an alleged dark side of the Google Street View technology, which may also be used by crooks to identify potential crime targets (cf. Supreme Security Systems, Inc., 2016).

Lastly, Realtor1 reported an increase in sales efficiency in respect to obtaining higher sales prices on properties due to the employment of the 360° virtual tour: a better bargaining position during price negotiations. This phenomenon is further explained and discussed in Section 4.4.3.

4.4.2 Strengthen the Competitive Position

When asked, what impact employing the 360° virtual tour has on the competitive positioning, Realtor1 reported, that the mere fact that the solution is there, strengthens the competitive position. An excerpt of the interview is given below:

> "Researcher: How would you say has the use of this technology affected the competitive positioning of the company?
> Realtor1: Very good. Many people who have already seen it elsewhere on the Internet ask directly for it because it has also inspired them. We really get a very positive feedback. So, if you really explain it again [to customers] on site – because we also have it on the mobile phone, we can simply show it as an example on site – we really always get very good feedback.
> Researcher: Ok. So the customers ask for it. Is this really a competitive advantage for you or is it just a "must have" nowadays?
> Realtor1: I don't think it's a must have yet, but it's an advantage.
> Researcher: An advantage. Just because it's there?
> Realtor1: Exactly. You can just present it better and it's just something that not everyone has, at this point in time."
>
> „Researcher: Wie würden Sie sagen hat sich der Einfluss dieser Technologie auf die Wettbewerbspositionierung der Firma ausgewirkt?
> Realtor1: Sehr gut. Viele die es schon im Internet wo anders gesehen haben fragen direkt danach, weil es sie eben auch begeistert hat. Ansonsten bekommen wir da wirklich ein sehr positives Feedback. Also, wenn man es dann wirklich vor Ort noch mal erklärt – dadurch das wir es ja auch auf dem Handy haben können wir es auch vor Ort einfach mal als Beispiel zeigen – da bekommen wir wirklich immer ein sehr gutes Feedback.
> Researcher: Ok. Also die Kunden fragen danach. Ist das also auch wirklich ein Wettbewerbsvorteil für Sie oder ist das einfach ein „Must Have" heutzutage?
> Realtor1: Ich glaube ein „Must Have" ist es noch nicht, aber es ist ein Vorteil.
> Researcher: Ein Vorteil. Einfach weil es da ist?
> Realtor1: Genau. Man kann es einfach besser präsentieren und es ist einfach was, was jetzt, also zum jetzigen Zeitpunkt noch nicht alle haben."

4.4.3 Collect New Types of Data

As previously explained in Section 3.9.1, the researcher learned about the 360° virtual tour case by coincidence. He was particularly intrigued by the statement from Realtor1, that the 360° virtual tours revealed new, additional information about prospective buyers. During the interview, she further elaborated, that the information revealed from the 360° virtual tour back-end includes detailed information, on how long clients explored individual rooms.

> "So we as brokers get feedback. So now when customers come to see our Ogulo tour, we get feedback and see exactly how long they've been in the property. So we see, they were now 5 seconds in the hallway, then 10 minutes in the kitchen and of course that's also something, which in the end, especially when it comes to price negotiations, is often really a big factor. So, if we now see that we were now in a three-room apartment for three quarters of an hour, then we know, ok, their interest is really high. And then we can take more action accordingly, so to speak. ... We can see exactly who stayed in which room for how long and when they go out of the bedroom and into the hallway again, this is displayed every time. That's a list of – depending on the situation – a list of seconds, minutes, how long you've been in which room." (Realtor1)

> „Also wir als Makler bekommen ein Feedback. Also wenn jetzt die Kunden sich unsere Ogulo-Tour anschauen, dann bekommen wir ein Feedback und sehen ganz genau wie lange die sich in der Immobilie aufgehalten haben. Also wir sehen, die waren jetzt 5 Sekunden im Flur, dann 10 Minuten in der Küche und das ist natürlich auch was, was dann am Ende, gerade wenn es um die Preisverhandlungen geht, häufig wirklich einen großen Faktor ausmacht. Also wenn wir jetzt sehen, wir waren jetzt in einer 3-Zimmer-Wohnung eine Dreiviertelstunde, dann wissen wir, ok, das Interesse ist wirklich hoch. Und dann können wir dementsprechend auch härter durchgreifen, sozusagen. … Wir sehen ganz genau, wer wie lange sich in welchem Raum aufgehalten hat und wenn er jetzt dann aus dem Schlafzimmer wieder in den Flur geht, dann wird das jedes Mal angezeigt. Das ist eine Auflistung von, je nach dem von Sekunden, Minuten, wie lange man sich in welchem Raum aufgehalten hat." (Realtor1)

The researcher further asked, whether the system would also return data on the direction in which prospective buyers looked. This was negated; however, the researcher contends, that in the future, this information could be included. Thinking ahead towards virtual reality goggles, even more data might become collectable. Systems might be able to capture what exactly a prospective buyer is looking at, for how long, and how intensively. This then would open up entirely new possibilities for data analysis (perhaps to be performed by artificial intelligence algorithms), as well as entirely new challenges, for example regarding privacy issues.

From a business model innovation perspective, collecting these new types of data offers novel opportunities to enhance or offer new value propositions. Just as the real estate company benefits from this new type of information by being able to assess the level of interestedness of a prospective buyer (see detailed description in Section 3.9.1), other data collection scenarios likely present new value proposition opportunities for the party collecting the data, as well as for the users of the AR/VR solution: The solution may be optimised to reflect a user's personal interest, perhaps even in real time.

4.5 RQ4: What challenges do companies in Germany face, when implementing augmented reality and virtual reality projects?

This research question aims to explore what challenges companies in Germany face, when implementing augmented reality and virtual reality projects for business model innovation. This research question was not part of the initial set of questions and surfaced during the analysis of the pilot case study data. Once this theme was identified, the researcher noted that the expert interviews also contained hints towards challenges, which the start-up encountered; and was able to identify recent literature (e.g. Capgemini, 2018), that reports on the significance of challenges companies encounter when attempting to employ augmented reality and virtual reality technologies. An extract from the researcher's case study log regarding this topic is presented below:

> 2018-09-28 (Friday)
> Researchers notes:
> [10:39h] … Another interesting thought appeared during the data analysis: do I need to add an additional research question addressing the challenges companies have with the implementation of AR/VR projects? For example, it was interesting to see, that the Realtor1 encountered some challenges when using the hardware and software to create the 360° photos; however, these challenges arose from side issues, such as malfunctioning tripod, or lack of Internet connectivity.
> These thoughts are further supported by Capgemini (2018):
> "Because the technology is new, it's no surprise that organizations lack in-house AR/VR expertise. In fact, it is one of the top three barriers to growth identified by our respondents" (Capgemini, 2018, p.19)
> "For organizations, the major brakes on progress will be technological integration, data readiness, the inability to identify use cases, talent, and general awareness" (Capgemini, 2018, p.23)

Challenges identified from the research thus far, are presented in the next sections.

4.5.1 Technical Challenges

Overall, the pilot case study interviewees both reported, that the virtual reality tour solution employed in the case was easy to use and easily integrated into the existing business processes and pre-existing IT infrastructure. However, Realtor1 reported that she encountered some technical issues when creating the content for the virtual tour on site:

> “What we had problems with in the beginning, which we[14] unfortunately noticed, was the tripod. In the meantime, we have improved versions. That was really very, very complicated and in the beginning, we had connection problems. You switch on the WLAN on your device and then connect it to your mobile phone. That means you don't need [a pre-existing] WLAN on site. In the beginning there were always connection problems. Or if you're really somewhere – I mean it almost doesn't happen anymore – but if you really say ok, you don't have a [mobile] network, it's rare, but it still happens, then it's also difficult, because then the app simply doesn't load properly. … but that's probably a system error from the mobile phone, I don't know exactly how that works. Let’s be completely honest, I don't know enough about it. (Realtor1)

> „Womit wir am Anfang Probleme hatten, das haben wir ja auch leider gemerkt, war das Stativ. Da haben wir mittlerweile verbesserte Varianten. Das war tatsächlich sehr sehr kompliziert und am Anfang hatten wir auch Verbindungsprobleme. Man schaltet ja das WLAN an sich am Gerät ein und verbindet es dann mit dem Handy. Das heißt man braucht kein [bereits bestehendes] WLAN vor Ort. Da gab es am Anfang immer mal Verbindungsprobleme. Oder wenn man jetzt wirklich mal irgendwo ist – ich meine mittlerweile kommt es fast nicht mehr vor – aber wenn man wirklich sagt ok, man hat kein Netz, es ist zwar selten, aber es kommt ja immer noch vor, dann ist es auch schwierig, weil dann die App einfach nicht gescheit lädt. … das ist wahrscheinlich ein Systemfehler vom Handy, weiß ich nicht wie das genau ist. Bin ich ganz ehrlich, kenne ich mich zu wenig mit aus.“ (Realtor1)

It is interesting to note, that the challenges Realtor1 encountered were caused by circumstances which were external to the employed system solution; namely a malfunctioning tripod (which is used to mount the 360° camera), lack of mobile network coverage, and connectivity problems via WLAN (the WLAN connection is facilitated by the 360° camera). On one occasion, the researcher was present, when Realtor1 captured the 360° photos at a site. There, he observed an additional technical issue Realtor1 encountered: the rechargeable battery of the 360° camera had worn out. Consequently, the camera kept turning off and Realtor1 was not able to complete the photo shooting, that day (she returned on a different day with a different camera).

The author contends, that from a technical perspective the technology solution under investigation is of a relatively low degree of complexity. This might explain, why employing the solution was perceived to be relatively easy, overall. It is also noteworthy, that all employed hardware components (tripod, 360° camera, mobile phone) are

[14] with “we”, Realtor1 refers to the researcher, who was on site one time, when Realtor1 captured the 360° images for a virtual tour.

consumer grade quality, rather than build for professional use. On the one hand, this might help explain some of the hardware issues encountered by Realtor1; on the other hand, it is interesting to note that business model innovation through augmented reality or virtual reality technologies does not require specialised hardware, in this case.

4.5.2 Getting Humans on Board

CTO2 explained, that company C is very cautious not to unsettle its employees through the introduction of digital technologies, which could be perceived as a threat to the employees' jobs:

> "I say with such products (this [the virtual tour] is a simple product; in financing there is also a project which aims to offer construction financing advice completely without humans – there you have to be extremely careful of course … not to frighten the team and to somehow to generate panic, that "the day after tomorrow you will no longer be needed"). And in the end that's a communication strategy for us, we try to bring the best of both worlds to our customers, online and offline, in order to make the process as simple, efficient and successful as possible for our customers. And in the end these are tools that can only support you as a sales person …". (CTO2)
>
> „Ich sage mal bei solchen Produkten (das [die virtuelle Tour] ist jetzt auch ein einfaches Produkt, in der Finanzierung gibt es auch ein Projekt Baufinanzierungsberatung komplett ohne Mensch – da muss man natürlich extrem vorsichtig sein um die Mannschaft … nicht zu verschrecken und irgendwie Panik zu generieren „übermorgen wirst du nicht mehr gebraucht"). Und das ist halt; am Ende bei uns ist es eine Kommunikationsstrategie, wir versuchen das Beste aus beiden Welten quasi an unsere Kunden zu bringen, sprich Online und Offline, um Kunden quasi den Prozess möglichst einfach, effizient, erfolgreich zu gestalten. Und am Ende sind das Tools die dich als Vertriebsmensch nur unterstützen können …" (CTO2)

While CTO2 states, that this virtual tour case "is a relatively harmless project", he also indicated that virtual reality might pose a job threat in the future (cf. Section 4.3.2). CTO2 elaborated further, that the virtual tour project was actually beneficial for employee acceptance in the sense, that it helped to open up the minds of employees for digital technologies. This potential benefit of augmented reality and virtual reality technologies is further discussed in Section 4.2.4.

4.5.3 Slow Market Development

The researcher was surprised of how slow virtual reality and augmented reality market development appears to be, as reported by the interviewed experts. Despite numerous predictions by the world’s top advisory and research firms (e.g. Gartner, Inc., 2016; Goldman Sachs, 2016; Digi-Capital LLC, 2016; KPMG, 2017; Deloitte, 2017), the market for augmented reality and virtual reality application seems to be developing significantly slower than hoped for. The researcher discovered hints at this slower development in the media (e.g. Bastian, 2017; Bezmalinovic, 2018); and interviewee EXP2 stated that:

> “I think the market did not grow as much as we expected in the last year, but also how most parts of the market would have expected that, you have to say it that way. I think those were the expectations one to two years ago. So the expectations were very high that it would really explode. I think that has not happened so far. But that's probably going to happen later, but it's not clear yet when the topic [AR/VR] will get really big.” (EXP2)
>
> „Na ja, also ich glaube der Markt ist im letzten Jahr nicht so stark gewachsen wie wir das erwartet hätten, aber auch wie die meisten Teile am Markt das erwartet hätten, dass muss man ganz ehrlich so sagen. Ich glaube die Erwartungen waren vor ein bis zwei Jahren, da waren die Erwartungen sehr hoch, dass es wirklich explodieren wird. Ich glaube das ist bisher nicht eingetreten. Aber das wird wahrscheinlich für später eintreten, aber es ist noch nicht so klar wann wird das Thema so richtig groß.“ (EXP2)

This observation, however, seemed to discourage neither of the two experts, who both felt, that it was the right time for them to launch the start-up, and that “their time will come”.

Similarly, Realtor1, and CTO2 also answered with a clear “yes”, when asked whether they consider the application of the virtual reality technology beneficial for their company, and whether they would employ the technology again, if they had to choose again. As discussed earlier in Section 4.3.2, augmented reality and virtual technologies are further expected to have a bright future.

4.5.4 Much Explanation Needed

Interviewee EXP1 reported, that one of the main challenges for augmented reality and virtual reality is, that it requires a lot of explaining:

> “VR is extremely difficult to present on slides. You always notice that again and again. In principle, you give a lecture. You show it on slides, but nobody gets it, it's too hard to understand. You can only transport that [the product properties and benefits] and properly compensate for it, … if you really show something live.” (EXP1)

> „Was ein generelles Thema natürlich ist, ist VR lässt sich extrem schwer auf Slides präsentieren und zeigen. Das merkt man immer wieder im Prinzip, man hält einen Vortrag, man zeigt es auf Folien, aber das kapiert keiner, das ist schwer zu verstehen. Das kann man nur transportieren und kompensieren richtig das Produkt, den Nutzen und so weiter, wenn man wirklich was live zeigt." (EXP1)

Consequently, the expert explained that it is extremely difficult to develop a product for virtual reality, at this point in time. The researcher, – an active entrepreneur in the field of augmented reality and virtual reality – can confirm this challenge, only too well. To address this challenge, his company (company A) installed a "innovation lab", which essentially is a showroom for augmented reality and virtual reality hardware and software. Virtual reality is something "you have to see, to believe it".

4.6 RQ5: How can companies in Germany deploy and use augmented reality and virtual reality technologies for business model innovation?

This research question is aimed at exploring how companies in Germany can deploy a (first) virtual reality or augmented reality project, and then employ it for business model innovation. This research question emerged during the data analysis of the pilot case study. First insights identified in the pilot case study are presented below.

4.6.1 Turnkey Solutions

The solution Ogulo employed for the pilot case is offered as a turnkey solution[15]. CTO2 reported, that integrating the solution into the existing IT infrastructure was straightforward. Web integration, for example, is done via a simple HTML embed code integration. Similarly, creating the 360° photographic content seamlessly fit into the already existing business processes: Realtor1, for example, already visits customers' real estate properties on a regular basis to take pictures on site. Taking additional images with the 360° camera is only one additional task, that can easily be done by the realtor. After the images are taken, they are sent to the back office, where an assistant to the real estate agents post-processes the images. Here again, team assistants are already used to post-processing data, such as photographs. Post-processing the 360° images and combining

[15] The term "turnkey" refers to a solution which requires little or no adaptation and can be used/integrated by an interested company, quickly (cf. USLegal, Inc., nd).

them to a 360° virtual tour via the provided web-based platform is again just an additional work step, which fits seamlessly into the pre-existing data editing process.

Given these findings, the researcher concludes that one way how companies in Germany can deploy a first augmented reality or virtual reality project is by searching for turnkey solutions which are already tailored to the company's needs. Today, numerous start-ups are developing novel solutions striving to address industry specific challenges or aiming to offer new value propositions. Searching and evaluating these new solutions may be a quick and simple way to implement an augmented reality or virtual reality project in a given company. During the evaluation phase, companies should check the amount of effort needed to technically implement the new solution and how well it integrates into the company's existing processes. The business model innovation framework, this links back to the element "value creation mechanism".

4.6.2 Provide a Contact Point for Innovation and a Roll Out Process

Realtor1 reported, that the initial impulse for the innovation came from a colleague: a real estate agent of company C had discovered the virtual reality solution and proposed it to CTO2. As previously explained, CTO2 acts as a first point of contact for innovative ideas. Once the innovative solution was identified, it was presented during a regular meeting, followed by a testing phase, and finally deployed for daily use. Both, CTO2 and Realtor1 stated, that "management probably does not even know about this project". Linking back to the business model innovation framework (cf. Appendix A), the researcher would like to note that this is an example of an innovation in the business model which was initiated in the value network element: a benefit of a well working network within company C is, that innovation can be introduced and implemented from within the company. From this example, the researcher concludes, that fostering a positive environment for internal networking – for example by providing a contact point for innovative topics and a dynamic business process, which is open for innovative ideas – might be a good approach for enabling business model innovation through augmented reality and virtual reality technology.

4.6.3 Best Practises for Start-Ups

In this section, the author summarises best practice recommendations as formulated by the two expert interviewees (cf. Section 3.8). This summary is primarily aimed at start-ups that are entering the field of augmented reality and virtual technology.

4.6.3.1 Focus on Acquiring Projects and Gain Experience with the Technology, First

Company B is a start-up that initially solely focused on developing a virtual reality product for collaboration. According to the interviewees, this initial strategy had to be modified due to slow market growth. When asked, what they would do differently, if they could start over, both interviewees reported, that they would focus more on acquiring projects. If they could go back in time, interviewee EXP2 would give the company the recommendation to try to become profitable more quickly, and to gain as much experience with the technologies augmented reality and virtual reality through the development of software for clients, as possible. Both interviewees reported, that they were very proud of the software solution which they developed; however, they felt that this development could have been pushed forward with a lower priority. The lion's share of the profit is made through providing software development services; the revenue made with software licenses is marginal, to date, according to the research participants.

4.6.3.2 Build a Framework with Re-usable Elements; Develop In-house, Outsource Non-core Business

The research participants reported, that they were successful in building a "competitive edge" (EXP1), by developing a virtual reality framework for collaboration with reusable software modules. The advantages of this strategy are twofold: first, it enables them to present potential clients with a reference and demo-application; second, it empowers the business to offer shorter development times at lower cost, because large sections of software code can be reused.

In respect to the development of the software, the interviewees explained that most of the development is done in-house. Furthermore, they work very closely with a near-shore software development company, that basically acts as an extended work-bench. Lastly, some software development is outsourced to temporarily hired personnel. However, this outsourcing is only done for software development considered unrelated to the core software product.

4.6.3.3 Run Very Short Development Cycles

As the author knows, it is common practice in much of today's software development industry to follow a so-called agile software development process. The author will not go into explaining the details of this development philosophy in detail, here; however, briefly said, agile software development refers to the idea to begin with software development immediately, to implement requirement changes along the way, and to create a functional software product, as early as possible[16]. Having said this, the researcher was very surprised to learn about the extreme shortness of the software development cycles driven by company B. Both interviewees reported, that they meet with their customers on a weekly basis from the very beginning, when working on their clients' projects.

In the sections above, the author reported on the insights gained from implementing a full pilot case study, talking to two experts from the field, and from reflecting on the case study log. While it would be imprudent, to draw "hard conclusions", from a single case study, the author contends that this section shows, that rich insights can be gained from the research project, as designed and amended. Furthermore, the author would like to make a particular note in respect to the discovered "best practices", as presented in Section 4.6.3: as noted by Stahl (2014), the researcher merely describes how the given research participant conducts business. It cannot be concluded from this, that this is also the best way to operate a start-up in the area of augmented reality and virtual reality.

4.7 A Discrepancy between Business Model Importance, and Business Model Competence

During the research execution and data analysis, the following overarching point surfaced. The main section of the interview guide developed by the researcher concludes with the following two questions: "are you familiar with the term business model?"; which is directly followed by the question "if yes, what would you say a business model is?".

Here, the researcher observed a somewhat expected phenomenon in unexpected clarity: for example, both interviewed experts were very quick to answer the first question with a very confident "yes". However, when asked to explain, what they think a business model is, it became apparent, that they had not thought about defining the term "business model", before. Further, the researcher probed, whether business modelling was done in the company in a formal way. The answer to this was a clear "no" in company B. Despite the fact, that business models were frequently mentioned as being of upmost importance throughout the interviews; both interviewees did not feel, that it was important to explicitly sit down and discuss business models, as exemplified by the following quote:

[16] Minimal viable product (MVP) philosophy.

> "I think that [business model development] is something, that every business does implicitly; but no, not so explicitly that you'd sit down and say "we are now discussing our business model"" (EXP2).
>
> „Also ich glaube impliziert macht das eigentlich jedes Unternehmen, aber jetzt nicht so explizit das man sich hinsetzt und sagt wir diskutieren jetzt unser Geschäftsmodell." (EXP2)

The researcher asked CTO2, as well, whether business modelling was done in company C in a formal way. Contrary to company B, he confirmed this and disclosed that he had been attending business modelling sessions before. However, when probing further, the researcher obtained the impression, that CTO2 was not too keen on these sessions and doubted their contribution to praxis.

In summary, company B deemed business modelling to be important, but did not actually implement business modelling formally; and company C implements formal business modelling sessions, but – at least as far as CTO2 is concerned – does not appear to consider formal business modelling important. Overall, the researcher obtained the impression, that both companies (company B and C) are actively innovating their business models through augmented reality and virtual technologies; however, neither company can or is willing to discuss it from a theoretical viewpoint. Hence, the author concludes that it may be wise, to formulate his business model innovation related questions in further interviews in a very indirect fashion, rather than in context of theory. This conclusion is reflected in the revised interview guide, as provided in Appendix E for reference.

In this section, the author presented initial findings and insights gained from conducting the full pilot case study, from talking to two experts from the field, and from reflecting on the case study log. In the next section, the author gives a summary of the paper and presents the next planned steps.

5 Summary

This Research Design Paper builds on two previous papers; a Conceptual Paper, which develops a conceptual framework from literature; and a Methodology Paper, which reflects on the research philosophy underpinning the study, and justifies the multiple-case holistic "Type 3" case study design, which the author chose for this research.

Overall, the research is aimed at better understanding the impact of augmented reality and virtual reality technologies on business model innovation. The formal objective of the study is "*to explore the impact of augmented reality and virtual reality technologies on business model innovation in Germany*".

In this Design Paper, the author offers a review of the research steps taken, thus far; discusses initial learnings garnered from the implementation of a pre-pilot case study test run, two expert interviews, and a full pilot case study; reflects on insights gained from feedback from the WIT Ethics Committee, examiner commentary, and the author's personal reflections; and presents initial findings.

The next step in the research process is to collect and analyse more data through the implementation of further case studies. Furthermore, after completion of the individual case studies, the researcher will perform a cross-case synthesis.

The presentation of the overall findings, as well as the researcher's interpretation of the findings will be presented in a subsequent paper.

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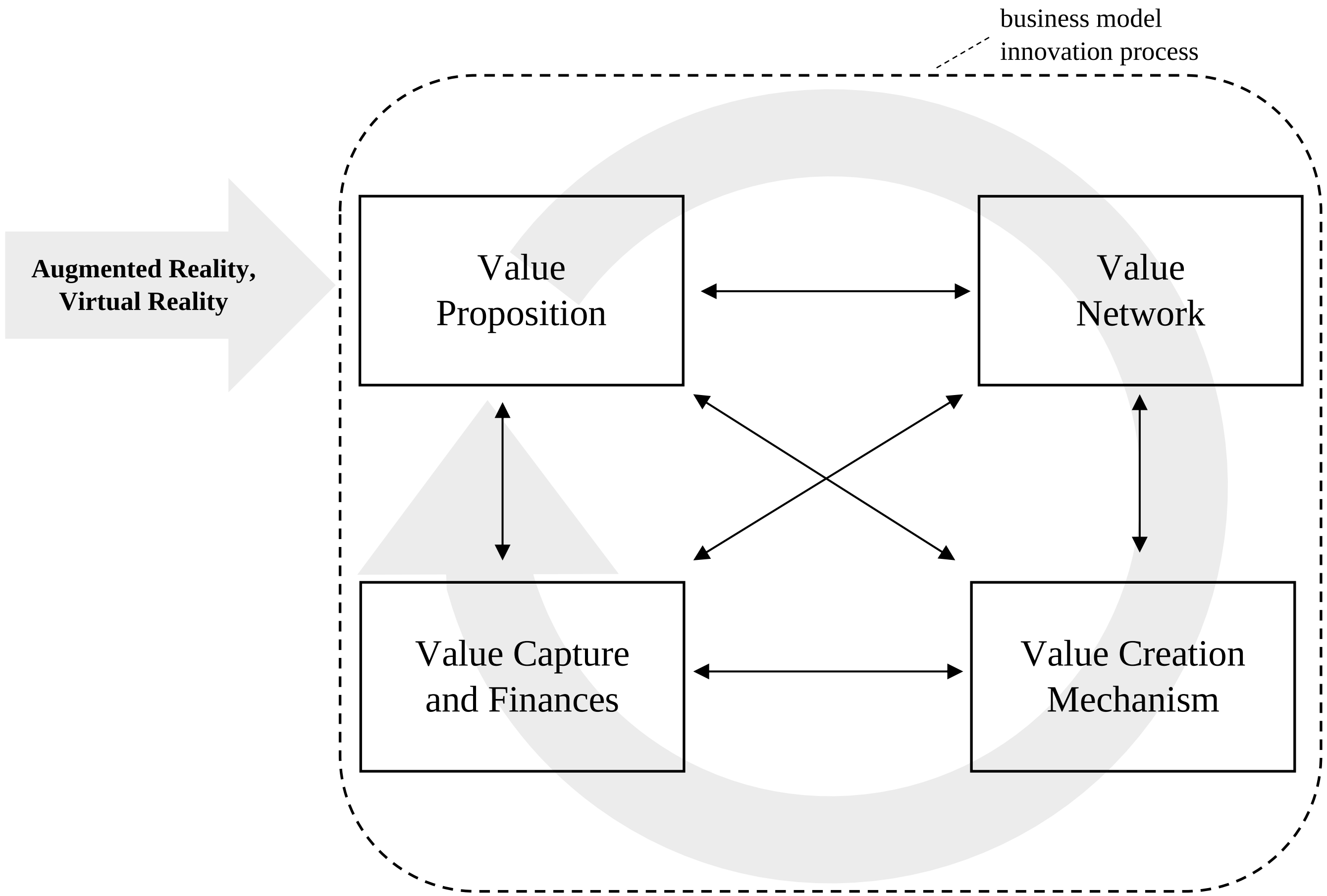
Appendix A Conceptual Framework to Explore the Impact of Augmented Reality and Virtual Reality on Business Model Innovation

As part of a previous conceptual paper, the author developed a conceptual framework to explore the impact of augmented reality and virtual reality technologies on business model innovation in Germany. The conceptual framework is presented in Figure 2.

To better understand the framework, the reader is directed to start at the right-hand side of Figure 2. There, the key findings of the business model, and business model innovation literature review are summarised and amended by the final objective of the business model innovation process: the innovation of an existing business model, or the creation of an entirely new business model. The left-hand side of Figure 2 presents an arrow labelled “augmented reality, virtual reality” indicating that these technologies offer new, potential business opportunities and therefore act as motivators to start the business model innovation process. At the centre of Figure 2, the business model value domains identified in literature are shown. They are connected by double-headed arrows, indicating that the business model is an inter-connected concept. Finally, a circular arrow in the background demonstrates that business model innovation is a continuous, dynamic process. Arguably, the first step in business model innovation can be the search for a new or improved value proposition, followed by the subsequent steps, as shown.

Figure 2 – Proposed conceptual framework to explore the impact of augmented reality and virtual reality on business model innovation. (adapted from Chesbrough and Rosenbloom, 2002; Morris *et al.*, 2005; Al-Debei and Avison, 2010; Lüdeke-Freund, 2013)



Business model
- Simplified but complete representation of how a company operates
- Holistic approach

Business model elements
- Value based
- Interconnected

Business model functions
- Communication tool
- Mediator between strategic objectives and technology
- Source of competitive advantage

Business model innovation process
- Continuous
- Dynamic

Business model innovation outcomes
- Innovated business model
- New business model

Appendix B General Information Sheet

Information sheet: Research project Richard Hagl

Research project: Impact of augmented reality and virtual reality on business model innovation

Dear Sir or Madam,

Thank you very much for your interest in my research project. I'm really happy about your general willingness to take part in a study!

On this information sheet I have collected the most important background information about my work. If you have further questions, please contact me at any time.

Sincerely yours, Richard Hagl, Mai 2018

About the research project

As a graduate student at the Waterford Institute of Technology (WIT), I'm interested in emerging digital technologies and their impact on business models. Specifically, I examine the technologies augmented reality and virtual reality.

The goal of the research project is to better understand the impact of augmented reality and virtual reality on business models from a scientific perspective. To accomplish this, I conduct "exploratory case studies".

I have been working intensively on the research project since 2014. Since then I have developed the theoretical foundations and designed the planned study. Now is the time to put the project into practice.

About the Waterford Institute of Technology[1]

Waterford Institute of Technology (Irish: Institiúid Teicneolaíochta Phort Láirge) (WIT) is a state funded third-level educational freely available large-scale institution situated in the city of Waterford, Ireland. The Institute has six Schools and offers programmes in Business, Engineering, Science, Health Sciences, Education & Humanities.

Waterford Institute *of* Technology
INSTITIÚID TEICNEOLAÍOCHTA PHORT LÁIRGE

The Institute is ranked by Unirank as 10th best higher education institute in Ireland (out of 32) and the top institute of technology (with the exception of DIT). Further information at www.wit.ie.

Why you should participate

Besides "idealistic" aspects, e.g. strengthening the science locations Germany and Europe, you and your company will gain further, concrete benefits. Firstly, I will share the results of my research with you in a concise and precise, comprehensible manner; and in German, prior to publication. In addition, you can – if you wish – take a free, telephone consultation with me. In the consultation session, we then individually deepen the research results and their applicability to your company.

[1] Source: https://en.wikipedia.org/wiki/Waterford_Institute_of_Technology

Stand: 05.05.2018 12:07 – 1 – Informationsblatt Forschungsvorhaben Richard Hagl V.1 (EN - general information).docx

Information sheet: Research project Richard Hagl

Research project: Impact of augmented reality and virtual reality on business model innovation

Who I am looking for

For the study, I am looking for companies that have implemented a project or application that incorporates augmented reality or virtual reality technologies. Here, the technologies can be at the centre of the project or used together with other aspects. The only important thing is that you feel that you have an idea of what impact the technology has had on your project.

In order to carry out the research work, I need your permission and support to talk to the relevant project participants individually. Depending on the case, this can be a single person or even several project participants. Of course, we will clarify details in advance.

Course of the study

One thing in advance: your time investment needed for study participation is relatively low. A discussion round (interview) with the study participants is planned in each case. During this time, I ask about 30 minutes relaxed questions. The conversation is recorded and converted text form. I will then send you the text, with a request to read it briefly, to make sure that everything you wanted to say was recorded by me, correctly. If it turns out to be necessary, I'll contact you with clarification questions. That's it!

Of course, you can "change your mind" at any time and stop participating in the study.

Scientific standards and confidentiality

It is very important to me to guarantee you, that in my work I will fulfil the highest, scientific, professional and ethical standards. Of course, no personal data or confidential project details will be published or disclosed to unauthorized third parties (unless you explicitly request this by agreement, for example for marketing purposes).

Unprompted, I will send you a confidentiality guarantee prior to conducting the study. I will also sign your own non-disclosure agreement, if you so wish.

All data collected by me are kept strictly confidential and used exclusively for scientific purposes. The data used for the analysis are primarily the textual form of the above-mentioned interview, as well as my notes (field observations) and preliminary information that I identified during my internet research. If you want to provide me with further documents, I will also treat those confidentially.

All data collected by me will be destroyed or deleted five years after completion of the study.

pto.

Information sheet: Research project Richard Hagl

Research project: Impact of augmented reality and virtual reality on business model innovation

About Richard Hagl

Richard Hagl, born in 1974, is a scientist, author[2], and entrepreneur. For two decades he has been involved in innovation in the IT sector (online technologies, networked digital systems), and since 2008 intensively with 3D technologies such as renderings, 3D printing, augmented reality and virtual reality. He is the founder of Phaenom GmbH, an innovative company focused on opportunities through the Digital Transformation.

Richard Hagl holds a degree in Systems Engineering (MSc) from the University of Munich, as well as degrees in Electrical Engineering (BSc) and Computer Sciences (BSc, second major) from the University of Wisconsin, USA.

Note of demarcation

Please note that I have deliberately taken active demarcation measures to strictly separate my professional activities and my research work. All data collected will be used solely for scientific purposes and for my private interest in obtaining a doctorate degree. Financially and organizationally, I am 100% independent. There is no exchange between my student work and any company. Also, no data is exchanged between research participants. Please contact me if you have further questions.

Finally, thank you very much! Your participation helps me a lot – and I am confident that the results of my work will be highly relevant for you and your company!

Contact

You have any questions or suggestions? Please contact me anytime:

Richard Hagl
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81375 München

richard@hagl.net
Tel.: 0049 177 365 8990

Scientific advisor
(Communication in English only)

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[2] „Das 3D-Druck-Kompendium", Springer Gabler, ISBN: 978-3-658-07046-5, www.3d-druck-kompendium.de

Appendix C Ethics Committee Approval Letter

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Foirfe chun fónaimh

29th May 2018

Re: Application for ethical approval for your study titled, *'A research approach for exploring the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany'*.

Dear Richard,

Thank you for submitting your revised proposal to the School Ethics Committee and for taking the time to address the recommended changes.

I can confirm that we are now satisfied to approve the revised submission.

We wish you with with your future research endeavours.

Yours truly,

Professor Denis Harrington

Head of Graduate Business, and Chair of the School of Business Ethical Committee, WIT

Appendix D Summary of Principles for Interpretive Field Research (Klein and Myers, 1999, p.72)

Table 4 – Seven principles for interpretive field research (Source: Klein and Myers, 1999, p.72).

1. The Fundamental Principle of the Hermeneutic Circle This principle suggests that all human understanding is achieved by iterating between considering the interdependent meaning of parts and the whole that they form. This principle of human understanding is fundamental to all the other principles. Example: Lee's (1994) study of information richness in e-mail communications. It iterates between the separate message fragments of individual e-mail participants as parts and the global context that determines the full meanings of the separate messages to interpret the message exchange as a whole.
2. The Principle of Contextualization Requires critical reflection of the social and historical background of the research setting, so that the intended audience can see how the current situation under investigation emerged. Example: After discussing the historical forces that led to Fiat establishing a new assembly plant, Ciborra et al. (1996) show how old Fordist production concepts still had a significant influence despite radical changes in work organization and operations.
3. The Principle of Interaction Between the Researchers and the Subjects Requires critical reflection on how the research materials (or "data") were socially constructed through the interaction between the researchers and participants. Example: Trauth (1997) explains how her understanding improved as she became self-conscious and started to question her own assumptions.
4. The Principle of Abstraction and Generalization Requires relating the idiographic details revealed by the data interpretation through the application of principles one and two to theoretical, general concepts that describe the nature of human understanding and social action. Example: Monteiro and Hanseth's (1996) findings are discussed in relation to Latour's actor network theory.
5. The Principle of Dialogical Reasoning Requires sensitivity to possible contradictions between the theoretical preconceptions guiding the research design and actual findings ("the story which the data tell") with subsequent cycles of revision. Example: Lee (1991) describes how Nardulli (1978) came to revise his preconceptions of the role of case load pressure as a central concept in the study of criminal courts several times.
6. The Principle of Multiple Interpretations Requires sensitivity to possible differences in interpretations among the participants as are typically expressed in multiple narratives or stories of the same sequence of events under study. Similar to multiple witness accounts even if all tell it as they saw it. Example: Levine and Rossmore's (1993) account of the conflicting expectations for the Threshold system in the Bremerton Inc. case.
7. The Principle of Suspicion Requires sensitivity to possible "biases" and systematic "distortions" in the narratives collected from the participants. Example: Forester (1992) looks at the facetious figures of speech used by city planning staff to negotiate the problem of data acquisition.

Appendix E Updated Interview Guide

Interview Guide

Meta information

Date: Time:

Interviewee: Role of interviewee:

Case ID: Interviewee ID:

Location:

Interviewer: Richard Hagl

Research aim: to better understand the impact of augmented reality and virtual reality technologies on business model innovation.

Questions

Room for short notes

(longer notes on separate paper)

Opening

[setup and start the recording]

1. First of all, I would like to thank you very much for participating in this research, and for this opportunity to learn about your case! As you know, participation is entirely voluntary. Do you have unanswered questions regarding research participation, or any other open topics such as confidentiality?

2. Offer a brief summary of the research project.
   [better understand the impact of augmented reality and virtual reality technologies on business model innovation in technology companies in Germany]

3. Explain the interview format and expected duration.
   [casual conversation, questions are guiding questions only; I am interested in *your* perceptions, thoughts, opinions, experiences, predictions, interpretations, and so forth; expected duration approximately 30 minutes]

Main Interview

Warm-up

4. OK, let's get started! Can you briefly introduce yourself, your background, and your role in the company and project?
   [probe for decision-making authority regards BMI]

5. Can you please describe the case briefly?

6. [Icebreaker question] What types of technologies were used for the case? (Hardware, software, infrastructure, anything else)

Research aim: to better understand the impact of augmented reality and virtual reality technologies on business model innovation.

Questions

Room for short notes

(longer notes on separate paper)

7. [Optional, if not clear already] What would you say is the most remarkable aspect of your project?

RQ1: How are augmented reality and virtual reality technologies being applied by companies in Germany, today?

8. [BMI outcomes: post this question only, if you are uncertain on the technology application, or feel that this needs to be further clarified; otherwise skip this question. Alternatively, summarise what you think that you know about the technology application in the case, and have it confirmed or amended.]
   Were the technologies used to drive a change within the existing organisation or product, or was it employed for a new organisation (such as a start-up) or to create a new product?

9. How were the technologies AR/VR applied, exactly? What was AR/VR used for? [Probe for efficiency, corporate image, human imagination, digital assistance, new service offering, winning trust, new product development, entry point for the Digital Transformation] [VP] [VCM]

10. [BM functions: Mediate between strategic objectives and technology] Can you describe the strategic objectives of your company and how this project may help achieving them? [probe for bigger strategic thinking, if possible]

11. [Collecting of data, skip if likely inappropriate] Does this project deliver new types of information/data about, for example, your customers customer? [value proposition]

Research aim: to better understand the impact of augmented reality and virtual reality technologies on business model innovation.

Questions

Room for short notes

(longer notes on separate paper)

RQ2: What are the anticipated effects of augmented reality and virtual reality technologies on business in Germany?

12. What would you say is or will be the impact of your case onto the company, overall? If there is an impact, is it / will it be significant?

13. [BMI as a process:] What are your concrete future plans regarding the work with AR/VR?

14. [Where is this all going?] Where will AR/VR lead your company to in the future? Where will it lead the industry that you're in to?

RQ3: What are the benefits of employing augmented reality and virtual reality technologies in Germany?

15. [Beneficial?] Would you do this project again (at all; at the same point in time)? If not, why not?

16. Is employing AR/VR beneficial? If yes, how did the company benefit? If not, why not?

17. If you could start over, what would you do differently?

18. [BM functions: source of competitive advantage] How would you say, did the employment of AR/VR impact your company's competitive positioning; meaning, what advantage do you have over your competitors now, that you did not have before?

19. [BM element: value proposition] What new value does the AR/VR project offer? Form whom? What would you/will you change/do differently? What do you see will be a next benefit?

Research aim: to better understand the impact of augmented reality and virtual reality technologies on business model innovation.

Questions

Room for short notes

(longer notes on separate paper)

20. [BM element: value network] can you think of anyone outside of your company and network, who benefited from the fact that you implemented an AR/VR project? In what way did they benefit?

21. [BM elements interconnected] [probing, to this intuitively as/if an opportunity presents itself.]

RQ4: What challenges do companies in Germany face, when implementing augmented reality and virtual reality projects?

22. Did you encounter challenges worth mentioning? If yes, which ones?

23. [Technical challenges] Which, if any, were the major technical challenges? [probe for challenge cause by AR/VR vs. external challenges]

24. [Getting humans on Board] How do people in your company react to this project? Do they feel threatened by it in anyway? Do they endorse it? Are they perhaps even excited about it?

25. [Market development speed] Do you think, that the market in your industry is ready for AR/VR? How fast will this market evolve, if at all?

26. [Explanation challenge] Is it difficult, to explain the project and its benefits to your colleagues and customers?

Research aim: to better understand the impact of augmented reality and virtual reality technologies on business model innovation.

Questions	**Room for short notes** (longer notes on separate paper)

RQ5: How can companies in Germany deploy and use augmented reality and virtual reality technologies for business model innovation?

27. [BM element: value creation mechanism] How was the project implemented (in-house, partners, contractors, turnkey solution, …)? What would you change/have done differently?

28. [Innovation process] How was this project initially introduced to the company (rollout)?

29. [BM element: value capture and finances] How was this project financed?

30. [Innovation process] Who is/is someone in your company responsible to identify, evaluate, integrate, and rollout innovative technologies?

31. [Innovation process] How did and does this project fit in your daily business processes and routines? Did those have to be changed?

32. [BM functions: Communication tool] How was this project / project details communicated to your company's stakeholders (employees, management)? Was the (anticipated) impact of your project visualised in some form (e.g. via a flow-chart, or other diagram form)?

33. [BM functions: Communication tool. Ask this question only for start-ups and technology providers] How is the anticipated market impact of your business communicated to stakeholders (employees, investors)? Is the (anticipated) impact visualised in some form? If yes, may I see these visualisations?

Research aim: to better understand the impact of augmented reality and virtual reality technologies on business model innovation.

Questions

Room for short notes

(longer notes on separate paper)

Additional topics

34. [BMI development and innovation] Can you explain, how your company's *business* [don't use the term "model", here] came about, and where it is going, e.g. what will be different in the future?

Closing

35. Do you have any further questions or comments?

36. Is there anyone else you think I should talk to? Is there any other informational material you think I should have a look at? Ask to be shown around / get a case demo, if possible.

37. Lastly, thank you very much for participating! As mentioned, in the next step the interview audio recording will be converted to text for further analysis. You will receive a copy of the text, as well as any conclusions I draw from statements. It would be great if you can review these documents and correct any misrepresentations or misinterpretations you find. The recording now ends [stop recording].

Appendix F Extract from Research Log: Reflecting on a Customer's Work Shop Agenda and Analogous Research Questions

2018-10-03 (Wednesday) Researchers notes

[14:41h] I am in the Munich office now … . So back to reflecting on the research questions.

How are AR/VR innovating business models? What impact does AR/VR have on companies in Germany? These are new question candidates. What exactly is it, that I want to find out? And what exactly is it, that potential readers of my research, as well as consulting customers of mine really want to know? Right now, we are offering a workshop to a client, who wants to bring AR to his customers. This client is the CEO of a successful marketing and media business, and also faces the problem, that it is not clear – neither to him, nor to his customers – how they could benefit from AR (potential value propositions) or even implement an AR project (value creation mechanism). His enquiry was also focusing on the question, how a software development process could look like: what input does the customer have to deliver?

So, let's link this to my research questions. The first thing, that the customer wants to know is, what AR components, hardware, software, solutions, and so on exist. Of primary interest is the question, what can AR/VR be used for? and for whom does it create what value? So, this links well to my RQ1, where I explore what AR can be used for; and RQ3, which is (more or less) aimed at identifying benefits of the implementation of AR/VR projects. Then, the question is, how do I get started with an AR/VR project (e.g. what does the customer have to deliver?) and how do I successfully implement this project. Further, what are the implications and challenges I have to master, when implementing an AR/VR project? And lastly, clients – and I have also observed this on other occasions – often are interested in where this all will go (desire to look into the future).

