Capturing the XR Market: Examining Strategies to Reach the Broader Market

An exploratory study of commercialization of XR enabled by 5G

Terese Hilmersson and Ebba Lindström

LUND UNIVERSITY

Terese Hilmersson and Ebba Lindström

June 2023

M.Sc. Thesis

MIOM05 Degree Project in Production Management

Division of Production Management

Lund University, Faculty of Engineering LTH

ABSTRACT

Living to some extent in a partly or fully virtual reality is a scenario that may not be as far in the future as many may think, and the development of technologies that enable this is fully underway. This thesis investigates the commercialization of extended reality (XR) technologies in the consumer market and what may facilitate and hinder this commercialization. The emerging ecosystem of actors is analyzed and mapped in order for the industry and academia to receive an overview of the actor landscape. A special focus is also directed towards the value of XR technologies, and how this value can be captured through different revenue models.

The research is a qualitative study with abductive reasoning, based on interviews and documents as the main data sources. The collection of data was facilitated by the support of the Swedish telecommunications company Ericsson, who see XR as a use case for their 5G technologies. Through 21 interviews with industry experts a more comprehensive view of the XR landscape, potential value-capturing opportunities, and commercialization is obtained.

To analyze the findings surrounding the industry landscape the thesis uses concepts such as the ecosystem pie model, vertical integration and ecosystem complementarities and network ties. The relevant revenue models are compiled in the findings and compared to revenue models often occurring in theory in the analysis. The most important commercialization concepts used to synthesize the findings are innovation diffusion models, success factors for commercialization, and concepts for the overarching commercialization process.

The results indicate that XR technologies have not yet reached the early majority and in order to do so it is crucial to ensure the timing with a whole-product configuration, support from the adoption network, and to collaborate with early adopters to find key value propositions. The thesis implies that the most important barriers to mitigate are the technological and trialability barriers.

Keywords: XR technologies, HMD, B2C commercialization, value capturing, revenue models, ecosystem mapping, adoption network, high-tech innovations

PREFACE

With this M.Sc. thesis, our five-year journey in studying Industrial Engineering and Management at LTH is brought to an end. In this thesis, we have utilized the knowledge we have gained through the M.Sc. program of Industrial Engineering and Management and applied it outside of the university sphere. This thesis has been conducted at the Division of Production Management at LTH and is facilitated by Ericsson.

This thesis would not have been possible without the support from LTH and Ericsson. It has been a delightful experience collaborating with all individuals involved in this journey, and there are multiple individuals we would like to thank. To begin with, we would like to express our heartfelt gratitude towards our supervisor at LTH, Izabelle Bäckström for guiding us through this journey, providing support in times of uncertainty, and encouraging us throughout the process.

We also like to express our gratitude to Ericsson and extend an extra big thank you to our mentor Michael Björn and Sara Thorson. Working with you has been an enjoyable and enlightening experience, and we truly appreciate you introduced us to the world of extended reality and acting as a sounding board. Finally, we would like to express our genuine gratitude to all the experts who generously spared their valuable time to participate in our interview study. We deeply appreciate your contributions, as this thesis would not have been possible without your insights, sincere thanks to you.

June 2023

Terese Hilmersson and Ebba Lindström

Table of Contents

List of Figures

List of Tables

List of Abbreviations

3GPP - Third-Generation Partnership Project

API – Application programming interface

AR – Augmented reality

B2B – Business to business

B2B2C – Business to business to consumer

B2C – Business to consumer

CSP – Communication service provider

HMD – Head-mounted display

ICT – Information and communication technology

IoT – Internet of Things

LBA – Location-based advertising

MR – Mixed reality

RQ – Research question

SDO – Standard development organization

UX – User experience

VR – Virtual reality

XR – Extended reality

1 Introduction

This section serves the purpose of introducing the studied area of XR, its scope, aim, and purpose. It provides a background on XR and its connection to mobile communication, followed by a problem discussion that highlights theoretical contributions and practical implications. The research questions are then formulated to guide the investigation, and the study's delimitations are presented to define its boundaries.

1.1 Background

In this section, the addressed phenomenon is explained to provide a deeper understanding of the subjects investigated in this thesis. A background on 5G, XR, and how they are connected is presented to establish a solid foundation.

1.1.1 Mobile communication and 5G

The first generation of mobile communication was launched around 1980 and was limited to only mobile voice calls (Dahlman, Parkvall & Sköld 2021). Around ten years later, the second generation was launched and included limited data services and SMS (Salih et al. 2020). A further ten years later, the third generation of mobile communication, referred to as "3G", was launched (Stüber 2017). 3G incorporated reliability and high-speed data transfer and greatly enhanced information transmission capabilities (Salih et al. 2020). This included an increase in bandwidth and data transfer rate, allowing for web-based applications, audio and video files, and support for IP-based services (ibid.).

The fourth generation, referred to as "4G", was introduced around 2010. 4G provided a significant improvement with wider bandwidth, higher security, and high-speed internet access (ibid.; Dahlman, Parkvall & Sköld 2021). The introduction of 4G enabled a new range of mobile applications, such as mobile payment options, bike- and car-sharing options, and smart home applications, making mobile communication an essential part of modern life (Li, Z., Wang & Zhang 2021).

There is an ongoing transition toward the fifth generation, 5G, which introduces a higher speed, reduced latency, energy savings, and support for an increased number of devices (Salih et al. 2020). As mobile communication is becoming an integrated part of life, 5G is designed to meet this growing demand (ibid.; Li, Z., Wang & Zhang 2021). Figure 1 visualizes the development of mobile communication. The next step after

5G is 6G. During a panel discussion at the 6G Innovation Centre in Guildford, UK, voices were lifted expressing the wish for 6G to be an enhancement of 5G rather than replacing it (Donkin 2023).

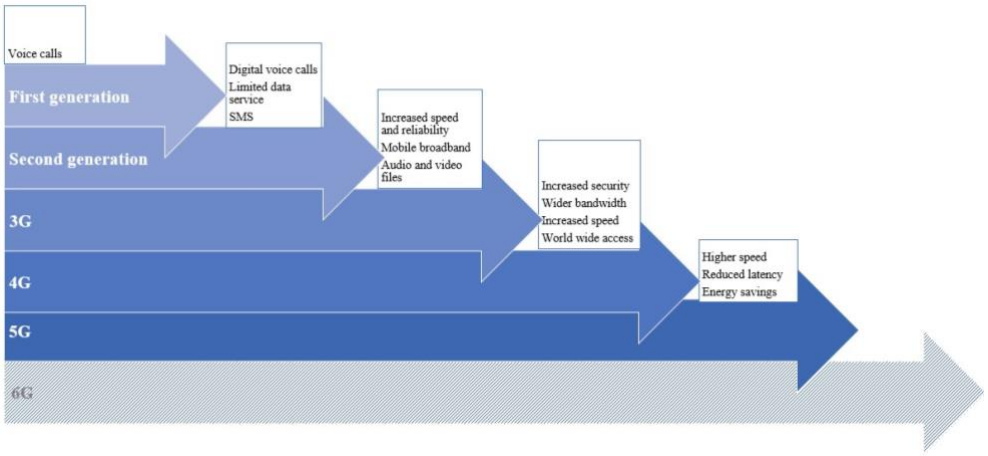

Figure 1. The development of mobile communication

The first two generations were developed separately by multiple players and the different versions were restricted to limited geographical areas (Dahlman, Parkvall & Sköld 2021). The lack of interoperability and geographical limitations were shortcomings of the early systems (Dunnewijk & Hultén 2007). This caused multiple European countries to develop the technology together (ibid.; Dahlman, Parkvall & Sköld 2021). Thus, this allowed their users to operate over several countries, and the technology covered a larger number of potential users (ibid.). Consequently, different regional standardization organizations came together and created the Third-Generation Partnership Project (3GPP), intending to create a mobile broadband standard (ibid.). Gradually the technology standard created by 3GPP became dominant. Thus, both 4G and 5G have been developed from this, leading to worldwide access (Salih et al. 2020; Dahlman, Parkvall & Sköld 2021; Li, Z., Wang & Zhang 2021).

1.1.2 Extended Reality (XR)

Extended Reality (XR) technologies are a group of prominent use cases for 5G (Kim et al. 2021). XR is a term often used to describe those computer technologies and wearable devices that create human-machine interactions through real- and virtual merged environments perceived by the user (Fast-Berglund, Gong & Li 2018). The focus of XR technologies is to improve the

user experience (UX) of digital content by providing enhanced ways of interaction, visualization, and remote collaboration (Cárdenas-Robledo, Hernández-Uribe, Reta & Cantoral-Ceballos 2022). XR is usually divided into the categories of virtual reality (VR), augmented reality (AR), and mixed reality (MR) (Fast-Berglund, Gong & Li 2018; Cárdenas-Robledo et al. 2022).

In VR, the user wears a headset with visual displays and experiences a virtual world through this (Ryoo & Winkelmann 2021). By using the headset, sensory stimulations from the real world are blocked and the user's motions are tracked in real-time which creates a three-dimensional experience of the virtual world (ibid.). VR is among other areas used for gaming, retail, and for educational purposes (Voštinár, Horváthová, Mitter & Bako 2021).

In AR, the real environment is used as a base where virtual attributes are added on top of the environment, an example of how this can be used is for architects to visualize structures where they are to be built into the real environment (Slater et al. 2020). The digital objects thus seem to coexist with the real world, as the technology runs interactively in real-time (Azuma et al. 2001).

MR is by some considered a hybrid between AR and VR, where the digital world is blended with the real world (Morimoto et al. 2022). Although there is no common definition of MR (Speicher, Hall & Nebeling 2019), a common way of viewing MR is the blended virtual and real reality where cameras are used to see the real world, in contrast to AR where the real world is visible through a lens (Björn 2023).

1.1.3 XR Enabled by 5G

XR is considered a potentially disruptive technology (Nisiotis & Alboul 2021) and is widely regarded by researchers as the next big thing with the potential to revolutionize various sectors including education, healthcare, and entertainment (Paris, Pedersen & Zhao 2022). To achieve this, it is crucial that the UX of XR is enjoyable, which requires seamless interaction between the real and virtual worlds. XR applications place significant demands on the quality of the UX (Taleb et al. 2022). Poor tracking, low framerates, or rendering lag, can cause a discrepancy between what users visually see and the sensory perception of their balance and spatial orientation, resulting in discomfort and nausea (Andrews, Southworth, Silva & Silva 2019). For instance, to keep users from experiencing motion sickness, the end-to-end latency needs to reach significantly low levels (Taleb et al. 2022).

Although XR is seen as the next big thing (Teixeira & Peres 2020; Paris, Pedersen & Zhao 2022), the existing XR technologies are currently mainly deployed in indoor environments powered by WIFI and wired connectivity (Gao, Xue, Ding, Peng & Pang 2021). According to Gao et. al (2021), one of the prime inhibitors for reaching mass commercialization is the restricted mobility of the technologies as they are today. Thus, for XR to live up to its full potential and reach the broader market, it needs to be mobile, in terms of being able to use the technology whenever, wherever. In addition, XR requires a high bandwidth, bit rate, and reliability, and low latency (Akyildiz & Guo 2022; Taleb et al. 2022). These requirements pose another big challenge with XR technologies. Namely power consumption and maintaining a satisfactory battery lifetime (Paris, Pedersen & Zhao 2022).

The goal of the deployment of the 5G network is to reduce latency, increase coverage, improve battery usage, and allow for higher data rates (de Almeida, Mendes, Rodrigues & da Cruz 2019). In addition, 5G networks aim to increase the number of smart devices and support more reliable device-to-device communication (Pratap & Das 2022). Thus, 5G networks are a potential solution to these main difficulties in reaching the mass market (Alriksson, Kang, Phillips, Pradas & Zaidi 2021). If XR technologies can be supported by wireless cellular connectivity, the usage will no longer be limited to indoor spaces (Gao et al. 2021). 5G enables offloading most XR processing to the mobile network edge which can improve the processing power and decrease power consumption in the XR

devices (Alriksson et al. 2021). By using a split architecture and exploiting the low latency in 5G networks the end-to-end latency may be low enough (Kim et al. 2021).