So, let me summarise this, and then based on these reflections revisit the research questions get once again (I just noticed, that I should also look at my framework and revisit the research questions while reflecting on the business model value domains and further business model and business model innovation literature review results):

This is what I, readers of my research, and my consulting clients really want to know:

- What is AR/VR?
- What can AR/VR be used for? (Finding use cases)
- How can who benefit from AR/VR? (Value proposition)
- How do I get started? (Value creation mechanism)
- How do I successfully implement and AR/VR project? (Process/value creation mechanism)
- What are the core challenges I have to address when introducing AR/VR into my company?
- Where is this all going? (A preview into the future)

PAPER 4: FINDINGS

PREFACE TO PAPER 4

The fourth paper in the paper series is the Findings Paper. In this paper, research findings are presented. Further, the paper may include an analysis, interpretation, and discussion of the research findings. In the researcher's case, Paper 4 focuses on the detailed and rich descriptions of the research case study companies, cases, and interviewees; as well as an in depth presentation of the collected data. A summary table of per case findings is included at the end of the paper. The overarching cross case analysis is performed later in Section Three of the thesis. A research participant overview is offered in Table 1 to visualise the scope of the research study.

Table 1 – Research participant overview.

Research participant code	**Associated company code**	**Date[1] of interview**	**Length of interview recording in minutes**	**Paper 4 section reference with further details**
ProjectManager1	SteelCo	2019-01-30	67 (on site)	2.1.3.1
Engineer1	SteelCo	2019-01-30	36 (on site)	2.1.3.2
Founder1	SportCo	2019-02-22	60 (on site)	2.2.4.1
Founder2	SportCo	2019-03-06	67[2] (on site)	2.2.4.2
SeniorDigitalManager1	TransportationCo	2019-03-05	28 (on site)	2.3.3.1
MarketingOfficer1	TransportationCo	2019-03-05	24 (on site)	2.3.3.2
Recruiter1	TransportationCo	2019-03-12	48 (on site)	2.3.3.3
DivisionManager1	TransportationCo	2019-05-06	40 (video call)	2.3.3.4
Owner1	SanitaryCo	2019-05-29	30 (on site)	2.4.2
DepartmentHead1	SupplyCo	2019-06-06	54 (on site)	2.5.3.1
Manager1	SupplyCo	2019-06-06	56 (on site)	2.5.3.2
DepartmentHead2	SupplyCo	2019-09-13	53 (on site)	2.5.3.3

The researcher notes that five research cases is a relatively small number. However, considering the tight schedule of the DBA, the limited resources available to the researcher, and the significant case access issues as previously reported in Preface to Paper 3 made the implementation of more than four to five research cases not feasible. However, given the exploratory nature of the study which does not try to test theory or

[1] Date format year-month-day
[2] The researcher captured two recordings: first 45 minutes of chatting, then 67 minutes of structured interviewing, as planned. Only the second interview was included in the detailed transcription analysis.

prove/disprove hypotheses, rather aims to generate rich phenomenological insights into a contemporary phenomenon, the researcher decided that four to five research cases are sufficient. This decision was made in close consultation with the examiners of Paper 3 and Paper 4.

Gaining access to research cases proved to be challenging and time-consuming. The researcher did notice, however, that his detailed preparation, which included a confidentiality guarantee and the detailed up-front addressing of ethical issues, helped pave the path, significantly. Further, a strategy that worked well for the researcher was to find “fellow campaigners” for his research within the investigated companies. These internal supporters proved to be crucial for the success of the research case. A strategy that the researcher adopted was to infiltrate companies bottom up. For example, this worked well in the case of TransportationCo. After numerous unsuccessful attempts to identify the responsible contact person in charge of the research case identified, the researcher finally got in contact with DivisionManager1 of TransportationCo. However, DivisionManager1 declined the researcher’s request and delegated him to a subordinate employee, SeniorDigitalManager1. The researcher and SeniorDigitalManager1 got along very well and SeniorDigitalManager1 became the researcher’s “comrade in arms” at TransportationCo. The researcher interviewed – additionally to SeniorDigitalManager1 – MarketingOfficer1 and Recruiter1. This required travelling more than 1000 km across Germany. Finally, the researcher re-contacted DivisionManager1 and disclosed his efforts, thus far. Likely as a result, DivisionManager1 felt obliged to speak with the researcher, at last. This strategy, however, is not entirely risk-free, as a different example shows. Following a similar strategy as just explained for TransportationCo, the researcher had identified an interesting logistics case. Similar to the TransportationCo case, the researcher’s upper management contact delegated him to an employee. Again, the researcher implemented interviews at lower hierarchy levels, transcribed them, and started the analysis; albeit hoping to ultimately gain access to upper management. This hope, however, was disappointed, and the researcher had to drop the case, after all.

Numerous software tools exist, which can aid the qualitative data analysis process (Leech and Onwuegbuzie, 2008). However, it can be preferable to perform the qualitative data analysis by hand; for example, if the researcher wants to be as close to the data as possible and is analysing a relatively small data base (Creswell, 2002). Basit (2003, p.152) states that the choice of approach depends "on the size of the project, the funds and time available and the inclination and expertise of the researcher". (Miles *et al.*, 2018) observe that computer aided software does not do the analysis for the researcher. Rather, computers help researchers speed up their process of retrieving data, categorising data, and finding data (Liamputtong, 2009). Said differently, computers excel in manipulating data mathematically (LeCompte, 2000). These capabilities, however, are not of central interest in interpretive studies. Instead, the richness and quality of data nurture qualitative research (Basit, 2003). As Yin (2017, p.166) describes it, "developing a rich and full explanation or even a good description of your case, in response to your initial "how" or "why" questions, will require much post-computer thinking and analysis on your [the researcher's] part". Based on the assumption that the researcher will collect a relatively small data base in the Creswell (2002) sense, the interpretive stance of the research, and the researcher's desire to be as close to the data as possible, he decides to move forward with a manual data analysis approach. This gives the researcher a maximum flexibility when implementing data analysis strategies, without potentially being distracted by software limitations or issues.

As a qualitative researcher, the researcher is interpreting the interpretations of fellow human beings (Stahl, 2014). Said differently, the researcher attempts to understand other people's interpretations, processes them through his own mental system, and then presents the reorganised and subjectively interpreted information back to other fellow human beings (Walsham, 1995). In this capacity, all interpretations are subjective to the researcher. This holds the risk of introducing researcher bias. Consequently, understanding and recognising bias is imperative for qualitative researchers (Galdas, 2017) and researchers must reflect on their role as part of the research throughout the entire research process (Sutton and Austin, 2015). Rather than trying to ignore their impact on the given research project (Sutton and Austin, 2015), researchers need to recognise and report their biases openly (Castleberry and Nolen, 2018) and should attempt to show that the research findings are not the result of the researcher's personal preferences, but truly reflect the thoughts and experience of the research participants (Shenton, 2004). Therefore, the researcher made great efforts to minimise any bias and to "act as neutral as possible". The researcher addresses this challenge by disclosing his thoughts and decisions throughout the entire research process. Additional to reporting key thoughts and decisions throughout the study, the researcher maintained a detailed account of his thoughts, feelings, interpretations, and research decisions in a research log. For example, he continuously reminds himself that his research quest is to “learn and listen” rather than to “teach and propose”, as he might otherwise have been inclined to do as a trained computer scientist and systems engineer. The researcher also made himself aware of his entrepreneurial interests: being active in the AR/VR entrepreneurial space made the researcher hopeful that the research would reveal that AR and VR technologies have a significant impact on BMI. To mitigate this predisposition, the researcher continuously remind himself that the study might reveal that AR and VR have little impact on BMI, perhaps no impact at all. Lastly, the researcher continuously doublechecked whether he understood research participants’ responses correctly by restating answers given by the interviewees during the interviews, as well as sending the interview transcriptions to the research participants, asking them to confirm that the transcripts represent the interviewees’ opinions properly.

A particular challenge arose through the manual data analysis approach. Being a doctoral study, data was collected, coded, and analysed by a single person (with the exception of transcribing the initial case study interviews). Consequently, the research cannot provide multiple perspectives on the collected data. Manual data encoding may introduce error and researcher bias. Arguably, this is a threat independent of computer employment, as computers cannot perform the data analysis for the researcher (Basit, 2003; Yin, 2017). During the process of coding the transcribed data, the researcher continuously challenged himself whether a different code could be assigned, as well, and invested great effort to minimise any bias. Furthermore, interview transcripts were fed back to research participants for confirmation and clarifying questions were posed to the interviewees during and after the interviews. At times, the researcher discovered analysis made previously and fix those. No one can work without making errors. However, since a huge amount of effort was spent on precision and correctness, the researcher expects no significant impact of errors onto the quality of the research findings.

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PAPER 4: “EXPLORING THE IMPACT OF AUGMENTED REALITY AND VIRTUAL REALITY TECHNOLOGIES ON BUSINESS MODEL INNOVATION IN GERMANY. FINDINGS.”

Doctorate in Business Administration (DBA)

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Date: 24 / 09 / 2019

RESEARCH PAPER SERIES

Paper 4:

FINDINGS PAPER

"Exploring the impact of augmented reality and virtual reality technologies on business model innovation in Germany. Findings."

ABSTRACT

The entrepreneurial environment of the 21st century is becoming ever more complex. Consequently, companies that wish to succeed in the long run need new concepts that help them continuously reinvent themselves. Business model innovation (BMI) is such a concept. Furthermore, BMI is impacted by emerging technologies such as augmented reality (AR) and virtual reality (VR). However, little is known about the effect of this impact. Therefore, this study aims at better understanding the impact of AR and VR on BMI. In this findings paper, the author describes five cases in which AR or VR technology impact BMI in companies in Germany. Furthermore, company background details and research participant descriptions are offered and an analysis of the findings arising from the case data is presented.

Keywords: business model innovation, augmented reality, virtual reality, emerging technologies.

ETHICAL DECLARATION

I declare that this submission is wholly my own work except where I have made explicit reference to the work of others. I have read the relevant notes, guidelines and procedures on conducting academic writing and research and hereby declare that this submission is in line with these requirements.

I have uploaded the entire submission as one file to Turnitin in Moodle, examined my "Match Overview" by viewing the detailed percentage listings and the overall "Similarity" score, and have addressed any matches that exceed 3%. I have made every effort to minimise my overall "Similarity" score and the number of matches occurring.

Name: *Richard Hagl*

Date: 24 September 2019

1 Introduction

Since the break of the 20th century, newly emerging digital technologies keep driving an unprecedented global change with unforeseeable outcome (Brynjolfsson and McAfee, 2014; Harari, 2016). The digital transformation is upon us (Streibich, 2017). However, turbulent times also present opportunities. Companies that wish to circumnavigate the significant risks of these eventful times, as well as strive to seize associated opportunities, need to apply new concepts that help them handle this new level of entrepreneurial complexity. Business model innovation (BMI) is such a concept. Furthermore, emerging technologies such as augmented reality (AR) and virtual reality (VR) impact BMI. However, little is known about the effect of this impact. Therefore, this research is aimed at better understanding the impact of AR and VR on BMI. The formal objective of the study is “to explore the impact of AR and VR technologies on BMI in Germany”.

The theory underpinning this research is outlined in the Conceptual Paper (Paper 1). A second paper, the Methodology Paper (Paper 2), reflects on the philosophical underpinnings of the study and justifies the chosen phenomenologist, subjectivist, interpretivist research approach and the multiple-case holistic “Type 3” case study design (cf. Yin, 2017, p.48). In the Design Paper (Paper 3), the researcher discusses initial learnings gained from piloting the research design. In this fourth paper (Findings Paper) the author describes the five case studies in detail and presents the findings.

The remainder of this paper is structured as follows. In Section 2, details regarding the individual case studies are given. Section 3 is dedicated to presenting the findings that arose from an analysis of the case data. The paper then concludes with a summary in Section 4.

2 Description of the Case Studies

This section provides details of the individual case studies. In order to get a broad view onto the impact of AR/VR technologies on BMI in Germany, the author chose a wide range of companies of different sizes and from different industries. Company descriptions, case descriptions, and interviewee details are presented. An overview of the case studies, the associated encoding schemes, and references to sections where further details can be found, are provided in Table 1. The encoding schemes for research participants are presented in Table 2. Information on the cases’ data collection periods is provided in Table 3. References to companies and research participants' names have been codified for confidentiality.

Table 1 – Encoding scheme for participating companies and brief case descriptions.

Participating company code	**Internal case ID**[1]	**Brief case description**	**Section reference for further company details**	**Real name**
SteelCo	#770036	Case 1 – SteelCo: Employing Head Mounted Augmented Reality for Spatial Measurement and Instant Project Visualisation	2.1.1	(removed for privacy)
SportCo	#770032	Case 2 – SportCo: Virtual Reality as Enabler for a Visionary New Product	2.2.1	(removed for privacy)
TransportationCo	#770015	Case 3 – TransportationCo: Personnel Recruiting with Virtual Reality	2.3.1	(removed for privacy)
SanitaryCo	#770044	Case 4 – SanitaryCo: Sanitary Planning with Virtual Reality	2.4.1	(removed for privacy)
SupplyCo	#770027	Case 5 – SupplyCo: Using Augmented Reality to Assist Construction Workers	2.5.1	(removed for privacy)

Table 2 – Encoding scheme for research participants, company association, and references.

Research Participant Code	**Associated Company Code**	**Internal participant ID**	**Section reference for further details on research participant**	**Real name**
ProjectManager1	SteelCo	#770036A	2.1.3.1	(removed for privacy)
Engineer1	SteelCo	#770036B	2.1.3.2	(removed for privacy)
Founder1	SportCo	#770032A	2.2.4.1	(removed for privacy)
Founder2	SportCo	#770032B	2.2.4.2	(removed for privacy)
SeniorDigitalManager1	TransportationCo	#770015A	2.3.3.1	(removed for privacy)
MarketingOfficer1	TransportationCo	#770015B	2.3.3.2	(removed for privacy)
Recruiter1	TransportationCo	#770015C	2.3.3.3	(removed for privacy)

[1] Internal case IDs stem from a project management system used to organise research progress.

Research Participant Code	Associated Company Code	Internal participant ID	Section reference for further details on research participant	Real name
DivisionManager1	TransportationCo	#770015D	2.3.3.4	(removed for privacy)
Owner1	SanitaryCo	#770044A	2.4.2	(removed for privacy)
DepartmentHead1	SupplyCo	#770027A	2.5.3.1	(removed for privacy)
Manager1	SupplyCo	#770027B	2.5.3.2	(removed for privacy)
DepartmentHead2	SupplyCo	#770027C	2.5.3.3	(removed for privacy)

Table 3 – Case data collection periods.

Case	Date of First Contact	Date of interviews	Data Collection Period
Case 1 – SteelCo: Employing Head Mounted Augmented Reality for Spatial Measurement and Instant Project Visualisation	2019-01-18	ProjectManager1 2019-01-30 Engineer1 2019-01-30	January 2019
Case 2 – SportCo: Virtual Reality as Enabler for a Visionary New Product	2019-01-18	Founder1 2019-02-22 Founder2 2019-03-06	February and March 2019
Case 3 – TransportationCo: Personnel Recruiting with Virtual Reality	2018-06-07	SeniorDigitalManager1 2019-03-05 MarketingOfficer1 2019-03-05 Recruiter1 2019-03-12 DivisionManager1 2019-05-06	March through May 2019
Case 4 – SanitaryCo: Sanitary Planning with Virtual Reality	2019-02-15	Owner1 2019-05-29	May 2019
Case 5 – SupplyCo: Using Augmented Reality to Assist Construction Workers	2018-07-05	DepartmentHead1 2019-06-06 Manager1 2019-06-06 DepartmentHead2 2019-09-13	June through September 2019

2.1 Case 1 – SteelCo: Employing Head Mounted Augmented Reality for Spatial Measurement and Instant Project Visualisation

2.1.1 SteelCo Company Description

SteelCo is a diversified industrial group with a strong focus on steel processing. The annual turnover of SteelCo is in the EUR billions. SteelCo is active in approximately 100 countries and the number of employees at SteelCo is six-figured. Currently, SteelCo is experiencing turbulences caused by the consolidation of the German steel industry. It strives to innovate its product and service offering by digitalising company processes.

2.1.2 Case Description

SteelCo deployed a high-end augmented reality headset to help increase the overall process efficiency of an established product, from first customer contact to product manufacturing. The trigger for this highly innovative project is a clearly formulated strategic effort by management to significantly reduce the time-to-market.

A unique feature of this case is that the AR hardware employed was "hacked" in order to perform tasks, for which it hasn't been originally designed for[2]: create detailed measurements and 3D models of complex indoor structures. After measurement with the AR headset, the computed 3D data is transferred to a tablet, wirelessly, and amended with a visualisation of SteelCo's product. This visualisation can then be viewed on the tablet in the form of video films offering product-in-action views from different angles or in the AR headset itself. Furthermore, the 3D data, the visualisations, and any additional project and/or customer information is directly forwarded to manufacturing via an associated cloud solution.

SteelCo's solution is not a stand-alone solution but is integrated with pre-existing business processes and the sales cycle. The overall business process has been digitalised and moved to a new (new to the company) cloud service and infrastructure, in parallel, which posed additional challenges for the project.

[2] The researcher spoke to product experts of the AR headset manufacturer and discussed this topic in detail. The manufacturer confirmed that the headset solution is not designed to perform this task. Furthermore, the experts – who are familiar with the application – acknowledge that SteelCo underwent significant effort to develop this measurement capability and is owner of newly generated intellectual property in this area.

2.1.3 Interviewee Descriptions

2.1.3.1 ProjectManager1

ProjectManager1 is a business professional in her 30s. She holds a Bachelor of Sciences degree in Management and Economics, as well as a Master Degree in Management. ProjectManager1 has worked at SteelCo for more than six years and has moved from the research and development department to SteelCo's project management office and then back to research and development as a project manager. ProjectManager1's role and responsibility is the general project management of the augmented reality solution, including cost control, specification of functionalities, creation of training materials, and rollout of the solution. ProjectManager1 spoke with a lot of enthusiasm about the project and freely shared many details including industry insights and software development partners.

2.1.3.2 Engineer1

Engineer1 is a professional software developer in his late 30s and holds a graduate degree in Computer Sciences. His job title is "Solution Architect Cloud Applications and Integration". He joined the company during the implementation phase. His main responsibilities are comprised of all issues regarding technical setup, infrastructure, and cloud services. Engineer1 is particularly knowledgeable about the technical business process implementation and hosting infrastructure details.

2.1.4 An Impressive Product Presentation

After the two interviews, the researcher was given a detailed product presentation. The product presentation was held in an environment which – given his extensive experience – the author would consider especially challenging and not suitable for AR. However, the product presentation worked very well and left an unusually strong and positive impression on the author. During the presentation, the author captured videos and photographs, documented his observations, and tried all aspects of the setup himself.

2.2 Case 2 – SportCo: Virtual Reality as Enabler for a Visionary New Product

2.2.1 SportCo Company Description

SportCo is a start-up focusing on new product development of their own hardware products and associated software, which are related to physical training, gaming, and physiotherapy. SportCo has about 15 employees. SportCo was launched after a product design idea conceived by Founder1. It was seed-funded by a design and investment company held by Founder2.

2.2.2 Case Description

SportCo has developed a new VR-enabled sports device designed for VR. The product was conceived well before the commercial availability of high-performance VR hardware and software to actually implement the product idea (Founder1). Inspired by the market introduction of Oculus Rift virtual reality goggles, the founders decided to go ahead and "run with the idea". The development of the first version of the sports device is complete and the product was successfully introduced to market. The product won numerous design awards.

2.2.3 A Word on eSports

The term "eSports" is a short version of "electronic sports" and can be defined "as a form of sports where the primary aspects of the sport are facilitated by electronic systems; the input of players and teams as well as the output of the eSports system are mediated by human-computer interfaces. In more practical terms, eSports refer to competitive video gaming (broadcasted on the internet)" (Hamari and Sjöblom, 2017, p.1). David Segal (2014, p.1) observes that eSports "resemble conventional sports insofar as they have superstars, playoffs, fans, uniforms, comebacks and upsets. But all the action in eSports occurs online, and the contestants hardly move". In the case of SportCo, eSport has an additional dimension: while SportCo facilitates online competitive multiplayer (VR) video gaming tournaments in the "classic" sense, the contestants actually *do* exercise physically while playing the VR game. This "physical eSport", as the author labels it, is a unique product feature of SportCo's solution.

2.2.4 Interviewee Descriptions

2.2.4.1 Founder1

Founder1 is a young entrepreneur with an academic background in industrial design. During his training, he designed a "sports device of the future" as part of his diploma thesis. This sports device relies on VR in addition to special hardware. The core idea of the product innovation is to inspire people to exercise while enjoying a specifically designed VR experience. Founder1 is well informed about VR and the competitive environment around SportCo.

2.2.4.2 Founder2

Founder2 is a seasoned entrepreneur and founder of a renowned international innovation consulting business. According to Founder2, the majority of German stock index companies are customers. Founder2 has an academic background in industrial design, mechanical engineering, and arts. He has won numerous design awards including the prestigious Red Dot.

2.3 Case 3 – TransportationCo: Personnel Recruiting with Virtual Reality

2.3.1 TransportationCo Company Description

TransportationCo is a leading logistics and mobility company in Germany. The number of employees in TransportationCo is six-figured and its revenue in Germany is in the EUR billions. A core challenge for TransportationCo is the continuous staffing of several thousand open positions for hundreds of different job profiles.

2.3.2 Case Description

TransportationCo turned to VR to support the recruitment process of new personnel. For this, customised VR software was developed, and 360-degree videos were shot at different job sites. The 360-degree videos are presented in VR so job candidates can see and experience different job settings. The solution is a suitcase comprised of several VR headsets, a smart phone acting as a controller device, and a WLAN powered mirroring solution used to display selected users' VR experiences on a TV screen. The setup is used at recruitment fairs and at internal company events. The objective is to present numerous job settings to potential new employees. The researcher spoke with four research participants who were involved in the project at different levels, from ideation and initial product development to decision-making. The interviews were held in three different locations in Germany. Interviewees are described in more detail below.

2.3.3 Interviewee Descriptions

2.3.3.1 SeniorDigitalManager1

SeniorDigitalManager1 is a young business professional. He is part of the recruitment marketing team and is responsible for all aspects of the company's career portal, including the career section of the company's website, the applicant management system, and interfaces with neighbouring teams. He was the researcher's main contact person and he helped him to gain access to the other interviewees.

2.3.3.2 MarketingOfficer1

MarketingOfficer1 is an experienced business professional with an educational background in business economics and public relations. She is working for TransportationCo for more than seven years and is responsible for personnel marketing in a live communication context. MarketingOfficer1 regularly visits recruiting expos and internal events and strives to bring the company closer to potential candidates/applicants. MarketingOfficer1 inherited the subject of mixed reality one year ago when a colleague changed job positions.

2.3.3.3 Recruiter1

Recruiter1 has an academic background in the tourism business and has been a professional personnel recruiter at TransportationCo for more than seven years. He was one of the initiators of the "occupation-glasses-project", as the VR personnel recruiting project is called internally. He has been in close contact with the external software development partners and guided the project development process. He introduced the innovative software solution at high-profile company events and he won a European human resources excellence award for this project. When the researcher met with Recruiter1, he demonstrated the solution in detail and reported on his experiences gathered in the field.

2.3.3.4 DivisionManager1

DivisionManager1 is a HR manager with 25 years industry experience and holds the title "Head of Talent Acquisition" at TransportationCo. With responsibility for almost 700 employees, DivisionManager1 is responsible for the overall recruiting challenge of filling more than 20,000 open job listings. She is also directly mandated by senior management to increase the overall employer-attractiveness of TransportationCo. DivisionManager1 has an academic background in business comprised of two Bachelor degrees and an MBA. The interview was conducted via video conferencing.

2.4 Case 4 – SanitaryCo: Sanitary Planning with Virtual Reality

2.4.1 SanitaryCo Company Description

SanitaryCo specialises in modern sanitary, heating, and bath construction. SanitaryCo is a small business with four employees: the owner, a sanitary planning specialist; his wife, who is responsible for bookkeeping; and two fitters, who implement bathroom construction and plumbing installations. SanitaryCo has been in business for less than five years.

2.4.2 Case Description

SanitaryCo uses a professional bathroom planning software to design projects for customers. A recent addition to this planning software is support for VR to present the designed and planned bathrooms. Thus, VR was deployed to support the design and sales process.

2.4.3 Interviewee Description Owner1

Owner1 is the Managing Director and owner of SanitaryCo. Owner1 is an experienced plumber in his mid-40s. He specialised in designing and building bathrooms. Furthermore, he is an early and avid adopter of the VR add-on to the bathroom planning software and he invests in new VR headsets as they become available. When the researcher visited the interviewee, a newly release VR headset had just arrived at SanitaryCo.

2.5 Case 5 – SupplyCo: Using Augmented Reality to Assist Construction Workers

2.5.1 SupplyCo Company Description

SupplyCo is a large, internationally active manufacturer and supplier of scaffoldings, formwork systems, engineering services, and complementary products such as equipment rental or gear cleaning services. SupplyCo has almost 10,000 employees and its annual revenue exceeds 1.5 billion EUR. SupplyCo has a company history of 50 years and its products are positioned in the premium segment. SupplyCo considers itself a technology and innovation leader and hence continuously explores innovative solutions and emerging technologies for the construction industry, including augmented reality and virtual reality.

2.5.2 Case Description

SupplyCo developed an AR apps and cloud content management ecosystem to manage, distribute, and display AR content on construction sites. The AR content is aimed at supporting construction workers in setting up scaffoldings and formwork systems. Apps for tablets, smart phones, and selected AR headsets are available. The apps can be obtained from the publicly available app stores. Customer and product specific content can be downloaded after supplying login credentials. The apps are used by SupplyCo's employees, as well as by SupplyCo's customers. The needed 3D content is created in standard CAD software, which is already used by SupplyCo during the planning process. 3D data fitting, such as polygon reduction, is partially done manually, partially assisted by specially programmed data conversion scripts. A proprietary file format is used for data encryption, distribution, and display.

A unique feature of SupplyCo's solution is that it is industry-neutral and could theoretically be transferred to other industries, as well. Furthermore, virtual reality content can also be managed and distributed by the solution. This capability is used within SupplyCo to a limited extent for sales presentation purposes, however, in the presented case the researcher focuses on AR.

2.5.3 Interviewee Descriptions

2.5.3.1 DepartmentHead1

DepartmentHead1 is a seasoned manager at SupplyCo who has worked with the company for more than 22 years. He holds a Diploma Degree in Civil Engineering. He joined SupplyCo's Design Engineering Office in the late 1990s and worked his way up through numerous engineering departments to Head of Building Information Management Competence Centre at SupplyCo, a department that was formed a few years ago.

2.5.3.2 Manager1

Manager1 is an engineer in his late 20s. He joined SupplyCo after completing a carpentry apprenticeship and successfully pursued a Bachelor Degree in Civil Engineering in parallel to his daily work tasks at SupplyCo. His job title is Building Information Management (BIM) Manager. Manager1 describes himself as a "digital enthusiast who pushes XR[3] in construction". Manager1's first contact with the subject of AR was in early 2017. Since then, he developed a high interest in the technology and obtained more and more responsibilities in managing the AR activities of SupplyCo.

2.5.3.3 DepartmentHead2

DepartmentHead2 is an internationally experienced manager with an undergraduate background in business mathematics and a PhD in applied statistics. DepartmentHead2 started his professional career in a large management consultancy and joint SupplyCo in

[3] XR is an abbreviation for "extended reality", a summary term for AR, VR, and MR (mixed reality is a term used by some vendors when referring to AR headsets).

2015. He is Department Head of the Digital Transformation Office (DTO) and reports directly to the management board of SupplyCo. The Building Information Management Competence Centre, which is headed by DepartmentHead1, is subordinate to the DTO. As head of DTO, DepartmentHead2 is responsible for pushing forward the topic of "digitalisation" within SupplyCo. He explains that his department acts as an "enabler and accelerator for focus topics, where we see that we still have to take up a little more speed". According to DepartmentHead2, AR is such a topic.

In this section, the author presented details of the individual cases that were investigated. In the next section, the author presents the findings that arose from analysing the case data.

3 Data Analysis and Findings

In this section, the author presents an analysis of the findings arising from the case data. The collected data of each case has been analysed chronologically and is presented separately per case in order to do justice to the exploratory research approach. According to Creswell (2002), documents can be an important source of information in qualitative research. Hence the researcher kept the option open to include documents in the analysis, if interesting documents exist, are accessible, and contribute to the research (cf. Paper 2 Section 3.4.3). During research implementation, the researcher could not access documents he considers valuable for analysis: in some cases, no documentation was available; in other cases, potentially interesting documents were classified and not provided to the researcher. For the data analysis, the author follows a "think inside the box", then "think outside the box" approach (cf. H. O'Connor and N. Gibson, 2003, p.66): first, data is analysed to answer the original research questions; then the data is skimmed for "surprises" and other unexpected and overarching themes or ideas. An overview of the research questions, aim, link to praxis, and section reference are provided in Table 4. All interviews were implemented in German language. The 114 quotations provided are translations by the researcher; German quotes are available from the author upon request.

Table 4 – Overview over research questions and link to praxis.

#	Research question	Aim	Link to praxis	Section references
RQ1	How are augmented reality and virtual reality technologies being applied by companies in Germany, today?	The aim is to describe how companies in Germany employ augmented reality and virtual reality, today.	What is going on, today? What can be / is AR/VR used for, today? (Identify use cases)	3.1.1 3.2.1 3.3.1 3.4.1 3.5.1
RQ2	What are the anticipated effects of augmented reality and virtual reality technologies on business in Germany?	The aim is to describe how augmented reality and virtual reality technologies may impact business model innovation in Germany, in the future.	Where is this all going? (A preview into the future)	3.1.2 3.2.2 3.3.2 3.4.2 3.5.2
RQ3	What are the benefits of employing augmented reality and virtual reality technologies in Germany?	The aim is to explore how companies in Germany can benefit from the employment of augmented reality and virtual reality technologies.	How can who benefit from AR/VR? (Value proposition)	3.1.3 3.2.3 3.3.3 3.4.3 3.5.3
RQ4	What challenges do companies in Germany face, when implementing augmented reality and virtual reality projects?	The aim is to explore what challenges companies in Germany face, when implementing augmented reality and virtual reality projects.	What are the core challenges companies have to address when introducing AR/VR?	3.1.4 3.2.4 3.3.4 3.4.4 3.5.4
RQ5	How can companies in Germany deploy and use augmented reality and virtual reality technologies for business model innovation?	The aim is to explore how companies in Germany can deploy a (first) virtual reality or augmented reality project.	How do companies get started? (Value creation mechanism) How do companies successfully implement an AR/VR project? (Process/value creation mechanism)	3.1.5 3.2.5 4.6 3.4.5 3.5.5

3.1 Case 1 – SteelCo: Employing Head Mounted Augmented Reality for Spatial Measurement and Instant Project Visualisation

In this section, the author presents an analysis of the findings from Case 1. The interviews resulted in transcribed text of 9626 words for ProjectManager1 and 4646 words for Engineer1. After numerous times of reading the text, 128 descriptive statements were extracted into a Microsoft Excel spreadsheet. These were further reduced to 17 themes and finally collapsed to the five codes presented below (code counts are provided in parentheses):

1. Challenge (48)
2. New tool for process optimisation (36)
3. Approach (20)
4. Company development (19)
5. Outlook (4)

Some comments on the identified codes are elaborated on in Table 5.

Table 5 – Comments on the codes identified in Case 1.

Code	**Comment**
Challenge (48)	This code emerged from statements the interviewees made regarding numerous technical and non-technical hurdles, which had to be overcome during project implementation. The statements will help answer RQ4. The statements made by the research participants revolve around the maturity level of the technology, technology acceptance, integration into corporate structures, and further general challenges.
New tool for process optimisation (36)	Statements gathered under this code include "employment as a visualisation tool", "support decision-making", and numerous statements regarding "process optimisation". These statements are analysed to help answer RQ1.
Approach (20)	This code groups statements made by the research participants regarding the deployment of AR and is analysed to help answer RQ5.
Company development (19)	Statements made by the interviewees regarding strategic objectives, company reputation, synergies, and opportunities are grouped and analysed under this code. These statements are analysed to help answer RQ3.
Outlook (4)	RQ2 is aimed at finding out, what research participants think that the future will hold in respect to AR technology. The participants statements concerning this are grouped here.

3.1.1 RQ1: How are augmented reality and virtual reality technologies being applied by companies in Germany, today?

3.1.1.1 New Tool to Capture Measurement Data

ProjectManager1 explains that the previously established process for capturing room measurement data had been implemented via a cumbersome photographic process. The collected data was then forwarded to engineers by email. Product visualisations were then implemented manually by humans.

> "He [the salesperson] has so to speak laid out markers on every [building details removed for privacy], so he marked everything, there were up to 200 markers. Then he had to take about 50 to 60 photos with a SLR camera of the [building details], so that all markers are on it and

> then he put the SD card into the computer and there we had a software that translated these photos into a technical drawing, so into a DXF format. Then this DXF format was manually sent by e-mail to our drawing office, where the engineers visualised the [product details]." (ProjectManager1)

This process has been replaced by the AR headset and tablet solution (Engineer1), as previously explained in Section 2.1.2. The researcher was able to try out the overall solution in detail and was impressed by its ease of use and the quality of the visualisation outcome. Engineer1 explains what this measuring approach is based on:

> "We use it [the AR headset] for measurements, that was in principle the internal part of it ... in order to operate AR Augmented Reality at all, any AR device ... must know the room and must know what the room looks like … from this the idea was born, that if the [AR Glasses] knows and can measure the space, hey we can also measure the [interior] so that you can produce a drawing accurately to the centimetre, millimetre and that's what we do. We measure the [room] and the salesman can then relatively simply mark the edges, for example, mark the walls, doors, ..., mark everything and all the information is then later transferred into a 3D drawing." (Engineer1)

During the interview, the researcher wondered, why SteelCo underwent such tremendous effort to implement its own measuring solution. ProjectManager1 explains that the hardware vendor was not willing to support SteelCo regarding measurement accuracy to the extent desired. Hence, SteelCo took the risk of implementing its own software technology, thereby creating technological know-how and intellectual property.

3.1.1.2 Support Decision Making

Engineer1 describes how the AR solution enables instant product visualisation, configuration, and customer presentation. Furthermore, ProjectManager1 illustrates the life-like visualisation quality.

> "That's it. Visualization, after we have ... measured, we can show the customer directly a picture of his future [product], so he can wish that [the product] for example is red, green or blue ... you can really look into the room with the help of visualisation and show, hey, that's what [the product] looks like if we built it" (Engineer1)

> "Well that's really how is, it really looks when you see the visualisation, … it really looks as if there is [the product] there. I never thought it could look so real." (ProjectManager1)

ProjectManager1 states these visualisations support the sales pitch and customers' decisions. Furthermore, she illustrates SteelCo's plans to extend the visualisation solution to social media functionality to facilitate decision-making by remote stake holders.

> "Yes and our plan is for the future, that will be the next step, we want to develop a so-called Influencer UI, which means that what is visualized is recorded as a video sequence and the influencers – because at the end of the day it is often the son or daughter who decides – ... that we can then send them these video sequences via visualisation." (ProjectManager1)

3.1.1.3 Process Optimisation

As explained in Section 3.1.1.1, the AR headset was introduced as a replacement solution for a pre-existing measurement system. According to both research participants, this new solution speeds up the measurement process.

> "So, we really built it up analogous, that means those who knew this photo measuring system, for them it's just a simplification. We are also much faster with the measurement itself, it used to take an average of one hour for a single-storey system, with the photo measurement system, now they can do it in 15, 20 minutes if they are trained." (ProjectManager1)

Furthermore, Engineer1 reports that the overall process from sales to manufacturing required significant coordination effort. This resulted in an overall time duration for sales product delivery of 40 to 60 days (ProjectManager1). The new target time given by management was "14 days order-to-delivery, which means that we have to deliver [the product] within 14 days or 10 working days" (ProjectManager1). To achieve this, the entire process from ordering to product manufacturing and delivery had to be digitalised (ProjectManager1). This digital process was implemented in the Cloud and it is the main process speedup factor (Engineer1).

According to Engineer1, capturing the spatial data by the AR headset does not have an impact onto the production process, yet. However, "in the future, our [SteelCo's] plan is to move directly from sales to production" (ProjectManager1). Furthermore, ProjectManager1 sees a potential to save time by automating the CAD design process directly from the 3D data captured by the AR headset.

> "We are working on it, that's still our goal, that we also completely automate it, that the salesperson really presses the button and that [the product] is then quasi produced [at our factory]" (ProjectManager1)

Engineer1 reports that a second angle on process optimisation through AR headsets is to support the sales process with the objective to increase sales opportunities.

> "… and on the other hand, the sales opportunities should also be increased, among other things by the visualisation of the [products of SteelCo] which we carry out with Augmented Reality." (Engineer1)

3.1.2 RQ2: What are the anticipated effects of augmented reality and virtual reality technologies on business in Germany?

3.1.2.1 Technology Improvements and New Product Development Opportunity

Engineer1 expects that AR hardware will become better over time. Engineer1 believes the AR headset hardware "is already very good, but there is still a lot of potential for improvement, … in terms of accuracy and in terms of usability". Furthermore, Engineer1 reasons that the AR data combined with order history data could potentially be used to analyse user behaviour and to draw conclusions about which product configurations are the most successful.

With respect to the unique measuring capability of the implemented solution, Engineer1 observed that an entirely new product has been created – a high-end indoor measuring device. ProjectManager1 describes how SteelCo is actively approached by external companies that wish to use SteelCo's technology for different industries.

> "We are even approached by external people, whether kitchen builders or stair builders – i.e. everywhere where measurements are taken – or pipeline construction. Of course, we are also contacted from the most different areas, yes, can't we use your measuring app, aren't there possibilities." (ProjectManager1)

Furthermore, ProjectManager1 imagines sales presentations held via an AR headset in the near future. She speculates consumers might even be able to perform measurements by themselves.

3.1.2.2 Perhaps Just an Interim Technology?

Regarding the future of AR headsets in the application case of SteelCo, ProjectManager1 wonders if SteelCo's product could be replaced entirely by a radical alternative solution such as a robot or an exoskeleton.

> "My vision would be or what would be cool, I mean there are robots or something like that nowadays ... yes, there is also the REHACARE

> [expo] once a year in Düsseldorf, which is especially for people with disabilities or older people, how can they be supported and there were for example these exoskeletons or so I think, where people who sit in a wheelchair, can put things on their legs and then really walk with it, suddenly." (ProjectManager1)

3.1.3 RQ3: What are the benefits of employing augmented reality and virtual reality technologies in Germany?

3.1.3.1 Achieve Strategic Goals

ProjectManager1 describes the need to react to market needs, respond to the competitive environment, and to quickly adapt to new market conditions.

> "Above all our strategy department, which also carried out market analyses and so on, saw what the competition is doing, yes, they said that because we have direct sales – no B2B business, but B2C business – and the customers tell us, *that has to go faster* [emphasis added], I want in a week ... or in two weeks, I would like to have [the product] ... That came up more and more often and we said we have to react." (ProjectManager1)

Engineer1 states it is a key strategic objective of management to simplify the business and sales processes and to increase the number of sales opportunities. ProjectManager1 confirms it was a strategic management decision to digitalise the overall process and to employ an AR headset to innovate the measuring process. Ultimately, management formulated the goal to reduce the order-to-delivery-time significantly, as presented in Section 3.1.1.3.

> "I would say that with the [AR glasses] and so on and all those innovative things come from above [from management], that's just been the direction and the strategy, generally and especially from the business unit board, here from the board, this we need to get faster ..." (ProjectManager1)

A potential future objective is to "lock in key resellers of SteelCo, by supplying them with the innovative AR solution from SteelCo" (ProjectManager1). Currently, resellers offer solutions by numerous manufacturers, but in future they may be persuaded to only offer SteelCo's products, if SteelCo equips them with the best sales tools. ProjectManager1 proudly proclaims that SteelCo is the first company worldwide to implement such an innovative solution which – according to ProjectManager1 – gives SteelCo a competitive advantage as first mover with the technology.

3.1.3.2 Positive Company Image and Synergies

According to ProjectManager1, this AR project is one of the most innovative in the business unit's history and required the backing of top management. Engineer1 states the mere fact that SteelCo is working with such innovative technology positively impacts company reputation.

> "... on the other hand, it still has an effect on the perception of [SteelCo] that [SteelCo] works with such modern means and that this time definitely is a pioneer in this respect." (Engineer1)

While speaking with the research participants, the author determined that both interviewees are very proud to be working with such innovative technology. Arguably, this results in a positive company reputation, internally – at least in the research participants.

ProjectManager1 believes the know-how gained from implementing the AR solution might be beneficial for SteelCo beyond the business unit in which she works. Other business units are now reaching out to ProjectManager1 and ask her to share her expertise with them.

> "... I was contacted by [country removed], there we have a research centre, from [business unit removed], they really want to go after us now, ... they strive to see what potential we have for service technicians and they want our experience also in regards to the accuracy of the measurements and the experiences we have made, there they want to get our input and there are also more ideas." (ProjectManager1)

3.1.4 RQ4: What challenges do companies in Germany face, when implementing augmented reality and virtual reality projects?

3.1.4.1 Vendor Dependency

Both interviewees report a high risk to be the dependency on the AR hardware manufacturer. The first generation of the AR headset employed by SteelCo is no longer accessible, while the second generation of hardware is announced, but not available yet (Engineer1).

> "Final rollout, so we're on it, so not all vendors are using [the AR headset] actively, yet. There are various reasons, priority reasons, but also ... that we don't have enough hardware. [The vendor] has just stopped production [of the first hardware generation] but has not yet introduced or sells [the second hardware generation]. There is just such a transition and we are still missing [headsets]." (Engineer1)

Furthermore, according to ProjectManager1, it was not yet clear whether the next generation of hardware would actually support the solution implemented by SteelCo as "none of us has yet seen it [second hardware generation], we don't know if we can just play our apps on it and whether it all works" (ProjectManager1).

3.1.4.2 Difficult to Identify Suitable Software Development Partners

As explained in Section 3.1.1.1, SteelCo felt "forced" to implement its own software solution, since the hardware vendor refused to help SteelCo to the extent desired. However, SteelCo did not have the necessary know-how in-house to implement such a solution. Consequently, SteelCo had to identify a suitable development partner, which proved to be challenging because the technology was so new.

> "Yes and then we did a lot of testing and [the manufacturer] said, "no, we can't help you with that, we can't offer you that"; and then the project was really close to failure ... and then at the Hanover Trade Fair [StreelCo] met [company name removed] and [company name removed] said "yes, we are specialists in augmented reality ... and we dare to do that"." (ProjectManager1)

3.1.4.3 Maturity of the Technology: Developing a Technology Hack

Once a suitable software development partner was found, numerous technical hurdles had to be overcome. These included the common limitation of AR headsets to properly operate in poor lighting conditions and the short battery life of the headset hardware and associated input devices (ProjectManager1). However, according to both interviewees, the biggest challenge by far remained to fine-tune the software to deliver the anticipated measurement accuracy. Engineer1 explains this is because the AR hardware was never meant to be used this way.

> "The biggest challenge concerning the [AR Hardware] was the measurement accuracy, the [AR Hardware] had never been developed to really measure. AR Hardware] can explore a room, but it had never really been designed to really measure, to measure to the centimetre and to the millimetre, and that was one of the biggest challenges in getting that measurement accuracy right." (Engineer1)

3.1.4.4 Technology Acceptance Well to Neutral, But High User Expectations

Engineer1 states the technology was not perceived as a threat by SteelCo's employees and ProjectManager1 cannot think of any negative feedback. However, Engineer1 reports that in some cases it was difficult to meet the expectations of users who overestimated the capabilities of the new technology.

> "Of course, there are still some shortcomings, it's a great new technology, but the accuracy depends a lot on how the user handles it. ... You have to take some time for [the AR headset] to really get to know everything ... and then we realise that the user has the expectation, hey I have the great [AR hardware] here, it can do anything, it measures the space by itself, which quickly leads the user to think "oh, I don't have to do so much anymore, I can just run through" ... That's a bit of a difficulty to get that across, of course. Yes, it's new technology, but yes we still have to be careful what we do." (Engineer1)

ProjectManager1 also reports one incident where a salesperson's aversity to new technology caused difficulties during a training session. However, she recalls that initial concerns that older generations might be dismissive towards new technology did not manifest. To the contrary, both salespeople and end-customers responded mostly with positive or neutral feedback to the innovation.

> "Yes, so far our key users always ask in the field how does it go down with the customers, do they think oh God, what do they put on their heads now and so far it [the feedback] is actually positive throughout or they [the customers] don't care. It is people who have a bit of an affinity for technology or engineers or former engineers who show real interest and say "oh that's great" and "explain it" or they just don't care and they say measure it, go ahead, but so far we haven't had any negative experiences." (ProjectManager1)

3.1.4.5 Rollout and Operation of the AR Solution

Engineer1 describes challenges encountered during rollout and operation of the new AR solution. He describes how salespeople now must operate numerous new devices and digital tools, many of which have been rolled out simultaneously. Since SteelCo's salesforce tends to be an older generation in this specific case, special attention has to be given during training sessions, which is a sometimes cumbersome process.

> "A challenge can also be named the training, because everything is new technology and even more so for the salesmen a lot of new technology came at once: [AR headset], iPad, WiFi Hub and everything digital. Before they used everything on paper and today they have several devices that support them, that they have to operate and that is a big change for users, especially when you know that the salesmen at [business unit name removed] are not the youngest people, because the [target] customers are not the youngest, either ..." (Engineer1)

ProjectManager1 testifies that training is an important, but burdensome endeavour and states that salespeople are often difficult to catch for training, because a training day means a day lost for sales. Furthermore, she reports that setting up the additional infrastructure and support hardware such as tablets, Wi-Fi routers, and mobile printers adds an additional time-consuming dimension to the daily operation of the overall solution.

> "It is in the end a change, that means they have to learn something and it is for them also more effort at the end of the day, because they have to be trained, on the day of the training they can not sell, they always get a commission if they sell or have sold ... What I maybe still remember, this whole setup of all the things, so put on the [AR glasses], download the iPad app, put on the – we have such a small WiFi hub so that they always have their own WiFi – the setup, connect the printer to the WiFi, all these things, the whole setup always took us half a day to three quarters of a day ... really this setup of all the devices, it always took a relatively long time." (ProjectManager1)

Finally, ProjectManager1 acknowledges that humans always need to adapt to new technology to some extent, rather than the other way around. She observes that operating new types of interfaces and interactions facilitated by the AR headsets, initially turned out to be a challenge for some users.

3.1.4.6 Corporate Structure Challenges

The AR solution is part of a greater digitalisation effort of SteelCo and is accompanied by a cloud solution that optimises the entire business processes from sales, to order, to product delivery. Furthermore, SteelCo is an internationally operating corporation with multiple divisions and subsidiaries. This poses additional organisational and corporate-cultural challenges. ProjectManager1 reports that different countries are at different stages regarding their willingness to embrace new technology. This is not unique, but it is a challenge for SteelCo.

ProjectManager1 also explains that many business processes within SteelCo have grown historically and hence are not unified across countries and divisions. Reducing the complexity caused by numerous different processes through digitalisation is challenge and opportunity for SteelCo, at the same time.

> "So, a lot is done manually, because the group has grown historically. ... companies have been bought, they have brought their own processes

> with them, accordingly much has simply grown historically, has become more and more complex [over the years].” (ProjectManager1)

ProjectManager1 contends that numerous authentication procedures have to be mastered, accounts need to be created, and passwords must be remembered long before the actual work with the AR solution can even begin. In this context, Engineer1 reports that not only did the accompanying cloud solution pose additional challenges, but also the newly introduced cloud infrastructure as a service platform. In essence, both interviewees confirm that all project participants had to deal with numerous new technologies and associated challenges, simultaneously. Furthermore, connectivity to pre-existing IT solutions, for example SteelCo’s ERP system, had to be insured (ProjectManager1) and the seamless integration into pre-existing business processes had to be implemented (Engineer1).

Lastly, Engineer1 explains, that AR devices capture photographic data. This poses unprecedented challenges in respect to data privacy regulations. Accordingly, salespeople are trained to make sure that no privacy relevant data is captured during the measurement process. If in doubt, personal items at the end-customers’ residencies are temporarily removed.

3.1.5 RQ5: How can companies in Germany deploy and use augmented reality and virtual reality technologies for business model innovation?

3.1.5.1 Find External Experts and Be Agile

As explained in Section 3.1.4.2, developing AR software solutions requires specialised expertise which may not be available within a given company. SteelCo took on the challenge to identify a suitable software development partner for the AR software development (ProjectManager1). Once this partner was identified, SteelCo implemented several workshops with the partner and took an agile software development approach with short development cycles followed by a proof of concept phase (ProjectManager1).

> “Yes and then we went into workshops, said ok, we’ll try it together and then started the project at the end of February 2018 with [the software development partner] with an agile project management approach, we had different sprints, always three weeks per sprint, after that we always had a sprint change meeting, looked ok, what did you do, they gave us a demo, do we have to change the scope or not and then we just went on like this and that went on until July 2018; and July 2018 it was the way we have it [the solution], today. Of course, we’ve improved a few little things since then, but the system as we have it

> now, for the [AR part], so for the iPad app and the [AR headset] app, they really developed and programmed it within a couple of months." (ProjectManager1)

Engineer1 states that two software development partners were involved: one for the implementation of the AR apps (AR headset software and accompanying iPad software) and one for the associate cloud solution. Overall, he considers the challenges that arose to be "similar to the standard challenges of classic IT projects" (Engineer1) and states that in his eyes the project went well.

3.1.5.2 Replace and Improve a Pre-Existing Solution

ProjectManager1 considers it advantageous that the AR technology was employed to replace a pre-existing measurement solution. This minimised the explanatory needs for salespeople since, in essence, everything stayed the same; only a new measurement technology was introduced to the pre-existing process.

As explained in Section 3.1.4.3, the AR headset hardware was employed for a task for which it never had been designed for. Engineer1 explains that using new technologies for initially unintended purposes – so called hacks – represent interesting employment opportunities for AR and technology in general.

3.2 Case 2 – SportCo: Virtual Reality as Enabler for a Visionary New Product

In this section, the author presents an analysis of the findings from Case 2. The two case study interviews resulted in transcribed text of 10018 words for Founder1 and 14418 words[4] for Founder2. After numerous times of reading the text, 180 descriptive statements were extracted into a Microsoft Excel spreadsheet. These were further reduced to 32 themes and finally collapsed to the six codes presented below (code counts are provided in parentheses):

1. Strategy (57)
2. Challenge (52)
3. Assessment (23)
4. Deployment (17)

[4] In the case of Founder2, 5999 words were spoken before the researcher was able to implement the semi-structured interview process. This text turned out to be very difficult to analyse and revealed – in the eyes of the researcher – no valuable research insights. Hence, the researcher decided to focus his analysis primarily on the remaining 8419 words.

5. Employment (16)
6. Benefit (13)

Some comments on the identified codes are elaborated on in Table 6.

Table 6 – Comments on the codes identified in Case 2.

Code	Comment
Strategy (57)	This code emerged, as the research participants spoke a lot about strategic choices they made, when they saw the opportunity for the company spin-off/start-up. The topics of how important timing was for the venture, new market creation, and new business opportunities were dominant and central to the conversations. The insights gained under this code help answer RQ1.
Challenge (52)	Exploring what challenges companies face when implementing a VR project is one of the objectives of the research (RQ4). Insights gained from the interviewees in respect to challenges are collected under this code.
Assessment (23)	During the interviews, numerous opinions and views were expressed by the interviewees. Some of the statements are at a very abstract level. The statements collected under this code were analysed to answer RQ2.
Deployment (17)	Insights regarding how companies may implement a VR project (RQ5) are reported under this code.
Employment (16)	Findings how companies may employ VR (RQ1) are analysed under this code. Key topics were emotionalisation, creating experiences, motivation, and gamification.
Benefit (13)	Benefits of employing VR (RQ3) as reported by the research participants were analysed under this code.

3.2.1 RQ1: How are augmented reality and virtual reality technologies being applied by companies in Germany, today?

3.2.1.1 Develop New VR-Enabled Products

SportCo has been founded as a subsidiary of a company held by Founder2. The company's aim is to develop, build, and sell new products comprised of hardware and software (Founder2). In this context, Founder1 explains that even though SportCo wouldn't exist without VR, he doesn't consider SportCo to be a VR company.

> "We [SportCo] are not a virtual reality company – this [differentiation] is important to us. Virtual Reality is a tool that we like to use and that we use a lot, but it is not the only one for us. … In other words, if there is a completely different technology in two years' time, we are just as open to it." (Founder1)

In this capacity, SportCo employs VR as enabler for the development of entirely new products (Founder2). Founder1 claims, that this approach is different from their competitors' approach, who employ VR as an incremental innovation for pre-existing products.

> "And that, I think, distinguishes us from many other companies where it was certainly the case, who said in the fitness sector, we already have an [product description removed for confidentiality], okay, now there is VR, now we put [VR] glasses on them. With us it was completely different. We developed it as a unit from day one." (Founder1)

Founder2 believes that a sustainable new business opportunity can be reaped if this technology is used for something nobody has thought of already. This can be achieved by combining VR technology with other factors.

> "The viability of inventions or new technologies does not arise from the fact that the first application case is established, but from the fact that there are applications which nobody has thought of before, which result from combinations. And I see such a combination in us – quite clearly." (Founder2)

In the case of SportCo, the newly developed product rests on a combination of mechanical engineering hardware, custom-built electronics, and VR software (Founder1). Furthermore, other external industry factors matter (cf. Section 3.2.1.4).

3.2.1.2 Create Experiences, Motivate, and Inspire

A unique feature of VR is that it enables immersion (Founder1). In this context, "immersion" describes the VR-phenomenon of feeling physically present in a virtual world. This phenomenon can be used to emotionalise experiences such as sports exercises through simulation of reality, thereby creating entirely new experiences for consumers (Founder2). These new experiences can have an inspiring and motivating effect on the user (Founder1) and help motivate for healthy training (Founder2).

> "And our goal is to merge experience quality and training in such a way that many people are motivated to train in the first place so that cardiovascular problems go down." (Founder2)

According to Founder1, a further application opportunity of VR is its employment for entertainment and competitions. The gamification of sport exercises opens up the possibility for facilitating virtual competitions online and hence taps into the business potential of eSports (Founder1), as previously commented on in Section 2.2.3. This is further elaborated in Section 3.2.1.3.

3.2.1.3 Think Global, Create and Capture New Markets, Tap into New Revenue Streams

Founder1 indicates that the industry that builds exercise equipment is primarily an appliance business. Manufacturers design and produce exercise equipment to sell. Once sold, the potential for further revenue is limited. However, Founder2 beliefs that adding VR software applications presents an opportunity to tap into continuous revenue streams.

> "We're thinking about selling the equipment, of course. This is what we currently live on. But we are also thinking about membership/subscriptions, reoccurring revenues so to speak." (Founder2)

Founder1 explains digital services can be scaled to an international reach more easily than the physical exercise equipment business. Furthermore, the VR component of the solution created by SportCo builds a bridge for cooperating with other sectors. As an example, Founder1 reports that SportCo is cooperating with businesses in tourist regions that have created VR content to promote the tourist region. This content is integrated into SportCo's VR software and the generated revenue is shared. Founder2 states that even a cooperation with Google and its prestigious Google Earth project had been initiated.

Combining the exercise equipment business with VR enables SportCo to reach out to the eSport business. However, SportCo's solution differs from "classical" eSport since it includes a physical exercise dimension to the otherwise sedentary eSport. In essence, this "physical eSport" exposes a new, previously unknown market. SportCo's high ambitions in the eSport market are best summarised by Founder2:

> "Our future shall be, we want to become "the" number [one] in e-sports. For that you can cut off one of my limbs, I'll do that! They'll be battling live, in a race, whatever that looks like. The guys who can fly that will [have to] be athletic enough – the ladies alike, they are the better pilots, the ladies, actually. It will be a new sport, there will be new professionals. There will be leagues …, there will be world championships, and then there will be prize money in the millions." (Founder2)

Founder1 observes that SportCo's product addresses numerous market segments: "we are active in three industries. Fitness, Entertainment and Health". The importance of VR differs per industry and each industry needs to be approached in a different way (Founder1).

3.2.1.4 Seize the Moment: Timing is Essential

Both interviewees stress the importance of timing. According to the interviewees, the hype around VR presented a time-limited opportunity for fundraising and resulted in "free marketing effects".

> "Without VR our company would not exist. And not because we call ourselves a VR company, we don't, but the technology received a lot of praise through investments and PR and was then listed in the Gartner Hype Cyle and was simply new, new enough, because it wasn't really new, but it was new enough at the time to create a pull in the sense of marketability and to push a train that we jumped on." (Founder2)

Founder2 further reports that in this early phase of technology-awareness at consumers, the quality-expectations were low and hence offered the possibility to enter this new market with a product with limited features and functionality. Founder1 confirms that "timing is everything" and elaborates "the early adopter is your dearest customer; he pays the highest price and gets the worst product". However, both interviewees concede that the technology might have been hyped too early and that the initially limited product quality is causing challenges later on.

> "... the product wasn't actually ripe yet. And maybe you made a quick turnover here and there back then; and now – three years later – you're sitting here and say you have the product and the service now … at a level we'd have needed at that time. But of course, you don't tell your customer to wait … Nobody does that. But in the end I think it's sometimes smart, especially when you're dealing with big, potentially big customers." (Founder1)

According to Founder1, another advantage of "perfect timing" is that there was little to no competition in the beginning. Founder1 also observes that the hype around VR wasn't the only relevant timing-factor: a new, overall health and fitness trend and the observation that large global players – such as Samsung and Facebook – adopted VR were considered of central importance for the decision to enter the VR market space.

3.2.2 RQ2: What are the anticipated effects of augmented reality and virtual reality technologies on business in Germany?

3.2.2.1 VR Will Become Part of Our Daily Lives

Founder2 is convinced that "VR is here to stay". He assesses hardware miniaturisation will further drive the relevance of VR as an emerging topic in the health sector.

> "In the fitness industry – I think – Virtual Reality will continue to play a big role, because it's just something different if you look into a screen or if you really build a Three Sixty environment around you. And that's actually where the time and also the development structure of electronics is completely on our side or on VR's side, because things can simply be miniaturised very quickly and it just goes on that the technology we're using now is generally being further developed, strongly." (Founder2)

Founder1 observes that the number of people who actually understand VR is increasing continuously; and Founder2 predicts that continuous VR improvements will ultimately result in VR becoming a part of our daily lives.

> "The E-processors are getting smaller; cooling might be better solved. This means that the devices themselves will shrink, making them even lighter and more adaptable to human dimensions. So, similar to what happened with headphones, which have now become just buttons and can deliver their own power. This [VR] will all become wireless and will become a part of our world ... the whole world will become a playground." (Founder2)

In respect to SportCo's own product, the founders report that the current focus lies on incremental product quality improvements.

3.2.2.2 In the Future, VR Will Have Numerous New Applications

Founder2 suggests that VR is already a new standard in sport exercises. However, while the interviewees are focusing on further developing SportCo's VR product for exercise, they acknowledge that VR has many other applications. Founder2 sees potential for VR to optimise processes and support decision-making. He suggests applications to the fields of digital assistance, training and simulation, and virtual tourism, where he predicts that tourists of the future will visit places first virtually and then in reality.

> So, what is clear is that designers are now in a better position to communicate the intermittent results of their unfinished work in order to make decisions easier. They can be engineers, industrial designers from the automotive industry, they've been doing it for a long time, they were one of the first to jump on it. But it's also about process optimization, and so on. You can do a lot of things beforehand and therefore – let's say – in the machine world and in the physical world, there you can do a lot of things, from architecture, real estate, hotels, tourism, all the way to delicate tasks." (Founder2)

3.2.2.3 VR Might Help Save the World

Founder2 takes a critical look onto the world's population growth development. He observes, that with an increase in education and financial resources, human desires result in increased resource consumption and larger ecological footprints. He believes this is not environmentally sustainable. Artificially curtailing what people are allowed to consume is not the answer, either. Consequently, he argues that virtualising otherwise resource intensive activities in VR is a natural, evolutionary step from living in physical reality to having experiences in virtual reality and it will have a positive impact on global resource conservation.

> "For example, I am of the opinion that every person in the world should at some point be able to call at least the standard of a Germany from 1980 his own and be able to access it ... This is an issue for 7.5 billion people. ... We have to think about how we deal with the quantity we represent. ... At the same time, however, it is the case that when people have access to capital, when they have access to education, they all want to travel and have experiences in order to enrich their lives. And they all should. Only if you imagine that you let 7.5 billion people all travel at the same time, all with the same conditions, then we have ruined our planet much more quickly than we are already doing at the moment. Hence, we have to provide alternative offerings. ... I believe that we as human beings are forced to keep a little out of reality because we are simply too many. ... Consequently, we must develop systems that satisfy us ... [that] have a certain sustainability and ensure that they are good enough as surrogates, as substitutes, so that we don't have to do other things ... We as a society, as a global society have the responsibility to deal with ourselves at the point where we need to satisfy things that are inside us, that are slumbering in us, but that are not socially compatible or ecologically compatible." (Founder2)

While Founder2 is convinced that VR will remain relevant and states "I don't think that we'll live in a world without VR again", he doubts that VR will fundamentally change the world.

3.2.3 RQ3: What are the benefits of employing augmented reality and virtual reality technologies in Germany?

3.2.3.1 VR is Fun and Fosters Synergies

While the interviewees did not formulate it directly, the researcher could clearly observe positive excitement and passion for VR in both founders. Founder2 reported that he benefits himself personally from VR (in SportCo's product) because it enables him to virtually visit exotic regions.

According to Founder1, integrating remote destinations into SportCo's VR application isn't only considered to be beneficial for Founder2 on a personal level, but is also seen as synergistically beneficial for the featured tourist regions as explained in Section 3.2.1.3. Lastly, subcontractors, such as special mechanical engineering companies, profit from the product development and manufacturing needs of SportCo.

3.2.3.2 Free Marketing Effects and New Marketing Capabilities

Founder1 describes how the digital VR component of SportCo's product enables them to reach out into social media, for example to implement online eSport competitions. This new capability opens up new marketing opportunities. Furthermore, he reports that VR represents a differentiation from competitors' products and leads to free media attention. According to Founder1, this results in purchase decisions even for customers who choose a SportCo product without the VR component.

> "Without VR, [SportCo] probably wouldn't exist. It is still the same now. Even with a customer who buys a product from us and equips it with a tablet, … in 99 percent of the cases we have been found [by the customer] through VR." (Founder1)

Founder2 also explains how the employment of VR resulted in free marketing effects during the acquisition of funding, as reported in Section 3.2.1.4.

3.2.4 RQ4: What challenges do companies in Germany face, when implementing augmented reality and virtual reality projects?

3.2.4.1 Market Environment and Market Expectations

Founder2 thinks it unfortunate that obtaining funding is particularly challenging in Germany. He further explains that the German and even European markets are relatively small compared to the US market and that expanding from Germany to the US has proved to be difficult, even fraudulent. Founder2 narrates that in an attempt to open a branch in the USA, SportCo became a victim of fraud: the hired manager never truly opened up the branch office and disappeared with a significant amount of cash. However, he is still confident that SportCo's business approach will work with the company based in Germany, as well.

> "I think that it [the business approach] is possible in Europe too. I think it's all much smaller, I think it's all much more tedious." (Founder2)

According to Founder2, it has also been difficult to communicate SportCo's business and target market because SportCo is aiming at numerous markets including an entirely new one (cf. Section 2.2.3). Both founders state that Germany as a business location is less emotional and more sober than other areas in the world.

> "In the USA we could have done it the other way round, but in Europe, especially in Germany, we have to develop a functional, object-oriented relationship that is sustainable. Training on this device makes you healthier, scientifically proven here and here by independent bodies. ... In the USA it would have been different. In the USA we would not have needed that. In the USA we would have been on the entertainment track." (Founder2)

Founder1 reports one challenge to be the management of customer expectations. For example, proficient gamers "are used to buying software for their homes that will keep them busy for two or three months" (Founder1), which is neither the case nor the intent of SportCo's initial product concept. Consequently, the founders decided to target B2B markets initially. Similarly, the founders feel that they need to give their customers the impression that the product – including the VR component of it – is a mature application, despite the fact they struggle with the VR technology themselves on a daily basis. This puts them sometimes in a conflicting situation.

> "And we're in a real hermaphroditic role somehow. Internally we really know what challenges there are with the [VR] components, with the [VR] technology, we have to struggle with it ourselves every day. But we still have to communicate to our external customers every day that this is the hottest thing ever, it is completely mature." (Founder1)

3.2.4.2 Technology Maturity Level

As previously indicated, the maturity level, or rather the lack of it, poses numerous challenges for SportCo. According to Founder2, the most significant challenges are a lack of systems inter-compatibility and diversity. Founder2 insists this is caused by ill-guided strategic objectives of VR hardware manufacturers that try to fend off competition from their software platforms and marketplaces and ultimately pose a threat to the entire VR industry.

> "The biggest technical challenges in Virtual Reality are currently the diversity of the systems, the incompatibility, the desire to keep others out of one's own system world ... Complete idiots from back to front, the whole gang! … Keeping each other out of each other's systems, competing with each other instead of thinking together about what is

> the ideal application. And this is a threat for the technology, in my opinion this [behaviour] leads to the death of their current business models of the current [VR hardware] players – if that doesn't change." (Founder2)

Key VR challenges reported by Founder1 are hardware availability, hardware fragmentation and lack of hardware compatibility, complicated system setups, generally limited VR functionality/features, a short hardware life expectancy, lack of multiplayer-support, and hardware not designed for continuous operation, which can lead to hardware failure. However, Founder1 also reports that the overall situation keeps improving.

> "So, VR challenges were of course manifold, so really a complete farce ... with Oculus Rift it all started. We developed Oculus Rift, then they had no product, then we switched to Samsung Gear just before launch because they were the only ones who had such a sellable product ... So that was the point of origin of our first challenge with Virtual Reality, apart from all the technical hurdles, frame rate is too low. The S6 back then, after half an hour the wires were glowing, you could bake an egg on it, the battery was empty. Such problems don't exist anymore. ... I can finally set up my own HTC Vive setup for [SportCo's product] relatively quickly, so it works, even I still sit there sometimes and think, why doesn't the shit work now? What's it like with our customers who never had a VR set in their hands before in their lives? ... Then the sound doesn't work, then the camera doesn't work, then the Bluetooth connection doesn't work. Then the things break after a year, then you have the hygiene topic. Virtual Reality, I could have a rage here the whole day about Virtual Reality, but that doesn't help me either. In the end you have to see what's better, it's gotten better. As I said, we've had the technology from the beginning from the battery to today, things are up to the customer and he doesn't know how to use it." (Founder1)

3.2.4.3 VR Technology Related Peripheral Challenges

Delivering a fully immersive experience is the core strength of VR (Founder1). However, it is exactly this characteristic that also causes the challenge of user isolation (Founder2). When asked whether customers have reservations about VR, Founder1 responds he is surprised how well the technology is accepted, overall. Some individual issues exist; however, the broad audience gets along fine with VR.

> "Oh, surprisingly little. I don't really think so. No, I can't say that that way. There are people who just get sick even if they just sit and put on a pair of VR goggles. There are people who don't get along well with VR or who have a hygiene problem or something. On the contrary, I'm still surprised, even after three or four years, when we're at fairs, the snakes standing there, so we really take care of hygiene and everything. So that really doesn't matter to the people, they put on the things,

> hooray, hooray. No, I can't really say that there are any fears of contact." (Founder1)

From a software development perspective, SportCo struggles to find qualified personnel and invests much effort in building up a good software development team.

> "A big challenge is the whole team-up ... That means building up the software team that now exists here, ... that was a big challenge to get the people ... You want someone with experience in a technology that's only been around for a month – so (laughs). That was a huge challenge." (Founder1)

A VR-related burden is the fact that VR hardware manufacturers and retailers do not supply product support. Operating a VR set up can be complex and customer support intensive. Since SportCo is retailer of a complete product solution, SportCo's customers expect product support including support on VR topics.

> "So, this transfer of knowledge, and ultimately we are taking here about the job of HTC; it's actually their job to make sure that that stuff work, not ours. But since we've sold the product, ultimately they [the customers] call us and not HTC … we have to tell our customers that in the end it all really works great and provides support, because you can't reach anyone on the phone at Oculus or HTC. They don't even have a phone number." (Founder1)

3.2.4.4 Strategic Positioning

Founder1 reports it is challenging for them to survive overall in the VR market. Furthermore, SportCo is working hard every day to bring the business to the next level.

> "The market has consolidated us strongly, we still exist, and we make good products, but of course we also have to get to the next level somehow. It's not a self-runner, the Daily Grind is still there." (Founder1)

According to Founder2, VR has been hyped too early and at a point of insufficient technological maturity. With this precondition, both founders found it very tricky to decide with what level of product quality to enter the market. Furthermore, Founder2 states "the problem we have is business models ... not too few, but too many" and explains, that VR offers so many opportunities that it is difficult to stay focused.

3.2.5 RQ5: How can companies in Germany deploy and use augmented reality and virtual reality technologies for business model innovation?

3.2.5.1 Get Started Pragmatically

Founder1 explains it is difficult to get started with a new and unknown product for a not yet existing market. Ideally, he would have liked to design SportCo's product around its customers, however they didn't have any customers at that time. Hence, the only way forward was to just get started and then react to customer feedback as quickly as possible.

> "And another point: customer-centric development, customer-centric development, customer-centric development – that's what everyone is saying nowadays ... ultimately, it's true, that's the damn truth. On the other hand, of course, you also have to consider the reverse conclusion if we had started off the company with a customer-centric product development … there were no customers. You have to throw the ball in first. Then a few people kick it back, you've got it again and you think: "Oh, I see!" But one could be even faster there. So, react very quickly to customer feedback, to customer wishes. Meanwhile we are doing that much more." (Founder1)

Furthermore, Founder1 observes that getting started with a VR company requires "comparatively little investment". In part, this is the case because low-cost, off the shelf, consumer-grade, hardware can be used for VR (Founder2). Still, Founder1 clarifies that it makes sense to secure external funding eventually in order to be able to act entrepreneurially, to accelerate growth, and to stay around longer.

> "Relatively speaking, we are small fish, if you look at what others collect there. We have the first round that we collected, like 300,000 Euros or so, which we simply needed to push the production etc. A second round for a little growth. Those were just smaller rounds [of investment]. And now the last round we did, in 2018, was a bit bigger. That also made sense. Yes, you must get your hands free to develop. You need personnel. We have always both acted very entrepreneurially and yet always strived to be profitable." (Founder1)

3.2.5.2 Involve Employees and Customers Wisely

Founder1 stresses the importance of user-centric product development. Similarly, Founder2 emphasises that product development must focus on usability for the end-user. He elaborates, that "there are no technical problems, only human problems".

> "If you want to make an application available to the broad masses, to many, many users, then this application must also be usable and enjoyable and consumable without special knowledge." (Founder1)

Founder1 reports that SportCo fosters an open innovation culture where all employees are encouraged to contribute ideas. However, he suggests a certain balance between openness and decision-making competency must be kept.

> "We can't shut the door now and say we're constructing something. That means – of course everyone, including all colleagues, is involved in the process. ... On the other hand, it is sometimes the case that it has to be a bit top down, because otherwise it simply doesn't work." (Founder2)

3.3 Case 3 – TransportationCo: Personnel Recruiting with Virtual Reality

In this section, the author presents an analysis of the findings from Case 3. The four interviews resulted in transcribed text of 4973 words for SeniorDigitalManager1, 3522 words for MarketingOfficer1, 8372 words for Recruiter1, and 5896 words for DivisionManager1. After numerous times of reading the text, 283 descriptive statements were extracted into a Microsoft Excel spreadsheet for further analysis. Over the course of several days, the descriptive themes were further reduced to 30 themes, then 13 codes, which were finally collapsed to the five codes presented below (code counts are provided in parentheses):

1. Technology employment (104)
2. Assessment (71)
3. Adjacent challenge (45)
4. Technology-specific challenge (30)
5. Technology deployment (20)

Some comments on the identified codes are elaborated on in Table 7.

Table 7 – Comments on the codes identified in Case 3.

Code	Comment
Technology employment (104)	Finding out what AR/VR is being used for, today, is a primary objective of the research (RQ1). Hence, it is not surprising that many statements were concerned with the application of the technology. Four additional[5] sub-groups were identified under the theme "technology employment": "brand reputation", "increase efficiency", "strategy", "visualisation and presentation tool". This observation is further discussed in the sections below.

[5] Additional to technology employment as a theme, itself.

Code	Comment
Assessment (71)	This code emerged as a good fit for RQ2 and RQ3. Under this code statements regarding the future expectations and future VR plans of the interview partners are collected. Further, statements regarding the perceived benefits of, impact of, and opportunities arising from VR are grouped under this theme.
Adjacent challenge (45)	This code emerged as a good candidate to help gain insights for RQ4. It embodies non-technical challenges encountered during the VR project including technology acceptance, organisational issues, legal topics, and technical-but-not-VR-technology-related challenges.
Technology-specific challenge (30)	This code also addresses RQ4 and focuses on technical challenges that are specific to VR technology.
Technology deployment (20)	This code emerged in the data from interview questions addressing RQ5. Under this code the author unites themes regarding approaches, processes, and procedures that appeared when they VR project was implemented.

3.3.1 RQ1: How are augmented reality and virtual reality technologies being applied by companies in Germany, today?

3.3.1.1 Support a Positive Brand Reputation: VR Employed as a Differentiating Factor from other Companies

SeniorDigitalManager1 explained that VR was used in TransportationCo as a means to differentiate TransportationCo from other employers.

> "… when [VR] was this hype topic, there was said by the management, of our leader, that we must also pursue this, we must do something, in order to stand out from the grey mass of employers in Germany." (SeniorDigitalManager1)

Recruiter1 elaborates it is very helpful in the recruitment process of TransportationCo to be perceived by job candidates as innovative and "cool". According to Recruiter1, this is particularly helpful in an expo or job fair setting where numerous other attractive employers, for example well-known reputable Bavarian car manufacturers, participate in the "war for talent". Besides this positive corporate image, the VR recruiting tool also helps TransportationCo in explaining job position details to potential future employees.

> "We noticed it when we were at trade fairs that there is a lot of competitors on the Bavarian labour market with whom we have to compete. ... We at TransportationCo were simply not cool enough. We really do have a very dusty image on the outside. ... We are a supercool employer and our campaigns are now actually showing our diversity on the market, but we had to convey that. ... In the beginning we always had the problem that we – yes – were bypassed [by job candidates]. We were passed by, we were used as a stopover to grab a pen and then hit

> it at Siemens or BMW. And since we've been using the [VR] glasses, it's really not like that anymore." (Recruiter1)

DivisionManager1 also reported an increase in employer attractiveness due to the employment of VR, as well as a positive impact on the brand of TransportationCo.

> "... the topic innovation is transported with it [with VR], as well. Then people notice that TransportationCo does cool things, they are innovative and there you go, the topic of image training positively attributed once more." (DivisionManager1)

Similar to supporting a positive brand reputation to the "outside world", the employment of VR also helps foster an innovative company image for employees of TransportationCo. This has been observed by MarketingOfficer1, Recruiter1, and DivisionManager1. Recruiter1 argues that employment of VR resulted in broad media attention for TransportationCo which is a free marketing benefit.

3.3.1.2 Visualisation and Presentation Tool

Employing VR as a "visualisation and presentation tool" emerged as the most often named topic when discussing how VR was applied in TransportationCo. SeniorDigitalManager1 explains that TransportationCo houses a huge number of different working environments which are not known to potential job candidates. Thanks to VR, TransportationCo can present "what different trades do" and "make job environments experienceable".

> "It was about making working environments accessible for occupational fields with this VR technology, ... very few people know what TransportationCo has to offer additionally [to standard job setting] and that are somehow seven thousand jobs, seven thousand different ones we have and there we said ok, which ones [the job settings] are really explainable and where you can show something – apart from an office environment – we should try to make these [settings] really experienceable through VR." (SeniorDigitalManager1)

Recruiter1 further explains many job settings of TransportationCo are not easily accessible. Some job settings are, for example, in remote locations or are subject to security restrictions. Thus, MarketingOfficer1 describes how VR aids the identification of applicants for these jobs which are otherwise difficult to fill. According to Recruiter1, VR in the case of TransportationCo helps job candidates better understand what their potential future job will be like. This way job candidates can gain insights which cannot otherwise be gained. Ultimately VR supports the decision-making process of potential employees (DivisionManager1).

> "... and in the end, we actually have to explain these jobs transparently and clearly what is behind them and Virtual Reality helps us to dive into such a job in a very short time, very uncomplicatedly, sometimes very briefly. So, if I had a lot of money and a lot of possibilities, then of course you could say that we invite all interested parties ... but of course you can't do that in the masses. That is why we have to turn it around and say ok, how do we get the job to the person, to the interested party and that's very simple and uncomplicated and in the end that's Virtual Reality, which of course helps us. That's just this transparency, this being able to look behind the scenes, a good basis for making decisions, they need a basis for making decisions as candidates. Is that something, is TransportationCo something for me, is the job something for me and that's a kind of first decision-making aid." (DivisionManager1)

3.3.1.3 Increase Process Efficiency Through VR

DivisionManager1 states that due to the use of VR, the faster and more efficient presentation of job settings increases the efficiency of the recruitment process, helps conserve resources, and hence leads to overall cost savings. While this is not measurable in "hard" numbers, VR is perceived to have clearly increased visitor rates at job fair exhibition stands of TransportationCo (DivisionManager1). Recruiter1 also reports on the observed cost savings and increased efficiency effect produced by the use of VR.

> "Normally you need an aptitude test, if you move in the [job description removed] area or in a safety-relevant area, you have to go to the psychologist, you have to go to the medical examination. And that's a huge amount of work, it's almost impossible to do from a cost point of view. Or I just send a complete security team with the people [the job applicants]; and that's also simply not feasible in terms of cost. But we had to show these professions to the applicants, that they exist." (Recruiter1)

SeniorDigitalManager1 explains that lower abandonment rates in the candidate application process are expected when using VR to present job opportunities. However, he also realises that this desirable increase in efficiency may be hindered by additional time and resource needs arising from operating the VR tool. This aspect is further discussed in Section 3.3.4.

3.3.1.4 VR Can Help Achieve Strategic Objectives

DivisionManager1 knows that one of the top three strategic objectives of TransportationCo is to be perceived as one of Germany's top (and most innovative) employers. Furthermore, MarketingOfficer1 reports that recruitment is a top priority for the company.

> "Perhaps this is something you noted in the press, that we have a recruiting assignment that comes from very high up in the company, which [the recruiting assignment] concerns to a magnitude of the size of a small German town. So, we have to recruit a lot of employees every year, because in TransportationCo … so we have special jobs to fill ... it's all about jobs that are hard to find. We have a workforce that will turn around in ten years. Then people will retire, we need junior staff." (MarketingOfficer1)

According to SeniorDigitalManager1, the use of VR was pushed by upper management as part of the strategic objective to create a unique selling point, a differentiating factor from other employers. In the case of TransportationCo where being perceived as a "top employer" (DivisionManager1) is important, VR has helped achieve this strategic company objective.

3.3.2 RQ2: What are the anticipated effects of augmented reality and virtual reality technologies on business in Germany?

3.3.2.1 Overall Impact on BMI not Measurable, Assessed to be Minor

SeniorDigitalManager1 states he perceives VR technology to be a hyped topic, which he expects to increase in importance again, after hitting a bump. While there are several VR and AR activities within TransportationCo (MarketingOfficer1), thus far no major change of the existing business processes has occurred (SeniorDigitalManager1). MarketingOfficer1 suggests VR is only one of many other (digitalisation) activities in TransportationCo. DivisionManager1 also finds the direct impact of VR difficult to quantify. In summary, all four interviewees believe the use VR positively contributes to the recruitment process of TransportationCo. However, no major impact on the company overall can be observed.

3.3.2.2 VR for Recruiting Predicted to be "Here to Stay"

Despite the fact that the interviewees couldn't attribute a major impact on TransportationCo through VR overall (cf. Section 3.3.2.1), they still assess that VR will continue to be employed for recruitment. MarketingOfficer1 states "it [the VR solution] goes on", because not using VR poses a disadvantage, since "other recruiters use VR" (SeniorDigitalManager1). Recruiter1 even expects VR to be permanently used across the entire HR industry.

> "Particularly if you have places ... where you just can't go to yourself, the topic [of VR] will certainly stay there and will be intensified, definitely" (Recruiter1)

3.3.2.3 VR Needs to Become More Interactive

Currently, the VR job presentation solution as described in Section 2.3.2 is fairly static. Job candidates can only see 360-degree videos of job sites. Only in some cases a very basic interactivity-functionality has been implemented: in some cases, the VR user can transport him-/herself to different camera positions. Recruiter1 states that focus on interactivity is important and SeniorDigitalManager1 reports on more interactive VR experiences used by other departments in TransportationCo.

> "You can now do this in such a way that you can move around freely, interact with things, with joysticks or whatever and there are already completely different applications in the [TransportationCo] group. So if, for example, you use VR for training ... Then it's the case that they have VR glasses, then they have a controller and then they take the [product[6]] apart, virtually. And that's a thousand times cooler than when I can only look around passively in a 360-degree video and everything just happens without me being able to influence it." (SeniorDigitalManager1)

DivisionManager1 expects the next development step in VR for recruitment in TransportationCo to be "interactivity". However, when asked regarding the future plans for the VR project she indicated that, despite the permanency of the VR solution, no further software development is planned. Instead a new *augmented* reality project is being pursued. Details of the AR project are confidential and were not disclosed to the researcher.

3.3.2.4 VR Offers New Opportunities

According to SeniorDigitalManager1, TransportationCo management felt pressured to be part of the emerging VR developments and associated opportunities (cf. first quote in Section 3.3.1.1). DivisionManager1 explains that the business model of HR recruitment changes continuously due to constantly emerging new technologies. Reacting to this trend, TransportationCo implements continuous technology and opportunity scouting.

> "We have our own troops. We observe, I'd say trends per sè, very IT-heavy topics or tech. There are, I think you talked to [SeniorDigitalManager1] too, they look at this corner all the time, they

[6] product details removed due to confidentiality.

> look at the startup scene, those are the people who take care of it. That's probably unusual for HR and personnel recruiting, so how can I say, I'd say it's our advantage and our strength that we can react very quickly [to trends] and just have a good understanding of [the technology]. ... We'll even set up an innovation team." (DivisionManager1)

While this technology and opportunity scouting as described by DivisionManager1 is done on a general scale, SeniorDigitalManager1 sees numerous further opportunities for using VR within TransportationCo. For example, VR could be used to facilitate virtual trade fairs and perhaps even for remote recruiting. Recruiter1 also sees a multitude of further possibilities: "VR has many application opportunities throughout TransportationCo", some of which are already actively exploited[7]. He speculates that the "personnel recruiting with virtual reality project" might have served as the initiating spark for the broader use of VR in TransportationCo.

3.3.3 RQ3: What are the benefits of employing augmented reality and virtual reality technologies in Germany?

3.3.3.1 Employing VR is Perceived to be Beneficial, But Timing Matters

All four interviewees unanimously agreed that the implementation of the VR project was beneficial for TransportationCo. One could argue that project-stakeholders tend to judge project-results somewhat euphemistic. However, DivisionManager1 is certainly in a position where she can present critical thoughts to researchers. Similarly, MarketingOfficer1 "inherited" the VR project from her predecessor. Hence, her assessment of the project benefits is arguably more neutral (compared to project-initiators).

"Timing" emerged as a topic of importance when the researcher discussed the benefits of the VR project with the interviewees. MarketingOfficer1 states "what was special, was the fact that we were the first ones to do this [VR] in the recruiting context" and DivisionManager1 is certain that being a "first mover" with VR created a competitive advantage for TransportationCo. Similarly, SeniorDigitalManager1 agrees that being first to market justifies the investment into the VR project. However, he admits that TransportationCo has not been able to develop a clear follow-up vision. Hence, no further project development is planned.

[7] examples not named here due to confidentiality reasons.

3.3.3.2 Emotional Icebreaker: VR Creates Open Atmosphere for Communication

MarketingOfficer1 reports that VR fulfils an icebreaker functionality and states the VR experience "simply creates a more open atmosphere for discussion, if you have the same understanding of the same topic". Recruiter1 also reports one of the benefits of VR to be its door-opener function in job fair settings, as expo visitors are curious to find out what this "VR thing" is all about.

> "... what actually gives us such an opener is that I can approach the people and say: Are you interested in something in particular? Or I go directly into the VR topic and say, exciting topic etc. That I first have such an icebreaker helps me start a conversation with people." (Recruiter1)

In this "icebreaker function", VR not only caters to the young generation (Recruiter1) but is well perceived by all age groups (DivisionManager1).

3.3.3.3 Gain Hidden Insights on Job Candidates Interests

MarketingOfficer1 finds that VR offers an opportunity to present the company in a new, easy, and barrier-free way. Recruiter1 suggests observing how candidates use the company presentation in VR helps recruiters gain insights into the interests of job candidates.

> "I use it when I'm out and about at the fair and I notice, for example, that a [job description removed for reasons of confidentiality] has been dealing with a subject for a very, very long time, that he's staring at monitors for a very, very long time, staring at telephones, etc., then of course I use it as a starting point for talking to him. ... Or this: Oh, that was cool now, but I want to see that, I want to see that, I want to see that [in VR]. Then it is also this [VR] video sequence, it is of course important for me to understand the interest of the applicant, which he actually shows." (Recruiter1)

3.3.3.4 Entry Point for the Digital Transformation

According to DivisionManager1, the VR project set a general impulse within TransportationCo, namely the realisation, that innovation scouting is important. She even refers to this as a "wake-up call". Furthermore, she told the researcher about how proud she and her team are in respect to the pragmatic and quick project implementation. This exemplary showpiece is frequently used as a role model within TransportationCo (also refer to Section 3.3.5.1). Recruiter1 also observes the pioneering role of the VR project within TransportationCo.

> "The topic of digitalisation is currently making its way into our lives. And I believe that this was the first impulse for [TransportationCo] to actually come in contact with the subject of virtual reality and also augmented reality. In the meantime, this has become much more potent in the [TransportationCo] group." (Recruiter1)

3.3.4 RQ4: What challenges do companies in Germany face, when implementing augmented reality and virtual reality projects?

3.3.4.1 Maturity Level of the VR Technology

While the technological capabilities of VR have come a long way and VR hardware is improving every year, there are still numerous challenges that are specific to VR technology. For example, operating VR in an expo setting is a slow and cumbersome process due to its limited throughput[8] capabilities and lack of plug-and-play readiness (SeniorDigitalManager1). Another challenge is that the consumer-grade hardware is not designed to withstand continuous operation (Recruiter1). Furthermore, choosing the right hardware for the occasion is challenging (SeniorDigitalManager1). On the one side, VR hardware is continuously evolving, which results in the need to permanently upgrade the hardware (MarketingOfficer1), on the other side, high end devices tend be immobile, are more complicated to use, and are costly (Recruiter1). Even though VR is perceived to be more mature than AR (MarketingOfficer1), numerous desired functionalities such as interaction and communication with people in VR, mirroring the VR sessions to external screens, multi-user support and display of avatars are not standard (Recruiter1).

3.3.4.2 Organisational Issues

From an organisational viewpoint, the VR project needs to be integrated into the pre-existing organisational structure of TransportationCo. Overall, the interviewees report that the VR solution was received with open arms apart from some resistance from the "typical sceptics and doubters" (DivisionManager1). MarketingOfficer1 argues that recruiters are thankful for every new idea and target-group orientated format that helps them to do their job. During project development stakeholders had to fight for scarce resources.