Accordingly, XR is by some considered a key use case among the multiple ones of 5G (Camps-Aragó, Delaere & Ballon 2019; Kim et al. 2021). Camps-Aragó, Delaere, and Ballon (2019) argue that the technology and architecture of 5G will enable multiple use cases in a wide range of areas. Capturing value from enabling technologies, such as 5G, is challenging (Teece 2018), and even if a wide range of actors are announcing their plans to, in the upcoming years, roll out their 5G networks, their business models for this are unclear (Camps-Aragó, Delaere & Ballon 2019). According to Camps-Aragó, Delaere, and Ballon (2019), there is potential to grow with the launch of 5G, but increased competition from new players can be expected. Therefore, it is crucial to find a sustainable business model that will work in the emerging 5G ecosystem and leverage the effects 5G will have in value capturing (Ibid.).

1.1.4 The potential of XR

The promising future of XR technologies becomes evident with the potential for widespread mobile usage enabled by 5G technology. This indicates that XR has the possibility to seamlessly integrate into our everyday lives. Therefore, this thesis investigates how XR the form of head-mounted displays (HMDs) will reach the broader market. XR technologies are believed to have the potential to disrupt the digital world (McKinsey & Company 2022). The worldwide XR B2C market revenue in 2022 was estimated to be 25 billion USD (Statista 2022a). In comparison, the worldwide B2C market revenue for smartphones was estimated to be 460 billion USD in 2022 (Statista 2023), and the global market revenue for tablets in 2022 was 57 billion USD (Statista 2022b).

The global B2C market revenue for XR technologies is estimated to double in size during the five-year period between 2022 and 2027 and reach 52 billion USD in 2027 (Statista 2022a). By 2030 XR technologies are believed to have an impact of over 2 billion USD on e-commerce, more than 140 billion USD impact on the advertising market, and more than 100 billion USD impact on the gaming market (McKinsey & Company 2022). Thus, studying XR technologies in their initial stage and how to reach this potential is of high interest.

1.2 Problem discussion

In this section, both practical and academic gaps are discussed, and the subject reviewed in this study are further presented. These gaps highlight the academic contributions and practical implications of the research.

1.2.1 Academic implications

Technologies play a crucial role in driving economic progress, but to bring benefits to society and profits to businesses they need to be effectively commercialized in the market (Kirchberger & Pohl 2016). In the literature review "Commercialization of disruptive innovations: Literature review and proposal for a process framework" from 2021, Nieto Cubero, Gbadegeshin, and Consolación investigate the current literature on the commercialization of disruptive innovations. The authors shed light on the fragmented knowledge on this topic in academic research.

Chiesa and Frattini (2011) argue that most studies on commercialization failures focus on the product itself, and not commercialization decisions such as timing and positioning. Further, Nieto Cubero, Gbadegeshin, and Consolación (2021) argue that most studies on commercialization of disruptive innovations, such as XR (Nisiotis & Alboul 2021), are done in narrow fields, and that there consequently is a gap in taking a holistic approach to capture the complete picture of commercialization. Commercialization of high-tech innovations is described as one of the most critical phases for the innovations, and yet not well managed or studied (Chiesa & Frattini 2011; Datta, Reed & Jessup 2013; Nieto Cubero, Gbadegeshin & Consolación 2021). Chiesa and Frattini (2011) point out the need for further investigations into commercialization of high-tech innovations, especially reasons for failure in adopting new technologies and to what extent their findings are generalizable.

Conceptualizing value in business model development is essential for a successful commercialization of innovations (Dmitriev, Simmons, Truong, Palmer & Schneckenberg 2014). As mentioned in the background section, the literature suggests that the launch of 5G creates a possibility for market growth, but multiple question marks regarding the emerging ecosystem of 5G remain (Camps-Aragó, Delaere & Ballon 2019). According to Camps-Aragó, Delaere, and Ballon (ibid.) developing a sustainable business model is difficult for the providers of 5G since it is a general-purpose technology. They argue that the two main effects of 5G and network slicing technologies will have to do with the control (distribution) and value aspects. The authors

shed light on the fact that there is a research gap regarding which other factors may drive and shape the ecosystem around the technology and the different business models.

The new types of experiences that XR is enabling are driving transformation across several industries such as commerce, manufacturing, education, healthcare, entertainment, and communications (Teixeira & Peres 2020). According to Takeishi and Lee (2008), to understand the development of industries, it is important to analyze the business ecosystem. Takeishi and Lee (ibid.) further argue that non-economic factors such as power structures have a significant influence on the progression of the development of business ecosystems. The authors also urge that there needs to be more studies in the area to create a more robust framework.

1.2.2 Practical implications

This thesis is facilitated by the Swedish multinational telecommunication company Telefoniaktiebolaget LM Ericsson, commonly referred to as "Ericsson". Ericsson is a world leader in the dynamic world of communications technology (Ericsson n.d.-a), providing a wide range of products and services in the field of information and communication technology (ICT), including 3G, 4G, and 5G equipment, cloud software services and infrastructure, and IoT solutions, to enable the full potential of connectivity (Ericsson n.d.-b). Since Ericsson is a provider of the general-purpose 5G technology, they are researching multiple different use cases, one being XR technologies. The practical implications are hence derived from the discussion with Ericsson.

In accordance with Kim et al. (2021), Ericsson consider XR as a prominent use case for their 5G technology but see multiple question marks regarding the ecosystem for XR technologies. They too see the challenge in developing a sustainable business model for their 5G technology, as visualized by Camps-Aragó, Delaere, and Ballon (2019). Communication service providers (CSPs) have raised the issue of deriving value from investments in 5G to deliver on their promises (Donkin 2023).

Connectivity infrastructure actors and CSPs see a gap in the willingness to pay for connectivity compared to the costs of the level of connectivity that is needed (BCG & ETNO 2021; Lago 2021; Stewart & Nickerson 2021; DCF 2022; Donkin 2023; GSMA 2023). This has left multiple CSPs and connectivity infrastructure providers unsure of how value capturing will be

done. Thus, there are question marks regarding the challenge of building out high-performance networks for advanced XR services and merely profiting from raised costs of mobile subscriptions. This has caused Ericsson to want to investigate how the ecosystem will evolve and become economically sustainable, and how the technology will reach the broader market.

1.3 Purpose

In this section, the research aim, research questions, and this thesis' academic contributions and practical implications are presented.

1.3.1 Research Aim and Research Questions

The research aim of the thesis is to explore how XR technologies can be successfully commercialized to reach the broader market through mapping the ecosystem, investigating the interdependencies and roles in the ecosystem, as well as examining how value can be captured.

The overall research question is presented as: **"How can XR technologies be commercialized to reach the broader market?"** which is supported by the following sub-research questions that are of importance when investigating the overall research question:

RQ1: Who are the actors, what roles do they play, and what are the interdependencies?

RQ2: How can value be captured from XR technologies?

Through these research questions, this thesis will contribute with increased knowledge within the area of commercialization of high-tech and disruptive innovation, as previously described as a fragmented and understudied area. Additionally, the thesis will answer how the ecosystem is structured and what possible value-capturing methods may be used which was explained as an unsure area by the collaboration company.

1.4 Delimitations

This section aims to present the delimitations of the study to define the boundaries within which the research is conducted.

The focus of the thesis will be on XR technologies used through wearable devices such as headsets and glasses, in the literature referred to as HMDs (Ratcliffe, Soave, Bryan-Kinns, Tokarchuk & Farkhatdinov 2021; Zagury-Orly et al. 2023), made for mobile use both indoors and outdoors. Therefore, technologies used solely through a smartphone and technologies with restricted mobility are disregarded. A further significant limitation of the scope of the thesis is the focus on commercialization in consumer markets. Possible applications in industrial, medical, or other B2B markets are therefore not studied in this thesis.

It is worth mentioning that in academic literature, there is yet to achieve consensus on what the "X" in XR should be the abbreviation for (Ryoo & Winkelmann 2021; Rauschnabel, Felix, Hinsch, Shahab & Alt 2022). While many state that the X as mentioned previously should be short for "extended" (Fast-Berglund, Gong & Li 2018; Yavoruk 2020; Ratcliffe et al. 2021), others state that this definition is too narrow and that "X" should encompass "all" new reality formats (Rauschnabel et al. 2022). Others emphasize the combination of elements from virtual and physical platforms by referring to XR as "cross reality" (Ryoo & Winkelmann 2021). For the purpose of this thesis, the term "extended reality" will be used, however relevant literature is considered whether it claims XR stands for all-, cross- or extended reality as long as the technology referred to is fundamentally the same. In this thesis, the term XR will be used as a hypernym for VR, AR, and MR technologies.

1.5 Thesis outline

In this section, the structure of the thesis is presented together with a short summary of the different chapters.

Chapter 1 – Introduction

The opening chapter aims to set the context of the thesis. This is done by providing a background and problem discussion, outlining the purpose, and specifying the delimitations. The overarching research question is presented together with two sub-research questions (RQ1 & RQ2).

Chapter 2 – Theoretical Framework

The purpose of this chapter is to provide the theoretical foundation of this thesis. Relevant ecosystem and network theories, value-capturing models, and commercialization frameworks are provided to facilitate the analysis and discussion of the findings and to answer the research questions. Finally, a synthesis of the theoretical framework is presented to guide the reader in the usage of the theory.

Chapter 3 – Methodology

The methodology chapter aims to increase the credibility of this thesis by thoroughly describing and motivating the research process of this thesis. This is done by discussing the research strategy, data collection, data analysis, as well as trustworthiness.

Chapter 4 – Findings

In the fourth chapter, the findings from the interview study and documents are presented. The presentation of the findings is structured in accordance with the two subordinate research questions concerning the industry landscape and value capturing, and subsequently aligned with the overarching research question on commercialization.

Chapter 5 – Analysis

In the analysis chapter, the findings are studied through the theoretical lens provided in the second chapter. Similar to the outline of chapter four, the analysis is structured around the research questions.

Chapter 6 – Discussion

This chapter contributes with a deeper discussion of the findings and research themes and the topic structure follows that of the previous chapters: findings, and analysis.

Chapter 7 – Conclusions

The concluding chapter summarizes the thesis by answering the research questions, firstly RQ1, then RQ2, and lastly the overall research question. The contributions related to the research questions are stated respectively.

2 Theoretical framework

In this section, the relevant theoretical framework to answer the research questions is presented. After which a synthesized theoretical framework is presented showing how the theory relates to the studied phenomenon.

2.1 Innovation classification

This section serves to clarify the terminology around innovations that is used in this thesis.

There is a myriad of different classifications for different types of innovations (Garcia & Calantone 2002; Nieto Cubero, Gbadegeshin & Consolación 2021). Bower and Christensen (1995) distinguish between sustaining and disruptive innovations, and Teece (1984) distinguishes between autonomous and systemic innovations. Frattini, De Massis, Chiesa, Cassia, and Campopiano (2012) divide innovations as either incremental or radical, and or either continuous or discontinuous.

Discontinuous innovations are innovations that necessitate a significant change in the supporting infrastructure in order to fully deliver their inherent value (Frattini et al. 2012). Radical innovations are innovations, usually incorporating advanced technologies, that significantly transform behaviors and consumption habits in the market (PDMA n.d.). Radical innovations create a demand rather than responding to one (Garcia & Calantone 2002). According to Garcia and Calantone (ibid.), discontinuous innovations are a broader category than radical, with some, but not all, discontinuous innovations being radical.

According to the Christensen Institute (2023), the term *disruptive innovations* is widely used, yet commonly misunderstood and misused. The term was coined by the founder of the Christensen Institute, Clayton Christensen. Christensen defines disruptive innovations as innovations that enhance accessibility and affordability by being simpler and more affordable (ibid.), thus opening up new markets and eventually taking over old ones (Christensen 2016). Disruptive innovations alter the foundations of competition, modify the attributes that are valued by users, and change the performance metrics by which firms compete (Nieto Cubero, Gbadegeshin & Consolación 2021).

Teece (1984) defines systemic innovations as innovations requiring crucial readjustments in the system, stressing the key differentiation from autonomous in the extent of the need for coordination in the development and commercialization process, with systemic innovations requiring more coordination. According to (Kovacs, Verhoeven, van Looy & Marullo 2019), some scholars use “radical” or “discontinuous” for innovations that are highly novel and “disruptive” or “breakthrough” for innovations that may have a great impact.