> "It was clear that we needed something in this area and then we first set up a project team, initially we were seven people who actually started [the project] – unfortunately always in addition to the operative daily business. This means that there was always limited time left for this and actually only a few people remained on the project, so that only two of

[8] throughput in the sense of how many users per time can make use of the VR experience.

> this [initial] project team were left in the end, me and an intern and we actually have completed 95 percent of the project – from the conception to the finished app and the presentation – we actually initiated and accompanied [the entire project].” (Recruiter1)

One organisational challenge was “privacy regulations”, which ultimately had the potential of stopping the project, if participants on the 360-degree videos hadn’t agreed to be shown in public.

> “Privacy on 360-degree video footage – who actually appears where on the video; that’s brutal. Viewing the videos afterwards to find out who is really still recognizable on the video. Of course, I need a clearance from them [the people on the video] that I can use the video. Nothing is as strictly regulated as data protection, with good reason. But this is actually also an issue that I may not have had so high on my screen at the beginning, ... where we actually had to reformulate the data protection declarations, for what purpose I actually use it. In the beginning I didn’t have that on my screen at all and that presented me with one or two challenges.” (Recruiter1)

3.3.4.3 The Human Factor

As previously stated, all four research interviewees report that the VR solution was well accepted by job applicants, as well as employees of TransportationCo. Furthermore, the VR solution was perceived to offer new value rather than being a job threat (SeniorDigitalManager1). However, SeniorDigitalManager1 observes that technophile employees encounter less challenges while using VR in comparison to less tech-savvy colleagues. SeniorDigitalManager1 also reports a target-audience dependent limitation: when catering to primary school pupils, using the devices of school children (to speed up throughput rates, cf. Section 3.3.4.1) is not an option, since they tend to own low-end smartphones with little or no mobile data volume. Recruiter1 reports a human-related challenge to be “motion sickness” in some VR users. To solve this problem, the VR solution is used in a set-up where users sit on revolving chairs. Another challenge here is that job applicants are isolated from the recruiters while in VR (Recruiter1).

DivisionManager1 states that she was very surprised how little contact people had thus far with VR technology. Consequently, she found it difficult to explain what VR is, what it does, and how the company can benefit from it.

> “That was difficult. If someone had no contact with it, has never put on such a thing before, then it is difficult to explain. Then it sounds a bit like science fiction, but it’s easy, take it with you, show it, and then it’s

> good. I took it with me a lot to conferences when I talked about the subject [VR and recruiting] myself. I always asked if someone else was going in this direction, it was really amazing how little contact they had [with VR technology] in the beginning and then I just took it with me to conferences to show what it looked like." (DivisionManager1)

3.3.4.4 Peripheral Challenges

Some challenges arose from peripheral topics. While SeniorDigitalManager1 considers the overall setup process of the VR solution on job fairs to be simple, in principle, he reports that the surrounding infrastructure, particularly wireless LAN connectivity, frequently causes considerable problems. Further challenges are the production of VR content, such as 360-degree videos (Recruiter1) and the delivery of the produced content, which tends to be rather data intensive (SeniorDigitalManager1). To mend this, a content management system needs to be developed (MarketingOfficer1). In respect to the deployment of VR to mass markets, DivisionManager1 regrets the limited availability of hardware devices suitable for virtual reality with end-consumers, which hinders the overall usefulness of VR.

> "... and that is always the question – as well with VR – which technology do I use, are the devices equipped by the normal users so far that I can use them at all? It doesn't help me if I have something cool, but nobody has the necessary software or the device. So, I always have to make sure that I'm suitable for the masses, because otherwise it won't pay off at a certain point. And just for the nerds, sorry if I say that, but it's nice to do that for a mini target group, too, but we're not just techies, I have the whole broad mass." (DivisionManager1)

3.3.5 RQ5: How can companies in Germany deploy and use augmented reality and virtual reality technologies for business model innovation?

3.3.5.1 Just Get Started!

DivisionManager1 states that a key challenge of new technology is its newness. Hence, convincing decision-makers to invest in something they don't understand is difficult. Therefore, she decided to go ahead with the project "under the radar" adopting a quick, pragmatic, and cost-efficient approach.

> "That was the first time we said come, let's do it quickly, pragmatically, and important is that it's piloted, that it's just done. That we went to the start like that. The classic would have been, they make a big project plan, they make it perfect, they take a lot of money into their hands, so I'm exaggerating now, but that would be the classic way." (DivisionManager1)

3.3.5.2 Identify Pre-existing Innovation Potential in Your Company

In the case of TransportationCo, the initial impulse to use VR for recruiting came from a technology-interested regional manager (MarketingOfficer1) who learned about VR from social media (Recruiter1). This manager found in Recruiter1 a VR enthusiastic comrade-in-arms who supported the project from beginning to end and invested numerous hours of his spare time (Recruiter1). Apparently, TransportationCo was able to identify and use a pre-existing innovation with potential and then led it to successful project implementation.

3.3.5.3 Work with External Experts

Three external suppliers were involved with software development and content creation (SeniorDigitalManager1). The software was custom-built for TransportationCo (Recruiter1). SeniorDigitalManager1 reports that TransportationCo is frequently approached by start-ups offering innovative solutions to problems that may or may not exist. TransportationCo then has to evaluate whether the proposed solution actually does solve a business problem.

> "We just have a lot of startups that ask us somehow, that offer us some solution and then we have to look, if that somehow fits to our problems, because oftentimes the impression arises that they [the start-ups] are not looking for the problems of the potential customer, but they have somehow a case which they try it out. So they already have a solution and don't know if there is a problem." (SeniorDigitalManager1)

Working with external companies seems to help in the development of new technical solutions for which the necessary capabilities are not present in a given company.

3.4 Case 4 – SanitaryCo: Sanitary Planning with Virtual Reality

In this section, the author presents an analysis of the findings from Case 4. The interview resulted in transcribed text of 4376 words for Owner1. After numerous times of reading the text, 71 descriptive statements were extracted into a Microsoft Excel spreadsheet for further analysis. The descriptive themes were reduced to 17 themes and finally collapsed to the five codes presented below. Code counts are provided in parentheses.

1 Application of VR (20)
2 Business impact (16)
3 Implementation (14)
4 Challenge (10)

5 Assessment (8)

Some comments on the identified codes are elaborated on in Table 8.

Table 8 – Comments on the codes identified in Case 4.

Code	Comment
Application of VR (20)	Under this code, statements are grouped regarding employment of VR as a visualisation tool, to support decision-making, and for process optimisation. These statements are considered useful to help answer RQ1.
Business impact (16)	Investigating what the benefits of employing VR are is a central research objective as formulated in RQ3. Codes addressing this are collected here.
Implementation (14)	Statements regarding how SanitaryCo went about implementing the VR solution help answer RQ3 and are clustered under this code.
Challenge (10)	Statements collected under this code address challenges, technology acceptance, and overall VR perception by customers and employees and are analysed to help answer RQ4.
Assessment (8)	Statements made by the interviewee regarding future assessments of VR are gathered under this code help answer RQ2.

3.4.1 RQ1: How are augmented reality and virtual reality technologies being applied by companies in Germany, today?

3.4.1.1 Visualisation Tool

Owner1 explains that a VR headset is used to present virtual walk-throughs of designed and planned bathrooms as an addition to the pre-existing planning materials, such as calculations, 2D plans, and visualisation printouts. He elaborates that all planning details from cost analysis to utilised products and materials are stored in the planning software; the visual aspects are accurately reproduced in the VR experience.

> "But I enjoy designing and building bathrooms very much and I use the [planning] software to do the bathroom planning. I use it to draw the bathrooms, just as I discuss this with the customer, and then I put it on my old VR glasses until now, from tomorrow on with the new VR glasses. Then I will go to my customer with it or the customers just come to me in the company and then this is discussed, it is looked at in paper form, a real plan is created, with all measurements, on DIN A3 brought and then as well with the VR glasses bathroom is toured virtually. The way the customer imagines it, including the tiles he has chosen, including the right ceramics he has chosen, because I – I don't know, I think there are two million articles in there, in the program – and I can just, no matter what the customer wants, if I have a number of it [the material], then I enter it, then I have exactly the component he wants and he sees it in principle one to one." (Owner1)

Owner1 states enthusiastically that for him, VR is the ultimate presentation tool which enables him to truly present his designs to his customers rather than to merely offer numbers.

> "That I don't just give my customers an offer where numbers are in it, but that I can really present my customers virtually their bathroom, where they have to go in every day." (Owner1)

Furthermore, Owner1 reports that VR supports the imaginative capacity of his clients and confirms that "virtual reality is more than just an image". Owner1 also describes an example at an exposition where he used VR to visualise the barrier-freeness of bathroom designs.

3.4.1.2 Support the Design Process

Owner1 reports that it is not only his customers that benefit from the visualisation power of VR. He uses VR during the design process himself. In this capacity, he double-checks his plans in VR. Observations made in VR influence and improve his designs.

3.4.1.3 Enchant Customers

Owner1 reports that he employs VR as a benefit for his customers, often times in the form of a surprise. In this approach, he does not tell his customers beforehand that he has prepared a VR walk-through of the planned bathroom, but waits until they get to his office or to the showroom site and then tells them "look here, I've got something more to show you". He explains this is very well received by clients who feel enchanted by this unexpected experience. Furthermore, this approach eliminates potential explanatory challenges in respect to what VR is, since all Owner1 needs to do is to demonstrate VR.

3.4.2 RQ2: What are the anticipated effects of augmented reality and virtual reality technologies on business in Germany?

3.4.2.1 VR Technology is Mature and Important for the Interior Design Industry

Owner1 confirms that he considers current VR hardware mature enough to be used by end-users, such as himself. He does not have plans to further grow his business, however, he states that he wants to further optimise his trait and states "my goal is simple … to make what I do perfect" (Owner1). Owner1 believes VR is helping him achieve this objective. Furthermore, Owner1 assesses that VR is very important for the interior design and planning industry and hence won't disappear.

> “Because the people and the customers and the people who want to see something, who want to record something, they want to be able to imagine it and you can only imagine it visually ... That’s why I don’t think it will somehow disappear from the market, I don’t think so.” (Owner1)

Owner1 reports that he plans to install a VR-centred presentation room in his office location. He also indicated he is open for further VR innovations, for example interactivity with objects such as drawers or faucets.

> “… I would gladly install a small room where I can make my designs undisturbed, where I can also present this [the designs] on a reasonable large television set, present [VR] and so on. That’s what I still have in mind. ... everything that has to do with bathroom planning, VR.” (Owner1)

3.4.3 RQ3: What are the benefits of employing augmented reality and virtual reality technologies in Germany?

3.4.3.1 Positive Company Reputation

Owner1 reports that using VR results in a positive company reputation. Both clients and employees like the idea of working with VR. Owner1 elaborates that “we [Owner1 and his employees] see each other every morning – we sit here, drink coffee and when I have something new, I show them that [including new bathroom designs in VR]”. He states this is beneficial and well perceived by his employees.

> “They all know that [I use VR] and they think it’s good, because it’s easier for them if they know and imagine it visually, how we plan the bathroom and not just make lines on the wall and say that’s where this goes and that’s where that goes. Of course, they also profit from it [the use of VR].” (Owner1)

Owner1 reports that the use of VR also delivers free marketing benefits because his innovative planning and presentation approach is fairly unique in this region and differentiates SanitaryCo from other businesses. According to Owner1, this results in word-of-mouth advertising. Lastly, Owner1 reports that his company is doing very well and that therefore his suppliers also profit from the good company performance. He attributes this to the use of VR as explained in the next sections.

3.4.3.2 VR Improves the Sales Performance, Significantly

Owner1 observes an increase in customer satisfaction because customers' expectations and project outcomes match better than they would without VR. Furthermore, he is convinced, that the use of VR increases the number of orders received significantly.

> "I'd say that I get 95 percent of the bathrooms as a job … 95 percent of the time I think the order situation has something to do with the fact that I work with VR and with this software." (Owner1)

Owner1 believes that VR delivers a competitive advantage for SanitaryCo. He states that VR (and the used planning software) "actually got me as far as it is now".

3.4.4 RQ4: What challenges do companies in Germany face, when implementing augmented reality and virtual reality projects?

3.4.4.1 Initial Setup is Challenging, Operation is an Additional Effort

Owner1 reports that getting started with the VR technology was a bit tricky and numerous issues, such as creating needed accounts and learning how to operate the VR hardware, had to be figured out initially. However, once the setup was complete and Owner1 had familiarised himself with the technology, using VR during daily business was perceived to be simple.

> "I had to get it working with the app and such, and, and, and, and, register and things like that. That was a little tricky, I admit, but everything afterwards, once I knew how to do it, it's really easy." (Owner1)

Furthermore, Owner1 reports a key challenge to be to find sufficient time to familiarise oneself with the new technology. Beyond this, he did not encounter any "real" challenges.

> "That's a lot of time I invest there, yes, that's the only thing that annoys me, because I never have time, but real challenges? No." (Owner1)

Lastly, Owner1 states that creating the data for the VR experience is a time-consuming process.

3.4.4.2 "Virtual Reality" Not a German Term, Just Show It

Overall, Owner1 reports VR is well perceived and accepted by customers. When asked, whether it is challenging to explain to his clients what VR is, he states "not really". He acknowledges that "virtual reality" is not a German term, which he considers problematic, at times. However, as explained in Section 3.4.1.3, Owner1 takes the approach to simply show his clients the VR application when they are on site. This eliminates most explanatory issues.

> "That [the fact that virtual reality is not a German term] is a bit problematic. But when I show them [the customers] that and they put on glasses, then it's great." (Owner1)

3.4.5 RQ5: How can companies in Germany deploy and use augmented reality and virtual reality technologies for business model innovation?

3.4.5.1 Love Innovation

Owner1 describes himself as a technology enthusiast who "does not like stagnation". He explains that he has been working with computers all his life and that he enjoys figuring out IT-related things.

> "So that means, I've always worked with computers, my whole life, and yes, in respect to the Oculus [VR headset], I have to work my way into it, how do I do that with the chip now, how do I get stuff on it; but that's not a challenge for me, I just enjoy it." (Owner1)

Besides having an affinity for computer technology, Owner1 reveals that he actively scouts for innovation online and regularly visits relevant trade fairs.

3.4.5.2 Strive for Seamless Integration

Owner1 uses an off-the-shelf standard software solution specialised in bathroom design. The solution offers the VR functionality as an add-on. Owner1 states that without this out-of-the-box solution he would not be able to employ VR. Furthermore, Owner1 reports that the vendor from whom he purchases the materials for bathroom construction, operates a showroom where clients can inspect material samples. This vendor employs the same software as Owner1. Therefore, Owner1 can easily transfer his planning data to the showroom and present there as well. The VR experience is also used in the showroom.

> "Exactly, ceramics, fittings, bathtub, everything together. A beautiful exhibition and they work with the same bathroom software as I do, ... that's why it harmonizes so beautifully. All I have to do is send it over by e-mail and off it goes." (Owner1)

Finally, Owner1 stresses the importance of vendor support and states this well working, fully integrated software solution is a key driver for SanitaryCo's business success.

3.5 Case 5 – SupplyCo: Using Augmented Reality to Assist Construction Workers

In this section, the author presents an analysis of the findings from Case 5. The three interviews resulted in transcribed text of 8000 words for DepartmentHead1, 7909 words for Manager1, and 7898 words for DepartmentHead2. After numerous times of reading the text, 388 descriptive statements were extracted into a Microsoft Excel spreadsheet for further analysis. Over the course of several days, the descriptive themes were further reduced to 22 themes, which were finally collapsed to the six codes presented below (code counts are provided in parentheses):

1. Usage (98)
2. Approach (78)
3. Challenge or risk (77)
4. Future forecast and plans (49)
5. Benefit (45)
6. Company transformation (26)

Some comments on the identified codes are elaborated on in Table 9.

Table 9 – Comments on the codes identified in Case 5.

Code	**Comment**
Usage (98)	The statements by the research participants collected under this code address the usage of AR as a sales and visualisation tool, revealed product features and service innovations, and gave the researcher insights into how AR can help achieve strategic objectives. The statements help answer RQ1.
Approach (78)	This code emerged when the research participants spoke about how the AR topic was approached within SupplyCo, how the software was developed, and what learnings were made. The analysis of statements under this code are aimed at answering RQ5.
Challenge or risk (77)	The researcher identified this code when the interviewees described technological, human, and organisational challenges when introducing AR. The analysis of these statements helps answer RQ4.
Future forecast and plans (49)	Statements collected under this code address RQ2. This code emerged when the interviewees revealed details about SupplyCo's future AR plans and assessed potential future developments, in general.
Benefit (45)	This code emerged when the research participants reported benefits of employing AR, such as a positive impact on company reputation or differentiation from the competition. Statements gathered under this code help answer RQ3.
Company transformation (26)	The interviewees reported that SupplyCo's processes, staff composition, and product service offering is being transformed by the introduction of AR technology. The statements are grouped and analysed under this code help answer RQ2

3.5.1 RQ1: How are augmented reality and virtual reality technologies being applied by companies in Germany, today?

3.5.1.1 Achieve Strategic Objectives

DepartmentHead2 explains SupplyCo's strategic objective is to be, or to become its customers' leading partner for innovative scaffolding solutions and formwork systems. He states that it is imperative for SupplyCo with the aspiration to be innovation leader to explore and offer newest technologies, including AR.

> "SupplyCo wants to be the leading partner in formwork and scaffolding applications for its customers. If I have the topics "partner" and "leadership" in mind, then I have to go along with the technology ... I am close to the customer, I understand the customer, the customer understands me; of course, I would use any kind of technology that contributes to these attributes. ... and currently AR is one of them." (DepartmentHead2)

DepartmentHead1 states that SupplyCo developed an eight-year company strategy based on three pillars, one of which is a strong focus on "digitalisation". Therefore, SupplyCo is currently undergoing a change process in which AR plays a twofold role. First, it is seen as a technology that can aid the overall company transformation efforts; secondly, due to its visualisation capabilities, AR helps make the digitalisation visible and thus functions as an entry point for the digital transformation.

> "The whole topic [AR] belongs to the third pillar "digitalisation" and to the associated change process. To make it simply interesting that people just see, watch out, something is really happening and there really are people who are intensively involved with it. So, it helps to make this strategic pillar of "digitization" tangible, to make it more visual, to make people curious and to make them deal with it. ... because, of course, the topic is also too big a word for many people, many people are afraid of it [the digital transformation] and then everything that makes the whole thing ... more tangible helps." (DepartmentHead1)

Lastly, Manager1 confirms that AR fits well into the strategic orientation of SupplyCo to digitalise its business processes and to develop new digital products and services (cf. Section 3.5.1.3).

3.5.1.2 Innovate Processes

DepartmentHead1 explains the current trend of digitalising the construction industry is termed “building information management” (BIM[9]) and is “ultimately all about the value-added chain of a project; it’s about creating additional value with the support of digital technologies, that is what we understand as BIM” (DepartmentHead1). He further elaborates that in the entire BIM context the focus always lies on the technology side and the process side. Given this background, AR technology is used within SupplyCo to support existing company processes, to increase process efficiency, and to establish new processes, as well as to develop new products and services (DepartmentHead2).

DepartmentHead1 states that there are three aspects that need to be considered when talking about process optimisation. One, how are the processes of SupplyCo’s customers changing (see also Section 3.5.2.3) and what does SupplyCo have to do, in order to stay compatible with its customers’ processes. Second, how can SupplyCo optimise its own internal processes, for example how employees communicate with each other (refer to Section 3.5.2.1 for more on how AR technology drives transformation within SupplyCo). Third, what new (AR) products and digital services can be developed to aid process optimisation.

> “To say ok, how do we have to position ourselves so that we are compatible with our customers in the future, that is one thing. What does our customer do? … . The second is then the topic, which of all the new technologies or new possibilities, including the new process definitions, can we use internally ourselves for our internal processes in order to optimize our own value chain? For example, more efficient cooperation or better date exchange and so on, internally speaking. The third is, of course, how can we develop services that we can offer our customers as added value, i.e. change our business model with regard to the customer as well.” (DepartmentHead1)

3.5.1.3 Develop New Products and Services

DepartmentHead1 reports that AR technology is seen as an opportunity to develop new products and digital services. According to him, SupplyCo is a first mover in this direction, however, other industry players have also begun developing AR solutions.

> “We were now in our industry ... the first ones to do something in this direction and our competitors then followed up with some apps piece by piece, which from our point of view were only focused on having something, too. ... there are individual pilot projects which we are aware

[9] Sometimes also referred to as building information *modelling* (DepartmentHead1)

> of, but there are also certainly large construction companies that are also dealing with it [AR] in this area." (DepartmentHead1)

DepartmentHead2 underlines the importance of creating these "flanking digital services" and he believes that not having these services would result in a competitive disadvantage, in the future.

> "And if he [the customer] says ok, that's great, I can get my floor plan, I get a formwork solution, I get a parts list, whatever I need – that's why I buy the product. It could be, so hypothesis, if he doesn't have such possibilities, then he says well, then the SupplyCo formwork doesn't bring me anything, then I prefer to go to the competition, because I have everything there .... In other words, this are things that secure a certain sales volume for me. I just have to have that, that's a hygiene factor." (DepartmentHead2)

Manager1 adds that further scaffolding or formwork systems innovations are nearly impossible, since these products are matured. According to him, the opposite is true for emerging digital technologies, such as AR, where the cards are freshly shuffled. Further, Manager1 reports that SupplyCo is currently applying for several new AR-related patents.

SupplyCo sees numerous opportunities for the development of new digital services including progress monitoring at construction sites (Manager1), AR assisted approval procedures (DepartmentHead1), or responding to poorly skilled construction workers with AR digital assistance tools (DepartmentHead2). Digital assistant tools could, for example, assist construction workers with insufficient language skills in the setup of scaffoldings or formwork systems (DepartmentHead1).

3.5.1.4 Support the Sales Pitch and Human Imagination

DepartmentHead2 reports that SupplyCo professionalises the sales pitch by supporting the sales process with AR. This creates unique sales experiences and helps in the acquisition of key accounts (Manager1).

> "That was actually this marketing approach and then the whole thing was further developed in the context of visualisation. Visualisation is an immensely important component in the most different areas, in the sales process, that is to say to make a solution clear to the decision makers visually, which is not only in a table in it, in a price list in it, in a 2D plan in it, because possibly the decision maker is no longer the technician. If you can visualise the solution there, then it already has immense added value, perhaps also emotionally, because it impresses. Especially when we're talking about large infrastructure solutions. This means the professionalisation of these sales pitches, which plays a role

here, but also really has added value in the process in order to bring information to the construction site." (DepartmentHead2)

DepartmentHead1 further reports, that AR is used as a visualisation tool for construction plans. This aids knowledge transfer in the sense that "CAD data ... is processed in such a way that the user gets insights that he probably would not be able to get otherwise." (Manager1). DepartmentHead1 explains that is the objective of SupplyCo to visualise construction plans in AR on construction sites at exact locations and in the proper dimensions.

"This is our objective, now in our main focus, that we say how can a formwork solution that was planned in our engineering department be visualised on the construction site in the XR environment, so to speak, and how can I best visualize it in one to one size, at the exact geo-location where it is to be erected." (DepartmentHead1)

3.5.2 RQ2: What are the anticipated effects of augmented reality and virtual reality technologies on business in Germany?

3.5.2.1 AR Transforms Companies

DepartmentHead2 states that accompanying SupplyCo's tangible products with digital services is becoming increasingly important. Hence, according to DepartmentHead2, AR software development is becoming a new core competency of SupplyCo. As a consequence, according to DepartmentHead2, SupplyCo has to become a software company, to some extent. This in turn transforms the company significantly (DepartmentHead2) and poses numerous new challenges, such as hiring the needed staff (cf. Section 3.5.4.3) or a proper strategic alignment (cf. Section 3.5.4.5).

"... from a strategic point of view, you might have to set it a bit higher – not to say we've become an app company or whatever or an app developer. I mean, when I think of Marc Andreessen, the founder of Netscape, the first Internet entrepreneur to say "software eats the world", I mean that's a point where he's partly right that every company has to become a software company to a certain degree. That's perhaps a bit pointed, but these apps we're talking about, which are there to accompany the process, are very, very close to the core competence of the respective company, of course [e.g. SupplyCo]. And it's almost easier for me to build up the development competence and do that and I'm much faster than having to rely on an external development company and become dependent on it. Especially because this emphasis on these applications or accompanying things to the physical product, as we still have it now, is becoming more and more important. That's also the point that we say ok, we're a production company, historically, we've always produced, but the customer needs become a bit different.

> That's not just the physical product, but the customer wants a solution to a need." (DepartmentHead2)

Manager1 also assesses, that AR will have a great impact on the overall company in the future and reports that the AR activities have already served as innovation impulses for other departments to look into the employment of AR, as well.

> "So potential, I'd say, has it [AR] a lot. The influence right now – so we are getting attention. We don't have to force anyone to argue anymore. It's more like if you release something or something, then there's a lot of demand, so I hardly get to serve the internal requests." (Manager1)

> "We have consciously or unconsciously become the internal innovation driver in this area. This means that we now also get calls from other departments who say: Hey, you guys have some [AR] equipment, we'd like to do a quick test, we're now dealing with the topic [AR] in our area." (Manager1)

Furthermore, Manager1 observes that "at the same time, 3D planning is increasing more and more, because it is also necessary from a legislative point of view". In this context, AR helps push forward the transformation from 2D planning to 3D planning since it motivates engineers who wish to see their plans in AR to implement their CAD plans in 3D (Manager1).

Lastly, DepartmentHead1 reports that usage of AR also pushes a change in SupplyCo's relationship with its customers. Thus far, SupplyCo has been primarily perceived as mere supplier of construction equipment. Driven in part by AR technology, SupplyCo is beginning to transform from a simple construction material supplier to a provider of complete construction solutions.

> "So the whole topic of Extended Reality is a bit of a lever to build up a different relationship with the customer, on a different level, not only to be perceived as a supplier of scaffolding material, but as a company, so to speak, with which I can also sit down together on other topics and perhaps also work together on the digital topics that concern me. ... Everything around VR/AR/MR, that helped a lot." (DepartmentHead1)

3.5.2.2 Source of New Business Opportunities

As previously explained in Section 3.5.1.3, SupplyCo tries to develop new digital services powered by AR technology. Looking ahead, Manager1 identifies additional potential for new business spin-offs based on the implemented AR solution, which is capable of managing any 3D model and can hence be further developed into an industry independent solution (DepartmentHead1), for example, to enable architects to present their 3D plans in AR (DepartmentHead2). In this respect, DepartmentHead2 states that spinning off new companies has its own set of challenges and that SupplyCo has to carefully make important strategic choices whether to expand into new areas or to stay focused on its core competence (refer to Section 3.5.4.5 for further details on this).

> "Of course, we have also toyed with the idea that if you pay all the effort for yourself, you can somehow release the whole thing as a white label product. How big is the effort? You can somehow make it available for other industries, for example window construction, so that window manufacturers X, Y can load in their products, their solutions, go to the customer and make their sales pitch there, just like SupplyCo does." (Manager1)

DepartmentHead2 states that he sees many further application and business opportunities through AR, for example for training purposes, as an intuitive 3D planning tool, or to enable predictive delivery of construction gear. He indicates he cannot share further details with the researcher due to confidentiality reasons.

3.5.2.3 AR Contributes to Industry Transformation

All three research participants agree AR "is here to stay" and will become increasingly important in the construction industry. DepartmentHead1 even assesses digital services combined with AR might change the entire construction industry, an industry he considers rather inefficient at the moment.

> "Scaffolding work is such that actually nothing is planned, but the scaffolder delivers two trucks of material to the construction site and starts erecting. So, we said, no, we do it differently, we make it plannable, we plan it in advance, we know exactly what needs to be done on the construction site and we make all the information available digitally. The conclusion to be drawn is that at some point this will be done using Mixed Reality technologies or Extended Reality technologies." (DepartmentHead1)

DepartmentHead2 asserts that AR technology will remain part of the digital agenda of SupplyCo, however, he states that future AR value propositions will depend on the technological development of AR. Furthermore, DepartmentHead2 expects technological innovation in other areas, such as robotics, as well.

> "I do believe that we will see in the medium term, so I would not say in the distant future – whether it is now really fast, that is the question – robots, drones, autonomously moving vehicles, and to some extent workforce with high-tech gadgets, we will see all this on the construction site, definitely. ... I think [AR] will play a role here, yes." (DepartmentHead2)

All three interviewees state that the abilities of construction personnel have been declining over the last few years. They also report that traditionally SupplyCo's customers have not been willing to pay for planning and engineering services. According to DepartmentHead1, SupplyCo's customers see the benefits of the new, digital, AR-enabled service offering, which may hopefully lead to a change in the willingness to pay for services.

> "... the personnel on the construction site has been getting worse and worse over the last few years. Whether it's the language or the way they are trained. That means I can explain to my people on the construction site [with AR] much, much easier what needs to be built. In any case, this added value is also seen by our customers. To what extent the customer now … is really willing to pay money for it, that will be the exciting question." (DepartmentHead1)

3.5.2.4 Further AR Innovations Expected

The three interviewees state they expect further AR innovations in the future. DepartmentHead1 reports that SupplyCo's AR app is only a first step and that further developments are planned. DepartmentHead1 expects AR hardware improvements within the next three years and forecasts that AR will eventually be backed by additional scanning hardware.

Manager1 reports that bug fixing, support for multiple platforms, and general improvements are the next planned steps for SupplyCo's AR solution. In the future, Manager1 assesses, AR technology could be used to measure employee efficiency or to measure employee attentiveness, for example during training sessions. He considers even interaction via thoughts a possibility.

DepartmentHead2 confirms that SupplyCo will continue its efforts to improve the current AR solution and states his belief that "there's a lot of air left up there". Again, DepartmentHead2 indicates to the researcher that he cannot disclose what the next planned features are. Looking further into the future, DepartmentHead2 predicts that tracking of AR app feature usage or tapping into location-based data will become important topics.

3.5.3 RQ3: What are the benefits of employing augmented reality and virtual reality technologies in Germany?

3.5.3.1 Introduction of AR Well Perceived by Customers and Employees, Overall

DepartmentHead1 reports that he has received feedback of all kinds on the AR solution and that the echo thus far confirms the usefulness of the chosen approach, since AR is perceived to be a good support for daily business. For example, he informs the researcher that introducing AR on the BAUMA[10] expo in the first half of the year 2019 was a success with customers and employees alike, and that he received numerous requests regarding AR after the expo.

> "You can already see the BAUMA, the construction fair every three years, where – I think at least as far as the feedback is concerned – we had the best fair appearance of all times in this area. Not only internally, but also in comparison to the competition ... now in the aftermath to BAUMA we have a lot of inquiries for all the digital topics and there, Mixed Reality was a main focus. We received very, very much positive feedback and now we have customers who just come up to us and say, "you showed this and that, let's do something together." (DepartmentHead1)

Manager1 observes that the AR technology is well liked and that he received mostly positive feedback. He describes further that the AR app was actively used on the BAUMA expo by top-level management.

> "Regarding the management level we've reached everyone. There is no managing director who has not installed the application on his mobile phone and shows it regularly. So, we regularly got the families of the managing directors at BAUMA complete with everything. That was a member of the family, of the advisory board. He freaked out when he saw it [AR] ... We then met the managing director of production/technology, who regularly dragged groups along, but who also stood next to us with his mobile phone and showed us how he was using it [the AR application] during his conversations." (Manager1)

Lastly, DepartmentHead2 confirms that the AR application is very popular within SupplyCo. He states that he has received mainly positive feedback, besides some scepticism from very conservative employees who'd prefer to continue working in the

[10] The BAUMA is the world largest trade fair for the construction industry.

old fashion. When asked whether employees perceived AR as a threat, DepartmentHead2 responded with a clear "no".

> "In general, positive feedback, of course, sometimes "stay away from me with that rubbish, it has worked [the old way] for the last ten years, then it'll continue to work" ... you always have that." (DepartmentHead2)

3.5.3.2 AR is Impressive

Both, DepartmentHead1 and DepartmentHead2 report that AR technology causes a "wow-effect", which is very impressionable for customers and employees.

> "Of course, this wow-effect is still very strong, so you can simply make an impression with it [AR]." (DepartmentHead1)

DepartmentHead2 believes that using AR on the construction site will become something like a status symbol. He explains that the attractiveness of the construction industry is low and that contractors are desperate to win young talents back to the industry. Hence, the mere fact that AR is used at a given construction company may be enough, regardless of whether the technology delivers "hard" value.

> "If I look at the DACH[11] region, there are currently the company founders who have founded construction companies and now comes the second generation. And when the second generation sits in the executive chair, things can happen very, very quickly .... Partly they don't care if it [AR] brings something or not, they just want to say that the technology is used. One building contractor, for example, said to me, "I don't care if I have any added value from a HoloLens or a technology on the building site, if you bring young talents back to the building site", e.g. simply increase the attractiveness of the industry, again. " (DepartmentHead2)

3.5.3.3 Working with AR Assessed to Have a Positive Impact on Brand Reputation

DepartmentHead2 explains that the initial idea to employ AR had been born in the marketing department, where the wow-effect caused by AR (cf. Section 3.5.3.2) was used to impress customers, as well as to differentiate SupplyCo from the competition.

> "That means the whole thing was born from a marketing idea, Augmented Reality, I have a trigger, the 2D plan in our case, I hold the

[11] Abbreviation for the regions Germany, Austria, and Switzerland.

> device over it and then the 3D model appears, which then always has this beautiful wow-effect.” (DepartmentHead2)

Manager1 confirms that AR is used in marketing and sales to differentiate SupplyCo from the competition and states “if you want to stand out, at least during the sales talk, then you have to offer a little more”. DepartmentHead2 declares “working with AR communicates something to the customer”. He acknowledges that it is very difficult to measure brand awareness and that it is nearly impossible to determine whether being perceived as an innovative brand results in actual turnover. However, he still hypothesises that the use of AR has a statistically significant impact on the brand reputation of SupplyCo and ultimately its turnover.

> “Of course, it is difficult to determine ... the extent to which this affects brand awareness, i.e. the perception of the brand as an innovative brand and so on, is very, very difficult to measure. If you are then perceived as an innovative brand and a good brand, then to say ok, then I also buy from SupplyCo or rent from SupplyCo … it’s hard to measure. Nevertheless, I would hypothesise that this will also have a statistically significant influence. ... if I set myself the goal of being an innovation leader, then I must also be able to deliver accordingly in these areas.” (DepartmentHead2)

Manager1 reports using AR also had positive effects on SupplyCo’s brand from an internal perspective. According to Manager1, SupplyCo might sometimes be perceived as an old-fashioned company by its employees. Working with AR indicates to employees that SupplyCo truly is an innovation leader in its industry.

> “An added value is that ... a company that seems a bit dusty is represented differently, also in the internal perception, i.e. by the employees. Because many people also say: Okay, there’s something going on here, something visible, something tangible. I’d say that’s an inner reputation.” (Manager1)

Lastly, Manager1 reports that the AR solution received recognition at management level. Manager1 believes this resulted in a positive reputation for his department, as well as for himself.

3.5.4 RQ4: What challenges do companies in Germany face, when implementing augmented reality and virtual reality projects?

3.5.4.1 Technical Limitations

The interviewees reported some technology-related challenges they encountered while working with AR. For example, DepartmentHead1 details that the handling of data is difficult, because AR data files tend to be very large. Consequently, SupplyCo continuously works on improving the proprietary 3D data format they implemented for their AR service.

> "Ultimately the main challenge we still have is ... the actual data handling, i.e. how do we manage as quickly as possible large models. The question is simply up to what size can devices device handle such as HoloLens or normal tablets, or smartphones. So the subject of performance, depending on the model size, is a subject where we still have to improve." (DepartmentHead1)

Manager1 explains that AR devices, particularly AR headsets, only provide for limited computing power. Furthermore, he suggests a lack of fast network connectivity, which is required to download AR data onto AR devices, can be problematic in some settings.

3.5.4.2 The Construction Industry is a Conservative Industry

DepartmentHead1 explains that the construction industry is a particularly conservative industry and DepartmentHead2 illustrates that innovation in the construction industry is especially challenging, because the industry is "very unforgiving".

> "I think this [the roll-out of AR] will be a difficult process because the construction industry does not forgive well. Once you take a topic, "ah it doesn't work", they don't tackle it on the construction site anymore. That means you have to be a bit cautious." (DepartmentHead2)

Manager1 finds that being very innovative may also hold the danger of being perceived as a threat, rather than an opportunity, by the industry.

> "But there is also the fact that as a supplier of such a digital mystery you may also be perceived as a threat and not as an opportunity." (Manager1)

3.5.4.3 Necessary Staff is Hard to Find

DepartmentHead2 reports that hiring software developers is a core challenge. He elaborates that game developers, who hold the needed expertise, are more interested in developing games, rather than programming applications for companies such as SupplyCo. He further explains SupplyCo has to compete for talent with other, more popular high-tech industries. Hence, DepartmentHead2 argues, SupplyCo's personnel marketing and recruiting of the future must adapt.

> "So, we're hiring UX/UI designers now, which we probably wouldn't have done five years ago. You can already see that we – and this is a good thing – are also making ourselves fit to recognise these new, emerging job profiles at an early stage and also to create areas that are attractive. By the way, this is one of the biggest risks in my opinion. If we go through such a change ... then to get the techies. Now they may all be going into finance, retail and some high-tech industries. ... automotive ... but also to turn up there [at SupplyCo] and say, hey SupplyCo is also an interesting employer, then they say you are a construction supplier. But no, we have to be a little different when it comes to personnel marketing and recruiting in the future." (DepartmentHead2)

DepartmentHead1 also observes that job profiles within SupplyCo are changing and that it is challenging for the company to transform towards these new employee profiles. He states that currently the external company image does not attract the needed employees and that "someone who has done something … in the direction of computer science, digitisation, or something like that, may never identify SupplyCo in his life, because nobody thinks that SupplyCo does something like that."

3.5.4.4 Organisational Friction, Getting Stakeholders on Board

DepartmentHead1 reports one challenge to be that the implemented AR solution needs to be integrated into the pre-existing IT landscape of SupplyCo. For example, support for single-sign-on had to be programmed and an interface to the CAD software used by SupplyCo's engineers had to be created.

> "So, one challenge was … the login area that we have now created that now runs with our normal Windows login. So just like people log on to their normal laptop, they log on to the app as well." (DepartmentHead1)

DepartmentHead1 acknowledges that using AR is an additional effort for the engineers on top of their daily work tasks. Therefore, according to DepartmentHead1, a key objective must be minimisation of any extra workload. In this context, Manager1 accounts that adapting the existing company structure to the needs of AR usage slows down the roll-out of the software to external users. He details that several issues, including staff training and legal concerns, have to be addressed prior to releasing the software to SupplyCo's customers. Furthermore, SupplyCo's divisions worldwide have to organise resources to ensure field support.

> "That's why I say that the external rollout has to take the back seat. From a technical perspective, it wouldn't be that demanding. ... This is more on the organisational side, that we have to adapt the internal structures as it were and what the people within SupplyCo also have to know, what the system can do, what it looks like, but also quite clearly the topic "what do we actually do with the data that is theoretically created?". In other words, it must be approved by the legal department, it must be quite clear from the point of view of data protection how we use it ... I would like to say that from a technological standpoint, a lot is possible ..." (Manager1)

According to Manager1, "there is little resistance against the app; it's more like if you want to have commitments, i.e. binding commitments, then it always gets a bit harder". He further states that there is a risk that AR is perceived as "not being serious" and not suitable for business. DepartmentHead1 further reports that it can be difficult to explain what AR is since people confuse it with VR, "because everybody has worn VR glasses before".

3.5.4.5 Defining the Proper Strategic Alignment

Looking back on implementation, all three research participants report that they are happy with how the project unfolded. However, DepartmentHead2 recognises that "in retrospect, this [the initial AR efforts] should have been pushed much, much more structured and forcefully"; and DepartmentHead1 concedes that virtual reality could have been pushed in parallel. VR technology was initially neglected because of the assumption that "on construction sites, they'll never run around with big VR goggles." (DepartmentHead1).

Looking onto SupplyCo's strategy, DepartmentHead2 observes that AR is used by SupplyCo's competitors, as well. He confirms that not using AR might result in a competitive disadvantage. DepartmentHead2 reports further strategic AR challenges to be "complexity management", "IT governance", and "strategic focus". According to DepartmentHead2, "complexity management" refers to the concept of keeping the IT landscape handleable for users; and "IT governance" addresses the question whether to buy software solutions (e.g. the AR software) from external providers or to implement oneself. In respect of SupplyCo's "strategic focus", DepartmentHead2 details that the fundamental decision has to be made whether to employ AR solely for SupplyCo's own core processes or also for spinning off new technology companies.

3.5.5 RQ5: How can companies in Germany deploy and use augmented reality and virtual reality technologies for business model innovation?

3.5.5.1 Support Internal Innovation Spirit, Start Pragmatically, then Professionalise

Manager1 recounts that SupplyCo's AR activities were initiated by an employee who enthusiastically explored AR technology together with his brother, a game developer, and simply went ahead and created our first AR showcase. DepartmentHead1 details that this happened in parallel to SupplyCo exploring the topic with an external company.

> "... in the end it was a parallel development. When the HoloLens came onto the market, we simply sat down with an external service provider, said we did something with the HoloLens, they showed us a few things a bit and then we finally carried things on ourselves and the colleague who was still working in the UK at the time did something at the same time and then we brought it together. In the meantime he has become part of our team and we've conflated the activities in a local subsidiary and as I said he just happened to have a brother who came from software development, from the games industry, which helped us a lot" (DepartmentHead1)

In the end, SupplyCo combined all efforts in a local subsidiary, due to strategic reasons. DepartmentHead2 explains that the AR software solution is very close to the core competence of SupplyCo. Hence, he argues, SupplyCo is likely better off with building up its own software development team, rather than working with potentially slower external companies. Furthermore, DepartmentHead2 prefers to avoid supplier dependency.

> "these apps we're talking about, which are accompanying processes, they are very, very close to the core competence ... it's almost easier for me to build up the development competence and do that and I'm much faster than if I have to track down an external development company and become dependent on it." (DepartmentHead2)

3.5.5.2 Ensure Seamless Integration and Foster Knowledge Transfer

As previously reported in Section 3.5.4.4, introducing AR to SupplyCo means additional workload for engineers. According to DepartmentHead1, it is therefore crucial to keep the new, additional effort during the daily work to a minimum. Manager1 states that seamless integration into pre-existing processes is important and that "it [the process integration] should work seamlessly, because the [pre-existing] workflows we've created so far are actually our orientation." (Manager1).

DepartmentHead2 explains that a seamless workflow and quick data provisioning are vital. He describes how the CAD plug-in and cloud distribution workflow enables AR experience delivery within minutes and assesses that this is a highlight of their solution, as well as a precondition for successful AR employment.

> "What I personally like very, very much ... [is that we] can very, very quickly provide customised models. So that not only the AR Experience ... is there, but also the corresponding plug-in in the CAD program, where the engineer, once he has planned, can publish the model quickly with two clicks. And of course, this is a fundamental requirement that the topics are quickly returned to the customer, for the whole thing to work, and to be accepted. If the customer says, "wait a minute, it takes four weeks until we created your model and made it ready [for presentation] … then the momentum is gone." (DepartmentHead2)

Manager1 and DepartmentHead1 report that SupplyCo offers trainings and workshops for its employees, communicates AR possibilities and best practice details via the company's intranet, and fosters active employee knowledge exchange. Furthermore, DepartmentHead1 details that SupplyCo organises special events for internal multipliers who are responsible for pushing the AR topic at their local regions.

> "Intranet, that's right. We're promoting it there, but we're doing something special – for example, in July we're holding a kind of BIM network workshop, where we are inviting our multipliers in the SupplyCo world, the local subsidiaries, to start with a small group, where we simply know they're the people who're already doing it on site, daily. Our aim is to say that here at the headquarter we push topics forward in a strategic way, train the people, and when it comes to scaling the whole thing, we always need our sparring partners locally, who are then responsible for promoting the whole thing in their local regions. " (DepartmentHead1)

Lastly, DepartmentHead2 confirms "internal communication is extremely important, so that people know why we do something" and Manager1 stresses the importance of being tactful the communication.

3.5.5.3 Focus on Applicability to Praxis

Manager1 states that SupplyCo deliberately took the path of striving to implement a praxis-relevant prototype, from the beginning, rather than merely implementing a "shiny showcase" designed only to impress at trade fairs.

> "... we have deliberately refrained from building a high-end use case that would not be scalable for us, but we really wanted to show that what we have also corresponds to how it will be made available and we didn't just make a shiny mock-up that is half-functional and only brings us over the trade fair so that we appear as innovative but nothing else." (Manager1)

Similarly, DepartmentHead2 asserts it is important to focus on "serious business", because otherwise, "if it [the application] is too frisky, you might even lose it [the desired target group]". Lastly, Manager1 reports there was a time where SupplyCo built numerous AR apps for different events without any real return or strategic value. He states that perhaps he should have approached the AR project in a more focused manner.

> "There was a time when we made applications for almost everywhere. It was just x apps that ... were made available for events. There was a lot of time, a lot of effort, but in the end, there wasn't much return. That means the strategic benefit was zero. Maybe I'd dance on fewer weddings and approach the whole thing more focused." (Manager1)

In this section, the author presented the findings and insights gained from conducting the full case study. In the next section, the author gives a summary of the paper and presents the next planned steps.

4 Summary

The research contributes to the literature by reflecting on the business model and business model innovation concepts and by constructing a conceptual framework to explore the impact of augmented reality and virtual reality on business model innovation in companies, which will assist future research efforts and support entrepreneurs in the innovation of business models. Digital technological innovations such as augmented reality and virtual reality reshape business models (Teece, 2006) and drive business model innovation (Casadesus-Masanell and Ricart, 2011). However, "it is ill-understood how changing market, technology and regulation conditions generally drive revisions in business models" (De Reuver *et al.*, 2009, p.1). Helping close this gap is a valuable contribution to theory, aligning it closer to practice.

This Findings Paper builds on three previous papers; a Conceptual Paper, which develops a conceptual framework from literature; a Methodology Paper, which reflects on the research philosophy underpinning the study and justifies the multiple-case holistic "Type 3" case study design; and a Research Design Paper, which presents initial learnings garnered from the implementation of a pre-pilot case study test run, two expert interviews, a full pilot case study, and research log reflection.

In this paper, the author describes five cases in which the use of augmented reality or virtual reality technology impact business model innovation. The individual AR/VR applications are described, the company background information is presented, and the research participants' profiles are reported. Furthermore, an analysis of the findings arising from the case data is presented.

Overall, the research is aimed at better understanding the impact of augmented reality and virtual reality technologies on business model innovation. The formal objective of the study is "*to explore the impact of augmented reality and virtual reality technologies on business model innovation in Germany*". In this respect, Table 10 provides a summary of how "*augmented reality and virtual reality technologies impact on business model innovation in Germany,* as per the research objective.

The next steps for the researcher are implementing a cross-case analysis, discussing the findings in detail, visualise the findings on the author's business model innovation framework, and reflecting on the study, overall. The detailed discussion of the findings, as summarised in Table 10, will be presented in Section 3 of the author's doctoral thesis. Hereby, the researcher will focus on similarities, differences, unique features, surprises, and overarching aspects of the individual case findings; for example, per technology (AR versus VR), per industry sector (the five cases stem from five different industries), and per company size (the five case companies vary in size from four to several hundred-thousand employees).

Table 10 – Summary of findings how AR and VR impact BMI.

Case	**Case 1 – SteelCo**	**Case 2 – SportCo**	**Case 3 – TransportationCo**	**Case 4 – SanitaryCo**	**Case 5 – SupplyCo**
RQ1: How are augmented reality and virtual reality technologies being applied by companies in Germany, today?	SteelCo applies AR is a new tool for measurements and to support decision-making in its customers. Further, AR helps optimise SteelCo's business processes as part of its digitalisation efforts.	The founders of SportCo had been waiting for consumer-grade VR for several years and apply the technology to develop a visionary "physical eSport" product. SportCo seized the moment during a VR hype time to establish the company, secure venture capital, and benefit from free marketing effects. Furthermore, as a digital technology, VR enables SportCo to go global and tap into international markets.	TransportationCo applies VR to help achieve its strategic staffing objectives and to foster a positive brand reputation. VR increases the recruitment process efficiency in TransportationCo and is used as a visualisation and presentation tool.	In SanitaryCo, VR is used as a visualisation tool for customers. Furthermore, VR supports the interior design process.	In SupplyCo, AR is used to innovate SupplyCo's internal processes, to develop new products and digital services, and to achieve its strategic objective of being perceived as industry innovation leader.
RQ2: What are the anticipated effects of augmented reality and virtual reality technologies on business in Germany?	The research participants of SteelCo expect further AR technology improvements. These might offer opportunities for new product developments. However, AR in Case 1 could theoretically be replaced by an alternate technology, in the future.	The research participants of SportCo predict that VR will become part of our daily lives in form of numerous new applications. Furthermore, VR may potentially help reduce the ecological footprint of humanity.	The research participants of TransportationCo find the impact of VR onto TransportationCo's business model to be minor. However, they still expect that VR for the recruiting industry will increase in importance.	The owner of SanitaryCo finds that VR technology is mature enough to be used in the interior design industry and expects that its relevance will increase in the future.	The research participants of SupplyCo describe how AR begins to transform SupplyCo and the entire construction industry. AR is seen as a source for new business opportunities and further AR innovations are expected.
RQ3: What are the benefits of employing augmented reality and virtual reality technologies in Germany?	AR helps achieve strategic company goals and its employment results in a positive company image.	Working with VR is Fun. Further, VR offers an opportunity for B2B cooperation across different industries. VR also enables new marketing capabilities for companies and can result in free marketing effects.	VR is beneficial for companies, who wish to enter the digital transformation. VR creates an open communication atmosphere and reveals insights on human interests.	VR has a significant impact on sales performance and drives a positive company reputation.	Using AR has a positive impact on brand reputation and impresses customers and employees, alike.
RQ4: What challenges do companies in Germany face, when implementing augmented reality and virtual reality projects?	Due to a low level of technology maturity, AR software development and operation is a challenge of its own. Employing AR hardware holds the danger of vendor dependency.	SportCo is challenged by the low maturity level of VR technology and the German market environment, which is experiencing a consolidation phase and is considered less fitting for VR than other regions. Furthermore, the lack of product support by VR vendors puts an extra burden onto SportCo.	TransportationCo has to deal with the low maturity level of VR technology and the common organisational challenges when introducing a technology to TransportationCo. The wide deployment of VR at consumers is hindered by the low penetration rate of VR hardware.	Working with the VR means additional effort; however, no major challenges were found within SanitaryCo.	SupplyCo is challenged by AR technology limitations and the conservativeness of the construction industry. Furthermore, expert staff is hard to get and introducing AR demands challenging strategic decisions to be made from top management.
RQ5: How can companies in Germany deploy and use augmented reality and virtual reality technologies for business model innovation?	Companies may get started with AR with the help of external expert suppliers and an agile software development approach. Furthermore, AR has the potential to improve and/or replace a pre-existing solution.	The interviewees of SportCo recommend getting started with VR pragmatically and to involve employees and customers wisely.	Just do it! Identify innovation potential within the company and get help from external experts. This is the approach that led TransportationCo to successful VR deployment.	A love for innovation is helpful when getting started with VR, striving for seamless integration into the daily routines is imperative for permanent use.	Start working with AR pragmatically, but with a clear focus on praxis applicability. Later on, ensure seamless integration into pre-existing processes and switch to professionalised in-house software development.

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Section Three:

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

1 Introduction

Global change is driven by an ever more interconnected world and by continuously emerging digital innovations (Brynjolfsson and McAfee, 2014) such as augmented reality (AR) and virtual reality (VR). Entrepreneurs who strive to reap the benefits associated with this change – as well as managers who strive to circumnavigate the associated risks of this rapid change – need to identify and apply new concepts to deal with these challenges (Streibich, 2017a). Business model innovation (BMI) is such a concept. Business models (BMs) are not static and need to be continuously innovated. Furthermore, they can be impacted by AR/VR technology. However, little is known about the impact of AR/VR technology on BMI. Therefore, the overall research aim is to better understand the impact of AR/VR technology on BMI. The research questions (RQ) ask:

RQ1: How are augmented reality and virtual reality technologies being applied by companies participating in the study?

RQ2: What are the anticipated effects of augmented reality and virtual reality technologies on business?

RQ3: What are the benefits of employing augmented reality and virtual reality technologies?

RQ4: What challenges do companies face, when implementing augmented reality and virtual reality projects?

RQ5: How can companies deploy and use augmented reality and virtual reality technologies for business model innovation?

The study adopts a subjectivist research approach; using a multiple-case holistic "Type 3" interpretive case study design (cf Yin, 2017, p.48), as explained in Section 2.2.4 of Paper 2. The five case studies focus on German companies using AR/VR technology for BMI. The applied method strives to generate qualitative insights into the contemporary phenomenon of the emerging technologies AR and VR and their impact on BMI (Wu *et al.*, 2016) in order to "understand and represent the experiences and actions of people as they encounter, engage, and live through situations" (Elliott *et al.,* 1999, p.216).

Chapter Three is structured as follows; Section 2 is dedicated to a cross case analysis of the case study data. This is followed by a detailed discussion of the cross case data analysis in Section 3. Section 4 then completes the document with conclusions, a presentation of contributions to theory and practice, recommendations for professional practice, and further concluding items and remarks.

2 Cross Case Data Analysis

Thematic analysis is the process of structuring the collect case data, disassembling it, and then reassembling it in different, meaningful ways (Castleberry and Nolen, 2018). In this section, the researcher presents a cross case analysis of the findings arising from the multiple case data, "to identify common and different themes among all of the cases" (Creswell, 2002, p.479). This approach reflects the recommendations of Creswell (2002), Stake (1995), and Yin (2017) as by conducting the cross case analysis after the individual case analysis (see Paper 4, Section 2), the researcher is able to explore the data with an open mind for as long as possible, without starting to interpret it too early.

The researcher adopted a manual approach to cross case data analysis (Basit, 2003) as he was working with a small data set in five case studies and because of a preference to be closer to the data (Creswell, 2002). Key themes were extracted onto notecards (Appendix G). The notecards were then grouped by common themes via several iterations (Appendix H). The aim was to recognise patterns or themes within the data (Fereday and Muir-Cochrane, 2006) which are interesting or important (Maguire and Delahunt, 2017). In this capacity, thematic analysis is significantly more than a summary of the collected case data (Maguire and Delahunt, 2017) and can generate novel insights well beyond the mere presentation of numbers (Castleberry and Nolen, 2018).

Applying Braun and Clarke's (2006) six phase approach to data analysis, the researcher got acquainted with the collected data throughout the entire collection and transcription process and continuously noted down initial ideas and observations (phase one). In the next step (phase two), data was coded systematically, first per case study (see Paper 4, Section 2) and later across cases (Table 1 below). Collating codes into themes and global themes (cf Guest *et al.* (2012), Appendix G, Appendix H) was implemented using a card sorting approach in phase three. In the fourth phase, themes emerging from the data were visualised on a thematic map (Figure 1 below) and probed for thematic interconnections. Defining, naming, redefining, and renaming themes never truly stopped (phase five) and arched well over into phase six, the production of the analysis report presented in this section. Table 1 exhibits the themes that emerged from the findings.

Table 1 – Themes emerging from the findings.

Global Theme	Case 1 – SteelCo	Case 2 – SportCo	Case 3 – TransportationCo	Case 4 – SanitaryCo	Case 5 – SupplyCo
Engaging with AR/VR requires openness to change	Companies may get started with AR with the help of external expert suppliers and an agile software development approach.	The interviewees of SportCo recommend getting started with VR pragmatically and to involve employees and customers wisely.	Just do it! Identify innovation potential within the company and get help from external experts. This is the approach that led TransportationCo to successful VR deployment.	A love for innovation is helpful when getting started with VR, striving for seamless integration into the daily routines is imperative for permanent use.	Start working with AR pragmatically, but with a clear focus on praxis applicability. Later on, ensure seamless integration into pre-existing processes and switch to professionalised in-house software development.
Unique properties of AR/VR technology	The research participants of SteelCo expect further AR technology improvements. Due to a low level of technology maturity, AR software development and operation is a challenge of its own. Employing AR hardware holds the danger of vendor dependency	The research participants of SportCo predict that VR will become part of our daily lives in form of numerous new applications. SportCo is challenged by the low maturity level of VR technology and the German market environment, which is experiencing a consolidation phase and is considered less fitting for VR than other regions. Furthermore, the lack of product support by VR vendors puts an extra burden onto SportCo.	The research participants of TransportationCo find the impact of VR onto TransportationCo's business model to be minor. However, they still expect that VR for the recruiting industry will increase in importance. TransportationCo has to deal with the low maturity level of VR technology and the common organisational challenges when introducing a technology to TransportationCo. The wide deployment of VR at consumers is hindered by the low penetration rate of VR hardware.	The owner of SanitaryCo finds that VR technology is mature enough to be used in the interior design industry and expects that its relevance will increase in the future. Working with the VR means additional effort, however, no major challenges were found within SanitaryCo.	SupplyCo is challenged by AR technology limitations. Furthermore, expert staff is hard to get. Further AR innovations are expected by the research participants.

Global Theme	Case 1 – SteelCo	Case 2 – SportCo	Case 3 – TransportationCo	Case 4 – SanitaryCo	Case 5 – SupplyCo
AR/VR technology employment has (hidden) benefits and offers new opportunities	SteelCo research participants state that AR employment results in a positive company image.	Working with VR is Fun. Further, VR offers an opportunity for B2B cooperation across different industries. VR also enables new marketing capabilities for companies and can result in free marketing effects. SportCo reportedly benefited from these free marketing effects. Furthermore, as a digital technology, VR enables SportCo to go global and tap into international markets. Founder2 believes that VR may potentially help reduce the ecological footprint of humanity.	TransportationCo applies VR to foster a positive brand reputation. VR is considered beneficial for companies, who wish to enter the digital transformation.	VR has a significant impact on sales performance and drives a positive company reputation.	Using AR has a positive impact on brand reputation and impresses customers and employees, alike. AR is seen as a source for new business opportunities.
AR/VR technology can be applied for various purposes	SteelCo applies AR is a new tool for measurements and to support decision-making in its customers. Further, AR helps optimise SteelCo's business processes as part of its digitalisation efforts. AR helps achieve strategic company goals. The expected AR technology improvements might offer opportunities for new product developments. However, AR in Case 1 could theoretically be replaced by an alternate technology, in the future. Furthermore, AR has the potential to improve and/or replace a pre-existing solution.	The founders of SportCo had been waiting for consumer-grade VR for several years and apply the technology to develop a visionary "physical eSport" product. SportCo seized the moment during a VR hype time to establish the company, secure venture capital.	TransportationCo applies VR to help achieve its strategic staffing objectives. VR increases the recruitment process efficiency in TransportationCo and is used as a visualisation and presentation tool. VR creates an open communication atmosphere and reveals insights on human interests [which yields in an optimised recruiting process].	In SanitaryCo, VR is used as a visualisation tool for customers. Furthermore, VR supports the interior design process.	In SupplyCo, AR is used to innovate SupplyCo's internal processes, to develop new products and digital services, and to achieve its strategic objective of being perceived as industry innovation leader. The research participants of SupplyCo describe how AR begins to transform SupplyCo and the entire construction industry. SupplyCo is challenged by the conservativeness of the construction industry and introducing AR demands challenging strategic decisions to be made from top management.

While grouping the notecards, subthemes emerged (cf Figure 6 of Appendix H). The list of global themes and associated subthemes and key findings is presented in Table 2.

Table 2 – Global themes, subthemes, and key findings.

Global Theme	**Subthemes**	**Key findings**
Theme One: AR/VR technology can be applied for various purposes	• Strategic objectives and implications • Development of new products and services • Optimisation of processes	• AR/VR can be applied in numerous ways and for multiple purposes. • Identifying innovation potential through AR/VR can be challenging. • BMI may originate on all levels of the organisation. • AR/VR technology is employed for two main strategic BMI objectives: one, optimising how something is done; two, for innovating something novel. The latter implies that firms also need to figure out how this can be done.
Theme Two: Engaging with AR/VR requires openness to change	• Approach • Best practice	• Engaging with AR/VR technology may require firms to adopt new approaches and consider best practice tactics. • Strategic guidance can help optimise the outcome of AR/VR employment. The guidelines developed by the researcher in Section 3.2.1 might help here.
Theme Three: Unique properties of AR/VR technology	• Technology usage may pose a wide range of challenges • AR/VR technology predicted to have a bright future	• Working with AR/VR presents unique challenges and opportunities. • AR/VR employment efforts and risks observed in the data varies widely. The researcher proposes that AR/VR employment risks should be managed. • AR/VR are still young technologies. • Further AR/VR developments expected in the future.
Theme Four: AR/VR technology employment has (hidden) benefits and offers new opportunities	• Positive impact on company reputation • Supports marketing efforts • Enables company growth	• AR/VR employment has visible and sometimes hidden benefits. • AR/VR employment offers new opportunities and enables company growth. • AR/VR can help tap into global markets and support the development of scalable, digital BMs. • The timing for AR/VR engagement should be wisely chosen. • AR/VR technology combined with BMI have the potential to transform firms and the entire industries. This comes with responsibilities.

Thematic analysis can be supported and presented through thematic maps (cf Braun and Clarke, 2006) and thematic networks[1] (cf Attride-Stirling, 2001), which are “web-like illustrations (networks) that summarize the main themes constituting a piece of text”

[1] the researcher will use the terms “thematic map” and “thematic network” synonymously.

(Attride-Stirling, 2001, p.386). This map then becomes a visual guide for the researcher to look at the data in a new way, as well as a tool for the reader to understand the researcher's interpretations of the presented data (Attride-Stirling, 2001). The thematic map developed by the researcher is presented in Figure 1. Global themes (Table 2) are shown within circles at the centre of the figure. Associated subthemes are shown in rectangles which are attached to the global themes. Further connections between subthemes indicate identified linkages between some subthemes. Finally, three arrows between the global themes symbolise that it might be useful to consider the topics identified in the indicated sequence from left to right. This is further explained in Section 2.5. Global themes and subthemes are further discussed in the following sections.

2.1 Theme One: AR/VR Technology Can Be Applied for Various Purposes

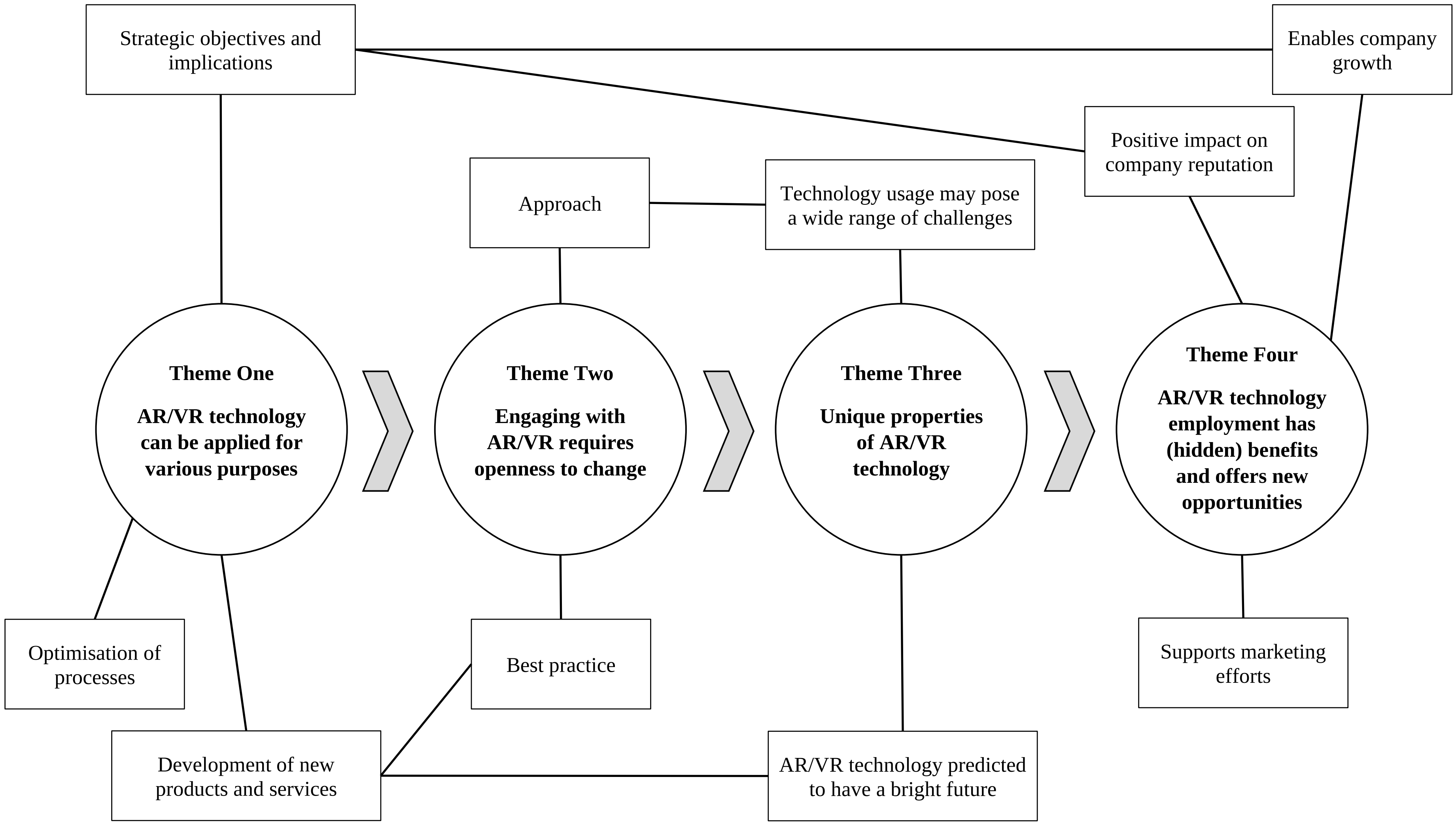
The data indicates that AR/VR technology can be applied for various BMI purposes. These include obtaining strategic objectives (which comes with implications), new product development, and the optimisation of processes.

2.1.1 Strategic Objectives and Implications

The interviewees report, that AR/VR technology is employed to achieve strategic objectives. TransportationCo and SteelCo, for example strive to be recognised as innovation leaders in their respective industries. SteelCo recognises the need to react to market needs and to respond to the competitive landscape (ProjectManager1). This is confirmed by the DepartmentHead2 of SupplyCo who states that not using AR might result in a competitive disadvantage. Furthermore, SupplyCo wants to become the leading partner for its customers.

SportCo used the hype around VR to secure venture capital funding (Founder2). SeniorDigitalManager1 states that the use of VR was pushed by upper management as part of the strategic objective of being perceived as a "top employer" (DivisionManager1). VR has helped achieve this strategic company objective. Furthermore, TransportationCo is faced with a huge staffing challenge of several thousand new jobs every year. Many of the job profiles offered by TransportationCo are very specialised, difficult to explain, and therefore hard to fill. VR can help here (MarketingOfficer1).

Figure 1 – Thematic map of the impact of AR/VR technology on BMI.



Engaging with AR/VR, comes with a set of implications. The technologies can transform entire industries, as exemplified by the construction industry: DepartmentHead1 assesses that digital services combined with AR might change the entire construction industry – an industry he considers rather inefficient at the moment. Consequently, industry resistance needs to be overcome. Furthermore, DepartmentHead2 notes that the construction industry is not very forgiving if a new technology fails to meet expectations.

AR application, however, also has the effect, that SupplyCo needs to undergo transformation as well, which is met by organisational friction ranging from issues concerning IT integration to not being taken seriously (Manager1). DepartmentHead1 further observes that job profiles within SupplyCo are changing and that it is challenging for the company to transform towards these new employee profiles. He states that currently the external company image does not attract the needed employees and that "someone who has done something … in the direction of computer science, digitisation, or something like that, may never identify SupplyCo in his life, because nobody thinks that SupplyCo does something like that." Lastly, AR/VR employment may require demanding strategic decisions from management. For example, in respect of SupplyCo's "strategic focus", DepartmentHead2 details that the fundamental decision has to be made whether to employ AR solely for SupplyCo's own core processes or also for spinning off new technology companies.

The data indicates that AR/VR technology employment actually is beneficial for the stated strategic objective to increase company reputation (cf SteelCo, TransportationCo, and SupplyCo). Furthermore, the technologies are enablers for company growth. These two points are further elaborate on in Section 2.4.1 and Section 2.4.3, respectively.

2.1.2 Development of New Products and Services

SportCo, SupplyCo, and SteelCo use AR/VR technology for the development of new products and services. As previously stated, SportCo has developed a new VR-enabled sports device designed for VR. This is particularly interesting, as this novel "physical eSports[60] device" may actually resemble an entirely new product category in itself. Thus far, eSport tends to be a sedentary activity while tangible sports devices have not been connected to the digital world to that great of an extent (according to the knowledge of

[60] refer also to Section 2.2.3 of Paper 4.

the researcher). SportCo's product combines these two worlds, thereby arguably creating an entirely new product category.

DepartmentHead1 of SupplyCo reports that AR technology is seen as an opportunity to develop new products and digital services. According to him, SupplyCo is a first mover in this direction, however, other industry players have also begun developing AR solutions. DepartmentHead2 underlines the importance of creating these "flanking digital services" and he believes that not having these services would result in a competitive disadvantage, in the future. Furthermore, according to Manager1, AR is an opportunity to innovate SupplyCo's products, which are otherwise matured to the extent that innovating them seems nearly impossible.

Lastly, while SteelCo mostly uses AR to optimise internal processes (see Section 2.1.3), the AR technology can act as an enabler for additional consumer services. In this context ProjectManager1 elaborates that SteelCo plans to extend the visualisation solution to social media functionality to facilitate decision-making by remote stake holders.

Looking at the thematic map (Figure 1 above), the researcher added links from "development of new products and services" to "best practice" and to "AR/VR technology predicted to have a bright future". The reasoning here is that the case data reveals potential best practice approaches to AR/VR software development (cf Section 2.2.2). Furthermore, research participants unanimously belief that AR/VR technology is "here to stay" and that numerous further applications and new product development opportunities are yet to come. This is further discussed in Section 2.3.2.

2.1.3 Optimisation of Processes

AR/VR technology can be applied to optimise business processes. SanitaryCo integrates VR into its bathroom design and sales processes. In this capacity, VR supports the imaginative capacity of Owner1's clients and helps him visualise concepts such as the barrier-freeness of a bathroom. But it is not only Owner1's clients who benefit from the VR experience. Owner1 uses VR during the design process to double-check created plans in VR. According to him, observations made in VR influence and improve his designs.

Similarly, TransportationCo uses the visualisation capacity of VR to increase the efficiency of the personnel recruiting process. TransportationCo is challenged by a huge number of different working environments which are not known to potential job candidates and often very difficult to access (Senior Digital Manager1). VR makes these working environments accessible at low cost, which directly results cost savings. Furthermore, Recruiter1 explains that observing how candidates use the company presentation in VR helps recruiters gain insights into the interests of job candidates. This in turn helps them assess the candidates' interests more efficiently, which speeds up the recruitment process. Lastly, VR is also employed to support internal company communication as it is a helpful tool to explain the numerous job settings within TransportationCo. This helps optimise internal processes.

Both, SupplyCo and SteelCo use AR to increase the efficiency of the internal product development process, from product design to manufacturing. In this context DepartmentHead1 explains the current trend of digitalising the construction industry is "ultimately all about the value-added chain of a project; it's about creating additional value with the support of digital technologies" (DepartmentHead1). He further elaborates that the focus lies on the technology side and the process side. Given this background, AR technology is used within SupplyCo to support existing company processes, to increase process efficiency of established processes, and to establish new processes, as well as to develop new products and services (DepartmentHead2). In the SteelCo case, AR is used to replace a pre-existing measurement solution. Here, the AR solution speeds up the measurement process and allows for integration into further digital sales tools and manufacturing systems. Furthermore, the sales process at the customer is improved by aiding the imaginative power of the end consumer through instant product visualisations.

2.2 Theme Two: Engaging with AR/VR Requires Openness to Change

The data indicates that engaging with AR/VR technology for BMI requires openness to change. Research participants describe approaches to getting started with AR/VR technology and disclose best practice tactics for AR/VR project implementation. These approaches and tactics, however, may require organisational change and willingness of humans to adopt new practices.

2.2.1 Approach

DivisionManager1 of TransportationCo states that it is difficult to convince decision-makers to invest into a new technology that they do not understand. Therefore, she decided to "just get started" and initiated the project in a quick, pragmatic, and cost-efficient way without adhering the usual approval processes. Similarly, research participants of SupplyCo and SportCo recommend starting AR/VR employment pragmatically, too. Founder1 of SportCo would have preferred to design the new SportCo product around prospective customers, however, the product idea was so new at the time, that they could neither identify a clear market, nor a concise customer base. VR technology lends itself to a pragmatic start because the technology requires "comparatively little investment" (Founder1) which is in part owed to the availability of low-cost consumer-grade hardware (Founder2).

Research participants of SportCo and SupplyCo, however, emphasise that despite all pragmatism it is imperative to strive for a user-centric product design (Founder1, Founder2) and a clear focus on applicability to praxis (Manager1, DepartmentHead2). Employees and customers should be encouraged to contribute ideas, however, this involvement needs to be carefully managed (Founder1).

Looking at the thematic map (Figure 1 above), the researcher added a link from "approach" to "technology usage may pose a wide range of challenges". The researcher believes that the just presented approaches (just get started, be pragmatic, involve employees and customers, and focus on applicability to praxis) are helpful in meeting the challenges that come with the usage of AR/VR technology. Further details on technology related challenges are included in Section 2.3.1.

2.2.2 Best Practice

SteelCo and TransportationCo have their applications developed by external experts, SanitaryCo employs a third party software solution, and SportCo and SupplyCo develop their own software. So which tactic is the best? Based on the findings, the researcher would like to argue "it depends".

Owner1 of SanitaryCo, for example, strives to continuously improve his service offering for his customers. The out of the box addon to the software package already in use provides a straightforward way to VR employment with relatively little effort. Furthermore, developing his own VR application is arguably beyond the capabilities of SanitaryCo. Similarly, the research participants of TransportationCo indicate that working with external companies was helpful in the development of the new technical solution for which the necessary capabilities were not present in the department. In this case, however, the software was custom-built for TransportationCo (Recruiter1) and involved three different external suppliers (SeniorDigitalManager1). In this context, it is interesting to note that TransportationCo is frequently approached by startup companies that offer solutions to TransportationCo, to which no problem exists (SeniorDigitalManager1).

SteelCo also decided to work with two external software development partners (Engineer1) because of the need for very specialised expertise (ProjectManager1). Once identified, the project implementation of the partners was conducted in an agile way.

SportCo and SupplyCo chose to develop the software in-house. In the SportCo case, the researcher did not discuss this choice in depth with research participants, because it felt like the only obvious choice for a startup. Looking at SupplyCo, building up an internal software development team is a clearly formulated strategic decision. DepartmentHead2 explains that the AR software solution is very close to the core competence of SupplyCo. Hence, he argues, SupplyCo is better off with building up its own software development team, rather than working with potentially slower external companies. Furthermore, DepartmentHead2 prefers to avoid supplier dependency. Lastly, the research participants of SanitaryCo and SupplyCo explicitly state the importance of a seamless integration of the new technology into pre-existing structures.

2.3 Theme Three: Unique Properties of AR/VR Technology

The data indicates that AR/VR technology has unique properties that need to be considered when engaging with these technologies for BMI. Working with AR/VR may pose a wide range of challenges; however, research participants still believe that the technologies will have a bright future.

2.3.1 Technology Usage May Pose a Wide Range of Challenges

The research participants report a wide range of challenges encountered when working with AR/VR technology. In all cases – except in the SanitaryCo case where Owner1 acknowledges that working with VR requires additional effort but feels that the technology is mature enough for his application purpose – the research participants report a low level of technology maturity. For example, ProjectManager1 of SteelCo explains that the AR hardware does not meet the measurement accuracy needs of SteelCo. Consequently, SteelCo underwent tremendous effort to implement its own software technology. This was accompanied by numerous additional technical hurdles such as the common limitation of AR headsets to properly operate in poor lighting conditions and the short battery life of the headset hardware and associated input devices (ProjectManager1). A significant risk encountered by SteelCo is the dependency on the AR hardware manufacturer (ProjectManager1, Engineer1). The first generation of the AR headset employed by SteelCo is no longer accessible, while the second generation of hardware is announced, but not available yet (Engineer1).

The research participants of TransportationCo also report a low level of technology maturity and explain that the consumer-grade hardware is not designed to withstand the continuous operation needed, for example in an expo setting (Recruiter1). Furthermore, the broad range of available hardware makes it challenging to choose the right hardware for the occasion (SeniorDigitalManager1). Even more challenges arise from the environment under which the technology is employed, for example wireless LAN connectivity issues (DivisionManager1); from VR content production, which tends to be data intensive (Recruiter1); and from the low penetration rate of suitable hardware at the end consumer which hinders a broader distribution of the VR solution (SeniorDigitalManager1).

The research participants of SportCo also report the low maturity of the technology to be a challenge and bemoan the lack of product support by hardware vendors, which results in additional workload for SportCo (Founder1). According to Founder2, the most significant challenges are a lack of systems inter-compatibility and diversity. The research participants of SupplyCo have also encountered their share of challenges caused by technical limitations of AR including difficult data handling due to large data files (DepartmentHead1) which stands in stark contrast to the limited computing capabilities of the AR devices (Manager1). From an organisational viewpoint, DepartmentHead2 reports that it is difficult for SupplyCo to find staff who holds the needed technology expertise. This is in part due to the fact that SupplyCo is not perceived as a software company by software developers.

2.3.2 AR/VR Technology Predicted to Have a Bright Future

Despite the challenges reported above, the research participants believe that the importance of AR/VR technology will increase. DepartmentHead1 reports that SupplyCo's AR app is only a first step and that further developments are planned. He expects AR hardware improvements within the next three years and forecasts that AR will eventually be backed by additional scanning hardware. DepartmentHead2 asserts that AR technology will remain part of the digital agenda of SupplyCo, however, he also discloses that further AR use will depend on how the technology evolves in the future. Furthermore, he points out, that technological innovations are also to be expected in other areas such as robotics.

The research participants of TransportationCo don't attribute a major impact of the researched VR case onto TransportationCo, however, they still predict that VR will continue to play a role in recruiting and that this role's importance will increase. Owner1 assesses that VR is very important for the interior design and planning industry and hence will not disappear. Owner1 plans to install a VR-centred presentation room. Engineer1 of SteelCo also expects that AR hardware will become better over time while Founder2 of SportCo is convinced that VR technology will become part of our daily lives. Lastly, Founder1 and Founder2 foresee numerous future VR applications, for example in the health sector, in the field of digital assistance, training and simulation, and virtual tourism.

2.4 Theme Four: AR/VR Technology Employment Has (Hidden) Benefits and Offers New Opportunities

The data indicates that AR/VR technology employment has (hidden) benefits and offers new opportunities for BMI. Benefits include a positive impact on company reputation and support of marketing activities. Furthermore, the technologies enable company growth.

2.4.1 Positive Impact on Company Reputation

A positive impact on company reputation accompanying AR/VR employment is reported in all research cases. SteelCo and TransportationCo even explain that a positive company image is explicitly part of the firms' strategy, as previously reported in Section 2.1.1 above. ProjectManager1 of SteelCo explains that this AR project is one of the most innovative in the business unit's history and Engineer1 states that the mere fact that SteelCo is working with such innovative technology positively impacts company reputation. Owner1 of SanitaryCo reports that this positive impact holds true for customers and employees, alike.

While on site at SportCo, the researcher observed great passion for VR in both founders. Clearly, the team enjoyed working with the technology. Founder2 reports that he benefits himself personally from VR (in SportCo's product) because it enables him to virtually visit exotic regions. Taking a visionary outlook, Founder2 beliefs that VR could be an answer to the growing hunger for resource consumption of consumers and help reduce the ecological footprint of mankind, significantly.

2.4.2 Supports Marketing Efforts

DepartmentHead1 and DepartmentHead2 of SupplyCo state that AR technology impresses and causes a "wow-effect" in customers and employees, alike. This helps marketing efforts. As a matter of fact, in SupplyCo the initial idea[61] to employ AR had been born in the marketing department with the aim to impress customers (DepartmentHead2). Founder1 explains that the digital VR component of SportCo's product enables them to reach out into social media, for example to implement online eSport competitions. Besides free marketing effects, this enables entirely new marketing capabilities. Founder2 even beliefs that without the marketing push of the early VR hype phase SportCo would not exist, because it would have been too challenging to secure risk capital. In this context, SteelCo also plans to reach out to new digital marketing channels by adding a so called "Influencer UI" (ProjectManager1) to the system, in the future. This new user interface shall deliver the video content created on the AR headset/tablet solution to social media channels. This is hoped to support the decision making process of prospective buyers by enabling them to share the planned staircase elevator with family and friends. SanitaryCo actively advertises its VR planning and presentation capability on the company's website and vehicles. According to Owner1, this represents an effective marketing campaign.

2.4.3 Enables Company Growth

According to DivisionManager1, the VR project set a general impulse within TransportationCo, namely the realisation that innovation scouting is important. She even refers to this as a "wake-up call". In this capacity VR can be used as an entry point to the digital transformation in a wider sense and aid company growth. Owner1 of SanitaryCo observes a direct impact on his sales performance and attributes much of his company's success to VR. The management of SupplyCo and SteelCo see in AR a potential source of new business opportunities and Founder2 of SportCo explains that VR enables them

[61] The researcher acknowledges that within SupplyCo several AR activities were launched simultaneously in different departments and by different people, independently from each other. This is further reflected on in Section 3.5.5.1 of Paper 4.

to go digital and thus global with their product. This is particularly helpful as the physical exercise equipment business is otherwise very difficult to scale.

Founder1 of SportCo further explains that the VR component of their solution builds a bridge for cooperating with other sectors, for example with the tourism sector where businesses in tourist regions already have created VR content to promote the tourist region. ProjectManager1 of SteelCo believes that the know-how gained from the AR project will be beneficial for the company beyond her business unit. In fact, other business units have already reached out to ProjectManager1 asking her to share her expertise.

2.5 Thematic Analysis Summary

The thematic analysis of the case data reveals that AR/VR technology can be applied for various BMI purposes, such as optimisation of processes, development of new products and services, and to meet strategic objectives. However, engaging with AR/VR for BMI requires openness to change. The data reveals possible approaches to AR/VR engagement, as well as best practice ideas for project implementation. When engaging with AR/VR for BMI, the technologies' unique properties and a wide range of potential challenges should be considered. However, the technologies are predicted to have a bright future. AR/VR technology employment has (hidden) benefits and offers new opportunities. For example, employing AR/VR technology for BMI has a positive impact on company reputation, supports marketing efforts, and enables company growth.

Referring to the thematic map (Figure 1 above), the researcher added three arrows between the global themes. The researcher would like to argue that it is useful to consider the topics identified in the indicated sequence from left to right. The argument is that the management of a given company first needs to recognise that AR/VR technology can be applied for BMI. Once a decision is made to engage with AR/VR, companies may have to be open for change, for example they may need to be willing to adopt an agile software development process, might have to hire new staff, or be willing to start working with new external expert companies. Whatever the case, as a next step companies should be certain that their approach is properly aligned to the unique properties of AR/VR technology. The researcher contends that it is only then that the company truly has a chance to fully capture the (hidden) benefits of AR/VR technology employment.

2.6 Pattern Coding: Creating Super Codes

Miles *et al.* (2018, p.79) state that "First Cycle coding is a way to initially summarize segments of data. Pattern Coding, as a Second Cycle method, is a way of grouping those summaries into a smaller number of categories, themes, or concepts". The researcher applies this idea to the individual themes and final codes generated on a per case basis during the initial "pre-cross-case-analysis". The statements extracted from the individual case studies and previously analysed and encoded were combined and pattern-encoded into super codes overarching all case studies. Table 3 outlines how the final individual case study codes were collapsed into "cross case super codes". Case references are provided in parentheses, (please refer to Paper 4 for detailed case descriptions).

Table 3 – Generating super codes

Collapsed codes	Included codes
Application	Application of VR (Case 4) Company transformation (Case 5) Employment (Case 2) Implementation (Case 4) New tool for process optimisation (Case 1) Strategy (Case 2) Technology employment (Case 3) Usage (Case 5)
Assessment	Assessment (Case 2) Assessment (Case 3) Assessment (Case 4) Future forecast and plans (Case 5) Outlook (Case 1)
Benefit	Benefit (Case 2) Benefit (Case 5) Business impact (Case 4) Company development (Case 1)
Challenges	Adjacent challenge (Case 3) Challenge (Case 4) Challenge (Case 1) Challenge (Case 2) Challenge or risk (Case 5) Technology-specific challenge (Case 3)
Deployment	Approach (Case 1) Approach (Case 5) Deployment (Case 2) Technology deployment (Case 3)

2.7 Skimming for Surprises and Overarching Issues per RQ

In this step, findings are regrouped per RQ and skimmed for surprises or overarching issues. Details of this process are included in Appendix I. In respect of RQ1, AR/VR are applied as visualisation and presentation tools, to support decision-making, and to aid sales and design processes. AR/VR are used for the development of new products and services. Ultimately, employing AR or VR can help achieve strategic company objectives and fosters a positive company brand reputation.

In respect of RQ2, the assessed impact of AR/VR on the case study companies differs. The interviewees of SteelCo and TransportationCo attribute no major impact of the technologies on its current business models; the founders of SportCo explain that SportCo would not exist without VR; Owner1 believes that VR technology is a key driver for his sales success; and the research participants of SupplyCo state that AR technology is transforming the entire company, and the entire construction industry. Research participants predict that AR/VR are here for the long term and will offer numerous new application opportunities. Future technology improvements are expected.

In respect of RQ3, the case data reveals that AR/VR foster a positive company reputation and that employing AR/VR results in a broad range of benefits. These include being fun, promoting synergies, functioning as an emotional icebreaker, and revealing insights on job candidates' interests. However, it is unclear how fundamental these benefits are in the long run. In the SanitaryCo case, Owner1 states that VR plays a significant role in his sales success. When on site at SanitaryCo, however, the researcher got to know Owner1 as an enthusiastic, entertaining, and professional expert, passionate for what he does. Arguably, Owner1's success can be primarily attributed to his personal attitude and professional aptitude. In respect of RQ4, the case study data reveals numerous challenges encountered when working with AR/VR. Some of these challenges; such as vendor dependency, a low level of technology maturity, general technical limitations, and user expectations, are directly related to AR/VR technology. Others are adjacent challenges such as the difficulty to identify suitable software development partners, challenges posed by pre-existing corporate structures, general organisational and legal issues, and industry resistance. Decision-makers describe strategic challenges such as deciding where to take the technology next.

RQ5 addresses the issue of how to deploy AR/VR for BMI. The data reveals that getting started pragmatically, developing agile and working with the help of external experts is considered a feasible approach. Furthermore, finding a suitable use case, focusing on applicability to praxis; and striving for seamless integration, are all considered important aspects. While conducting this research, the researcher noted that the introduction of the AR/VR had been driven by enthusiasts in most cases. A description of how initial AR/VR implementations are rooted in technology enthusiasm is included in Appendix J.

2.8 Firm Level Analysis

The researcher analysed the cross case data per firm on a strategic level, a product level, and an operations level. To help the researcher's thinking regarding these firm levels, the researcher uses a three-strategic-levels (corporate level, business level, and operation level) approach and combines strategy level thinking with firm level analysis. Details on this cross case firm level analysis strategy are include in Appendix K. To help understand commonalities between – and uniqueness of – tagged findings, the researcher derived a visualisation strategy. Details of the visualisation strategy are included in Appendix L.