2.2 Network and ecosystem theory

In this section, the relevant network and ecosystem theory is presented. The main focus of the theory in this section is to create a theoretical basis for answering RQ1 and in extension the overall research question.

The notion of an ecosystem refers to a group of interdependent actors who collaborate to achieve a core value proposition (Adner 2017; Zhang, H., Hu, Shi & Gao 2022). Actors included in the ecosystem are the ones who need to adapt to changes in the technology and cannot be indifferent to changes (Adner 2017). According to Takeishi and Lee (2008), it is important to analyze the ecosystem in order to understand the development of industries. Thus, to be able to answer RQ1 it is crucial to obtain a comprehensive understanding of the existing literature and frameworks concerning innovation ecosystems and network theory. Further, industry-level regulatory and strategic factors play a crucial role in shaping an industry’s structure (Cacciatori & Jacobides 2005). The significance of ecosystems becomes apparent when the complex network of relationships supporting a value proposition cannot be reduced to several separate bilateral relationships (Adner 2017).

When presenting ecosystem theory, it is worth noting that the literature sometimes distinguishes between business ecosystems and innovation ecosystems. In some cases, business ecosystems are referred to as the same concept as innovation ecosystems, as a network of interdependent actors that jointly create value for customers (Gawer & Cusumano 2014; Overholm 2015). After doing a literature review on the innovation ecosystem construct, Gomes, Facin, Salerno, and Ikenami (2018) suggest a difference between the two concepts, namely what part of the joint business model the two types of ecosystems refer to. They state that the innovation ecosystem is connected to the value creation phases and that business ecosystems rather refers to value capturing. They also stress the fact that the

term innovation ecosystem has been more recently utilized in place of the term business ecosystem. In contrast, Jacobides, Cennamo & Gawer (2018) claim that the difference between business and innovation ecosystems is that business ecosystems focuses on a firm and its environment, and innovation ecosystems centers around a specific innovation or value proposition and the constellation of supporting actors. Consequently, there is no complete consensus in the literature on their nature, but the following ecosystem theory will focus mostly on cases where the innovation or technology is the focal point.

Other than business ecosystems and innovation ecosystems, additional types of ecosystems that have been identified in the literature are entrepreneurship ecosystems, digital business ecosystems, and industrial ecosystems (Pilinkienė & Mačiulis 2014). According to Cacciatori and Jacobides (2005), also vertical ecosystems can arise, meaning that there can be multiple ecosystems within the same sector that partly cooperate, and partly compete.

2.2.1 Innovation ecosystems

In order for innovating companies to reach desirable more complex value propositions, these companies need to depend on other players in their innovation ecosystem (Talmar, Walrave, Podoynitsyna, Holmström & Romme 2020). An innovation ecosystem can be defined as the collaboration of companies where the individual offerings of the involved companies are integrated in order to create a unified solution for customers (Adner 2006). In Jacobides, Cennamo, and Gawer's (2018) theory on ecosystems research, they stress the insight that companies are required to form a certain structure and alignment of their relationships in order to create value. They further describe ecosystems as a type of value system, presenting it as more complex than market-based or hierarchy-based value systems which are visualized in Figure 2 below.

As seen in the figure, different types of *complementarities* underpin the ecosystem and characterize relationships between actors in ecosystems. Jacobides, Cennamo, and Gawer (2018) base their reasoning on *unique complementarities* on the research done by Hart and Moore (1990) and Teece (1986), which can be a spectrum varying from strict complementarity, where X requires Y to function, to specific complementarity, where X requires Y to be customized to it to function, and all the way to generic complementarity, where the assets or activities can be

placed in the market. Thus, generic complementarity does not require certain structures of relationships, which means the complementarities in ecosystems may not be generic. The unique complementarities can be either two-way, where X and Y require each other, or one-way where only X is dependent on Y but not vice versa.

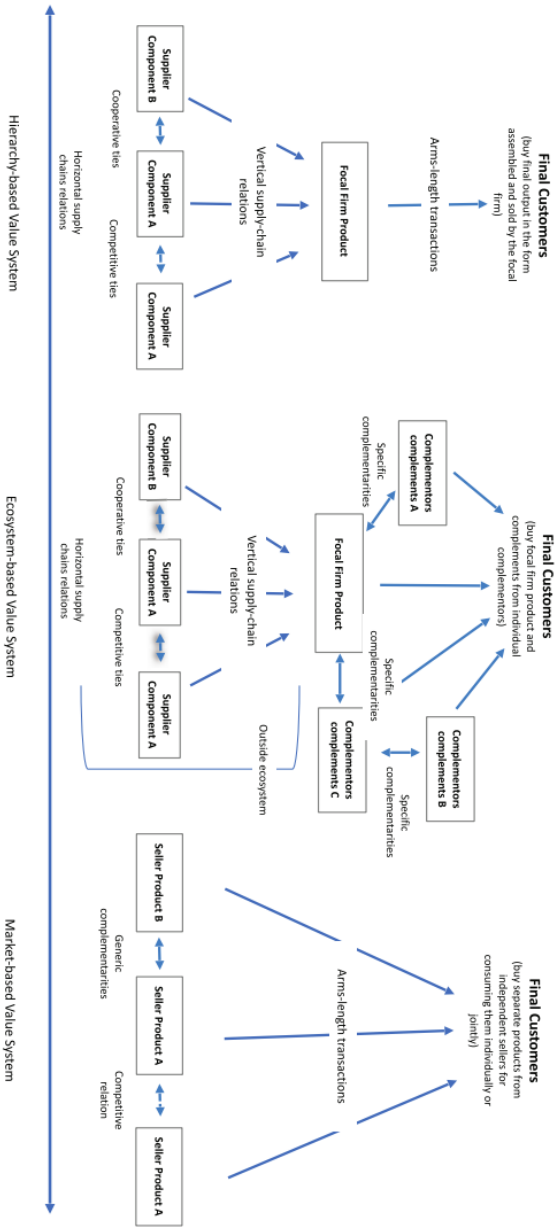

Figure 2. Ecosystem-based value system in comparison with hierarchy-based and market-based value system (Jacobides, Cennamo & Gawer 2018)

The explanation of *supermodular complementarity* is based on Milgrom and Roberts' (1990) study of supermodular games, and presents a type of complementarity where an increase of X makes Y more valuable. An example of this would be where an app cannot function without an app platform, but the existence of more apps increases the value of the app platform (Jacobides, Cennamo & Gawer 2018). Another aspect of interdependencies in innovation ecosystems is competitive substitution which is brought on by the intensified competition between incumbents and new entrants for core components (Zhang, H. et al. 2022).

Since an ecosystem refers to a group of interdependent actors (Adner 2017; Zhang, H. et al. 2022), and need to depend on other players in their innovation ecosystem to reach complex value propositions (Talmar et al. 2020), this thesis uses the above mentioned complementarities as a way to define the different interdependencies in the XR ecosystem.

2.2.2 Ecosystem Mapping

Talmar et al. (2020) present a tool for graphically visualizing innovation ecosystems called the Ecosystem Pie Model. They claim using this mapping tool to visualize the ecosystem can be beneficial both for actors of the ecosystem in question, but also for externals wanting to analyze a specific ecosystem. This model is seen in Figure 3 and the relationships of the constructs are seen on an ecosystem level (EL) or actor level (AL). The center of the model contains the value proposition of the ecosystem and the actors engaged with value creation and capture are divided as pieces clockwise around the pie with post-its stating the resources the actor has, the activities they conduct, their value addition, and how the actor captures value. The targeted market of the ecosystem's value proposition is positioned under user segment #1.

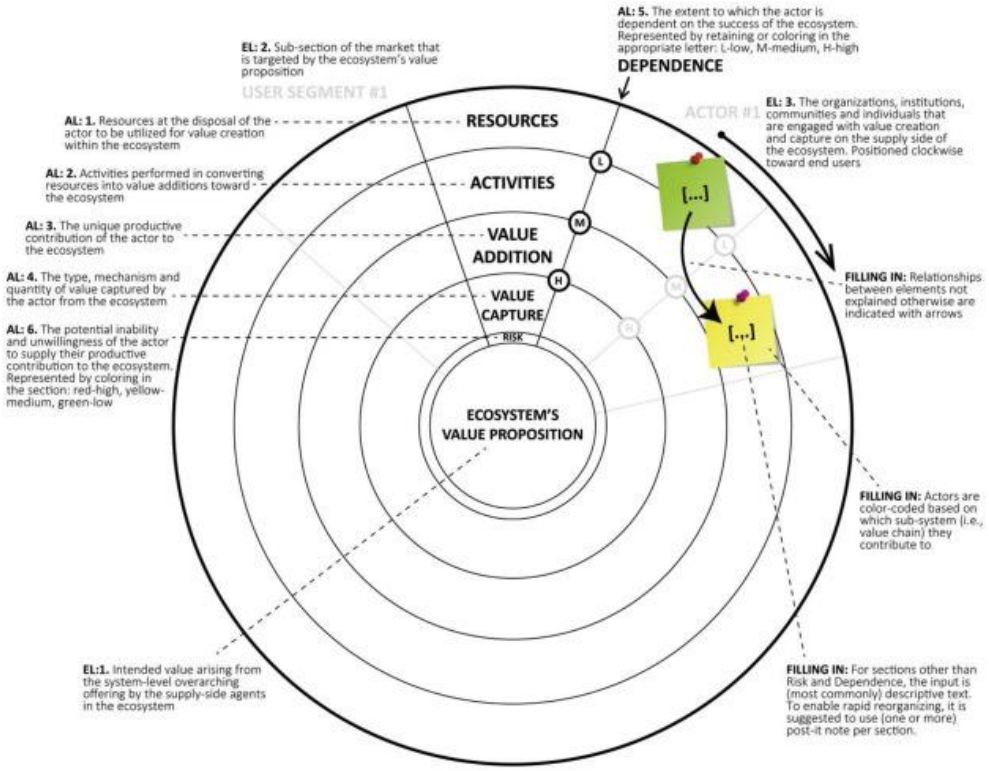

Figure 3 The Ecosystem Pie Model (ibid.)

For the same constructs presented in Figure 3, Talmar et al. (ibid.) presents a visualization of how each actor relates to the constructs, this is presented in Figure 4.

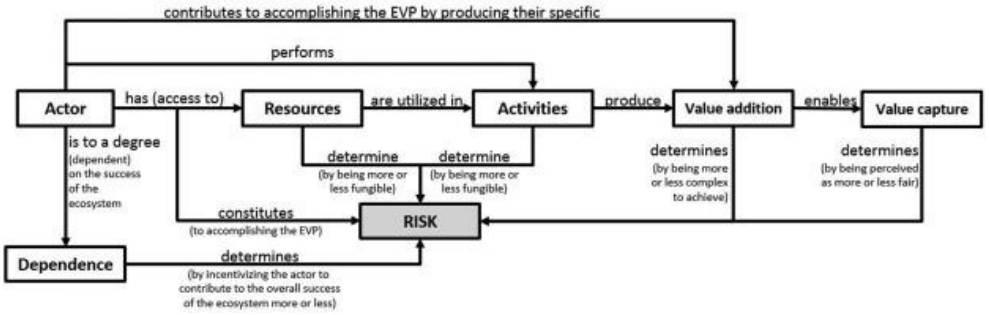

Figure 4. Intra-actor relationships to the constructs of the Ecosystem Pie Model (ibid.)

2.2.3 Network Theory

A further concept that aims to show collaboration between firms is the concept of networks, which in some literature (Ritter, Wilkinson & Johnston 2004) is used almost synonymously with the word ecosystem. Earlier literature on the subject was more characterized by describing business networks and relationships and a shift in the early 2000s was towards managing this subject (ibid.). The concept of business networks is described as resources, activities, and actors that are interconnected (Todeva 2006). The core aspects that connect these are, according to Holmlund & Törnroos (1997), relationships.

They further describe their view on business networks as a set of actors that in interaction with each other perform different types of business activities. The relationships they describe are defined as "an interdependent process of continuous interaction and exchange between at least two actors in a business network context" and are in this context characterized by mutuality, of long-term character, process nature, and dependent on context. This definition of relationships in business networks still holds as it has been referred to by scholars much more recently than when Holmlund and Törnroos first published their article in 1997 (Artto, Ahola, Kyrö & Peltokorpi 2017; Santos & Baptista 2021).

Holm, Eriksson, and Johanson (1999) presents findings that support the claim that engaging in business network commitments creates mutual commitment and dependence which creates value for the involved actors. This mutual dependence motivates the usage of network theory in investigating actor interdependencies. Thus, business relationships may be a strategically beneficial for firms to engage in. Another important aspect to keep in mind of the mutuality characteristic of relationships is that of power-dependence structures, where even though one actor may be stronger than others, no actor has complete control over the relationship (Holmlund & Törnroos 1997). The main determinants of bargaining are product specificity, alternative sources of suppliers, self-manufacturing ability, and dependence on suppliers, which can influence firms to control adjacent firms' assets without owning them (Harrigan 1984).

There are several ways in which network structures can be described. In their early work Håkansson and Ford (2002) describe networks as a number of nodes (business units) that are related to other nodes by threads

(relationships). Ford and Håkansson (2013) also present alternative structures of a network: one where there is a relationship between all actors of the network, a second where two actors both have individual relationships to a third actor, but not to each other, and a third where two actors have business relationships with each other but not to a third party. The reason for the third party not taking part in the business network can either be because it is too unrelated to the other actors, or that it is so similar to another actor that it is considered a substitute (ibid.).

Holmlund & Törnroos (1997) claim that a business network consists of three embedded layers, the production network layer, consisting of firm actors, the resource network layer, consisting of resource actors, and the social network layer, consisting of human actors. These layers in turn contain the nodes and threads explained previously.

An adjacent concept to business networks is that of organizational networks which also speaks of relationships of firm or business actors making this concept interchangeable with business networks (Ahuja, Soda & Zaheer 2012; Chen, Mehra, Tasselli & Borgatti 2022). The relationships between the firm and other actors in its organizational network can be either hierarchical, which reflects authority, referential, which represents certification relationships, market, which can be competitive or transactional relationships, or affective, which reflects an emotional bond (Ahuja, Soda & Zaheer 2012). These ties are visualized in Figure 5. Since the relationships were described as an interdependent process of interaction (Holmlund & Törnroos 1997), also these network ties are used to describe the interdependencies between actors in this thesis.

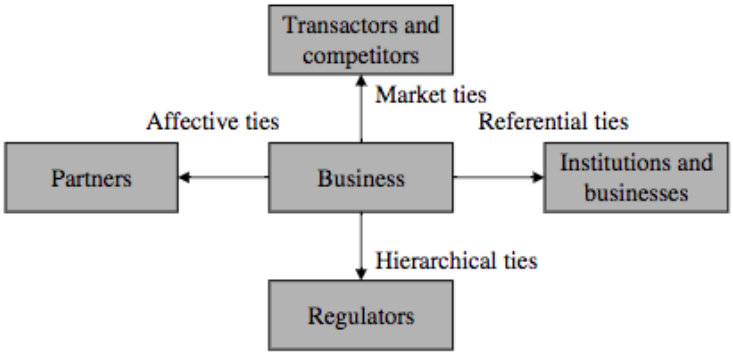

Figure 5. The relationships between a business and other actors of its organizational network (Ahuja, Soda & Zaheer 2012)

The aspect of network dynamics is mentioned in the process characteristic of relationships of business networks, where Holmlund & Törnroos (1997) explain that networks are dynamic in nature, and processes and events in the relationships cause changes in the relationships. Network dynamics are also discussed in the organizational network literature. A recent literature study concludes that three main drivers of network dynamics are contextual, actor attributes, and relational factors (Chen et al. 2022). Contextual drivers can be environmental shock, an event causing the network to change, or regulatory changes that alter the context in which the network operates. Actor attributes can be strategic decisions such as choosing to engage with other actors. Relational factors that were concluded drivers of network dynamics, were previous network ties shape the formations of new networks.

2.2.4 Vertical integration

When deciding on what kind of relationships to have with different actors in the network, there is also the option of vertical integration. A company is vertically integrated if it owns and controls multiple stages of the value chain (Perry 1989; Vergara 2012). Two examples of companies that are largely vertically integrated are Apple and Samsung, both owning and controlling the critical parts of the value chain (ibid.). The business strategy behind vertical integration is to gain control over a larger part of the entire value chain, and thus gain control over the final product (Díez-Vial 2007; Cho, Qiu & Bandyopadhyay 2020). Although whether or not vertical integration is efficient depends on the specific situation. The operational meaning of vertical integration varies across industries and within them, and firms must consider demand, competition, and the behavior of outsiders when developing integration strategies to meet resource needs (Harrigan 1984).

Vertical integration is also in some cases a strategy for large firms to enter new markets (Hortaçsu & Syverson 2007). Another reason for vertical integration is the potential to reduce transaction costs (Díez-Vial 2007). An advantage of vertical integration is the alignment of incentives and goals between the integrated entities (Liang, Yang, Huang & Zhu 2022). There is a lack of consensus on whether vertical integration facilitates coordination in the value chain or not, and what particular stages of the value chain are integrated is an important factor to consider (Díez-Vial 2007).

There are two kinds of vertical integration: backward- and forward vertical integration (Lin, Parlaktürk & Swaminathan 2014). Forward integration enhances a firm's demand signal processing capabilities, whereas backward integration increases the control of the supply side (Liang et al. 2022). In general, vertical integration is more common in situations where there is a power imbalance between firms, market uncertainties, a lack of market flexibility, or when it is difficult or costly to obtain or measure the specific investment or effort needed for a market transaction (Cacciatori & Jacobides 2005; Cho, Qiu & Bandyopadhyay 2020). Vertical integration is also preferable when the customer requests a "packaged solution" in new emerging markets (Cacciatori & Jacobides 2005). Further, vertical integration is common in industries characterized by complex technological interdependency (Zhang, H. et al. 2022).

Some risks with a high level of vertical integration are that it requires significant investments, creates an exit barrier, and the need for high level of coordination (Harrigan 1984). There is no consensus on whether or not vertical integration is positively correlated with market power. Some scholars have shown that there is no correlation in specific fields. For instance, Díez-Vial (2007), showed that there is no correlation in the Spanish meat industry, and Basant and Mishra (2019), did not find a significant correlation in the Indian manufacturing sector.

2.3 Business models

This section aims to present the relevant theory needed to answer RQ2 regarding how value can be captured. The concept of business models and value capturing is explained followed by a selection of revenue models found in related fields.

In order to promote the successful commercialization of innovations, it is imperative to gain a more comprehensive understanding of the mechanisms and dynamics that underlie business model development (Dmitriev et al. 2014). Different scholars have identified a variety of elements in business models. The most commonly recognized elements are value proposition, target market, revenue model, partner network, internal infrastructure, and processes (ibid.). This thesis will focus on the value-capturing and network aspects of business models as per the posed research questions.

The business model development process begins with expressing the inherent value proposition of the new technology (Chesbrough & Rosenbloom 2002; Sjödin, Parida, Jovanovic & Visnjic 2020). This involves identifying the needed value chain to offer the value proposition (Dmitriev et al. 2014). In their posed framework for business model development, Dmitriev et al. (ibid.) define the procedure to be a continuous and cyclic process of value conceptualization and value creation organization (see Figure 6). This cyclical relationship in the framework is visualized with the arrows in Figure 6.

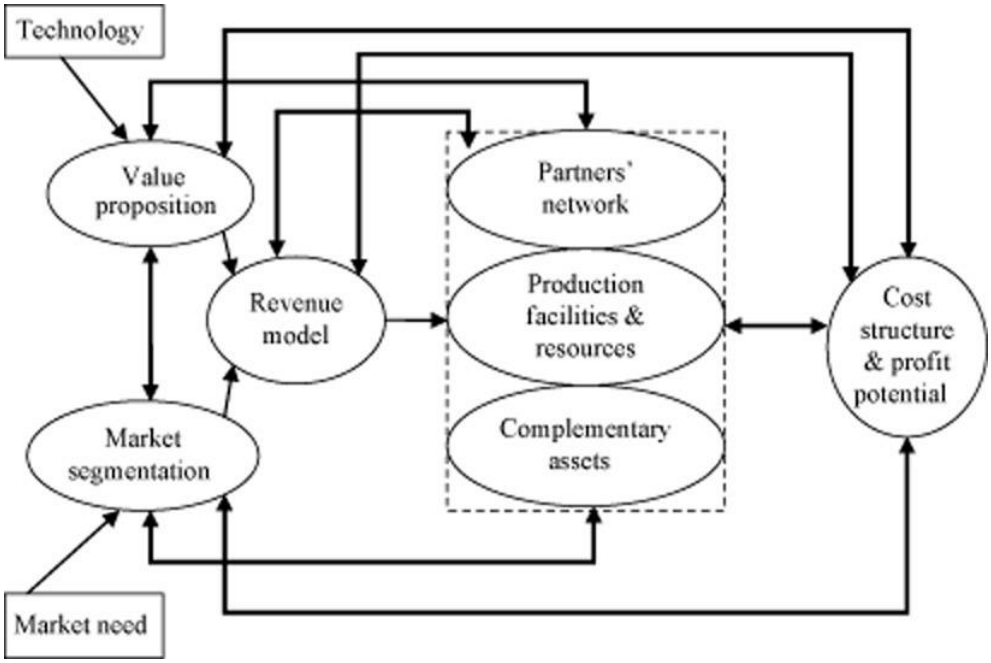

Figure 6. Business model development framework (ibid.)

2.3.1 Value Capturing

The goal of any ecosystem or network of business actors is to collectively create something that monetary value can be captured from (Holm, D. B., Eriksson & Johanson 1999; Jacobides, Cennamo & Gawer 2018). The way in which value is captured is through the revenue model of the firm (Linde, Frishammar & Parida 2023), which is visualized in Figure 6 as part of the firm's business model. Inadequate implementation of monetization strategies can backlash and lead to increased user unwillingness to pay (Salehudin & Alpert 2021).

Bowman and Ambrosini (2000) argue that the concept of value can be divided into two categories, the first being connected to the value the customer perceives by use and the second referring to the actual monetary price being paid for this perceived use value. Value capturing is linked to value creation in the sense that it is focused on obtaining financial or non-financial returns from the value creation (Chesbrough, Lettl & Ritter 2018). The total value that is able to be created in innovation ecosystems is tied to the alignment of the participating actors' objectives and commitment (Jacobides, Cennamo & Gawer 2018; Yaghmaie & Vanhaverbeke 2019).

2.3.2 Different types of revenue models

When investigating various social networking sites and the revenue models they are driven by, Enders, Hungenberg, Denker and Mauch (2008) found in their field studies that sites rarely generated revenue from a single source, thus combining two or more revenue models. Also, Kim (2018) describe it as common for online businesses to have multiple revenue sources. Below follows a set of revenue models for digital products or environments that have been found during the theory review process.

2.3.2.1 Subscriptions

A subscription is when a customer regularly pays a fee to a company to receive a product or service (Cambridge Dictionary n.d.). Subscription fees as a revenue model are currently used by many businesses including digital music (Li, S., Luo, Qiu & Bandyopadhyay 2020), video streaming services such as Netflix (Lee, Lee, Joo & Nam 2021), and news (Barthel n.d.). For instance, subscriptions can be offered to consumers as a means of preventing functionality limitations and advertisements (Li, S., Luo, Qiu & Bandyopadhyay 2020).

A study by Cheng Lu Wang, Yue Zhang, Li Richard Ye, & Dat-Dao Nguyen (2005) concluded that the willingness to pay of consumers for subscription-based web content is positively related to usage rate, service quality and perceived essentiality, added-value and convenience.

2.3.2.2 Advertisements

An advertisement is defined as "a paid-for communication intended to inform and/or persuade one or more people" (Fletcher 2010). The company using an advertising-based revenue model creates a digital media product that attracts an audience, then essentially sells the access to their user base where the advertiser can illustrate their advertisement to said user base (Bekh 2020).

Advertising was concluded as one of the most common revenue models for social networking sites such as Facebook and LinkedIn, and an important explanation for this is users expecting or even demanding free services (Enders et al. 2008). Ads are becoming a more important value capturing strategy, in 2022 the global mobile ad spend was 333 billion USD, which is equal to a 14 percent year-on-year growth (Data AI 2023). To put this in context, this is larger than the revenue from money spent in content stores which also decreased in 2022 (ibid.). Except for traditional advertising, two other types of advertising include product placement, where products or brands are included similarly to non-advertising products (Gillespie & Joireman 2016), and location-based advertising (LBA) explained in the following section.