2.8.1 Strategy Level Findings

On this firm analysis level, the case data reveals that marketing benefits resulting from AR/VR technology employment are reported in all cases. Furthermore, interviewees in all cases recognised that the timing of the technology employment plays a significant role; either in respect to free marketing effects and/or in the acquisition of (external) funding. In all cases, except SportCo, AR/VR was employed for process improvements.

A commonality between SteelCo, SportCo, and SupplyCo is that they use AR/VR technology for new product development and to create new intellectual property. On the contrary, TransportationCo and SanitaryCo did not use AR/VR technology to develop a new product on their own – they use third-party AR/VR solutions as a new tool to support existing processes or to offer a new service. The researcher notes that he has no knowledge regarding ownership of intellectual property in the TransportationCo case. However, the researcher is aware that the entire solution including the VR content was implemented and generated by external suppliers. TransportationCo did not express any interest in the intellectual property and no further project development is planned.

Lastly, SupplyCo and SteelCo, the two companies that each invested a tremendous amount of resources for the product development, stated that dependency on the AR headset vendor poses a significant risk for them. This was at the time when the first hardware generation of the AR headset used had been discontinued and the second hardware generation had been announced for a long time, but no official shipping date was available. Furthermore, fundamental changes to the hardware and necessary software platform were announced and it was unclear whether the implemented software would still work on the new system.

2.8.2 Product Level Findings

On this firm analysis level, the case data shows that SupplyCo is unique in that it is the only company that actively tries to change the processes of its customers. TransportationCo is the only company that has no further development plans for the VR solution, despite the fact that its employment is considered useful. SanitaryCo is the only company that did not report a struggle with the maturity level of AR/VR. SportCo is the only company that did not explicitly state that the visualisation capacity (in the sense of supporting the imaginative power of humans) of AR/VR was of central importance. A feature unique to the VR cases is the emotionalising effect of VR, apparently a phenomenon not observed in the AR cases.

TransportationCo, SteelCo, and SanitaryCo reported user acceptance challenges. The two companies that want to sell a VR/AR enabled product or service, namely SportCo and SupplyCo, indicate the importance of user centric product design. Lastly, the researcher was surprised to find that the so-called problem of user isolation in VR as often cited in the media was reported as not being an issue in any of the VR cases.

2.8.3 Operations Level Findings

On this firm analysis level, the case data shows that in all of the case studies it is challenging to work with AR/VR and its necessary surrounding IT infrastructure. As previously stated, Owner1 of SanitaryCo was the only one who does not struggle with the low level of hardware maturity. However, he states that setting up the system and the additional IT infrastructure connectivity did pose an initial challenge. Again, the three large companies, SteelCo, TransportationCo, and SupplyCo, report a challenge unique to them; namely the need to overcome general organisational resistance. The AR cases (SteelCo and SupplyCo) have in common that AR is used to digitalise company internal processes thereby replacing pre-existing processes. A challenge reported by the companies that develop in-house, SportCo and SupplyCo, is finding and hiring qualified personnel for software development. Lastly, except for the SportCo case, AR/VR is used to speed up daily company internal tasks and to support the sales teams. Furthermore, integration of the new technologies into established company processes is deemed important, again in all cases except the SportCo case. The researcher contends that this uniqueness can be explained by the fact that SportCo is a small start-up and it is the only case where a product for end consumers is being developed.

3 Discussion

In this section, the researcher presents a discussion of the findings analysed in Section 2. This section concludes with a definition of BMI for AR/VR technology in Section 3.6 and a BMI framework for AR/VR technology in Section 3.7.

3.1 Theme One: AR/VR Technology Can Be Applied for Various Purposes

3.1.1 Identifying Innovation Potential

The researcher chose to term Theme One "AR/VR technology can be applied for various purposes" because the case data unearthed numerous ways in which AR/VR can be applied. However, identifying innovation potential through AR/VR technology can be a challenge. Capgemini (2018) observes a lack of awareness in companies regarding what is AR/VR are and reports that while organisation are eager to test AR/VR, they are not able to identify fitting use cases. Given the newness of the technology, this is hardly surprising (Capgemini, 2018). However, awareness for the technologies continues to increase. This is, for example, indicated by the observation that 42 per cent of the German population has heard of AR and 8.5 million people (e.g. approximately ten per cent of the German population) have already used an AR application (Gaming-grounds.de, 2020).

The active innovation scouting (as indicated by DivisionManager1 of TransportationCo) and continuous engagement with BMI is useful for firms to identify innovation potential. Furthermore, the findings serve as a first source of ideation and inspiration. A deeper discussion of how to approach BMI through AR/VR is offered in Section 3.2.1.

3.1.2 An Antecedent of BMI

Where in the organisation is innovation initiated? One of the literature gaps identified by Foss and Saebi (2016, p.201) concerns the drivers of BMI: "does BMI exclusively originate in the upper echelons, or may it also originate in lower levels of the organization?" As per Section 2.7, AR/VR BMI originates in four of the five cases out of enthusiasm for the technologies. In SportCo, TransportationCo, SupplyCo, these origins are at lower levels of the organisations. In SupplyCo, the initial AR implementation efforts were supported by an employee's brother, who did not even work for SupplyCo at the time. This indicates that technology enthusiasts on all levels of the organisation may become drivers of BMI. The researcher would like to add that in his experience it is often times external companies that carry AR/VR innovation into larger firms.

3.1.3 New or Novel? Understanding the Impact of AR/VR Employment Options on BMI

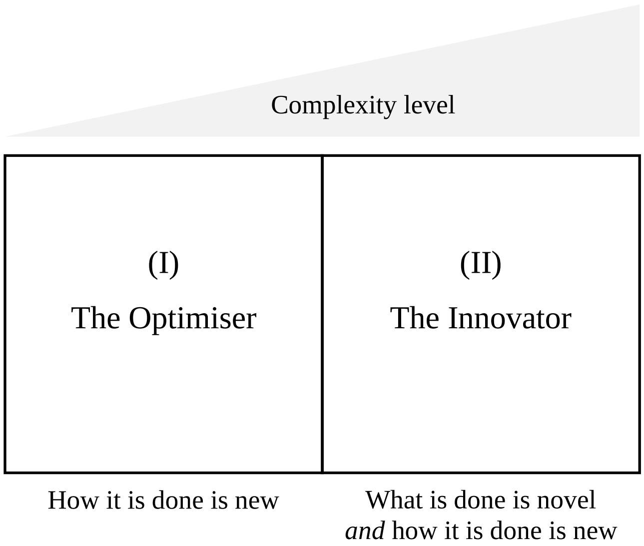
At least two fundamental dimensions for BMI exist (Foss and Saebi, 2016): novelty and newness. But what are newness and novelty? New or novel to whom? To the firm, to the industry, or to the world; as proposed by Joseph Schumpeter as innovation dimensions (Foss and Saebi, 2016, p.216)? After reflecting on the charts for BM novelty versus BM newness, BM novelty versus BMI outcome, and BM newness versus BMI outcome (see Appendix M), the researcher offers a pragmatic approach to looking at these questions. The researcher argues that from an organisations' perspective it is of primary interest to assess what is the *result* of a given BMI effort. Looking at BMI from this angle, the following two questions arise: "what does the firm need to do to achieve the desired result?" and "how does the firm get there?" Taking these questions and linking them to the BM concept, the researcher proposes the following definitions for "novel" and "new":

1. novel: what the BM does is novel; it has not been done by anyone yet;
2. new: how things are done in the BM is new; it has not been done this way before.

Freeing the newness and novelty concepts from innovation dimensions (e.g. firm, industry, world) facilitates a holistic view on generic contexts for BMI strategies. Said differently, it is up to the evaluator to decide, compared to whom or what the BM shall be novel or new. The researcher admits, however, that this will likely often have an industry related context. Taking "novel/what" and "new/how" as dimensions, the researcher spans a two by one matrix to form a BMI taxonomy. The objective of this new taxonomy is to build a foundation to help better understand the impact of AR and VR technologies on BMI. The taxonomy matrix is presented in Figure 2.

Taking a closer look at Figure 2, two strategic BMI options become apparent. One, the firm can decide to *optimise* what it does, e.g. do the same thing, but use AR/VR to do it in a new way (quadrant I); or two, the firm can decide to be an *innovator* and use AR/VR to do something novel (quadrant II). However, doing something novel in the context of AR/VR technologies comes with consequences. On the opportunity side, the findings show that working with AR/VR as new technologies results in free marketing effects and can help secure investments, and working with these digital technologies may open up new avenues to new monetarisation strategies.

Figure 2 – A BMI taxonomy to help understand the impact of AR and VR on BMI.



However, working with these new technologies also means that companies need to figure out *how* to apply the technology. This increases project complexity, is accompanied by numerous challenges, and may require fundamental changes to the organisation. Thus, implementing a novel BM with AR/VR is always accompanied by the newness aspects of AR/VR, in addition to the challenges of developing a new product/service. The findings from the BMI taxonomy (Figure 2) update the BMI outcomes on the BMI framework for AR/VR (Section 3.7).

3.2 Theme Two: Engaging with AR/VR Requires Openness to Change

3.2.1 Approaching AR/VR Engagement Requires Strategic Guidance

The researcher chose to term Theme Two "engaging with AR/VR requires openness to change" because of the approaches and best practice tactics discovered in the data. These approaches and tactics may or may not be present in a given firm. However, the successful implementation of an AR/VR project likely depends on a fitting approach and proper implementation tactics, as a mal-fitting innovation-management-process may result in a lack of capturing value from innovation (Chesbrough, 2003). As an example, DepartmentHead2 of SupplyCo confides that "in retrospect, this [the initial AR efforts] should have been pushed much, much more structured and forcefully". Furthermore, DepartmentHead1 concedes that VR should not have been neglected, initially. To the researcher this indicates that clear strategic guidance can help optimise the outcome of AR/VR employment.

As previously argued in Section 2.5, the researcher believes that it is useful to consider the themes identified in the sequence indicated in Figure 1 above (p.309). The argument is that companies first need to recognise that AR/VR could be applied to the given company, which can be challenging as discussed in Section 3.1.1. Should the company decide to engage with AR/VR, it then becomes imperative that the company ensures a proper alignment of its approach to the unique properties AR/VR. As the researcher contends, it is then that the company has the best chance to fully capture the (hidden) benefits of AR/VR employment.

Taking these thoughts to praxis, the researcher induces simple guidelines to approaching AR/VR engagement for BMI. These guidelines are offered in Table 4.

Table 4 – Strategic guidelines to approaching AR/VR technology engagement.

Step	Important aspects	Comments
1. Identify the innovation potential of AR/VR technology	Consider the firm's strategic objectives and identify application opportunities, for example process optimisation or new product development potential.	An example underlining the importance of this first step is revealed by DivisionManager1 who reports that the VR project poses a "wake-up call" within TransportationCo and set the general impulse to recognise the importance of innovation scouting.

Step	Important aspects	Comments
2. Decide whether to engage with AR/VR technology	Be aware that AR/VR engagement might require organisational change and facilitate the needed approaches and best practice tactics.	The SupplyCo case demonstrates how dramatic the impact of AR/VR engagement might become: DepartmentHead1 believes that AR technology has the potential to transform the entire construction industry. Furthermore, SupplyCo as an organisation might have to change fundamentally (DepartmentHead2).
3. Consider the unique properties of AR/VR technology	Know what you are getting yourself into and address the numerous, potential challenges that may come along with AR/VR employment. As the technology is still young, long term planning might be necessary.	The SteelCo case is an example of an AR project of enormous effort. It also reveals the high risk which lies in the matter: the extreme dependency on a single hardware vendor could wipe out all successes thus far, at any time.
4. Reap the benefits of AR/VR technology employment	Look beyond the strategically desired benefits of AR/VR employment, as using these technologies may have additional benefits, such as a positive impact on company reputation and support for marketing efforts. Furthermore, AR/VR can contribute novel ways for company growth.	The SportCo case exemplifies how VR can be used to create an entirely new product category: “physical eSport”. Furthermore, VR enables SportCo to pursue novel digital revenue models that scale significantly better than the tangible sports device business.

3.2.2 Assessing the Communication Function of BMs

The case data does not show that the BM construct is used as a communication tool (this is further discussed in Section 3.5.1). This may be the case because business modelling is not done formally in the researched cases. However, the researcher contends that communication is always an important aspect when striving to implement a strategy. Clearly, the BM cannot fulfil its mediator between strategic objectives and technology function, if no one is informed about the strategic objectives. Furthermore, strategy communication can be done without the BM as a tool. The researcher acknowledges that the BM *can* be used as a communication tool, however, he contends that the communication function should be integrated into the mediator between strategic objectives and technology capacity of the BM concept. Consequently, the researcher removes the communication function from the BMI framework as per Section 3.7.

3.3 Theme Three: Unique Properties of AR/VR Technology

3.3.1 Managing Risk

The researcher chose to term Theme Three “unique properties of AR/VR technology” because the data shows that working with the technologies presents unique challenges and opportunities. These properties are expected to develop further in the years to come, which makes AR/VR engagement a dynamic endeavour. As per Section 3.2.1, organisations may have to prepare properly to deal with these unique properties.

This research includes cases in which the researched company underwent significant effort to implement its project (SteelCo, SportCo, SupplyCo), thereby running high technology dependent risks[62] (SteelCo); as well as cases in which relatively little effort (TransportationCo, SanitaryCo) and technology related risks (SportCo, TransportationCo, SanitaryCo, SupplyCo) were taken . Taken to the extreme, much of the effort spent by SteelCo on implementing a proprietary measurement solution for the chosen AR headset can be in vain, if the chosen AR headset manufacturer were to decide to discontinue the hardware or, as in the case of Meta[63], were to declare bankruptcy. On the other hand of the spectrum, SanitaryCo employs an off-the-shelf hardware and software solution which Owner1 considers mature and ready to be used by end consumers. Arguably, SanitaryCo’s effort and risk investments are limited. The solutions implemented by SportCo and SupplyCo are compatible with numerous AR/VR devices, which spreads the risk but scales software development and maintenance efforts. In the TransportationCo case, the researcher got the hunch that much of the effort and risk was forwarded to the external suppliers which, according to Recruiter1, spent much overtime at no additional cost for the opportunity to work for TransportationCo. Recruiter1 also reports that he spent much of his spare time on this project out of enthusiasm. According to DivisionManager1, no further VR development steps are planned. It seems to the researcher that the VR project has already successfully served its time-limited purpose.

3.3.2 Future Developments

Even though the ideas behind AR/VR technology have been around since the 1960s (cf Morton L. Heilig, 1961; Sutherland, 1968), the research participants still consider AR/VR

[62] risk and effort assessments made by the researcher's discretion/expertise.
[63] the company declared bankruptcy in January 2019 (Heise Online, 2019), however, the technology has been revived by a new company in May 2019 (Robertson, 2019). Still, the hardware is currently not further developed, actively, and is not available for purchase, for the time being.

to be relatively young technologies. This is reflected on the one side by the numerous technology imperfections reported by the research participants and on the other side by the optimistic future expectations revealed by the case data. While it is impossible to foresee what the future brings, it is likely that AR/VR hardware will continue to be miniaturised (Founder2) and that computing power will continue to grow.

The significance of the AR/VR application differs noticeably across cases. The founders of SportCo state that the company would not exist without VR, while the interviewees of TransportationCo attribute little impact of VR onto the company. This may not be very surprising given the vastly different company sizes; however, this significance difference indicates that business opportunities can be found when AR/VR technology is applied to a fitting context. For example, given the assessments by DivisionManager1 and Recruiter1 that VR will play an important role in the future recruiting processes of firms, reveals an obvious cross-industry business opportunity. Similarly, the SanitaryCo application could be a signpost towards a new universal presentation service for the design industries. Looking at SupplyCo, AR may just be on the brink of disrupting the construction industry, and considering the SteelCo case AR employment contributes to meeting an important strategic company goal; namely the reduction of the order-to-delivery time from more than 40 days to 14 days (ProjectManager1). This said, the researcher believes that new product or service development efforts should be BMI driven, rather than technology driven, when employing AR/VR technology.

3.4 Theme Four: AR/VR Technology Employment Has (Hidden) Benefits and Offers New Opportunities

3.4.1 Leveraging Digital Technology for Scalable BMs and Global Reach

The researcher chose to term Theme Four "AR/VR technology employment has (hidden) benefits and offers new opportunities" because the data reveals that AR/VR employment has visible and sometimes hidden benefits and offers new opportunities enabling company growth. The researcher considers the following observation made while analysing the case data particularly noteworthy. The founders of SportCo define the company's objective to be the development of new hardware products and associated software, which are related to physical training, gaming, and physiotherapy. "Hardware" in this context primarily[64] refers to tangible sporting devices, rather than computer hardware. What is quite remarkable is the fact that SportCo strives to tap into globally scalable digital markets by leveraging the digital capabilities of VR technology. According to Founder1, VR offers the opportunity to gamify sport exercises, which ultimately opens up the possibility to facilitate virtual competitions online. This taps into the business potential of eSports (Founder1), a significant industry sector, which is forecasted to have a revenue of more than US-$ 1bn in the year 2020 (Statista, 2020b). The industry that builds exercise equipment is an appliance business with few revenue stream options once the devices are sold (Founder1). VR technology, however, has the potential to enable SportCo to offer new BMs such as membership/subscriptions which can lead to re-occurring revenue streams (Founder2).

In a similar fashion, DepartmentHead1 of SupplyCo explains that developing digital, AR-based services enables a new dimension of innovation for SupplyCo. This is particularly attractive because SupplyCo's products are very mature and offer a little remaining innovation potential by themselves (Manager1). ProjectManager1 of SteelCo has also identified BMI potential arising from AR employment. A future objective of SteelCo could be to "lock in key resellers" by supplying them with SteelCo's unmatched AR solution (ProjectManager1). The researcher contends that applying AR/VR technology in the capacity of a digital service holds the potential to lift companies that manufacture tangible products into entirely new business and revenue domains.

3.4.2 Timing Matters: BMI and First Mover Advantage

Research participants in all cases report that being early adapters of AR/VR technologies has advantages. For example, the mere fact that a new technology is employed leads to awareness in the media. Does this mean that companies should jump on new technologies as early as possible? Suarez and Lanzolla (2005, p.122) identify "two factors that powerfully influence a first mover's fate: the pace at which the technology of the product in question is evolving and the pace at which the market for that product is expanding". Looking back, AR/VR technologies improvements and market growth over the past three years lags behind the researcher's expectations. The shipping of the second generation of the AR headset Microsoft HoloLens, for example, was delayed by more than one year;

[64] SportCo also developed its own VR hardware controller, however, this controller had been considered already obsolete at the time of the interview. According to the founders, further computer hardware developments are planned.

and the other two major AR headset players failed to deliver on their promises: the AR headset start-up Meta had to declare insolvency (Heise Online, 2019). For VR, a similar picture exists.

These developments are also reflected in the market data predictions. Forecasts for annual AR/VR revenue by the year 2020 ranged from $40bn (SuperData LLC, 2017) to $120bn (Digi-Capital LLC, 2016). More recent estimates assess annual revenues for the year 2020 of $19bn (Statista, 2020a). From a BMI angle these numbers may not necessarily be that relevant for all cases. SteelCo and SupplyCo for example, use the hardware to optimise company internal processes. As long as the chosen technology is available and can deliver that, this objective is met. To sum it up, the researcher contends that employing AR/VR for BMI requires strategic considerations that include the primary technology employment objectives as well as assessments regarding technology maturity and market evolution. Furthermore, the entry point with the new technology should be chosen wisely.

3.4.3 Reaping BMI Benefits Responsibly: BMI Drives Industry Transformation and New Market Creation

The interviewees in the SupplyCo case expect that AR technology will fundamentally transform the entire construction industry; and SportCo employs VR in an attempt to establish a new market segment, namely “physical eSport[65]”. In the researcher’s mind, both cases illustrate how AR/VR technologies and BMI may drive industry transformation and new market creation. Furthermore, O Riordan *et al.* (2014, p.2) remark that “legendary firms that shape their industry structures are in fact business-model innovators”; and Founder2 of SportCo even deems it possible that VR ultimately may help save the world by contributing to resource conservation.

Said differently, BMI may have disruptive effects on established industries, as formulated as market destruction by Joseph Schumpeter (1942) and further explained by Bower and Christensen (1995) in their seminal work on disruptive innovation. More optimistically phrased, Hwang and Christensen (2008, p.1335) state that “by coupling technological advances with appropriately matched business models, disruptive innovation has brought affordability and accessibility to [numerous] industries”.

[65] See Section 2.2.3 of Paper 4 for more details. In brief, a unique feature of SportCo's product is that it combines traditional, sedentary eSport with actually physically demanding exercise.

Being non-scientific for a moment and fully aware that discussing morale has its risks, the researcher philosophises that the cognition that BMI can have a significant impact on industries – and therefore also on society – should steer BMI scholars and entrepreneurs towards (socially) responsible BMI. Taken to a positive extreme, sound BMI frameworks could theoretically be used by legislature to analyse, describe, and understand the BMs of companies with the aim to ultimately allow and support responsible BMs, or forbid irresponsible BMs; perhaps in form of a "responsible BMI certificate".

The observations just presented lead the researcher to update the conceptual BMI framework by adding a "driver for industry transformation and/or new market creation" as a new BM function. The framework is presented in Section 3.7.

3.5 Reflecting on Case Study Results in Light of the Theoretical Underpinnings of the Study

An important part in the research process is a detailed literature review. In Paper 1, the researcher develops an understanding of the BM, BMI, and the emerging impact of AR/VR technologies. From this, the researcher develops a conceptual model. Thus, at this point, the researcher must reflect on the data collected during the study with respect to how it interacts with the existing theory and knowledge base.

3.5.1 Business Model Functions

BM scholars describe three fundamental functions of BMs. First, the BM can serve as a communication tool (Magretta, 2002; Morris *et al.*, 2005) to help explain to employees how a given company works and what management expects (Nielsen and Lund, 2014). In the collected data, the researcher could *not* find business modelling to be formally used in this capacity. A second fundamental function of the BM can be mediating between strategic objectives and technology (cf. Chesbrough and Rosenbloom, 2002), making the strategic function of BMI a particularly promising research area (Morris *et al.*, 2015). No proof of formal business modelling can be identified in the collected data. The third function of the BM is the strategic goal of BMs providing sources of competitive advantage (cf. Casadesus-Masanell and Ricart, 2011; Boons and Lüdeke-Freund, 2013). SteelCo is the only company found to follow a clear strategic vision for the employment of AR/VR from the very beginning. In respect to SanitaryCo, the researcher questions that VR truly is a source of competitive advantage (Section 2.7).

Casadesus-Masanell and Ricart (2011) observe that even innovative and fully-functional BMs can fail if they do not successfully fend off more powerful imitators. The collected data neither confirms nor contradicts this statement.

3.5.2 The BMI Process

BMs are dynamic (De Reuver *et al.*, 2007) and need to be continuously reinvented (Sharma and Gutiérrez, 2010). Innovating BMs can be seen as a process (O Riordan *et al.*, 2014) similar to other innovation processes (Frankenberger *et al.*, 2013). Except for SteelCo, the BMI process has not been formally initiated in the investigated cases. Research participants did not disclose great detail on innovation management processes due to different reasons: either details were confidential (SupplyCo), the researcher was unable to extract details during the interview (SportCo), details were unknown to the interviewees (SteelCo), or there were none (TransportationCo, SanitaryCo[66]). Overall, the researcher can only conclude that, with respect to AR/VR employment, there are currently no *formal* – in the sense of holistic and consciously moderated – BMI processes being followed in the researched cases. This may be because of the low technology maturity level of AR/VR, and reflective of the fact that BMI must be seen as a process (O Riordan et al., 2014), however formal or informal its initiation may be.

According to the literature, the outcome of the BMI process may lead to two results; inventing or introducing an entirely new BM (cf. Mitchell and Coles, 2003; Khanagha et al., 2014), or innovating an existing BM (cf. Santos et al., 2009; Gassmann et al., 2017). The collected case data confirms both outcome statements, as illustrated in Table 5.

Two fundamental dimensions for BMI exist; the degree of novelty, and degree of newness to an industry (Foss and Saebi, 2016). When categorising the cases' BMs by degree of newness, as done in Table 5, the researcher notes that the degree of newness is high in all five cases. A possible interpretation for this is that employing AR/VR for BMI might (temporarily) push BM newness within an industry. The case data reveals that being a first mover is considered advantageous by research participants; an observation which can arguably be related to the "first mover advantage" idea as discussed in Section 3.4.2.

[66] arguably the continuous innovation scouting and philosophy of professionalising his trait as stated by Owner1 could be interpreted as an innovation process.

Table 5 – Categorising cases by degree of BM innovativeness.

Case	New BM	Innovated BM	Degree of BM novelty	Degree of BM newness	Comment
Case 1 – SteelCo		✓	Low	High	SteelCo innovated its pre-existing BM with the help of AR. The change in the BM can be considered minor, however, SteelCo was a first mover in the industry.
Case 2 – SportCo	✓		High	High	SportCo's new product and BM are unprecedented; they are both, novel approaches and new to the industry.
Case 3 – TransportationCo		✓	Low	High	TransportationCo integrated VR as an amendment to its pre-existing BM. The degree of novelty of the innovated BM can be considered marginal, overall. However, TransportationCo benefited from being a first mover in their industry.
Case 4 – SanitaryCo		✓	Low	High	SanitaryCo integrated VR as an amendment to its pre-existing BM. The degree of novelty is low. SanitaryCo benefits from being a first mover in its industry.
Case 5 – SupplyCo	✓		High	High	SupplyCo aims to employ AR for the development of entirely new business models. This might fundamentally transform SupplyCo from a construction supplier to a service and software company. The envisioned new BMs are likely both, novel and new to the industry.

A detailed review of Table 5 inspired the researcher to create quadrant charts for BM novelty versus BM newness, BM novelty versus BMI outcome, and BM newness versus BMI outcome (see Appendix M). The researcher notes that in all three charts, cases two and five; and cases one, three, and four are lumped together, thus exposing strategic similarities across cases when grouped by BMI outcome. The researcher believes that this could offer two insights. First, creators of new BMs might also be creators of novel BMs when BMI is driven by AR/VR. Therefore, there might be a future opportunity to transfer this new BM to other industries as new to the industry BMI. Second, in the three cases of innovating pre-existing BMs, the degree of BM novelty appears to be low. Does this indicate that BMI opportunities are missed here and that the investigated companies failed to unlock the full potential of the technologies? A deeper discussion on BM newness, BM novelty, and the role of AR/VR is offered in Section 3.1.3.

One interesting aspect found in the literature is not confirmed in the collected case data. According to Zott and Amit (2010) and Christensen *et al*. (2016), BMs are generally designed to resist change. Contrary to this, research participants reported that they encountered no real resistance when introducing AR/VR, neither within the company, nor from customers. On the one hand, this might indicate that AR/VR is a relatively easy way to drive BMI; on the other hand, the researcher notes that with the exception of SportCo, there is no money being charged for AR/VR employment yet, which might explain the low resistance.

3.5.3 Technology Impact on BMs and Industries

According to literature, BMs are shaped by technology (Teece, 2006; Zott *et al.*, 2011) which in turn has a fundamental influence on organisational structures (Nielsen and Lund, 2014). This is confirmed by the case data. Most notably, SupplyCo predicts that AR technology will transform the entire construction industry and SupplyCo. Managing AR/VR engagement requires new organisational processes, updated organisational structures, and necessary surrounding IT infrastructure. Streibich (2017b) and Euchner (2016) describe how digital technological innovations coupled with innovative business models disrupt industry after industry. While the literature presents numerous examples[67] of this, AR/VR did not yet disrupt the industries of the researched cases.

3.5.4 Impact on BM Elements and BM Element Interconnections

The researcher identifies four value-based elements of BMs in the Conceptual Paper (Paper 1); namely “value proposition”, “value capture and finances”, “value creation mechanism”, and “value network”. The researcher notes that the BM elements are interdependent and interrelated, making the business model an overarching concept (Frankenberger *et al.*, 2013).

Value proposition. Employing AR/VR technology offers the opportunity for new value propositions. Research participants expect further AR/VR innovations in the future which will drive new value proposition opportunities.

Value capture and finances. Except for SportCo, AR/VR employment does not yet result in new financial streams in the investigated companies. AR/VR employment may

[67] E.g. the film industry (Zhu, 2001), the photo industry (Weitzel, 2005), and the music industry (Moreau, 2013)

support funding efforts (example SportCo), however, it can be questioned if the hype around AR/VR is over, for the time being. The researched companies seamed to struggle in capturing monetary value from AR/VR technology at the time of research implementation.

Value creation mechanism. The findings indicate that working with AR/VR is a cumbersome endeavour full of hurdles. Likely, this is to be expected with immature technologies. AR/VR technology application can be aimed at process innovation, for example to help optimise the sales process, the design and presentation process, the recruitment process, and on-site construction processes.

Value network. The value network element not only describes the relationship with a company's customers, but also the value exchanged between multiple stakeholders (Hamel, 2001; Al-Debei and Avison, 2010). The data reveals that a key value gained from AR/VR employment is a positive company reputation. Further value exchanges within the investigated companies include catalysing company internal cooperation and fostering synergies.

BM elements are interdependent and interrelated. This means, that one BM element may influence another; Interdependencies may exist simultaneously between numerous BM elements, thus forming a potentially complex network of interconnections. The researcher deduces that such a network of interconnections is to be expected when innovating a BM with AR/VR. To exemplify, one is invited to consider the case where VR is used for a new value proposition, as in the SportCo case. This new value proposition needs to be financed, a value creation mechanism has to be built up to implement the promised value, the new value proposition leads to secondary value network exchanges, such as marketing effects, which in turn impact the finance and revenue streams in the value capture and finance domain. Further examples of one-to-one BM element interconnections are included in Appendix N.

3.6 Defining BMI for AR/VR Technology

Having completed an analysis and discussion, a revised definition of BMI for AR/VR technology is required. This definition excludes the communication function (see Section 3.2.2) and includes the new BM function "driver for industry transformation and/or new market creation" (see Section 3.4.3). The low degree to which the BMI process appears to be managed in the research cases is also reflected upon. As per Section 3.2.1, BMI efforts for AR/VR technology should be strategically guided. This guiding capacity should be the very purpose of the BMI construct. Integrating these findings into the original BMI definition developed in the Conceptual Paper (Paper 1 Section 2.2.2), the researcher defines BMI for AR/VR technology as follows.

The BMI construct for AR/VR technology is a conceptual tool to help guide AR/VR technology engagement for the continuous process of creating novel business models or innovating any of the business model components or their interplay namely: value proposition, value capture and finances, value creation mechanism, value network; or innovating its business function capacity as a mediator between strategic objectives and technology, as a source of competitive advantage, and/or as a driver for industry transformation and/or new market creation.

3.7 Refined Conceptual Model – A BMI Framework for AR/VR Technology

For the creation of a refined conceptual model and BMI framework for AR/VR technology as depicted in Figure 4, the researcher considers the aforementioned revised definition of BMI for AR/VR technology. Reflecting the research objective, the researcher focuses the conceptual framework on AR/VR technology and its impact on BMI. Furthermore, the need for BMI guidance is reflected by a new BM aspect which the researcher labels "BMI Guidance". Lastly, the BM elements are amended with core aspects identified in the case data. The researcher contends that this framework can be useful in the guidance of future BMI research in the context of AR/VR technology. Furthermore, it can be used by entrepreneurs and managers to continuously guide, structure, and implement BMI efforts when engaging with AR/VR technology. To summarise, the researcher refines the original conceptual framework[68] as follows.

1. remove the "impact arrow",
2. add the "BMI Guidance" aspect and remove the BMI process label,
3. amend BMI elements with core aspects identified in the case data,
4. add an explanation for the BMI construct for AR/VR technology,
5. add "conceptual tool" as a helpful introductory term to the BM description,
6. remove the communication function,

[68] see Paper 1 Figure 2.

7. add “driver for industry transformation and/or new market creation” as a new BM function as explained in Section 3.4.3, and,
8. update the BMI outcome options as explained in Section 3.1.3.

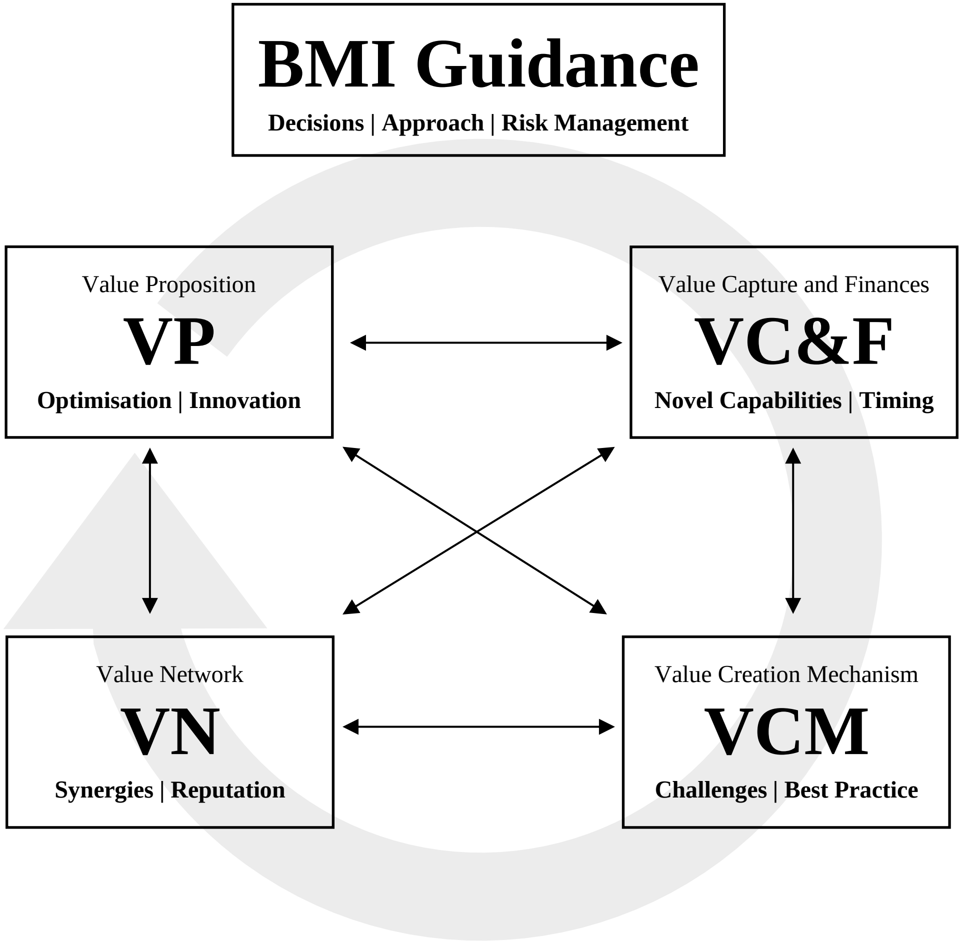
The reader is directed to start at the top-left side of Figure 3. There, the BMI guidance aspect is depicted and the core attributes “decisions”, “approach”, and “risk management” are shown. Key activities in guiding BMI efforts through AR/VR technologies include making important strategic and organisational decisions, fitting the technology engagement approach properly to AR/VR technology, and managing risks that come along with AR/VR technology employment. BMI guidance should be considered a continuous BMI process and overarches BM elements and BM element interconnections.

Below the BMI guidance aspect, the four BM elements and core attributes per BM element are shown. When engaging with AR/VR technology, the value proposition can focus on process optimisation and/or the innovation of new products and services. In respect to the value capture and finances element, AR/VR technology offers new capabilities to drive company growth. However, timing is a very important aspect, here. Looking at the value capture mechanism element, firms need to consider the unique properties of AR/VR technology and address associated challenges. For this, best practice tactics need to be implemented and followed. Finally, key aspects regarding the value network element are looking for synergies and cooperation opportunities, and leveraging the potential of heightened company reputation, for example for marketing purposes.

On the right hand side Figure 3, the BMI construct for AR/VR technology capacity “conceptual tool to help guide AR/VR technology engagement for BMI” is included and further central BM and BMI aspects elaborated on.

In this section, the researcher presented a discussion of the research findings and offered a definition of BMI for AR/VR technology. Furthermore, a BMI framework for AR/VR technology was presented. The next section will be committed to research conclusions and recommendations for future research and practice.

Figure 3 – A BMI framework for AR/VR technology.



Business model innovation for AR/VR
Conceptual tool to help guide AR/VR technology engagement for BMI

Business model
- Conceptual tool
- Simplified but complete representation of how a company operates
- Holistic approach

Business model elements
- Value based
- Interconnected

Business model functions
- Mediator between strategic objectives and technology
- Source of competitive advantage
- Driver for industry transformation and/or new market creation

Business model innovation process
- Continuous
- Dynamic

Business model innovation outcomes
- Optimised business model
- Innovated business model

4 Conclusions and Recommendations

In this section, the researcher presents the study's contributions to theory and practice, offers recommendations for practice, and addresses further organisational aspects. The section concludes with recommendations for further research and concluding remarks.

4.1 Contribution to Theory

The study contributes to theory in the following ways. The researcher developed and tested a theoretical research framework which successfully guided the research effort. After study completion, this framework was amended and formed into a BMI framework for AR/VR technology (cf. Section 3.7) that can support academics in future BMI research efforts related to AR/VR technology. The research questions the "communication tool" function of BMs and suggests that a new BM function ("driver for industry transformation and/or new market creation") is evident. Furthermore, a research gap identified by BMI scholars (e.g. Euchner, 2016; Foss and Saebi, 2016; Rayna and Striukova, 2016; Foss and Saebi, 2018), namely the lack of clarity in literature regarding the term "business model innovation" is addressed by offering novel contemporary definitions of BMI (see Section 2.2.2 of Paper 1), as well as of BMI for AR/VR technology (Section 3.6).

The study also contributes by identifying a BMI antecedent as discussed in Section 3.1.2. Foss and Saebi (2016, p.201) ask "does BMI exclusively originate in the upper echelons, or may it also originate in lower levels of the organization?". The research clearly shows that BMI origins may happen in lower levels of the organisation. Furthermore, the researcher identified a link between BMI for emerging technologies and the first mover advantage idea (cf. Section 3.4.2). The research further contributes to theory by developing a taxonomy for potential BMI outcomes (Figure 2). This BMI taxonomy is then applied to illustrate the impact of AR/VR technologies on BMI. Furthermore, the researcher presents a novel BMI framework for AR/VR technology (Section 3.7) and introduces the "BMI Guidance" idea (Section 3.6). Said in a different way, the researcher suggests that the BMI construct for AR/VR technology should be considered a conceptual tool to help guide AR/VR technology engagement for BMI. Lastly, the study illustrates how interpretive case study research can be applied for gaining a new understanding of "how to view the world in a certain way" as proposed by Klein and Myers (1999, p.75).

4.2 Contribution to Practice

The research contributes to professional practice in the following ways. Finding out how BMs are impacted by AR/VR technologies is a valuable contribution to praxis, as it helps practitioners to get an idea of what to expect when engaging with AR/VR. The research indicates that engaging with AR/VR technology for BMI should be strategically guided. The identified antecedent of BMI (see Section 3.1.2) might inspire professionals to scout for innovation potential within their organisations. Similarly, the risk profiles described by the researcher (see Section 3.3.1) have the potential to make entrepreneurs and managers aware of the importance of managing the risks inherent to AR/VR technology engagement. Another interesting observation for practice is that AR/VR technology can be leveraged to implement scalable BMs and for global reach (see Section 3.4.1). Possibly, some of the findings can be transferred to other emerging technologies in the context of how they impact BMI.

Furthermore, three tools which can be applied by practitioners emerged from the study. One, a BMI framework for AR/VR (Figure 3) which can guide practitioners to continuously structure and implement their BMI processes. Two, a BMI taxonomy (Figure 2) which – in addition to illustrating the impact of AR/VR technology on BMI – may be employed by practitioners to make strategic BMI decisions. The researcher agrees with Pisano (2015) who stresses the need for companies to have a (BM) innovation strategy. Three, the researcher offers strategic guidelines to approaching AR/VR technology engagement (Table 4). These guidelines can help practitioners in applying the research findings to praxis.

Lastly, an important contribution arising from this study is the recognition that BMI can have an industry transforming impact and therefore may noticeably effect society. This awareness is hoped to heighten practitioners' understanding regards the true nature of their responsibilities. The researcher suggests that sound BMI frameworks could be used by legislature to analyse, describe, and understand the BMs of companies with the aim to allow and support responsible BMs or forbid irresponsible BMs; perhaps in form of a "responsible BMI certificate" for the good of all society.

4.3 Recommendations for Professional Practice

These recommendations are inspired by the themes emerging from the case data and interpreted through the researcher's subjective entrepreneurial experience.

4.3.1 Implement Active Innovation Scouting for AR/VR Technology

AR/VR are young technologies, are considered to have a bright future ahead of them, can be applied for various purposes, and offer opportunities and benefits. Firms may find it challenging to identify innovation potential through these technologies. Therefore, the researcher advises practitioners to actively scout for innovation potential arising through AR/VR. Considering new product or service offerings, or searching for business process optimisation potential, are good starting points. Remember to search inside the company to identify dormant internal innovation potential (see also Section 4.3.5). The researcher recommends to utilise the BMI framework for AR/VR (Section 3.7) as a "focused search device for innovation potential". Getting started with the technology pragmatically is a first step in getting acquainted with the technologies' capabilities which may then lead to further innovation impulses. However, practitioners should be aware that AR/VR employment comes with potential risks and likely will only be successful if guided carefully. Once innovation potential is identified, the technologies need to be wisely integrated into the pre-existing company structures and the firm's strategy, or the other way around; meaning that the firm's strategy and/or organisational structures might have to be adapted.

4.3.2 Offer BMI Guidance

Engaging with AR/VR can be complex and risky. Not all benefits of the technology employment are immediately apparent. When engaging with AR/VR technology, numerous decisions need to be made (e.g. business process optimisation vs. product and/or service innovation) and how the AR/VR project shall be implemented (in-house vs. external partners vs. out-of-the-box solutions). Timing is an important aspect and firms need to moderate a technology engagement approach that fits the unique properties of AR/VR. Working with AR/VR technology may impact the entire organisation or even an entire industry, which may mean that practitioners need to be open for change. This, however, comes with responsibilities (see Section 4.3.6). Without clear strategic guidance, firms may fail to capture the benefits of AR/VR and run significant risks.

4.3.3 Leverage the Novel Capabilities Stemming from AR/VR Technology

AR/VR are digital technologies that can enable companies to reach out into the global, digital world. In this capacity, AR/VR offer novel ways for value capture, for example by implementing BMs with re-occurring revenue streams. These new capabilities should be explored and mined wisely. Employing AR/VR may support the funding process and can have a positive impact on company reputation. The researcher recommends integrating the fact that AR/VR technology is used into a firm's marketing strategy and internal company communication. AR/VR offer opportunities for securing intellectual property.

4.3.4 Foster BMI Driven Change, rather than Technology Driven Change

There are always forces shaping a business – internal forces, as well as external forces. Or to say it in the words of philosopher Terence McKenna "if you don't have a plan, then you are part of somebody else's plan." (Goodreads.com, nd). The researcher is an entrepreneur who learned "the hard way" that working with AR and VR out of a passion, while striving to deliver the best possible performance for customers, is not a guarantee for "adequate compensation". Technology driven BMI comes with substantial risks, especially if the innovation process is not properly managed. As an alternative, the researcher proposes that firms should drive change by actively conducting a formal BMI process. Practitioners should strive to understand the BMI concept, develop a routine for continuous BMI, and develop a strategy how to keep staff and shareholders informed. All the while, BM innovators should try to remain realistic and expect resistance: BMI will likely impact the entire organisation, it is complex to understand, and it requires continuous effort and support by all involved parties.

4.3.5 Identify Internal Innovation Potential

The research shows that organisations may be more innovative than they know or think. Especially when it comes to AR/VR innovations, depending on the size of the organisation, entrepreneurs and managers will likely find technology enthusiasts, who are knowledgeable about AR/VR and are full of ideas. These technology enthusiasts likely will be willing to invest extra effort for the opportunity to work on their passion. These properties of AR/VR might make introduction of these new technologies easy. The researcher therefore recommends that practitioners strive to identify this tacit knowledge, find ways to foster internal innovation impulses, and support innovation early on with BMI guidance.