2.3.2.3 Location-based advertising

LBA is a form of advertisement that delivers messages to consumers in places that have a positive advertising effect (Bauer & Strauss 2016). Traditional LBA includes billboards and signage (Dunham, Xu, Papangelis & Schwartz 2022). More recently digital LBA and especially mobile LBA has gotten increased attention since it allows for a flexible individual addressing of consumers based on their location (Bauer & Strauss 2016; Cheng, Lian, Chen & Liu 2022). By leveraging the information available from the usage of mobile devices, advertisements can be real-time customized to the location of the user (Bauer & Strauss 2016; Cheng et al. 2022).

Another form of digital LBA is location sponsorship (Dunham et al. 2022). Since Niantic launched their sponsored locations program, location sponsorship has become a new revenue source for location-based AR games (Gu, Wang, Li & Liu 2021; Dunham et al. 2022). The idea behind location sponsorship is to boost physical locations by directing application users to those locations (ibid.). Studies have shown that businesses can benefit from

the spillover of this boost in physical locations (Zhang & Zhang 2021). The revenue model builds on this, having business owners pay to attract users to their place of business (Frith 2017). According to Frith (ibid.), sponsored locations show substantial commercial potential.

2.3.2.4 In-app purchases

In-app purchases is a revenue model that is becoming more frequently used, with both free and paid apps and in combination with other revenue models as well (Lehdonvirta 2009; Salehudin & Alpert 2021). In-app purchases means that additional features such as additional levels, features, and virtual goods are purchased directly in the app (Lehdonvirta 2009; Roma & Ragaglia 2016; Salehudin & Alpert 2021). Studies have shown that virtual items are valued for similar reasons as tangible goods and that they form a separate category from information goods due to their ability to create and maintain social distinctions and bonds through built-in rivalry and scarcity (Lehdonvirta 2009).

In-app purchases can be used as a strategy to segment and price discriminate among customers to increase profits, providing users with the opportunity to upgrade to better features or download additional functionalities with an additional price charge, whether or not a free version has been released (Roma & Ragaglia 2016).

In the context of mobile app monetization, in-app purchases have demonstrated greater efficacy when implemented in conjunction with free apps, as opposed to paid apps (Salehudin & Alpert 2021). In addition, in-app purchases are most effective when applied to a heterogeneous customer base with varying levels of willingness to pay, allowing for value capturing from customers with high willingness to pay (Roma & Ragaglia 2016).

2.3.2.5 Freemium

In the freemium model, there are two different versions of the product or service, a free and a premium version (ibid.). A basic version of the model is provided for free, and then there is a premium version with a more enhanced value offering which the customers have to pay for (Holm & Günzel-Jensen 2017).

The model works well when the market is fragmented, the customers are heterogeneous, and the average willingness to pay is high (Roma & Ragaglia 2016; Numminen, Sällberg & Wang 2022). The free version of the product or service aims to capture customers who have a low willingness to pay and are not bothered by ads or time limits on the application, and the premium version aims to capture customers who are willing to pay for a higher quality experience (Roma & Ragaglia 2016).

The success of the freemium model depends on its appeal to the mass market, satisfying an existing or latent need, and requires constant user acquisition and retention, with perceived customer value increasing to keep users loyal (Holm & Günzel-Jensen 2017). Some advantages of the freemium model are that it encourages product trialability and can bring in multiple revenue streams, both through paying customers and ads (Roma & Ragaglia 2016). To successfully implement a freemium model and exploit these potential advantages, it is important to try to find the equilibrium between free and premium offerings (Holm & Günzel-Jensen 2017).

2.3.3 Content store revenue models

Content stores function as digital platforms that facilitate two-sided markets and create value for the involved parties (Hagiu 2007; Roma & Ragaglia 2016). The device provider and operating system developer enhance their value proposition by facilitating access to a greater range of content, while content creators benefit by expanding their reach to customers (ibid.).

A common business model for content store providers is that they employ a consignment contract with revenue sharing with the content creators (Avinadav, Chernonog, Meilijson & Perlman 2022). Under this type of agreement, the content creator retains the ownership of the application and pricing responsibility while the content store provider charges an agreed-upon percentage fee on each sold application on the content store (ibid.).

For instance, both Apple and Google both charge a 30 percent fee for the apps and in-app purchases in general and a 15 percent for businesses with an app revenue that is less than 1 million USD (Statista 2022c; Baggott 2023; Google n.d.). Epic Games charge a 12 percent fee and Steam a fee of between 20 to 30 percent depending on the application revenue (Statt 2018; Steam 2018; Epic Games n.d.). Apple takes a 30 percent fee the first year and then 15 percent in subsequent years for subscriptions through their App Store, and Google takes 15 percent for subscriptions on Google Play (Statista 2022c; Google n.d.).

From the content creators' side, they need to decide on which pricing strategy to employ (Roma & Ragaglia 2016). There are a number of common revenue models for content creators, some of which were mentioned above in section 2.3.2. Numminen, Sällberg, and Wang (2022) categorize some common content store revenue models as the paid-free model, the free-free model, and the paid-paid model (Roma & Ragaglia 2016; Numminen, Sällberg & Wang 2022). These four revenue models are explained further in Table 1.

An additional model that is also commonly used is the above-explained freemium model (Roma & Ragaglia 2016). I.e., the choice of the content creator concerns whether or not if consumer pays for the download, if there should be in-app purchases, if there should be multiple versions of the app, and if the app should be monetized though ads. Which model is the most suited depends on a multitude of factors such as the type of application, which content store, and the targeted consumers (ibid.).

Table 1. Explanation of revenue models in content stores according to Numminen, Sällberg, and Wang (2022), and Roma and Ragaglia (2016).

Revenue model	Short description	Pay for download?	In-app purchases?
Free-paid	The app can be downloaded for free and then the user needs to pay in the app for either additional content or to be able to fully exploit the app. I.e., monetize through in-app purchases.	No	Yes
Paid-free	The user pays everything upfront when downloading the app. No additional expenses may occur. I.e., monetize through app sales.	Yes	No
Free-free	The app is completely free, and mostly monetized by ads or user data. I.e., it relies on other revenue streams than direct payment from customers.	No	No
Paid-Paid	The user pays for the app when downloading it, and then there are additional optional in-app purchases, either for additional content, or to fully exploit the app.	Yes	Yes

2.4 Commercialization theory

In order to answer the overall research question: "How can XR technologies be commercialized to reach the broader market?", this section presents relevant commercialization theory to lay the foundation.

Commercialization of high-tech and disruptive innovations are often described as highly important yet understudied subjects (Chiesa & Frattini 2011; Datta, Reed & Jessup 2013; Nieto Cubero, Gbadegeshin & Consolación 2021). Datta, Reed, and Jessup (2013) argue that the commercialization of innovations necessitates research within a diverse range of fields. This thesis aims to help in closing this research gap by studying the commercialization of the relatively new field of XR (Khan 2023).

There are multiple different definitions of "commercialization". Cambridge dictionary defines it as "the process of making a product or service available for sale to the public" (Anon. 2023). Kirchberger and Pohl (2016) define technology commercialization as "the process of transferring a technology-based innovation from the developer of the technology to an organization utilizing and applying the technology for marketable products". Another definition of commercialization is "converting or moving "technology" into a profitmaking position" Siegel, Hansén, and Pellas (1995). Datta, Reed, and Jessup (2013) define the ability to commercialize as "a firm's capacity to bring a product into a market and reach the mainstream of the market beyond the initial adopters". Based on these definitions, this thesis defines commercialization as: *The process of bringing an innovation, product or service into the market and reaching the broader market beyond the initial adopter*.

2.4.1 Diffusion of Innovations

Since XR seems to follow the *Technology Adoption Life Cycle* (Kluge et al. 2022), the theory of diffusion of innovations is relevant to be able to answer the posed RQs. The theory explains how innovations are spread within and across organizations, over time (Batyashe & Iyamu 2021). The subject was studied within a multitude of fields independently in the 1940s and 50s (Rogers 2003). In 1962 Rogers introduced this topic in a more general model in the first edition of the book *Diffusion of Innovations* (ibid.). In doing so, Rogers has become regarded as the inventor of the diffusion of innovation theory (Kaur Kapoor, Dwivedi & Williams 2014).

In addition to generalizing the theory, Rogers (2003) made valuable contributions to the field by introducing the four key components of innovation diffusion: the innovation itself, communication channels, time, and the social system. Rogers also highlighted five critical characteristics of innovation that determine the rate of adoption: *relative advantage*, the extent the innovation is considered as better than the idea it replaces, *compatibility*, to which extent potential adopters perceive an innovation as aligned with their values, needs and experiences, *complexity*, how difficult or complex the innovation is considered to use, *trialability*, the extent to which an innovation can be tested on a limited basis, and *observability* , the extent to which the outcomes of an innovation are visible to others (Oyelana, Kamanzi & Richter 2021).

Additionally, Rogers also introduced the well-known bell curve model of the technology adoption life cycle, which explains how new technology products penetrate the market through different categories in the market (Rogers 2003; Owolabi Yusuf & Derus 2013). According to Rogers (2003), diffusion happens gradually through the five categories: innovators, early adopters, early majority, late majority, and laggards. Innovators and early adopters are characterized by being eager, excited about new technology, adventurous, and opinion leaders (Dedehayir, Ortt, Riverola & Miralles 2017; Cirus & Simonova 2020).

Some scholars have criticized Roger's diffusion theory for assuming gradual and smooth linearity in the process of diffusion (Dedehayir et al. 2017). To address this criticism, Moore (2014) contributed to the theory by expanding Roger’s theory to include the gap between early adopters and early majority in his version of Roger's technology adoption life cycle (Dedehayir et al. 2017; Roche 2019). This chasm in Moore’s version is visualized in Figure 7. According to Moore (2014), the chasm can be explained by the difference in the needs and motives to buy between the two categories.

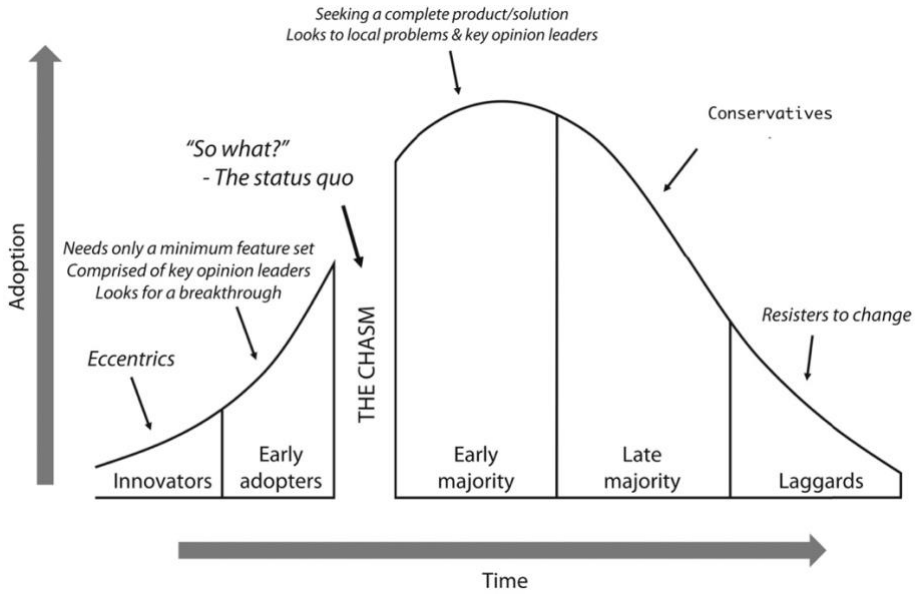

Figure 7. Visualization of the "chasm" in the diffusion theory (modification of Shah & Rothstein 2020).

Similar to Moore, Frattini et al. (2012) emphasize the distinction between early adopters and the mainstream market. They argue that the commercialization approach needs to be altered to these different segments' needs. Early adopters are driven by the newness of the underlying technology, whereas the mainstream market wants the solution to work seamlessly and be easy to use. Frattini, Bianchi, De Massis, and Sikimic (2014) highlight the role early adopters play in the adoption of the mainstream market.

Bianchi, Di Benedetto, Franzò, and Frattini (2017) build on the work by Chiesa and Frattini (2011) and Frattini et al. (2014) by examining the industrial innovation diffusion process. Their emphasis is on the iterative and interactive nature of the diffusion processes, and the active role commercializing firms can play. According to Bianchi et al. (2017), it is possible for commercializing firms to proactively shape the behavior of early adopters by repeated interactions with them in combination with modifying the innovations to meet their needs using co-developing techniques. The relevance of the concept of value co-creation extends to both B2C and B2B contexts (Auh, Bell, McLeod & Shih 2007; Cabiddu, Moreno & Sebastiano 2019; Gligor & Maloni 2022), thus the findings of Bianchi et al. (2017) can be relevant in the consumer market as well.

Nieto Cubero, Gbadegeshin and Consolación (2021) argue that commercialization is a non-linear process that should be present from the initial phases of innovation. They see the commercialization process as a dynamic process. Similarly, Aarikka-Stenroos and Lehtimäki (2014) highlight the dynamic nature of the commercialization process. Nieto Cubero, Gbadegeshin, and Consolación (2021) present six key elements of commercialization: market orientation, user involvement, market learning, market configuration, adoption networks and stakeholders, and organization culture. They summarize this in their integrative commercialization framework that divides the commercialization process into three different phases: *Discovery*, *Incubation*, and *Acceleration*, with a focus on concept and value proposition validation, business validation and market creation, and creating sales in the majority market respectively. The framework is visualized in Figure 8 below.

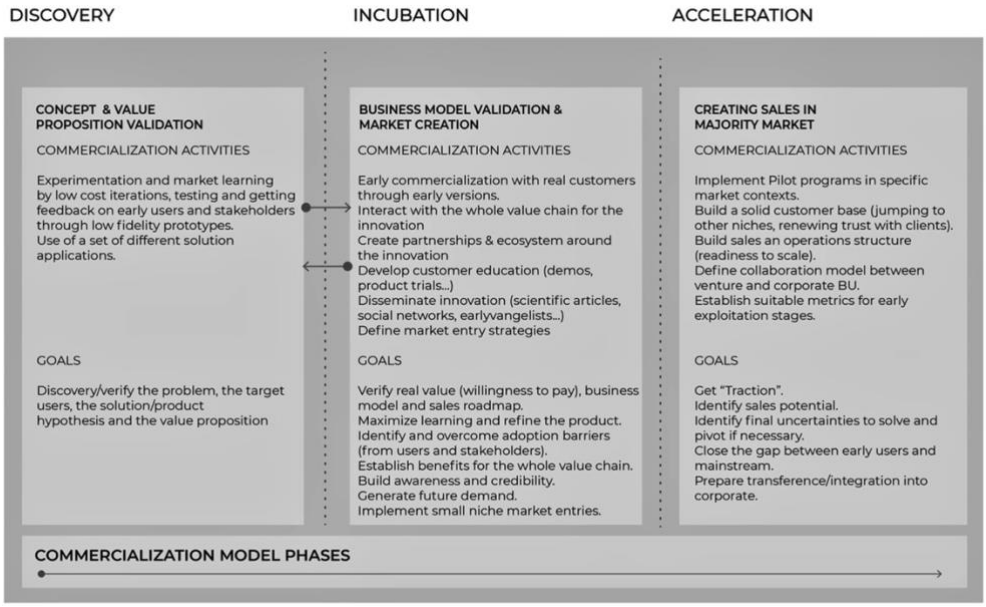

Figure 8. Visualization of integrative framework (Nieto Cubero, Gbadegeshin & Consolación 2021).

In the second phase of Nieto Cubero, Gbadegeshin, and Consolación's (2021) framework, the importance of the adoption network is highlighted. An adoption network can be defined as a network consisting of interconnected actors whose actions and decisions impact one another and the innovation's diffusion and market acceptance, for instance, end customers, companies involved in the innovation itself, and companies that

provide complementary products and services (Chiesa & Frattini 2011; Dell'Era, Frattini & Ghezzi 2013). Nieto Cubero, Gbadegeshin, and Consolación (2021) stress the importance of interacting with and creating an ecosystem around the innovation. Similarly, Chiesa and Frattini (2011) visualize the significance of the adoption network by arguing that the diffusion of a high-tech innovation will be significantly impeded if it lacks support from the crucial members of its adoption network.

In the framework constructed by Chiesa and Frattini (ibid.), decisions regarding commercialization are said to have a dual impact on consumer adoption of new high-tech products:

i) "By affecting the extent to which the players in the innovation's adoption network support the new product"
ii) "By affecting the post-purchase attitude early adopters develop toward the innovation, and hence the type of word-of-mouth (positive or negative) they disseminate among later adopters"

Thus, Chiesa and Frattini (ibid.) argue that both early adopters and the adoption network can be a bridge to cross the chasm. They further argue that the adoption network and early adopters may cause adoption failure for high-tech innovation.

Another model used to describe how innovations are accepted by users is Gartner's hype cycle (Perez & Kreinovich 2018). In Figure 9 the hype cycle is visualized, and the typical development of emerging technologies is seen with the axes of time versus expectations of an innovation. The model addresses the early stages of the technology life cycle which is typically characterized by an early overenthusiasm to a phase of disappointment from the technology not meeting expectations, which finally ends in a plateau where the technology finds its place in the market (Linden & Fenn 2003).

In the book *Managing the Hype Cycle* by Fenn and Raskino (2008) the stages of the hype cycle are explained in detail. In the first stage, *technology trigger*, happens when the initial hype of the product, technology, or innovation reaches the public, and a sudden interest is created. During the *peak of inflated expectations*, the user base broadens as users and companies want to keep up with new innovations, the technology receives great and positive coverage in the press and the innovation is essentially pushed to its limits.

In the third phase, *trough of disillusionment*, problems with performance and other factors not meeting expectations arise causing negative coverage in media and a decrease in hype. Following this phase of disappointment, the *slope of enlightenment* begins where the early users start to experience the benefits of the innovation more and more and learn how it can be used effectively. Finally, the *plateau of productivity* is reached when the innovation is integrated into everyday activities and long-term benefits of the innovation are experienced, which substantially reduces the risks associated with its adoption.

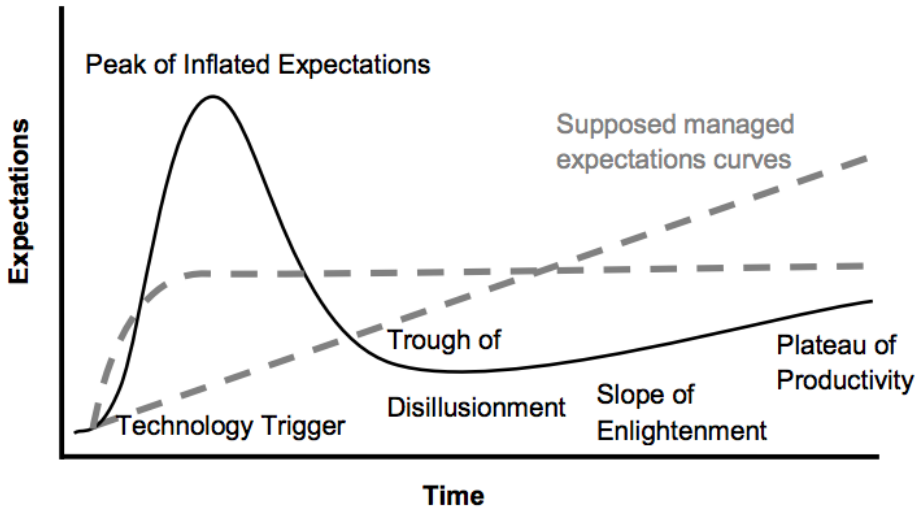

Figure 9 The Gartner's Hype Cycle (Budde 2015)

Although the hype cycle can be a valuable consideration for organizations when developing marketing strategies, the model has recently received some critique related to how many innovations actually follow the hype curve pattern (Dedehayir & Steinert 2016). The hype cycle can also be presented in relation to other technology life cycle models such as the more traditional Roger's technology lifecycle model (named adoption curve in Figure 10) where the peak of inflated expectation already happens in or before the innovators' phase. The hype cycle complements these by adding the dimension of human attitudes to the technology (Linden & Fenn 2003). A comparison of these different life cycle models is seen in Figure 10.

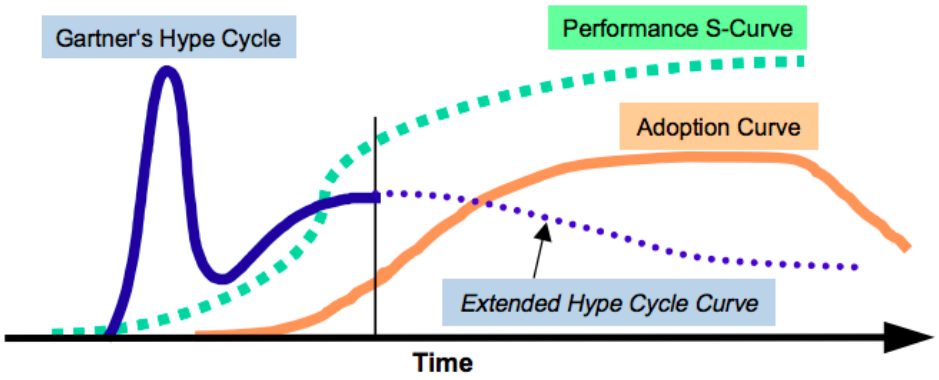

Figure 10. Comparison of different technology life cycle curves (ibid.)

Before going into success factors for commercialization it is also important to go through some common inhibitors for the diffusion of technology. Adoption barriers complicate the commercialization process and constitute a challenge (Aarikka-Stenroos & Lehtimäki 2014). All innovations meet customer resistance, which must be mitigated before successful diffusion of innovation is possible (Laukkanen 2016). It can sometimes be even more important to focus on and try to overcome barriers to adoption, rather than communicating reasons for adoption (Claudy, Garcia & O'Driscoll 2015).

According to Talke and Heidenreich (2014), consumers are not always open to change or interested in new things. They can be either passively or actively resistant to innovations (Heidenreich & Spieth 2013; Talke & Heidenreich 2014). Passive innovation resistance occurs when consumers have a general tendency to resist new innovations before evaluating them, while active innovation resistance arises when consumers evaluate a new product unfavorably (ibid.) and can be divided into two different types: cognitive and situational (Heidenreich & Kraemer 2016). Cognitive passive resistance refers to the extent to which a person's cognitive style impedes their willingness to consider and adopt new products, primarily driven by their resistance to change (Heidenreich, Kraemer & Handrich 2016).

Situational passive resistance occurs when an individual's preference for the current status quo hinders their adoption of innovations due to the associated changes (Heidenreich & Kraemer 2016). By being aware of what type of innovation resistance is present in the market there are ways to mitigate it. If there is cognitive passive resistance present it is important to help make the

learning process associated with the new product seem less steep, and if there is situational passive resistance the focus should lie on making the product seem superior to the status quo (Heidenreich, Kraemer & Handrich 2016).

Diffusion of innovation depends on consumer awareness, attitudes, and resistance towards the innovation (Claudy, Garcia & O'Driscoll 2015; Joachim, Spieth & Heidenreich 2018). The resistance can also be divided into different types of barriers to the adoption of innovation (ibid.). Traditionally barriers have been divided into two main categories: functional and psychological barriers (Ram & Sheth 1989). Functional barriers refer to barriers that are based on the consumer's assessment of the product's functionality or usefulness and psychological barriers refer to the internal factors that influence a consumer's acceptance or rejection of an innovation, such as norms and personal values (Talke & Heidenreich 2014; Joachim, Spieth & Heidenreich 2018).

Ram and Sheth (1989) further visualize five different types of barriers within these two broader categories, and Talke and Heidenreich (2014) 17 different ones. Joachim, Spieth, and Heidenreich (2018) further backs the comprehensive set of barriers from Talke and Heidenreich and have summarized them and their categories (see Table 2).Depending on the context, the impact of different types of barriers varies (Laukkanen 2016; Joachim, Spieth & Heidenreich 2018). Joachim, Spieth, and Heidenreich (ibid.) emphasize the importance for firms to be aware of what barriers hinder the diffusion of innovation in their case, in order to be able to efficiently mitigate them. They suggest a two-step approach:

1) Assess the influence of different barriers to adoption, using the 17 barriers as a base.
2) Investigate the predominant barriers to see ways to reduce them.