4.3.6 Assess the Consequences of BMI Decisions and Have a Plan

The researcher found that emerging technologies temporarily push the newness factor in BMI. This comes with a set of benefits, but also with new challenges. Therefore, practitioners must have a clear mind about what they want to achieve with the new technology, how they will go about it, and what the consequences for their organisation are going to be. The researcher further contends that practitioners should be aware that the strategic choices which need to be made might be challenging and that timing matters. BMI has an impact beyond the organisation. Hence, it is imperative to have a clear cognition of responsibilities associated with BMI decisions.

4.4 Addressing Rigor

Researchers striving to implement scientifically meaningful research need to follow the scientific method, which is a "standardized set of techniques for building scientific knowledge" (Bhattacherjee, 2012, p.5) and rests on the four fundamental assumptions of replicability, precision, falsifiability, and parsimony. However, in interpretive case study research adhering to these assumptions can pose challenges, as illustrated in Table 6.

Table 6 – Fundamental assumptions underlying the scientific method and associated challenges for interpretive case study research.

Principle	Explanation	Challenge
Replicability	Others need to be able to repeat and replicate the performed research.	Likely, it is impossible to reproduce exactly the same conditions under which original case data was collected. Furthermore, research participants will likely give different responses at different points in time (Carcary, 2009). This poses the question, whether case study research can be repeated, at all.
Precision	Concepts must be defined precisely enough, that they can be used by others.	Researchers can and should spend significant effort to present their concepts in great detail and with high precision. However, concepts employed in interpretive case study research are still subjected to the interpretations of the researcher and the reading audience.
Falsifiability	Theories need to be formulated such that they could potentially be rejected, if they were false, that is.	Interpretive research does not strive to prove/disprove theory. Rather, interpretive case study research is a journey "that investigates a contemporary phenomenon within its real-life context" (Kelliher and McAdam, 2018, p.1323). In this capacity, interpretive research is not aimed at attempting to "falsify" a previously defined theoretical statement; but aimed at gaining a new understanding how "to view the world in a certain way" (Klein and Myers, 1999, p.75).
Parsimony	The idea that the simpler the explanation, the better.	Presenting a rich "fairy tale-like" story (cf. Stahl, 2014) as a source of knowledge arguably opposes this idea. Interpretive research may not even strive to explain the investigated phenomenon but be content with offering detailed descriptions of the researched phenomenon.

The observations above then raise the question how the quality of interpretive case study research can be ensured. This is a debate not without controversy; a controversy which is rooted in the critical discussion concerning the interpretive research approach in information systems (cf Walsham, 1995). Yin (2017, p.42) proposes four tactics to test for and to improve the quality of case study research design; namely "construct validity", "internal validity", "external validity", and "reliability". However, Yin's view on knowledge creation can be considered to be leaning towards the positivistic side (Walsham, 1995) and the offered quality assuring tactics may not be best suitable for the implementation and interpretation of interpretive case study research (Klein and Myers, 1999; Stahl, 2014). Therefore, alternative quality criteria for trustworthiness have been proposed by other researchers, most notably by Lincoln and Guba (cf Guba and Lincoln, 1981, 1982; Lincoln and Guba, 1985) who offer the criteria of "credibility", "transferability", "dependability", and "confirmability" as alternatives. Table 7 offers a summary of qualitative and quantitative quality criteria amended with the researcher's strategy to address each quality criterion.

Walsham (1995, p.77) explains that "interpretive researchers are attempting the difficult task of accessing other people's interpretations, filtering them through their own conceptual apparatus, and feeding a version of events back to others". In this context, researcher bias can negatively impact the quality of a study. Consequently, understanding and recognising bias is imperative for qualitative researchers (Galdas, 2017) and researchers must reflect on their role as part of the research throughout the entire research process (Sutton and Austin, 2015). Rather than trying to ignore their impact on the given research project (Sutton and Austin, 2015), researchers need to recognise and report their biases openly (Castleberry and Nolen, 2018). The researcher addresses this challenge by disclosing his thoughts and decisions throughout the entire research process. Additional to reporting key thoughts and decisions throughout the study, the researcher maintained a detailed account of his thoughts, feelings, interpretations, and research decisions in a research log.

Table 7 – Evaluation criteria for interpretive case study quality and researcher's strategy.

Quality criteria in quantitative research (Yin, 2017)	**Quality criteria in qualitative research** (Guba and Lincoln, 1981, 1982; Lincoln and Guba, 1985)	**Explanation concerning qualitative quality criteria**	**Researchers strategy** (adopted from Shenton, 2004)
Internal validity	Credibility	Credibility is perhaps the most important quality criteria (Lincoln and Guba, 1985) and is concerned with matching findings to data as closely as possible (Shenton, 2004).	The researcher presents his research methodology in great detail, triangulates data collection across different firms and research participants, and offers thick descriptions of the phenomenon under investigation and the research data.
External validity	Transferability	Transferability addresses the issue of generalisability, a concept discounted by naturalists (Guba and Lincoln, 1982). Cope (2014, p.89) argues that a qualitative study meets this criterion "if the results have meaning to individuals not involved in the study".	The researcher presents the research context and settings in great detail and allows for comparisons to be made.
Reliability	Dependability	While qualitative case studies cannot be replicated under exactly the same circumstances (Carcary, 2009), researchers can still disclose their research process in great detail to enable potential future researchers to repeat the work as closely, as possible (Shenton, 2004; Cope, 2014).	The researcher reports his research methodology and data analysis methods in great detail.
Construct validity / objectivity	Confirmability	Confirmability is concerned with the confirmability of data (Guba and Lincoln, 1982). To assure this, a researcher must show that the research findings are not the result of his personal preferences, but truly reflect the thoughts and experiences of the research participants (Shenton, 2004).	The researcher reports on the research process truthfully and undergoes any effort to minimise researchers by. The researcher discloses his philosophical stance, personal background, axiological beliefs, and organisational contexts of the case studies. Research limitations are clearly formulated.

4.5 Limitations

As with any research effort, limitations arise. Being a doctoral study, data was collected, coded, and analysed by a single person. Consequently, the research cannot provide multiple perspectives on the collected data. Data encoding was done manually, which may introduce error and researcher bias. Arguably, this is a threat independent of computer employment, as computers cannot perform the data analysis for the researcher (Basit, 2003). Given the chosen research design, the researcher acts as an interpreter of all data collected. While the researcher made great efforts to minimise any bias, it is always conceivable that a researcher may influence the research subjects. Throughout the research process, data was revisited repeatedly, and the researcher continuously challenged himself whether conclusions drawn truly reflect what research participants reported. Interview transcripts were fed back to research participants for confirmation and clarifying questions were posed to the interviewees during and after the interviews. Since a huge amount of effort was spent on precision and correctness, the researcher expects no significant impact of errors on the quality of the research findings. While the study is aimed to better understand the impact of AR/VR technologies on BMI, it has only been implemented in Germany. Furthermore, the researcher looked at a limited number of cases of businesses of vastly different sizes that are active in diverse industries.

As Casadesus-Masanell and Zhu (2013, p.30) observe, “business model innovation is a slippery construct to study”. This is in part because BMI is a somewhat “soft” concept which leaves a lot of room for interpretation. As previously stated, the researcher is an entrepreneur himself, however, perhaps even more so a technology expert. Consequently, his tendency is to take a very “engineer like” look onto BMI and technology. Furthermore, the researcher’s knowledge regarding the industry settings of the researched cases varies. For example, he has some experience in the real estate industry (pilot case study), can personally relate to what SanitaryCo and SportCo do, but has no own experience in the steel industry, the core field of activity of SteelCo. Thus, this industry knowledge/lack of knowledge could influence interpretation of the case data.

4.6 Further Research

The study is focussed on AR/VR. The researcher suggests that future researchers may test the framework regarding the impact of other emerging technologies or for emerging technologies in a general sense. The case data confirms the interconnectedness property of BM elements, however, further research deepening the understanding of BM interconnection details promises to be fruitful. Similar research opportunities arise from taking a dedicated look at the “BMI Guidance” idea as introduced in Section 3.7, or from looking at one BM element at a time. For example, the BM element value network is not as self-explanatory as the other three elements.

The attentive reader might have noticed that the researcher changed the order of BM elements in the conceptual framework compared to the original framework from Paper 1. This modification is rooted in personal preferences, rather than based on concrete findings. However, should there be an order in the BMI elements and in the BMI process? This question offers another research opportunity. BMI is an overarching concept and bridges can be built to other theory such as Disruptive Innovation (cf. Bower and Christensen, 1995) or Effectuation (cf. Sarasvathy, 2001). The researcher believes that linking BMI other theory will reveal valuable insights.

The researcher found an antecedent for BMI to be enthusiasm in some employees. How can the tacit knowledge held by these employees be used in the BMI process? Lastly, the study focuses on the impact of AR/VR on BMI. However, what is the impact of BMI on AR/VR or technology in general? Or what is the impact of BMI on society (cf. Section 3.4.3), on the organisation, on operations level, on product level, and on strategy level? Finding answers to these questions could be very interesting, too.

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Appendix G Table 10 of Paper 4 With Themes Highlighted

Table 8 – Table 10 of Paper 4 With Themes Highlighted.

Case	Case 1 – SteelCo	Case 2 – SportCo	Case 3 – TransportationCo	Case 4 – SanitaryCo	Case 5 – SupplyCo
RQ1: How are augmented reality and virtual reality technologies being applied by companies in Germany, today?	SteelCo applies AR is a new tool for measurements and to support decision-making in its customers. Further, AR helps optimise SteelCo's business processes as part of its digitalisation efforts.	The founders of SportCo had been waiting for consumer-grade VR for several years and apply the technology to develop a visionary "physical eSport" product. SportCo seized the moment during a VR hype time to establish the company, secure venture capital, and benefit from free marketing effects. Furthermore, as a digital technology, VR enables SportCo to go global and tap into international markets.	TransportationCo applies VR to help achieve its strategic staffing objectives and to foster a positive brand reputation. VR increases the recruitment process efficiency in TransportationCo and is used as a visualisation and presentation tool.	In SanitaryCo, VR is used as a visualisation tool for customers. Furthermore, VR supports the interior design process.	In SupplyCo, AR is used to innovate SupplyCo's internal processes, to develop new products and digital services, and to achieve its strategic objective of being perceived as industry innovation leader.
RQ2: What are the anticipated effects of augmented reality and virtual reality technologies on business in Germany?	The research participants of SteelCo expect further AR technology improvements. These might offer opportunities for new product developments. However, AR in Case 1 could theoretically be replaced by an alternate technology, in the future.	The research participants of SportCo predict that VR will become part of our daily lives in form of numerous new applications. Furthermore, VR may potentially help reduce the ecological footprint of humanity.	The research participants of TransportationCo find the impact of VR onto TransportationCo's business model to be minor. However, they still expect that VR for the recruiting industry will increase in importance.	The owner of SanitaryCo finds that VR technology is mature enough to be used in the interior design industry and expects that its relevance will increase in the future.	The research participants of SupplyCo describe how AR begins to transform SupplyCo and the entire construction industry. AR is seen as a source for new business opportunities and further AR innovations are expected.

Case	Case 1 – SteelCo	Case 2 – SportCo	Case 3 – TransportationCo	Case 4 – SanitaryCo	Case 5 – SupplyCo
RQ3: What are the benefits of employing augmented reality and virtual reality technologies in Germany?	AR helps achieve strategic company goals and its employment results in a positive company image.	Working with VR is Fun. Further, VR offers an opportunity for B2B cooperation across different industries. VR also enables new marketing capabilities for companies and can result in free marketing effects.	VR is beneficial for companies, who wish to enter the digital transformation. VR creates an open communication atmosphere and reveals insights on human interests.	VR has a significant impact on sales performance and drives a positive company reputation.	Using AR has a positive impact on brand reputation and impresses customers and employees, alike.
RQ4: What challenges do companies in Germany face, when implementing augmented reality and virtual reality projects?	Due to a low level of technology maturity, AR software development and operation is a challenge of its own. Employing AR hardware holds the danger of vendor dependency.	SportCo is challenged by the low maturity level of VR technology and the German market environment, which is experiencing a consolidation phase and is considered less fitting for VR than other regions. Furthermore, the lack of product support by VR vendors puts an extra burden onto SportCo.	TransportationCo has to deal with the low maturity level of VR technology and the common organisational challenges when introducing a technology to TransportationCo. The wide deployment of VR at consumers is hindered by the low penetration rate of VR hardware.	Working with the VR means additional effort; however, no major challenges were found within SanitaryCo.	SupplyCo is challenged by AR technology limitations and the conservativeness of the construction industry. Furthermore, expert staff is hard to get and introducing AR demands challenging strategic decisions to be made from top management.
RQ5: How can companies in Germany deploy and use augmented reality and virtual reality technologies for business model innovation?	Companies may get started with AR with the help of external expert suppliers and an agile software development approach. Furthermore, AR has the potential to improve and/or replace a pre-existing solution.	The interviewees of SportCo recommend getting started with VR pragmatically and to involve employees and customers wisely.	Just do it! Identify innovation potential within the company and get help from external experts. This is the approach that led TransportationCo to successful VR deployment.	A love for innovation is helpful when getting started with VR, striving for seamless integration into the daily routines is imperative for permanent use.	Start working with AR pragmatically, but with a clear focus on praxis applicability. Later on, ensure seamless integration into pre-existing processes and switch to professionalised in-house software development.

Appendix H Notecard Sorting Steps

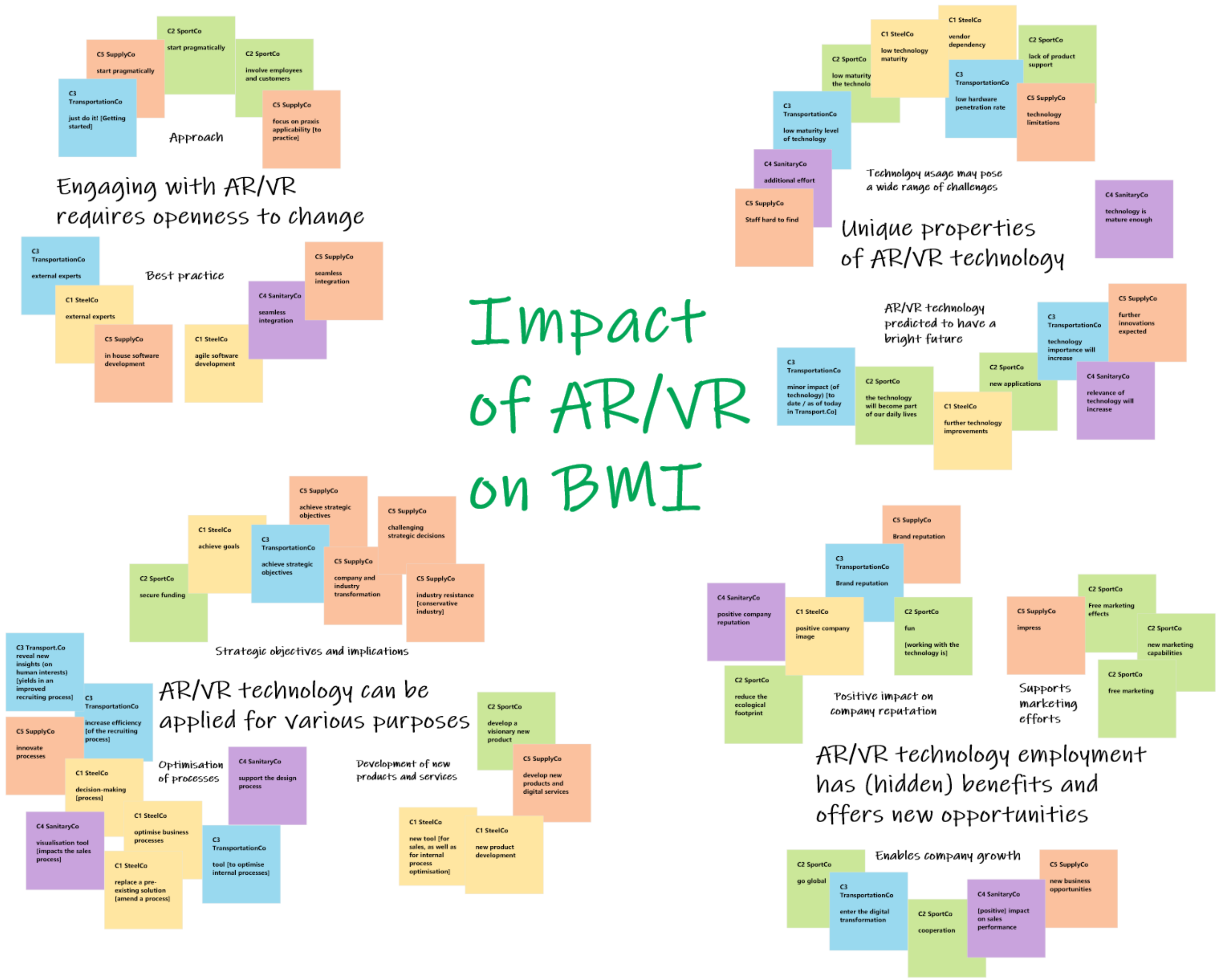
The sorting approach included the following steps:

1. Extract key themes identified per case onto notecards: the findings summary per case with key themes highlighted is included in Appendix G, the extracted notecards are depicted in Figure 4. The notecards are labelled with a capital C followed by the case number, case descriptor, and theme.
2. Go through several iterations of thematically grouping the notecards. An early iteration is presented in Figure 5, the final card groups are presented in Figure 6.

Figure 4 – Notecards extracted from summary Table 10 of Paper 4.

Figure 5 – Starting to group the notecards by common themes.

Figure 6 – Final notecard groups.



Appendix I Details on Skimming for Surprises and Overarching Issues per RQ

Table 9 – Cross case issues and findings for RQ1.

Issue	Finding	Case	Paper 4 section reference
Achieve Strategic Objectives (focus: differentiating factor from competition)	Support a Positive Brand Reputation: VR Employed as a Differentiating Factor from other Companies	Case 3 – TransportationCo	3.3.1.1
	VR Can Help Achieve Strategic Objectives	Case 3 – TransportationCo	3.3.1.4
	Enchant Customers	Case 4 – SanitaryCo	3.4.1.3
	Achieve Strategic Objectives	Case 5 – SupplyCo	3.5.1.1
Innovate processes	New Tool to Capture Measurement Data	Case 1 – SteelCo	3.1.1.1
	Process Optimisation	Case 1 – SteelCo	3.1.1.3
	Increase Process Efficiency Through VR	Case 3 – TransportationCo	3.3.1.3
	Support the Design Process	Case 4 – SanitaryCo	3.4.1.2
	Innovate Processes	Case 5 – SupplyCo	3.5.1.2
New product development, access new industries and markets	Develop New VR-Enabled Products	Case 2 – SportCo	3.2.1.1
	Create Experiences, Motivate, and Inspire	Case 2 – SportCo	3.2.1.2
	Think Global, Create and Capture New Markets, Tap into New Revenue Streams	Case 2 – SportCo	3.2.1.3
	Seize the Moment: Timing is Essential	Case 2 – SportCo	3.2.1.4
	Develop New Products and Services	Case 5 – SupplyCo	3.5.1.3
Visualisation tool	Support Decision Making	Case 1 – SteelCo	3.1.1.2
	Visualisation and Presentation Tool	Case 3 – TransportationCo	3.3.1.2
	Visualisation Tool	Case 4 – SanitaryCo	3.4.1.1
	Support the Sales Pitch and Human Imagination	Case 5 – SupplyCo	3.5.1.4

Table 10 – Cross case issues and findings for RQ2.

Issue	Finding	Case	Paper 4 section reference
Impact assessment varies widely from company to company	Overall Impact on BMI not Measurable, Assessed to be Minor	Case 3 – TransportationCo	3.3.2.1
	AR Transforms Companies	Case 5 – SupplyCo	3.5.2.1
	AR Contributes to Industry Transformation	Case 5 – SupplyCo	3.5.2.3
VR and AR are here to stay and will offer numerous application opportunities, once the technology is more mature.	Support Decision Making	Case 1 – SteelCo	3.1.1.2
	Technology Improvements and New Product Development Opportunity	Case 1 – SteelCo	3.1.2.1
	Perhaps Just an Interim Technology?	Case 1 – SteelCo	3.1.2.2
	VR Will Become Part of Our Daily Lives	Case 2 – SportCo	3.2.2.1
	In the Future, VR Will Have Numerous New Applications	Case 2 – SportCo	3.2.2.2
	VR Might Help Save the World	Case 2 – SportCo	3.2.2.3
	VR for Recruiting Predicted to be "Here to Stay"	Case 3 – TransportationCo	3.3.2.2
	VR Needs to Become More Interactive	Case 3 – TransportationCo	3.3.2.3
	VR Offers New Opportunities	Case 3 – TransportationCo	3.3.2.4
	VR Technology is Mature and Important for the Interior Design Industry	Case 4 – SanitaryCo	3.4.2.1
	Source of New Business Opportunities	Case 5 – SupplyCo	3.5.2.2
	Further AR Innovations Expected	Case 5 – SupplyCo	3.5.2.4

Table 11 – Cross case issues and findings for RQ3.

Issue	**Finding**	**Case**	**Paper 4 section reference**
Employment of AR/VR results in a broad range of soft, difficult to quantify, benefits.	Positive Company Image and Synergies	Case 1 – SteelCo	3.1.3.2
	VR is Fun and Fosters Synergies	Case 2 – SportCo	3.2.3.1
	Free Marketing Effects and New Marketing Capabilities	Case 2 – SportCo	3.2.3.2
	Employing VR is Perceived to be Beneficial, But Timing Matters	Case 3 – TransportationCo	3.3.3.1
	Emotional Icebreaker: VR Creates Open Atmosphere for Communication	Case 3 – TransportationCo	3.3.3.2
	Gain Hidden Insights on Job Candidates Interests	Case 3 – TransportationCo	3.3.3.3
	Entry Point for the Digital Transformation	Case 3 – TransportationCo	3.3.3.4
	Positive Company Reputation	Case 4 – SanitaryCo	3.4.3.1
	Introduction of AR Well Perceived by Customers and Employees, Overall	Case 5 – SupplyCo	3.5.3.1
	AR is Impressive	Case 5 – SupplyCo	3.5.3.2
	Working with AR Assessed to Have a Positive Impact on Brand Reputation	Case 5 – SupplyCo	3.5.3.3
Significant improvement	Achieve Strategic Goals	Case 1 – SteelCo	3.1.3.1
	VR Offers New Opportunities	Case 4 – SanitaryCo	3.4.3.2

Table 12 – Cross case issues and findings for RQ4.

Issue	Finding	Case	Paper 4 section reference
Adjacent Challenges	Difficult to Identify Suitable Software Development Partners	Case 1 – SteelCo	3.1.4.2
	Corporate Structure Challenges	Case 1 – SteelCo	3.1.4.6
	VR Technology Related Peripheral Challenges	Case 2 – SportCo	3.2.4.3
	Organisational Issues	Case 3 – TransportationCo	3.3.4.2
	Peripheral Challenges	Case 3 – TransportationCo	3.3.4.4
	Initial Setup is Challenging, Operation is an Additional Effort	Case 4 – SanitaryCo	3.4.4.1
	“Virtual Reality” Not a German Term, Just Show It	Case 4 – SanitaryCo	3.4.4.2
	The Construction Industry is a Conservative Industry	Case 5 – SupplyCo	3.5.4.2
	Necessary Staff is Hard to Find	Case 5 – SupplyCo	3.5.4.3
	Organisational Friction, Getting Stakeholders on Board	Case 5 – SupplyCo	3.5.4.4
AR/VR Related Challenges	Vendor Dependency	Case 1 – SteelCo	3.1.4.1
	Maturity of the Technology: Developing a Technology Hack	Case 1 – SteelCo	3.1.4.3
	Technology Maturity Level	Case 2 – SportCo	3.2.4.2
	Maturity Level of the VR Technology	Case 3 – TransportationCo	3.3.4.1
	Technical Limitations	Case 5 – SupplyCo	3.5.4.1
Managing Expectations, Get Humans on Board	Technology Acceptance Well to Neutral, But High User Expectations	Case 1 – SteelCo	3.1.4.4
	Rollout and Operation of the AR Solution	Case 1 – SteelCo	3.1.4.5
	Market Environment and Market Expectations	Case 2 – SportCo	3.2.4.1
	The Human Factor	Case 3 – TransportationCo	3.3.4.3
Strategically Demanding	Strategic Positioning	Case 2 – SportCo	3.2.4.4
	Defining the Proper Strategic Alignment	Case 5 – SupplyCo	3.5.4.5

Table 13 – Cross case issues and findings for RQ5.

Issue	**Finding**	**Case**	**Paper 4 section reference**
Find a Use Case	Replace and Improve a Pre-Existing Solution	Case 1 – SteelCo	3.1.5.2
	Identify Pre-existing Innovation Potential in Your Company	Case 3 – TransportationCo	3.3.5.2
	Focus on Applicability to Praxis	Case 5 – SupplyCo	3.5.5.3
Integrate	Involve Employees and Customers Wisely	Case 2 – SportCo	3.2.5.2
	Strive for Seamless Integration	Case 4 – SanitaryCo	3.4.5.2
	Ensure Seamless Integration and Foster Knowledge Transfer	Case 5 – SupplyCo	3.5.5.2
Start Pragmatically, Agile, and with the Help of Experts	Find External Experts and Be Agile	Case 1 – SteelCo	3.1.5.1
	Get Started Pragmatically	Case 2 – SportCo	3.2.5.1
	Just Get Started!	Case 3 – TransportationCo	3.3.5.1
	Work with External Experts	Case 3 – TransportationCo	3.3.5.3
	Love Innovation	Case 4 – SanitaryCo	3.4.5.1
	Support Internal Innovation Spirit, Start Pragmatically, then Professionalise	Case 5 – SupplyCo	3.5.5.1

Appendix J Overview over Initial Forces Behind AR/VR Employment

Table 14 – Overview over initial forces behind AR/VR employment per case.

Case	**Description of triggering event**	**Initiated by**
Case 1 – SteelCo: Employing Head Mounted Augmented Reality for Spatial Measurement and Instant Project Visualisation	SteelCo deployed a high-end augmented reality headset to help increase the overall process efficiency of an established product. This is driven by *management* as part of a clearly formulated *strategic effort* to significantly reduce the time to market.	Management
Case 2 – SportCo: Virtual Reality as Enabler for a Visionary New Product	SportCo has developed a new VR-enabled sports device designed specifically for VR. Founder1 is a VR *enthusiast* who conceptualised the product idea as part of his industrial design diploma thesis.	Enthusiast
Case 3 – TransportationCo: Personnel Recruiting with Virtual Reality	In the case of TransportationCo, the initial impulse to use VR for recruiting came from a *technology-interested regional manager* (MarketingOfficer1) who learned about VR from social media (Recruiter1). This manager, whom the researcher was not able to speak with, found in Recruiter1 a VR *enthusiastic* comrade-in-arms who supported the project from the very beginning and invested numerous hours of his spare time (Recruiter1).	Regional manager, enthusiast
Case 4 – SanitaryCo: Sanitary Planning with Virtual Reality	In the SanitaryCo case, it was Owner1 who decided to take up the VR technology. He describes himself as a technology *enthusiast* who enjoys figuring out IT-related things.	Enthusiast
Case 5 – SupplyCo: Using Augmented Reality to Assist Construction Workers	Manager1 recounts that SupplyCo's AR activities were initiated by an employee who *enthusiastically* explored AR technology together with his brother, a game developer (who was not working for SupplyCo at the time), and simply went ahead and created SupplyCo's first AR showcase. Manager1 who is now a driving force behind the AR project describes himself as a "digital *enthusiast* who pushes XR[1] in construction".	Enthusiast

[1] XR is an abbreviation for "extended reality", a summary term for AR, VR, and MR (mixed reality is a term used by some vendors when referring to AR headsets).

Appendix K Firm Level Analysis Strategy

To help the researcher's thinking regarding a cross case firm levels analysis, the researcher uses the three-strategic-levels approach as depicted in Figure 7. Combining strategy level thinking and firm level analysis, the researcher developed three analysis level descriptors, matched them to strategy levels, and formulated three guiding questions to help tag research findings with the developed analysis level descriptors. Strategy levels, descriptors, and guiding questions are presented in Table 15.

Figure 7 – Three strategic levels (source GrowThink Solutions, 2017).

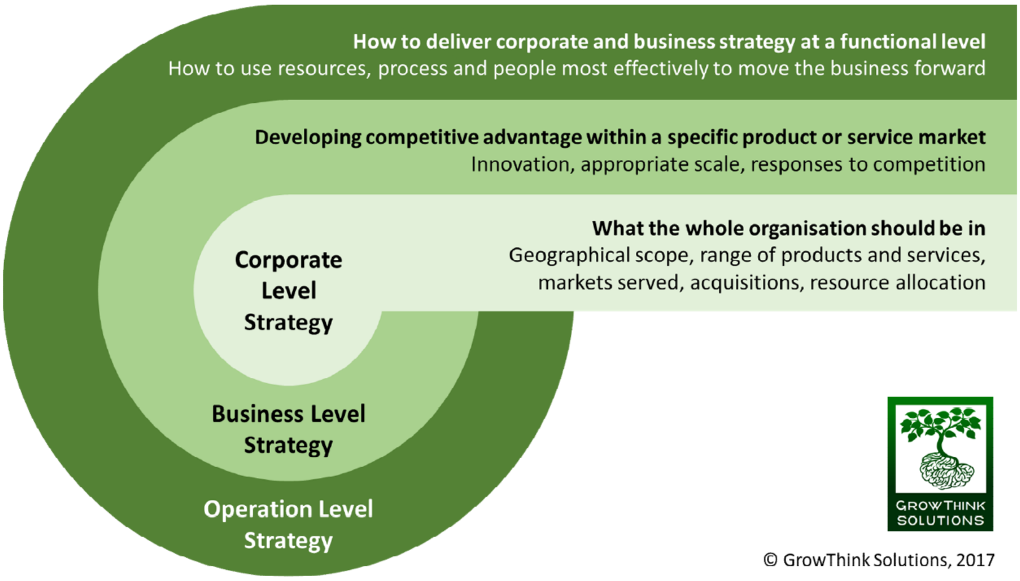


Table 15 – Levels of analysis to identify cross case commonalities.

Strategy level	Analysis level descriptor	Guiding question
Corporate level strategy	Strategic level (SL)	Is the AR or VR employment driven by a higher strategic objective?
Business level strategy	Product level (PL)	Are AR or VR employed to develop a new product or service, or to improve an existing product or service?
Operation level strategy	Operations level (OL)	Are AR or VR used to improve "daily business", for example to increase the efficiency of internal processes?

To implement the conceptualised tagging procedure, the researcher uses a clustering tactic as proposed by Miles *et al.* (2018, p.276).

> "Clustering is a tactic that can be applied at many levels to qualitative data: at the level of events or acts, individual participants, processes, settings/ locales, sites or cases as wholes, time periods, and so on. In all instances, we're trying to understand a phenomenon better by grouping and then conceptualizing objects that have similar patterns or characteristics."

The analysis level descriptors were added to the cross case analysis database file as new columns. Then the researcher went back to the findings as reported in Paper 4 once more and extracted subthemes per research finding section. These findings were tagged with the developed descriptors, grouped, and then analysed for common issues across cases. The full list of tags used for this analysis is presented in Table 16.

Table 16 – Abbreviations for tagging the cross case findings for further analysis.

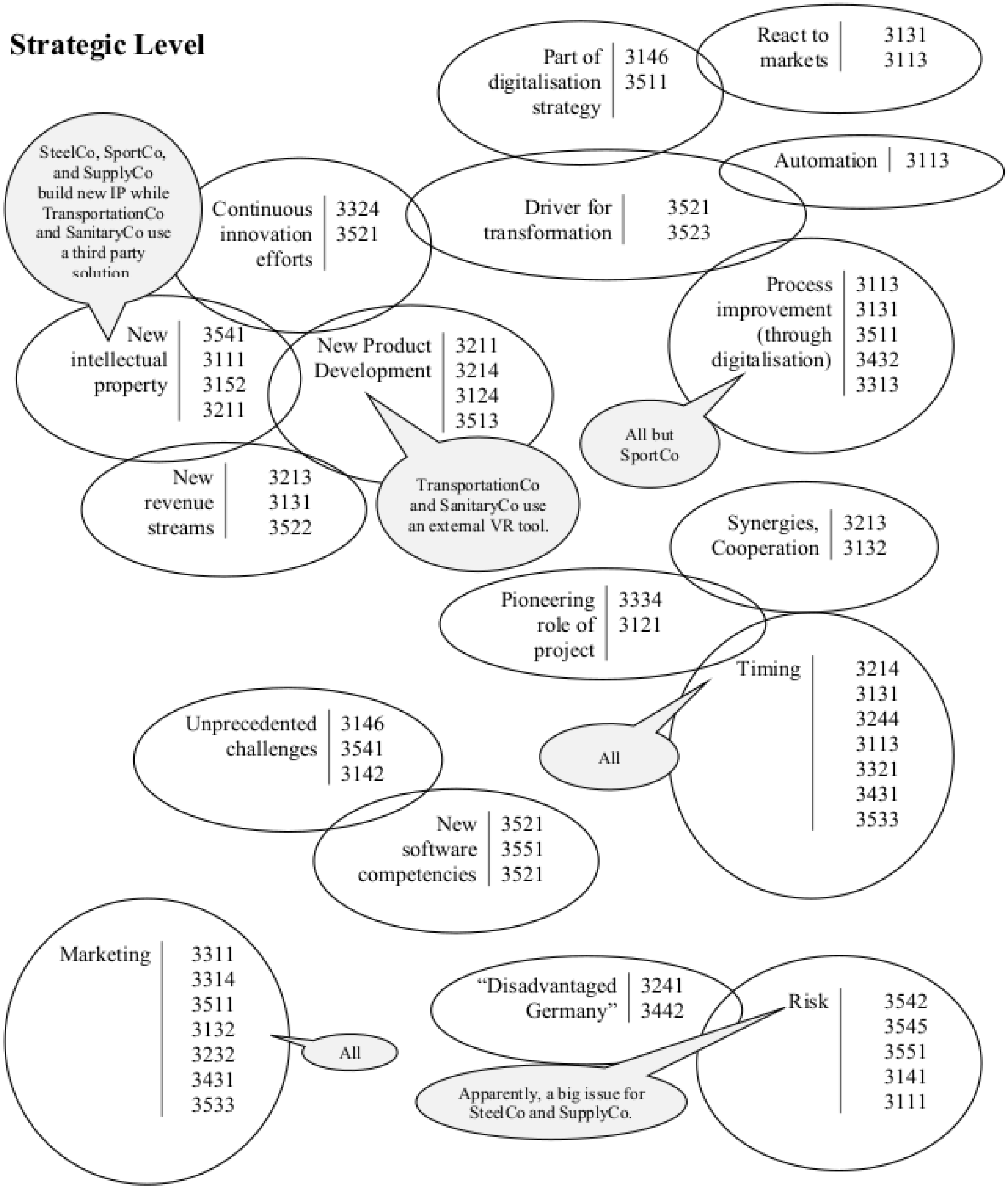
Domain	**Tag/abbreviation**	**Conceptual BM domain descriptor**
Business model element level	VP	Value proposition
	VC&F	Value capture and finances
	VCM	Value creation mechanism
	VN	Value network
Business model element interconnection	↔	Interplay, for example VP ↔ VC&F
Business model function	CT	Communication tool
	MD	Mediator between strategic objectives and technology
	CA	Source of competitive advantage
Business model innovation	IP	Innovation process
Business model innovation outcome	IBM	Innovated business model
	NBM	New business model
Firm level analysis	SL	Strategic level
	OL	Operations level
	PL	Product level
General	S	Surprise
	OA	Overarching
	IMP	Impact (findings that directly address impact topics)

Appendix L Cross Case Firm Analysis Visualisation Strategy

To help understand commonalities between – and uniqueness of – tagged findings, the researcher derived a visualisation strategy. In the case database, the researcher filtered the results by analysis level descriptors. The researcher then grouped them in a numerical format representing Paper 4 headings (the first digit represents the section number and is always the number three; the second digit represents the case number; the third digit represents the number of the RQ; and the fourth digit represents the sub-section number) and clustered them in circles, amending each circle with a description of the issue at hand. This enabled the researcher to identify common or unique issues across cases. This visual approach is included in the pages below.

The depicted numbers represent Paper 4 chapters. Hence, the second digit indicates the case number and the third digit indicates the RQ. The first digit is always 3 referring to Section 3 of Paper 4 and the last digit is the subsection number.

Strategic Level

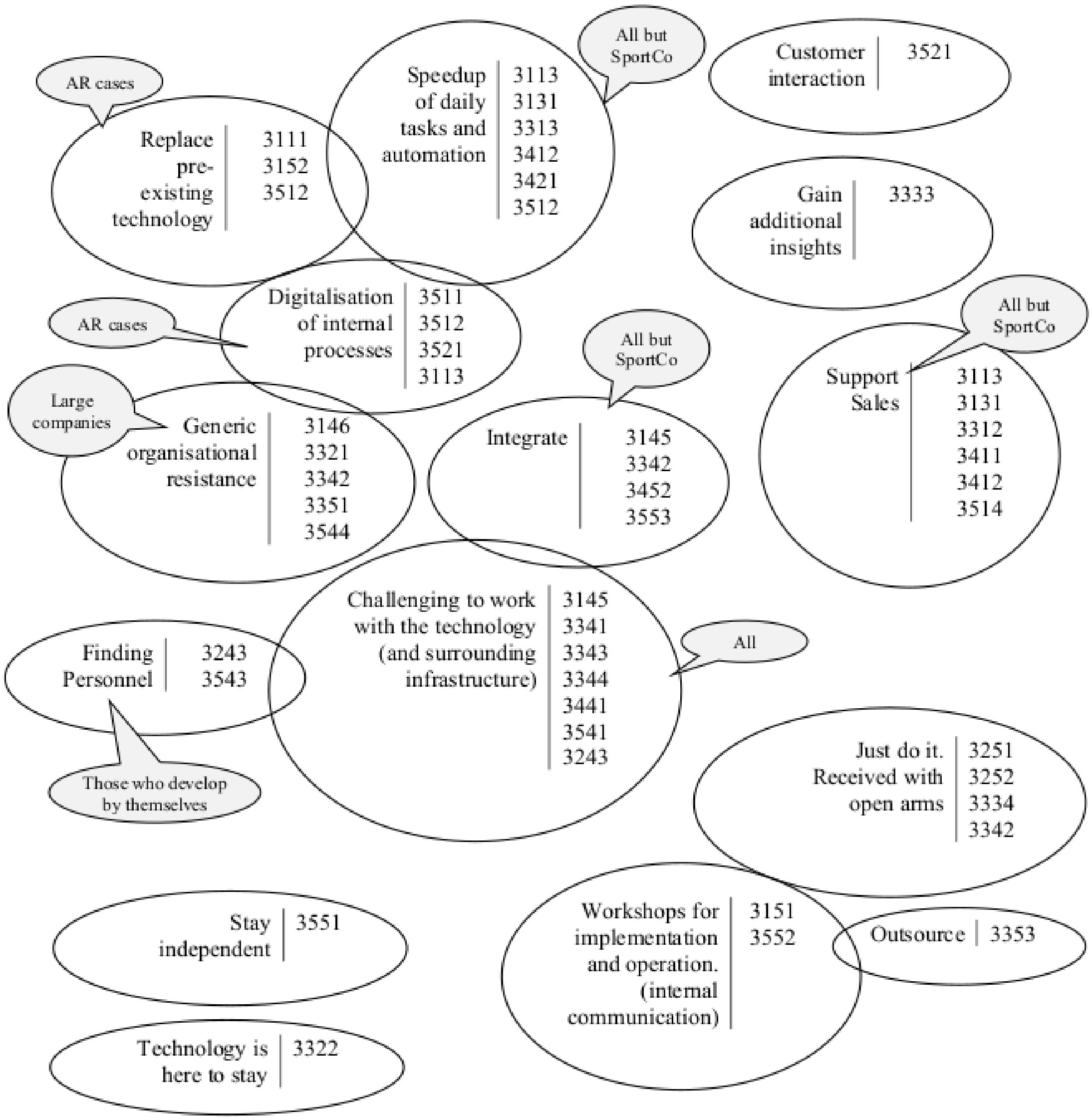


Researcher's notes: Vendor dependency is a risk for all involved parties. Timing: hype versus first mover. For the smaller companies, being in Germany is felt to be disadvantageous.

Product Level

Researcher's notes: Process optimisation is a broad term; it can refer to strategic decisions, product properties, or operational effects. Furthermore, it can also aim at the customers' processes. What does product level mean for SanitaryCo? Its product is not VR, VR is used to present the product. This is another differentiation: employ AR/VR as a tool vs. for new product development. SupplyCo is the only case, that aims to change the processes of customers. The "all" and "all but" indicate commonalities.

Operations Level



Researcher's notes: My instinct and experience tell me, that automation is a big deal. Privacy seems to be primarily a concern for large firms. With the exception of SportCo, AR/VR supports the sales process. Staffing vs. finding suitable development partners. "All but SportCo" – what is this uniqueness? Exceptions strengthen a case (Miles *et al.*, 2018).

Appendix M BM Novelty, Newness, and Outcome

Figure 8 – Charting BM novelty versus BM newness.

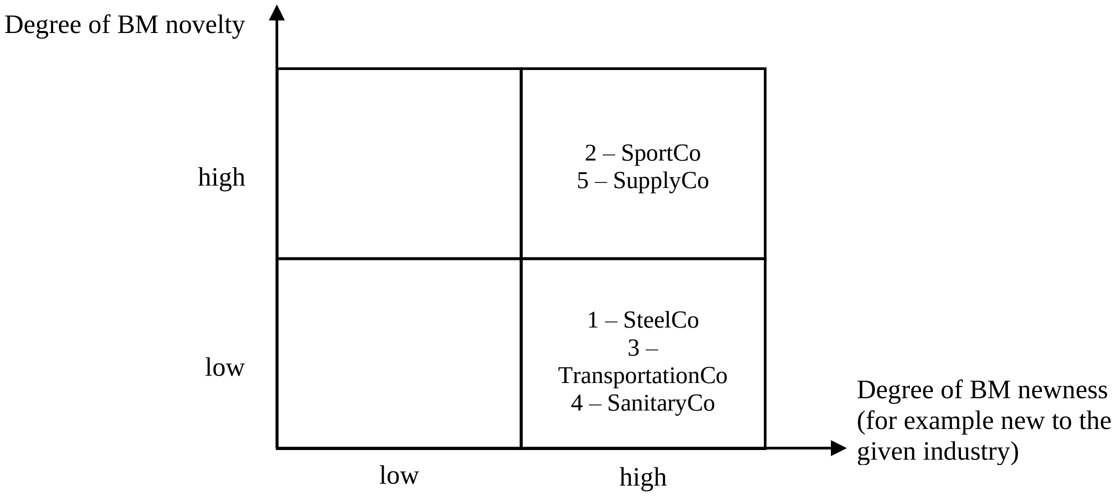


Figure 9 – Charting BM novelty versus BMI outcome.