Table 2. Summary of barriers to diffusion of innovation (ibid.)

Barrier	***Definition***	***Category***
Value	In comparison with its predecessor, the consumer believes that the innovation doesn't offer any significant advantage	Functional
Complexity	The innovation is seen as too complex to understand or use	Functional
Co-dependence	The innovation is seen as either incomplete or there is a significant demand for additional parts or services to complement it	Functional
Trialability	There is a perception that there are missed opportunities to test the innovation, either in general or within a specific context, or at the preferred time	Functional
Compatibility	The innovation is perceived to be incompatible with past or current products	Functional
Amenability	Consumers hold the belief that the innovation provides inadequate options for customization to meet their specific needs	Functional
Realization	The perceived time frame for the benefits of the innovation to become apparent is viewed as too long	Functional
Visibility	Consumers perceive challenges in observing others use the innovation	Functional
Communicability	Consumers feel an inability to effectively describe the advantages or drawbacks of an innovation to others	Functional
Functional risk	There is a concern that a product may be dysfunctional or malfunctioning	Psychological
Personal risk	There is a belief that the innovation is a potential hazard to a consumer's physical well-being or property	Psychological
Economic risk	The innovation is believed to be excessively costly, and the associated investment is deemed not worthwhile	Psychological

Social risk	There is a concern that an associated social group would not approve of the adoption	Psychological
Information	Consumers perceive information asymmetries that leave them uncertain about potential negative consequences	Psychological
Image	The innovation is associated with negative perceptions such as unfavorable brand reputation, or country of origin	Psychological
Norm	The innovation is perceived to be in conflict with established traditions, social norms, or family values	Psychological
Usage	There is a perception that adopting the innovation requires an undesirable disruption of established user patterns, workflows, and routines	Psychological

2.4.2 Success Factors for commercialization

Effective commercialization poses an extra big challenge in high-technology markets (Frattini et al. 2012; Kapoor & Teece 2021). According to Frattini et al. (2012), the most critical dimensions of commercialization of high-tech innovations are timing, targeting, positioning, distribution, pricing, communication, whole product configuration, and partnerships and alliances. They argue that the implications of the dimensions depend on which segment the commercialization efforts are aimed towards. For instance, the whole product configuration should be well-functioning but only including a smaller sample of functions when aimed towards the early market, whereas the product configuration should be as complete as possible for the mainstream market (ibid.).

Frattini et al. (ibid.) further highlight the importance of introducing a fully developed and flawlessly functioning complete product. Failure regarding the timing aspect may lead to an unfavorable market evaluation (ibid.). Kirchberger and Pohl (2016) stress the importance of perceived value by consumers. They state that the success of the commercialization depends primarily on how much consumers value the technology. An early comprehension of where the customer value lies can be a success factor for commercialization.

Frattini et al. (2012) suggest that due to the significant levels of technological uncertainty for radical innovations, the acceptance and diffusion to the early adopters are especially important for successful commercialization. For innovations that impact at a macro level, shaping markets or modifying existing markets' structures, and altering users' motivations, ideas of market creation, network building, and support from the adoption network are commercialization success factors (Chiesa & Frattini 2011; Nieto Cubero, Gbadegeshin & Consolación 2021).

Due to the nature of discontinuous innovations, they require at least one critical actor in their adoption network to adjust and provide the necessary support (Frattini et al. 2012). Frattini et al. (ibid.) have found that the most important success factor for commercialization of discontinuous innovations is the support from the adoption network. The authors have also found that the adoption network is more likely to provide the necessary support for diffusion into the broader market if the risks and costs are shared within the network. Cubero, Gbadegeshin, and Segura (2020) have found evidence strengthening this finding of the importance of the adoption network. According to Frattini et al. (2012), regardless of what type of innovation, a mainstream adoption strategy is always important.

Frattinit et al. (ibid.) propose a 3-step scheme to follow when setting up the commercialization strategy:

1) Evaluate the radicalness and discontinuity of the innovation.
2) Based on the type of innovation identify the critical commercialization strategies (see Figure 12).
3) For each critical strategy, determine the best set of commercialization decisions to maximize its effectiveness.

Frattini et al. (ibid.) also propose a framework for the most important commercialization decisions that is visualized in Figure 11.

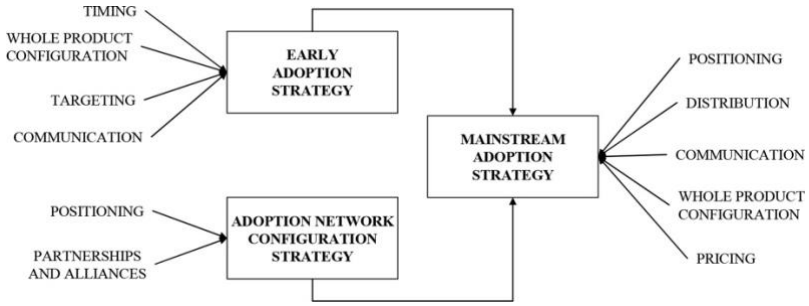

Figure 11. Critical dimensions of different parts of the commercialization strategy (ibid.)

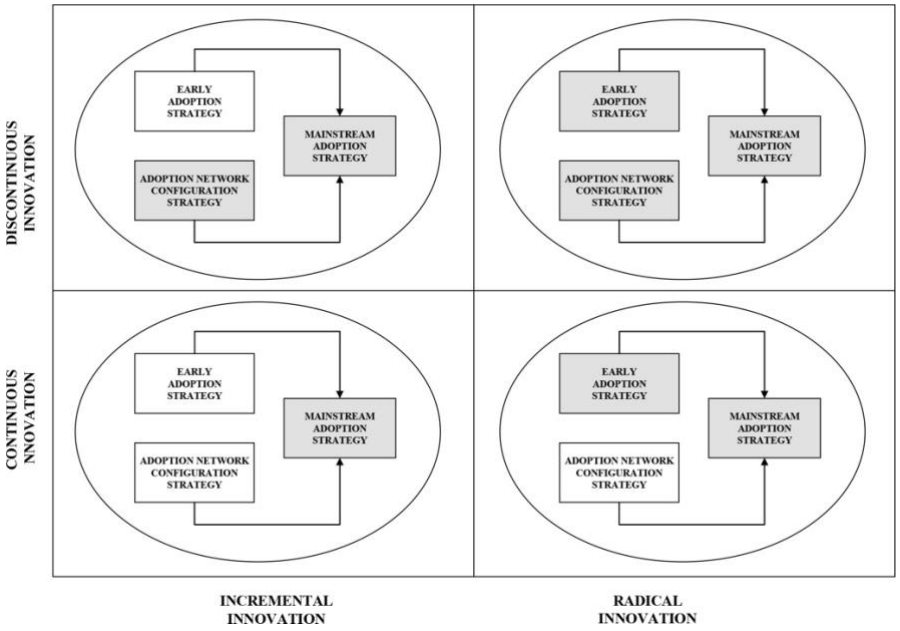

Figure 12. Critical strategies in commercialization depending on the type of innovation (ibid.)

2.5 Synthesized theoretical framework

This section presents a synthesized theoretical framework that offers guidance on how the theory contributes to addressing the research questions.

In the theoretical framework presented above, there seems to be a limitation regarding how the technology itself is analyzed. Although the innovation ecosystem literature typically has the innovation as the focal point, when reviewing existing literature on network theory, value capturing, and commercialization a large amount of the theory tends to have the basis of a focal firm.

For instance, the work of Bianchi et al. (2017), Nieto Cubero, Gbadegeshin and Consolación (2021), Frattini et al. (2012), as well as Chiesa and Frattini (2011) can be interpreted as addressing the commercializing firm's role. Similarly, Jacobides, Cennamo, and Gawer (2018) base their theoretical framework on ecosystem-based value systems on the focal firm. Moreover, the classical business model development framework (Dmitriev et al. 2014) is focused on the firm and how revenue will be generated for a specific firm, rather than taking the technology perspective.

However, in this specific case of XR technologies, there is no single firm owning the technology. Instead, there is a wide range of actors involved in the development and commercialization of XR technologies. To be able to analyze the situation of XR through the analytical lens of the theoretical framework, a slight modification of the approach to the theoretical framework is necessary. This has boiled down to the following synthesis of the theoretical framework which uses XR technologies as the focal point (see Figure 13).

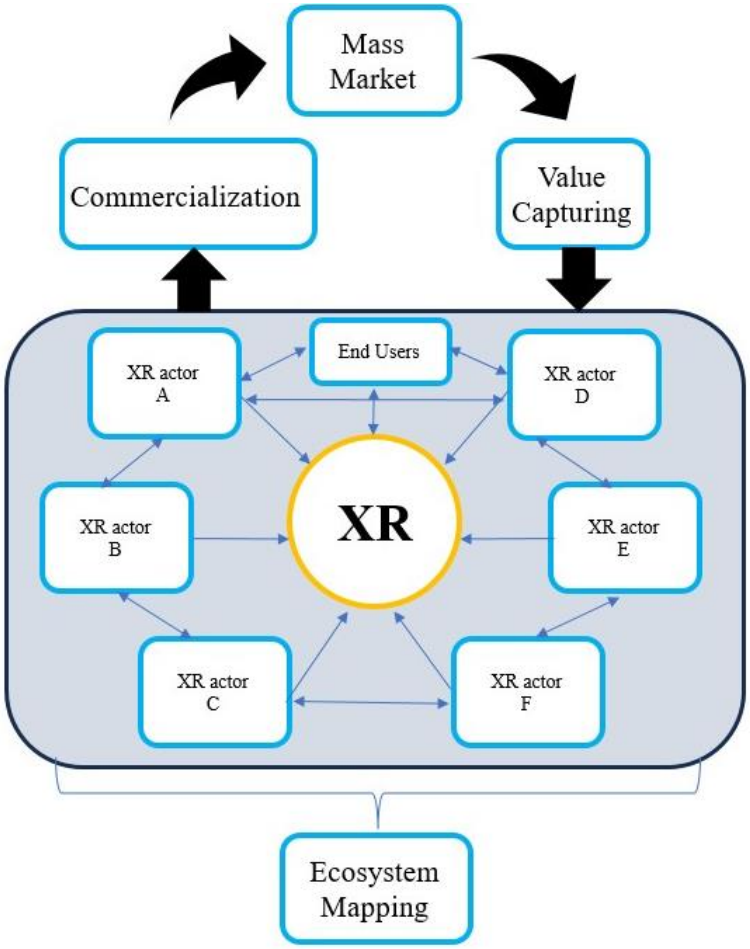

Figure 13. Synthesis of the theoretical framework

Through this illustration, supported by the theoretical framework, the thesis will investigate XR through the theory given on network and ecosystem theory, value capturing, and commercialization. All these aspects are important and interconnected, e.g., the total value that is able to be created in innovation ecosystems is tied to the alignment of the participating actors' objectives and commitment (Jacobides, Cennamo & Gawer 2018; Yaghmaie & Vanhaverbeke 2019), thus emphasizing the importance of the ecosystem on the value capturing abilities. Further, Dmitriev et al. (2014) argue that in order to achieve successful commercialization, gaining a comprehensive understanding of the underlying mechanisms and dynamics of business models, including value capturing, development is critical. This highlights the role of value capturing in commercialization.

The importance of the ecosystem in commercialization is highlighted by stressing the crucial role of the adoption network for commercialization which is also stressed in the literature (Frattini et al. 2012; Nieto Cubero, Gbadegeshin & Consolación 2021). An adoption network is defined as "a network consisting of interconnected actors whose actions and decisions impact one another and the innovation's diffusion and market acceptance" (Dell'Era, Frattini & Ghezzi 2013) and innovation ecosystems as "the collaboration of companies where the individual offerings of the involved companies are integrated in order to create a unified solution for customers" (Adner 2006).