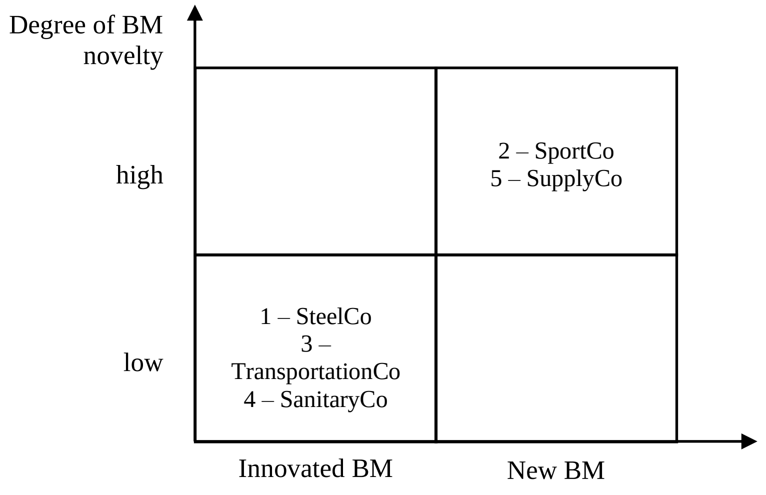
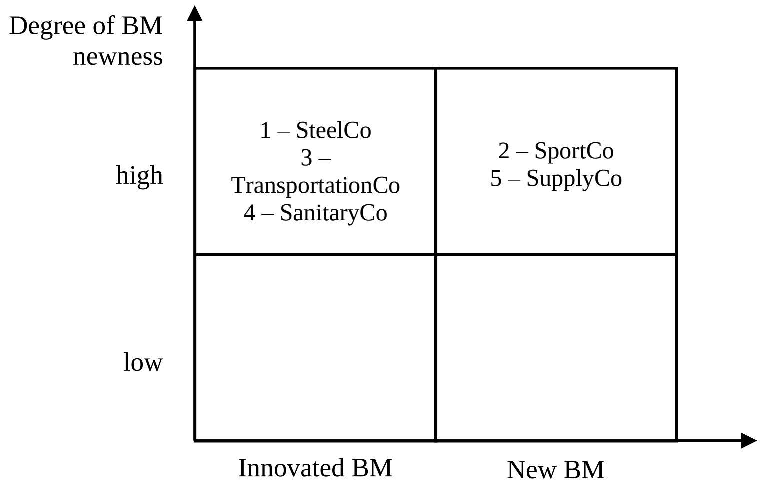


Figure 10 – Charting BM newness versus BMI outcome.



Appendix N BM Interconnection Examples

Table 17 – Example of BM element interconnections.

Interconnection	**Example**
VP ↔ VC&F	SportCo used the newness of its value proposition to help secure external investments. In turn, the external investments are now tied to expectations regarding the use of the funds.
VP ↔ VCM	In SupplyCo, the new value proposition requires the build-up of new software development competencies. This is a challenge of its own. Hence, how well SupplyCo succeeds in building a strong value creation mechanism determines the quality of the implemented value proposition.
VP ↔ VN	SupplyCo reports that the new value proposition begins to impact the relationship to its customers. On the upside, SupplyCo sees an opportunity to transform into a solution provider; on the downside, Manager1 fears that customers might feel threatened by SupplyCo being “a supplier of such a digital mystery”.
VC&F ↔ VCM	In SportCo, paying customers expect that their acquired hardware is supported long-term. Hence, the software development department must consider numerous VR headsets, including older hardware. This poses technical and conceptual limitations to the product development. In the opposing direction, the quality of the value creation mechanism directly impacts how well value capture can be executed (e.g. SportCo might lose customers if it were to deliver a poor product).
VC&F ↔ VN	In the cases TransportationCo and SanitaryCo, the mere fact that the companies work with VR is reported to have directly led to positive marketing effects. Ultimately, this has a positive impact on the value capture and finances domain.
VCM ↔ VN	In the SteelCo case, SteelCo decided to work with an external software development partner for the development of the AR solution. While SteelCo remains owner of the generated intellectual property, the supplier likely benefits from the gained experience as well as the high profile reference customer. However, having chosen a well-known expert company for software development, SteelCo also benefits from this company’s previous experience. Likely, this is why SteelCo chose the development partner in the first place.

Section Four:

REFLECTIVE LOG – EXTRACTS

1 Introduction

Maintaining a reflective log can be a helpful tool for students to facilitate personal development and to help structure researchers' thinking (MacFarlane, 2001). When the researcher commenced the DBA program, he was already a regular writer of diaries. Specifically, he kept two types of diaries (called "logbooks"), each of which pursues a dedicated purpose (one logbook for the development of entrepreneurial endeavours, and one logbook for personal development). Hence, the information relevant for the DBA program is spread throughout the two types of logbooks (well over 2000 pages of writing) and intertwined with other information.

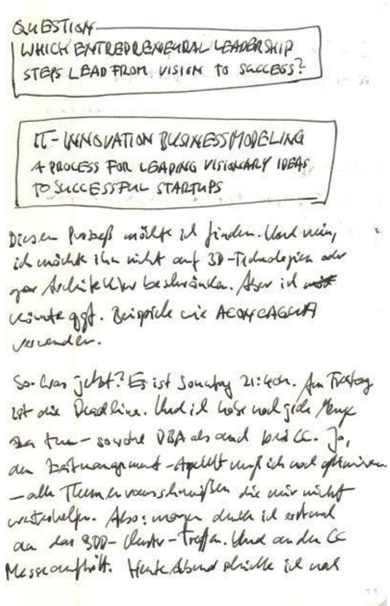
As the research progressed, the researcher arrived at a case study research as suitable research methodology. In order to ensure the reliability of the case study, the author followed the recommendation by Yin (2017) and installed a case study database. This database includes a case study log. In essence, the case study log is a chronological documentation of performed steps and events. Further, observations, ideas, and other useful information and notes are collected there. The first entry in the case study log stems from October 2, 2018.

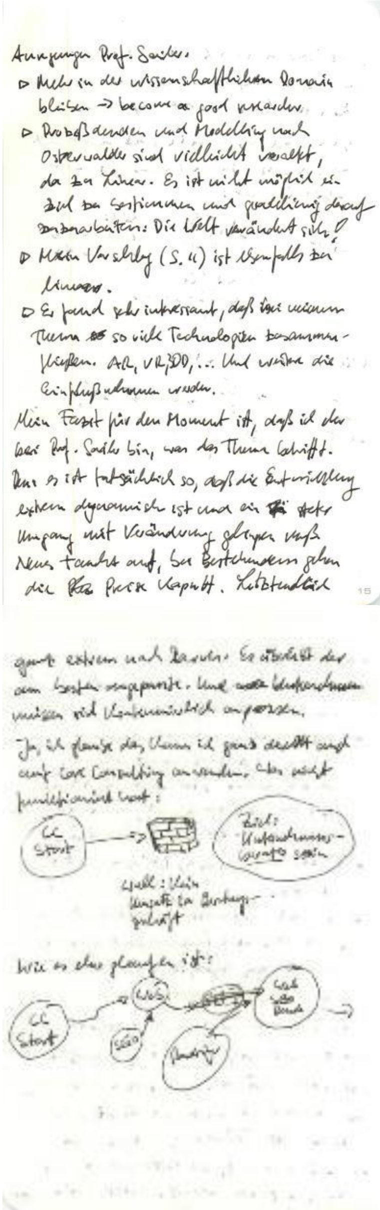
With introduction of the case study log, the researcher merged his reflective writing into the case study log. Furthermore, the initial logs were handwritten, while the case study log is maintained digitally. This was initially emotionally difficult for the researcher, however, looking back the advantages of keeping a digital log outweigh by far the researchers concerns regarding data security. For example, a digitally kept log is searchable and nearly almost accessible, for example from mobile devices. Furthermore, the researcher employs the Microsoft Word custom formatting feature combined with the table of contents functionality to automatically create overviews of key statements, observations, and findings. Reflective log extracts prior to the instalment of the case study log are presented in Section 2. Reflective log extracts as maintained in the case study log are included in Section 3.

2 Reflective Log – Pre-Case-Study Extracts

Reference[2] and date[3]	**Example diary page[4]**	**Translated summary statement[5]**
2014-11-02 LPE2-S.5-8		I want to be a charismatic and economically successful person. The DBA shall be a guiding path […] I am not looking for the topic or the vision for the DBA. I have been looking for the program for my vision since 2013-04-30. DBA Research rationale topic

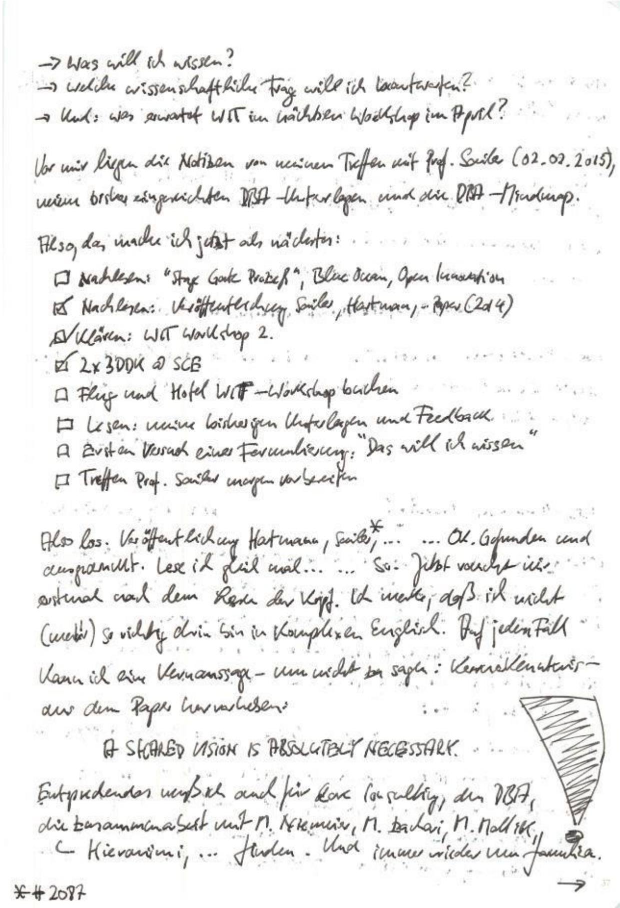
[2] Logbook referencing explanation: the author's log books are categorised ("LUE" indicates a logbook for entrepreneurial activities, "LPE" indicates a logbook for personal development activities) and numbered. The logbook indicator is followed by a dash and a page number. For example "LUE7-S.50" is a reference to the entrepreneurial logbook series, book number seven, page 50.
[3] Date written in the format year-month-day
[4] Not all described pages are shown due to space restrictions
[5] The text was translated from German and condensed to a summary in one step.

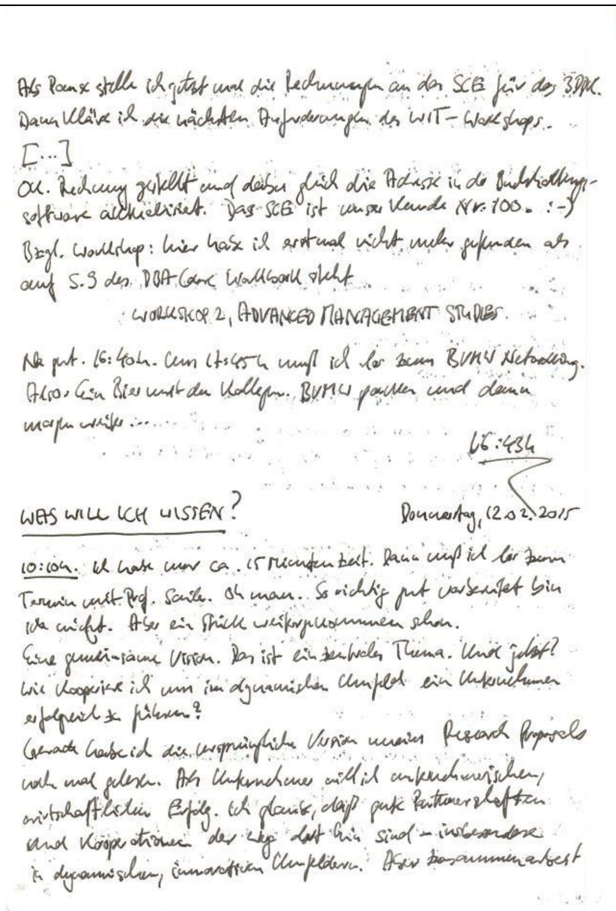
Reference[2] and date[3]	**Example diary page[4]**	**Translated summary statement[5]**
2014-11-02 LPE2-S.5-11	 QUESTION WHICH ENTREPRENEURIAL LEADERSHIP STEPS LEAD FROM VISION TO SUCCESS? IT-INNOVATION BUSINESSMODELING A PROCESS FOR LEADING VISIONARY IDEAS TO SUCCESSFUL STARTUPS Diesen Prozeß möchte ich finden. Und nein, ich möchte ihn nicht auf 3D-Technologien oder gar Architektur beschränken. Aber ich [illegible] könnte ggf. Beispiele wie ACONCAGUA verwenden. So. Was jetzt? Es ist Sonntag 21:40h. Am Freitag ist die Deadline. Und ich habe noch jede Menge zu tun – sowohl DBA als auch bei CC. Ja, den Zeitmanagement-Aspekt muß ich noch optimieren – alle Themen [illegible] die mir nicht weiterhelfen. Also: morgen denke ich erstmal an das 3DD-Cluster-Treffen. Und an den CC Messeauftritt. Heute Abend schicke ich noch	Question: Which entrepreneurial leadership steps lead from vision to success IT-innovation business modelling: A process for leading visionary ideas to successful start-ups. This is the process I want to find. […] What now? It is Sunday, 21:40h. Next Friday, there is the deadline.

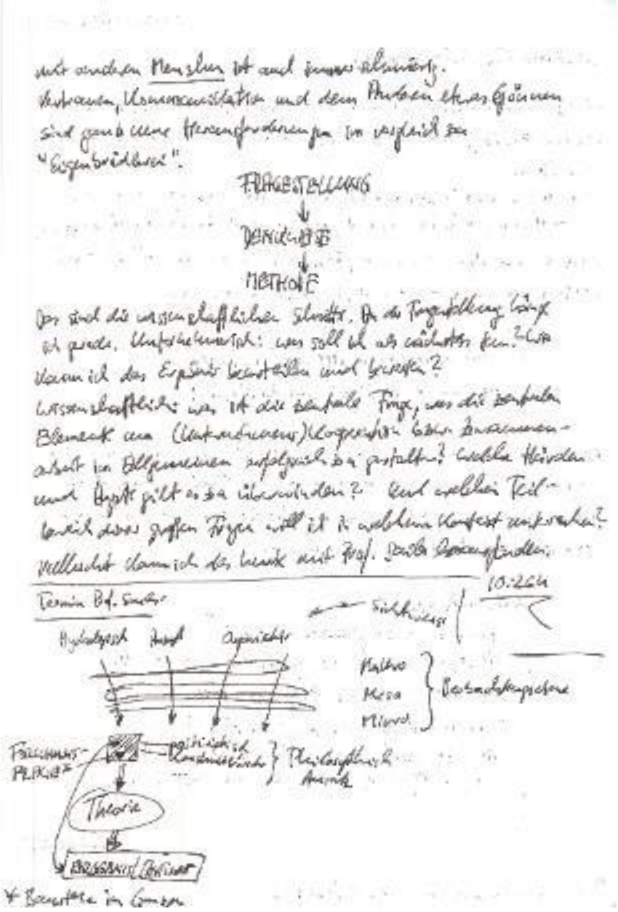
Reference[2] and date[3]	Example diary page[4]	Translated summary statement[5]
2014-11-06 LPE2-S.15, 16	 Anregungen Prof. Sailer. ▷ Mehr in der wissenschaftlichen Domain bleiben → become a good researcher. ▷ Prozeßdenken und Modelling nach Osterwalder sind vielleicht veraltet, da zu linear. Es ist nicht möglich ein Ziel zu bestimmen und geradlinig darauf hinzuarbeiten: Die Welt verändert sich! ▷ Mein Vorschlag (S. 4) ist ebenfalls zu linear. ▷ Er fand sehr interessant, daß bei meinem Thema so viele Technologien zusammenfließen. AR, VR, 3DD, … Und [illegible] die Einflußnahme werden. Mein Fazit für den Moment ist, daß ich [illegible] bei Prof. Sailer bin, was das Thema betrifft. Denn es ist tatsächlich so, daß die Entwicklung extrem dynamisch ist und ein [illegible] Umgang mit Veränderung [illegible] Neues taucht auf, bei Bestehendem gehen die [illegible] kaputt. Letztendlich 15 geht [illegible] extrem nach Darwin. Es überlebt der am besten angepaßte. Und Unternehmen müssen sich kontinuierlich anpassen. Ja, ich glaube das, kann ich ganz direkt auch auf Core Consulting anwenden. [illegible] CC Start Ziel: Unternehmens- [illegible] sein Wie es eher gelaufen ist: CC Start	Feedback Prof. Sailer Stay more in the scientific domain Procedural thinking may be old fashioned and limiting […] […] … like Darwin: survival of the fittest. And companies need to continuously adapt. Yes, I think I can apply this directly to Core Consulting[6]….

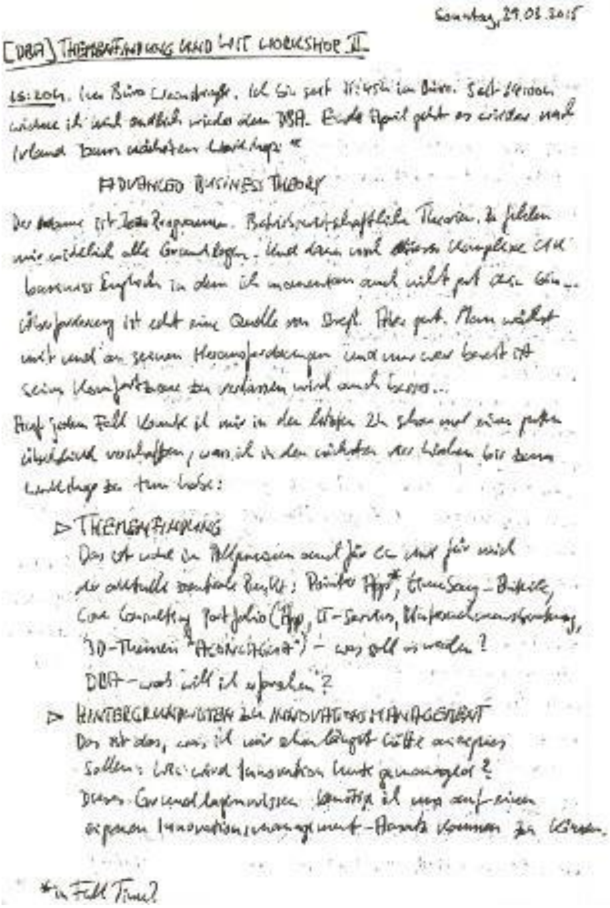
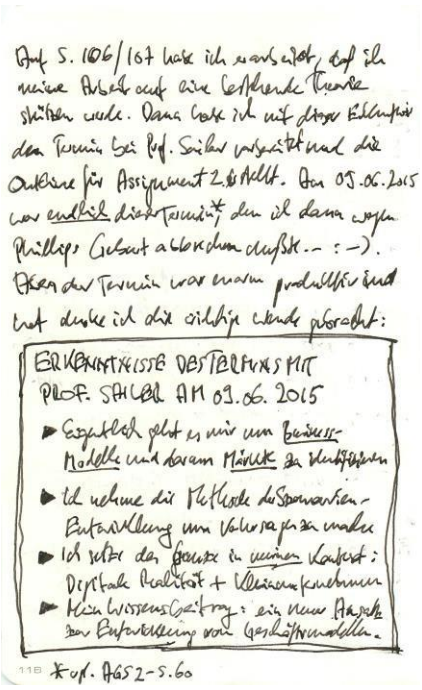
[6] The author's business at the time.

Reference[2] and date[3]	**Example diary page[4]**	**Translated summary statement[5]**
2014-11-30 LPE2-S.22	Die Anregungen aus Irland* waren grob: ▶ Mein Forschungsthema noch mehr fokussieren: "new technologies", "emerging markets" oder "entrepreneurial aspects". ▶ Anmerkungen beim "Research Skills Audit" einzufügen ▶ Und: Die Zielformulierung zu schärfen ("carrying out an action research study is not an objective in itself"). Meine momentanen Knackpunkte, bei denen ich im Augenblick noch nicht so ganz genau weiß "wie weiter" ~~ist~~ sind: ▶ Forschungsmethode: ich weiß gar nicht genau welche es da gibt. ▶ Thema fokussieren: Mein Titel des Rationale: „New approaches to managing dynamic innovation processes in the conflicting areas of new technologies, emerging markets, and entrepreneurial aspects" *vgl. AGS2-S.31 → 23 Soll ja, so wie es jetzt formuliert ist, den Konflikt der Themen beleuchten. Zu Deutsch: „das Spannungsfeld". Gerade habe ich LUB3 und LPB2 etwas bzgl. DBA-Erkenntnissen durchsucht, aber irgendwie nichts aufschlussreiches extrahieren können. Echt schwierig wieder so richtig reinzukommen, wenn man eine Pause eingelegt hat. ERKENNTNIS Ich muss wirklich kontinuierlich am DBA dranbleiben. Wenn Pausen auftreten oder die Ablenkung zu groß wird, dann kommt man echt schwer wieder ins Thema. Das dürfte wohl für <u>alles</u> im Leben so sein: KONTINUITÄT FÜHRT ZUM ZIEL UND ZUM ERFOLG! 24	Feedback from Ireland, roughly: You need to further focus your topic. […] … And: sharpen your objective. ("carrying out an action research study is not an objective in itself) My current key issues…..: Research method: I don't even know which ones exist Focus… Realisation: I really have to begin to work on the DBA regularly. If breaks are too long, or distraction is too strong, it becomes really hard to stay on topic.

Reference[2] and date[3]	**Example diary page[4]**	**Translated summary statement[5]**
2015-02-11 LUE4-S.35	 → Was will ich wissen? → Welche wissenschaftliche Frage will ich beantworten? → Und: was erwartet WIT im nächsten Workshop im April? Vor mir liegen die Notizen von meinem Treffen mit Prof. Sailer (02.02.2015), meine bisher eingereichten DBA-Unterlagen und die DBA-Mindmap. Also, das mache ich jetzt als nächstes: ☐ Nachlesen: "Stage Gate Prozeß", Blue Ocean, Open Innovation ☑ Nachlesen: Veröffentlichung Sailer, Hartmann, - Paper (2014) ☑ Klären: WIT Workshop 2. ☑ 2x 3DDK @ SCB ☐ Flug und Hotel WIT-Workshop buchen ☐ Lesen: meine bisherigen Unterlagen und Feedback. ☐ Ersten Versuch einer Formulierung: "Das will ich wissen" ☐ Treffen Prof. Sailer morgen vorbereiten Also los. Veröffentlichung Hartmann, Sailer*, … … Ok. Gefunden und ausgedruckt. Lese ich gleich mal… … So: Jetzt raucht mir erstmal nach dem Lesen der Kopf. Ich merke, daß ich nicht (mehr) so richtig drin bin in komplexem Englisch. Auf jeden Fall kann ich eine Kernaussage – um nicht zu sagen: Kernerkenntnis – aus dem Paper hervorheben: A SHARED VISION IS ABSOLUTELY NECESSARY. Entsprechendes muss ich auch für [illegible] Consulting, den DBA, die Zusammenarbeit mit M. [illegible], M. [illegible], M. [illegible], C. [illegible], … finden. Und immer wieder um Familie. * # 2087	DBA: next steps My new office in the Weinstraße is genius [… other topics …] Accordingly, I now have to find the re-entry with the DBA. Because, due to being sick and the amount of stress at work, I have quite lost track. … […] What do I want to know? What scientific answer to I want to find? What is expected of me at WIT next week? In front of me, I have the notes from my last meeting with Prof. Sailer (2015-02-02). Next steps: […] A shared vision is absolutely necessary! What do I want to know? I only have about 15 minutes left until the appointment with Prof. Sailer. Oh boy. I am not well prepared. But I proceeded a little. A joint vision. That is a central topic. [….]

Reference[2] and date[3]	**Example diary page[4]**	**Translated summary statement[5]**
	 Als Paux stelle ich jetzt nur die Rechnungen an das SCB für das 3DK. Dann kläre ich die nächsten Anforderungen des WIT-Workshops. […] Ok. Rechnung gestellt und dabei gleich die Adresse in der Buchhaltungs- software aktualisiert. Das SCB ist unser Kunde Nr. 100. :-) Bzgl. Workshop: hier habe ich erstmal nicht mehr gefunden als auf S. 3 des DBA Core Workbook steht. WORKSHOP 2, ADVANCED MANAGEMENT STUDIES Na gut. 16:40h. Um 17:45h muss ich los zum BVMW Netzwerktreffen. Also: Ein Bier mit den Kollegen. BVMW pausieren und dann morgen weiter ... 16:43h WAS WILL ICH WISSEN? Donnerstag, 12.02.2015 10:10h. Ich habe nur ca. 15 Minuten Zeit. Dann muss ich los zum Termin mit Prof. Sauter. Oh man. So richtig gut vorbereitet bin ich nicht. Also ein Stück weitergekommen schon. Eine gemeinsame Vision. Das ist ein schwieriges Thema. Und jetzt? Wie kooperiere ich nun im dynamischen Umfeld ein Unternehmen erfolgreich zu führen? Gerade habe ich die ursprüngliche Version meines Research Proposals noch mal gelesen. Als Unternehmer will ich unternehmerischen, wirtschaftlichen Erfolg. Ich glaube, daß gute Partnerschaften und Kooperationen der Weg dort hin sind – insbesondere in dynamischen, innovativen Umfeldern. Aber Zusammenarbeit	Working with other people is always difficult. Trust, communication and being able to allow others to profit are challenges in contrast to a self-breeding approach. Question > way of thinking > method This are the scientific steps. What shall I do next? […]

Reference[2] and date[3]	**Example diary page[4]**	**Translated summary statement[5]**
	 FRAGESTELLUNG ↓ METHODE ... Theorie	
Many pages of LPE2 in the first half of the year 2015		Entry not shown or translated in detail due to privacy. Writing about worries with children and hospitalised partner. Numerous family issues. … doubt, that the programme can be upheld…..

Reference[2] and date[3]	**Example diary page[4]**	**Translated summary statement[5]**
2015-03-29 LUE4-S.48	 Sonntag, 29.03.2015 [DBA] THEMENFINDUNG UND WIT WORKSHOP III 15:20h. Im Büro ... Ende April geht es wieder nach Irland zum nächsten Workshop * ADVANCED BUSINESS THEORY ... ▷ THEMENFINDUNG ... DBA – was will ich erforschen? ▷ HINTERGRUNDWISSEN ZU INNOVATIONSMANAGEMENT ... * in Full Time?	DBA finding the topic and WIT workshop 3 …. End of April I will go to Ireland again. Advanced business theory The name is programme. Business theory. I have really absolutely now basics in this. And then this UK – English. Being overwhelmed truly is a source of stress. So, what. One grows with his challenges. And only who is willing to leave his comfort zone has a chance of improvement. […]
2015-06-13 LUE5-S.111ff (Only summary page 116 shown)	 Auf S. 106/107 habe ich erarbeitet, daß ich meine Arbeit auf eine leitende Theorie stützen werde. Dann habe ich mit dieser Erkenntnis den Termin bei Prof. Sailer vorbereitet und die Outline für Assignment 2 erstellt. Am 05.06.2015 war endlich dieser Termin*, den ich dann wegen Phillips Geburt abbrechen mußte... :-). Aber der Termin war enorm produktiv und ... denke ich die richtige Wende gebracht: ERKENNTNISSE DES TERMINS MIT PROF. SAILER AM 09.06.2015 ▶ Eigentlich geht es mir um Business-Modelle und darum Märkte zu identifizieren ▶ Ich nehme die Methode der Szenarien-Entwicklung um Vorhersagen zu machen ▶ Ich setze das Ganze in meinen Kontext: Digitale Realität + Kleinunternehmen ▶ Mein Wissensbeitrag: ein neuer Aspekt zur Entwicklung von Geschäftsmodellen. 116 * vgl. AGS2-S.60	[….] Realisations from the appointment with Prof. Sailer What I am really interested in are business models and identifying markets. I will use the methodology of scenario analysis I set everything in my context My contribution….

2015-10-20

LPE2-
S.126, 127

Dienstag 20.10.2015

10:345. Ich bin im Büro im MTZ. Draußen ist es kalt und nebelig. Immernoch Halsschmerzen. Die Stimmung ist schlecht, Elise niest [illegible] und die Kaffeemaschine kaputt. Oh Mann.

WIT WORKSHOP 3

Letzte Woche war ich wieder in Waterford im DBA-Workshop. Diesmal waren es drei Tage, die schnell vorübergegangen sind. Insgesamt hatte ich das Gefühl, daß die Qualität etwas nachlässt. Die Lectures von Gorman und auch dem Department-Head O'Toole waren eher unstrukturiert und viele Folien wurden übersprungen. Und es war die ganze Zeit unerträglich kalt.
Trotz alledem war unter dem Strich der Workshop interessant und anregend. Tatsächlich hat die Diskussion über

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die Philosophie der Forschung sehr viel angestoßen und die nächste Runde wird jetzt richtig anspruchsvoll.

UMDENKEN

Das ist das Wort, das mir durch den Kopf geht. Ich muß jetzt tatsächlich umdenken und mich anders verhalten, sonst wird das nichts. Und damit meine ich die DBA und Phaenom. Ich muß jetzt jeden Tag Zeit für die DBA finden und auf Kurs kommen und bleiben. Ich muß jetzt genau wissen was ich wie erforschen will und das dann ab Januar 2016 machen.
Genauso für Phaenom. Jetzt muß ich anders agieren. Akquise, Projektmanagement, deutliche Umsatzsteigerung aber eben auch Risk und Planning. Und von dieser

127

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Genauso für Phaenom. Jetzt muß ich anders agieren. Akquise, Projektmanagement, deutliche Umsatzsteigerung aber eben auch Risk und Planning. Und von dieser

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WIT Workshop 3

Las week I visited Waterford, again. This time it was a three-day workshop, three days which passed by fast.

Overall, I had the feeling, that the quality is getting somewhat less.

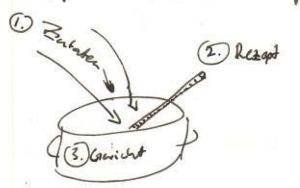
[…]

However, overall the workshop was interesting and inspiring. The philosophical discussions regarding research triggered something. The programme seems to become more demanding in some sense

Rethinking

That is the word appearing in my head. I really have to think different now and act differently, otherwise this will have no good end. And I mean both, the DBA and Phaenom[7].

[….]

Reference[2] and date[3]	Example diary page[4]	Translated summary statement[5]
2015-10-27 LPE2-S.135	Dienstag, 27.10.2015 DBA ASSIGNMENT 3 ROADMAP 10:36h. Das ist was ich jetzt brauche: Eine Roadmap für das Post Workshop 3 Assignment! Sehr erfreulich ist schon mal, daß das Feedback aus Waterford gut war! Das Pre-Workshop-Assignment wurde mit 75% (20% der Note) und die Gruppenarbeit mit 80% (10% der Note) bewertet. 30% der Note sind also schon gut geschafft. Allerdings nun als nächstes das zu erstellende Paper: und das ist doppelt wichtig, da es sich hierbei auch um die generelle Vorbereitung meiner Forschungsarbeit handelt! Ok, ich brauche jetzt eine Strategie und einen Zeitplan, denn am 7.12.2015 muß das Paper eingereicht sein. Dabei muß ich auch noch das "Fees-Thema" (vgl. S.128) 135	DBA Assignment 3 Roadmap That is what I need. A roadmap for the post workshop assignment 3! As positive the feedback was from Ireland ….
2015-11-22 LUE6-S.135	FOKUS MEINER FORSCHUNGSARBEIT Nochmal der Topf von S.119, diesmal erst Allgemein:  1. Zutaten ist das, was ich zum Kochen habe, die Lebensmittel die ich in den Topf werfe 2. Das Rezept ist die Anleitung wie ich koche. Temperatur, Reihenfolge der Zutaten, usw. 3. Das Gericht ist das, was ich essen möchte. Das sind die sichtbaren Dinge. Und was ist nicht sichtbar? • Der Hunger, also der Grund warum ich koche • Meine Einstellung zur Art des Kochens, z.B. vegetarisch oder nicht, also mein Weltbild • Die Ausgangssituation / Context (was ist im Kühlschrank, wo bin ich, was ist der / für/mit wem koche ich)	Focus of my research Again, the bucket from page 119, this time in a generalised form. Ingredients, this is what I have for cooking. Recipe, this are the instructions on how to cook. The meal is what I want to eat This are the visible things. And what is not visible? Hunger, the reason why I cook My attitude, the way I cook The initial situation and context: what is in the fridge

[7] The author's company which has transformed from Core Consuting to a new name and objective.

3 Reflective Log – Extracts from the Case Study Log

Log extracts from the authors case study log are presented below. The numbers given refer to the case study log[8] pages.

2018-02-16: The online research also reveals other, potentially interesting information. For example, the frequency of the appearance of a given company for a give search key phrase. Especially the amount of advertisement a given company posts online might offer insights into how active a company is. 23

2018-02-19 Important issue for the interview guide: cases/projects cannot be investigated directly. Hence, the data will be gathered involved individuals, who can be considered to represent the case, project, and involved companies, appropriately. Therefore, it is important to make sure that it is documented why I think that the person I talk to is the right person. 23

2018-02-28: From Dr. Duane: "There is a big difference between GERMAN technology companies (i.e. they are German owned) and technology companies in Germany (i.e. any technology company operating in Germany). I assume you intend the latter?" → Yes, I want to focus on technology companies who are operating in Germany. Hence, when looking at the cases, I have to precisely look at where the case is employed. 26

2018-03-23: During a business meeting I learned that part of the exposes created by the realter [name removed for confidentiality] are 360-degree visuals. These visuals are created by a 360-degree camera and then integrated in to the realters website. The solutions is offered by the company "Ogulo" [see #4384]. Two things were particularly interesting: A) The realter explained that she was offered detailed data of what potential clients looked at, and for how long. She described, for example, that she had a case where a potential client looked at the living room for almost 45 minutes. Therefore, she concluded, that "the client had already planned out the entire room in is head. Clearly, the client must be seriously interested. Consequently, the price negotiations were done harder". B) Virtual reality goggles were, according to her, not part of the solution and not necessary. For me, this initiates the need to re-open an old discussion; namely, revisiting the definition of virtual reality. Is viewing 360-degree-content on a web browser part of virtual reality? How about watching the 360-degree content interactively on a tablet or smart phone? Arguably, both could be part of a virtual reality definition. 29

2018-03-24: Need for clarification: what exactly are technology companies? For example, if I take the case of virtual reality real estate walk throughs: who do I talk to? The realter using the technology, or the company offering the technology, or both? Again, a brief literature review likely will help sharpen this, a potential starting point is the overview chart and quotes offered by Guzzetta (2016). 31

2018-04-10: Thus far, the identification of actually hard cases is progressing rather slowly. The online results (Google research) seem to be dominated by companies who

[8] Case Study Log V.44

are augmented reality and virtual reality service providers. Concrete cases are few and far between. 32

2018-04-14: Every once in a while, a company appears, which seems to be quite successful with a low technological approach to the augmented reality or virtual reality technology (cf. #4524, #4479) for examples. This, again, raises questions: what exactly is augmented reality/virtual reality, where do I draw the line; what exactly is a technology company; and what is the exact role of the technology on business model innovation? 33

2018-04-14: What I really need to do is to have a pilot case study lined up for the first week of May! Then I can use the feedback from the Paper 2 examination to optimise the interview protocol; conduct the pilot immediately, perhaps even two; and write Paper 3 by the end of May. 33

2018-05-16: Observations from conducting pilot interviews [#770001A/B]: On-site surprise: I had (and took) the opportunity to conduct two interviews. The interview guide worked well, in general; however, whenever a question was difficult to communicate, immediate discomfort could be observed in the interviewee. Overall challenge: the questions seem to be more fitting for a case within a company, who is not an AR/VR provider. The pilot case was an AR/VR start-up. Consequently, for the main study I will attempt to focus on established companies, who implemented an AR/VR case to innovate an established business or case. Clearly, I could observe a gap between "yes, I know what business models are" and the lacking ability to formulate what a business model is (same held true for the pre-pilot test run #770007). Interesting discrepancy in perception of the business focus: the CTO [#770001B] felt that the company was an agency, a service provider for augmented reality and virtual reality, whose focus is primarily on creating revenue though billable services (billable hours). He felt that this, perhaps, should have been more the initial focus of the company. The CEO [#770001A] felt that the focus is the development of their product. Offering services is a mere, temporary consequence of a slower-than-expected evolving market. Interview recording times: #770001A 38 minutes; #770001B: 42 minutes. 39

2018-05-16: The CEO [#770001A] mentioned a concrete augmented reality project which they implemented jointly with BCG. This project sounded very interesting. I should attempt to get access to this project and the stakeholders. 39

2018-05-27: Secondly, I would like to note down a hunch which appeared in my head from my case study log database analysis performed yesterday, combined with today's reading: a first theory resulting from my research could be to propose a business model innovation strategy as follows. When a new technology emerges, adapt the strategy to be a service provider for software development (agency model), first; then develop first products enabled by the new technologies, which are "not very ambitious" (low-hanging-fruit approach); and then, in a third stage, use the obtained experience to build highly-specialised, and technologically-sophisticated software products. In summary: A proposed business model innovation strategy: 1. In a first phase, start with an agency model; 2. begin the development of technologically "not very ambitious" software solutions ("low-hanging-fruit approach"); 3. once the market is ready, develop highly-specialised, technologically-sophisticated software solutions ("business model expert approach") 44

2018-05-27: Furthermore, it is noted, that the research is very focused on software, rather than hardware. To be more precise, focused on application development. It seems like the initial push of hardware plus "enabling frameworks" (primarily the Unity game engine) are the main drivers for business potential. Perhaps it is the location Germany, or the author's personal perception, but it seems to me like little impact can be observed by hardware innovations stemming from Germany. I sense a certain contradiction here: on the one hand, hardware is driving the evolution; on the other hand, it seems like the great opportunities lie within software. This, however, might not be an entirely new phenomenon. For example, arguably, the hardware industry for computers and smart phones is an extremely resource-intensive, risky, and low-margin business. The "real" money is made with software. Even hardware-innovators who thrive well – such as Apple – seem to be able to do this only in combination with an associated software eco-system. 44

2018-07-09 needed research modifications: Focus on already existing companies; perhaps even address this point specifically and mention in your research, that you exclude the branch of entirely new business models? Drop "technology companies" from the research project title; as noted earlier, this might be too much of a restriction – then again, this will depend on the cases that I actually implement: the real estate case is an example of a company, who isn't a technology business; however, other cases such as the case at Porsche [see #770005] or at [company name removed] [#770018] are cases at technology businesses. Hence, this will be a decision I need to finalise in Paper 4. 52

2018-08-02: Interesting feedback: case #770002 does not seem to work out, after all. Well actually, to be honest, I never had my hopes up too much. While I do have direct access to an employee at [company name removed], who is aware of AR projects, I just received the feedback, that I will have to go through the official affairs address. Most interesting is the explanation: my contact is not allowed to share any details, because of the strategic relevance of the topic. 53

2018-08-02: Observations from the Munich VR Meetup (Special edition) I attended on July 26, 2018: Overall, the community is still rather small. However, first companies seem to thrive rather well; at least this was the impression I got from the presentation of the company Holgate. Also, I had an interesting conversation with another visitor to the event: an adult woman, who apparently spends a significant amount of time in the SecondLife spin-off High Fidelity, a real-time social-VR platform. I was amazed to hear, what is already happening in VR cyberspace, and will have to try this as quickly as possible. 53

2018-09-12: Again, the issue of the term "technology companies" in the research questions is still challenging; particularly since my new pilot case study is conducted with a real estate business, which arguably is not a technology company. Furthermore, I was not able to find a decent definition of what a technology company is. Creating my own definition feels like opening an entirely new can of worms. Consequently, I will go back to Paper 1 and Paper 2, see how I address the issue there, and then deal with it somehow. 60

2018-09-15: #770010B observations of first read: on a side note, I was wondering, whether a AR or VR will become similarly disruptive as my mobile phone, which for example now serves as a recording device, and hence replaces traditional recording devices. What would have AR or VR to offer, to become this influential? Generally speaking, the motivation to employ VR for the interviewee was to simplify the service for the end consumer, to increase process efficiency, safe internal resources. I thought was interesting, that this innovation was brought to the company from the inside, rather than being a strategic topic brought into the company by upper management; in contrast, upper management likely does not even know, that this tool is in place and what its effects are. The key benefit of the solution seems to be, that end customers can obtain a much more detailed, reality matching impression of the real estate object. Furthermore, the interviewee claimed, that the two included a feature, enabling the end customer to visualise how an old bathroom would look after renovation. This is a functionality, which I have to take a look at. The interviewee also emphasised the simplicity of the integration of the service (integration of an iframe via embed code) and the low-cost. Looking forward, the interviewee theorised that solutions like this 360° tour might threaten jobs of real estate agents; or even open up entirely new ways for and customers to market their real estate property without a realtor. Further, the benefits of remote viewing were mentioned. An interesting key benefit of using this innovative service was, that the real estate company was perceived as cutting edge and innovative. This catered more importantly to the customers willing to sell their property, rather than to the buyers. From a strategic perspective, the project was deemed to be a good first step (it was the first project of its kind) to get ready for the era of digitalisation, in which more and more tasks are implemented by online services and digital solutions, and less and less by humans. In summary: an AR or VR project can be used to begin to get ready for the digital transformation, particularly as this type of project is not that threatening to employees, rather they are perceived as tool which is the daily work and improve the acquisition process. Further ideas and desired functionalities included the simulation of a true on-site experience through virtuality, the ability to perform remote visits, as well to visualise what a real estate object would like after renovation or structural modification to push the attractiveness of objects. Lastly, the interviewee mentioned an innovative new idea: a location-based mobile service (an app), which enables and customers to explore a real estate property directly at the site (when driving by) to virtually to the property (VR, x-ray vision). 60

2018-09-21: Initial observations of reading through interview #770010A: The solution is very tightly integrated into the IT and business process of the company. The solution is used autonomously. 360° images reveal more reality and put an end to manipulated photographs, which is desirable by customers. It is important, that the solution can be presented "on the spot" by the realtors smart phone. Likely, this is just an intermediary solution, until virtual reality becomes more readily available? The employment of the 360° tour is perceived to be competitive advantage, however, not a "must have". Interesting phenomenon: visitor tourism. These are people faking to be potential clients, who just want to visit their real estate object for pleasure. The employment of the 360 tour seems to reduce the number of "fake visits". The assumption is, that the desire to be inside the real estate object (voyeurism) is fulfilled through the 360° tour. This results into value propositions: one, less unqualified visits (good for the real estate agent's efficiency, and good for the seller, as it results in less visitor traffic); two, pleasure for real estate tourists. Business model innovation process: the 360° tour was introduced by employees for employees. Management has little to do with this innovation. Identification of value propositions for four groups (see comment in question 17 in the interview analysis document). 61

2020-02-08: Likely, it is best, if I insert the remaining items, such as pre-faces, from files, as well. Then, in a last step I modify table of figures and table of tables and then only update the page numbers, from then on. 171

2020-02-26: Note to self: developing methodology is very enjoyable to me. I can see this in the great success of my Paper 2, as well how much I liked writing the Paper for the 6th ARVR conference. Perhaps I take this as a future research Avenue for me. 174

2020-03-05: Now back to the DBA research. Absolutely no one I spoke with had anything like this [a BMI representation] to show. I guess this is a finding. 195

2020-03-05: Yes, this is my conclusion here. Looking at the data, I did not find any evidence that BMs are used as communication tools. Consequently, as a recommendation, I could later on right, that BMs should be used to communicate and explain in the company, what the company is aiming to. Regular BMI sessions should be used, to explain to everyone in the company, what is now being done differently. 195

2020-03-07: Introducing a new technology temporarily pushes BM newness within an industry. This observation may build a link from BMI theory for emerging technologies to the first mover advantage concept, perhaps extending or at least confirming it. 198

2020-03-07: if a company is just trying to jump on a contemporary topic (e.g. an emerging technology) for temporary marketing benefits, it might as well move fast and cheaply (numerous young startups are dying to find first, ideally high profile references); if the company plans to establish a new technology and BM in the long run, it might be prudent to wait until the maturity level of the technology is sufficient, until the markets have sorted out which vendors survive, and until technology costs are low. Furthermore, BMI must be considered if long-term gains are desired and the needed technological competences should be built up in-house. 198

2020-03-10: The case data confirms that augmented reality and virtual reality technologies can act as a driver for BMI. 204

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