Due to the similarities in the two concepts and their connection to this thesis' definition of commercialization (the process of bringing an innovation, product, or service into the market and reaching the broader market beyond the initial adopter), these actors are seen as the actors who are relevant in the answer to the overall research question "How can XR technologies be commercialized to reach the broader market?".

3 Methodology

In this section, the methodology and overall research process are presented. The research strategy, data collection, and analysis are described with a concluding section on trustworthiness.

3.1 Research strategy

In the subsequent section, the employed research strategy and its constituent elements are delineated and justified. The theoretical and methodological foundations that underpin the research strategy are discussed, and their relevance to the research question is assessed.

A research strategy is the plan of action to achieve the goal set out for the research and differs from the research methods which refers to the tools used for data collection (Denscombe 2010). Denscombe (2017) stresses that there are no straight answers to which research strategy to use in all cases, and that there are always choices to be made. They do however provide three main categories as a guide to the choice of research strategy, namely suitability, feasibility, and ethics. Jarvinen (2000) suggests that the research questions and objects be the main guide when choosing a research strategy and method for a study. The research questions of this thesis contain the words of who, how, and what, and are the baseline for choosing research strategy, indicating the exploratory nature of the study (Yin 2014). In addition, since the thesis aims to explore patterns in the data without the existence of a prior hypothesis, the research is considered exploratory (Nilsen, Bowler & Linnell 2020).

Figure 14 shows the overarching research process which was conducted in this thesis. The process started with initial meetings with Ericsson and literature research on the main subject and based on the increased knowledge on the phenomenon, interview guides for the expert interviews were made. Thereafter the interviews were conducted and analyzed in combination with the accessible documentation, from which the research questions were answered.

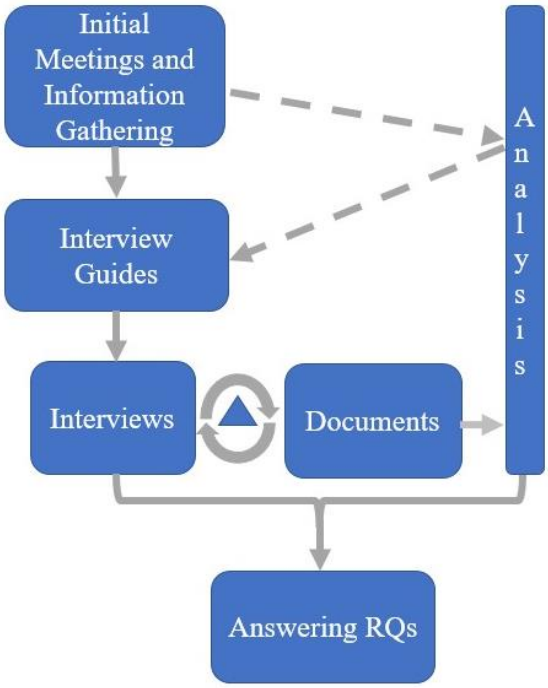

Figure 14. Research process overview

The research approach of this thesis that was considered most suitable and feasible, and therefore was applied is a qualitative approach with abductive reasoning. The data collection methods that were used were interviews in combination with documents. In the coming sections, the choices for the research methodology will be motivated.

3.1.1 Reasoning logic

There are three distinctively different ways of conducting research and drawing conclusions: deductive-, inductive- and abductive reasoning (Cramer-Petersen, Christensen & Ahmed-Kristensen 2019). Deductive reasoning involves creating or examining arguments that rely on hypotheses or premises by drawing logical conclusions (Kovács & Spens 2005; Gregory & Muntermann 2011) and is most suited when one wishes to test or confirm a hypothesis (Stentoft Arlbjørn & Halldorsson 2002; Råholm 2010a).

In contrast to the deductive approach, inductive reasoning goes the contrary direction, starting with observations of the world that lead to propositions that are generalized in a theoretical framework (Kovács & Spens 2005). Inductive reasoning involves exploratory elements and is more open-ended in comparison to deductive reasoning which is focused on testing and confirming hypotheses (Råholm 2010a). According to Stentoft Arlbjørn and Halldorsson (2002), inductive reasoning is well-suited for developing new theories. The inductive approach is also normally connected with qualitative studies (ibid.; Brinkmann & Kvale 2018).

Abductive reasoning can be seen as a combination of deductive and inductive reasoning (Gregory & Muntermann 2011). The schematic of abductive reasoning is visualized in Figure 15. According to Timmermans and Tavory (2012), abductive reasoning enables researchers to link a phenomenon with other observations either by identifying a hidden cause-and-effect relationship, recognizing similarities to previously encountered phenomena that were already explained in other contexts, or by generating new general knowledge.

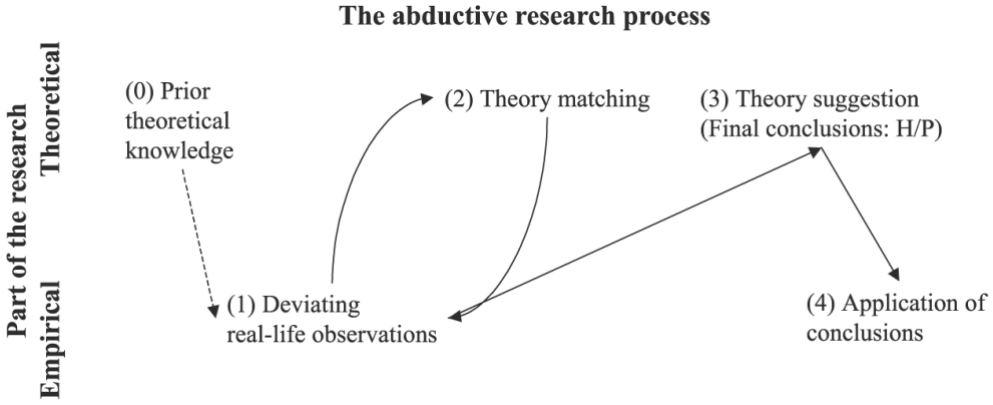

Figure 15. Visualization of abductive reasoning (Kovács & Spens 2005)

Abductive reasoning is appropriate when the studied phenomenon is complex (Mirza, Akhtar-Danesh, Noesgaard, Martin & Staples 2014). According to Brinkmann and Kvale (2018), abductive reasoning is used in situations when there is a need for understanding something that initially is diffuse. In unexplored areas, abductive reasoning can be used in the initial

stages where hypotheses are generated (Råholm 2010b). Then deductive reasoning can be used for testing the hypothesis, and inductive reasoning for verifying the findings (ibid.). Thus, due to the fragmented knowledge (Camps-Aragó, Delaere & Ballon 2019; Nieto Cubero, Gbadegeshin & Consolación 2021) in the area covered by this thesis, abductive reasoning was applied.

3.1.2 Qualitative versus Quantitative Approach

When choosing method researchers are often faced with the decision between qualitative, quantitative, or mixed methods (Williams 2007). Qualitative research methods are an investigation that uses non-numerical and non-statistical methods for data collection, analysis, and generation of evidence (Bhangu, Provost & Caduff 2023). Qualitative data consists of non-reducible textual elements such as words and visuals, which can be digitized and counted, but require interpretation to identify patterns and insights (Bansal, Smith & Vaara 2018).

In contrast to qualitative methods, quantitative methods employ numerical data as the primary unit of analysis (Denscombe 2010) and involve conducting controlled experiments, descriptive surveys, and systematic processing of numerical data (Adu, Owusu, Martin-Yeboah, Pino Gavidia & Gyamfi 2022). This inquiry method is used to ensure that the data collection methodology aligns with statistical standards (Williams 2007). As opposed to qualitative data, quantitative is expressed numerically and can be easily manipulated, added, and transformed into effective data displays (Bansal, Smith & Vaara 2018).

According to Bansal, Smith, and Vaara (ibid.), quantitative research utilizes logical reasoning based on prior insights to expand knowledge along existing or adjacent paths, whereas qualitative research reveals new insights that can lead to the development of entirely new theories. They further argue that new theoretical directions and insights can be deduced by inductively developing theories and using qualitative data. In comparison, quantitative research usually requires a larger amount of data to gain statistical significance, whereas qualitative research is better suited for small-scale studies (Denscombe 2010). Quantitative methods are thus better when the goal is to provide an objective measure of reality, whereas qualitative methods are more appropriate when the goal is to explore and gain a richer understanding of complex phenomena (Williams 2007).

The aim of this thesis is to explore and get an understanding of the understudied area (Chiesa & Frattini 2011; Nieto Cubero, Gbadegeshin & Consolación 2021) of how XR technologies can be successfully commercialized to reach the broader market. According to Adu et al. (2022), qualitative research place emphasis on the understanding of phenomena. Bansal, Smith & Vaara (2018) argue that qualitative research with an inductive approach is especially suitable for complex and understudied contexts. The data available to answer the posed research questions are mainly not quantifiable and of a more qualitative nature. Thus, a qualitative research approach is appropriate considering the posed research questions and the purpose of this thesis and was thus used.

3.1.3 Firm Collaboration

According to Guide Jr and Van Wassenhove (2007) collaborating with industry when doing research can lead to overall benefits such as relevant and refreshing research. Because of the nature of the studied phenomenon, a case study was disregarded since XR technologies are not bound to one single firm. Instead, the decision was made to do a study with the assistance of Ericsson. The reasoning behind this was that collaboration with a company enabled access to relevant expert interviewees and documentation and generated a practical contribution to the industry, which was the nature of the collaboration. The studied phenomena, XR, is being largely driven by firms in the industry making it natural to seek experts from companies. The practical contribution that is able to be investigated with the help of Ericsson is also supported by Guide Jr and Van Wassenhove (ibid.) who believe industry problems should be tackled in academic research.

The most important success factors for the collaboration between industry and academia according to Wohlin et al. (2012) are the support from company management, a key person promoting collaboration and teamwork, and the attitude and social skills of the researcher. Knowing this, the collaboration between the researchers and the company was done by having a supervisor at Ericsson who facilitated the collaboration by including the researchers in necessary meetings and making connections with experts.

3.2 Data collection

This section aims to provide a comprehensive description and motivation for the data collection process employed in this study, with the intention of strengthening the trustworthiness of this thesis.

3.2.1 Interviews

Research interviews are the use of answers given to questions provided by the researcher as a data source. Interviews are well suitable when investigating complex phenomena where there is a need for a detailed understanding of how factors are interconnected (Denscombe 2017), which was considered the case for commercialization. Another situation where the conduction of interviews is beneficial is that of privileged information, meaning circumstances arise where there is a possibility to speak with key actors with valuable knowledge based on their experience or position in a field (ibid.). For the case of this thesis, the opportunity that arose to collaborate with Ericsson was considered such privileged information.

3.2.1.1 Interviewee selection

Robinson (2014) lays out a four-step approach to be followed for interviewee sampling in qualitative research. This is as follows 1) "Define a sample universe", 2) "Decide on a sample size", 3) "Device a sample strategy" and 4) "Source the sample". Concerning the first step, where the interviewees are defined according to some inclusion or exclusion criteria, the sample was defined as experts in XR technologies, with the inclusion criteria of the person needing to work with some attribute of AR, VR or MR technologies daily, and have an insight in the industry. As for the second step, a sample size was not initially defined but the aim was to choose as many to be considered somewhat of theoretical saturation, but also in consideration of the time resources available.

Since the aim was to sample interviewees from different parts of the XR ecosystem in order to get different perspectives (Rowley 2012), an evaluation sample strategy was used for the main part of the study to select interviewees, which is common in exploratory research when a deeper analysis is wanted from few interviewee subjects (Lekvall & Wahlbin 2001). At the collaboration company, a form of self-selection was applied where the thesis was presented in internal meetings, and the employees then voluntarily chose to partake in the interview selection (ibid.). After the initial interviews, a type of selection called directed or specified selection was used where previous interviewees were asked if they knew a person or a

company with expertise in the same field, thereby yielding further experts in the area of XR. All interviewees, except for internal interviews at Ericsson, were contacted through email where the topic and scope of the thesis were described, making it possible for the interviewee to accept or decline the offer of partaking in the interview based on their expertise in the subject.

The selection of the participating interviewees along with the sector their firm is operating in is visible in Table 3.

Table 3: Selection of Interviewees

Current Working Title	**Sector of the company**
Head of Publishing	Content creator - Gaming
General Manager / Studio Manager	Content creator - Gaming
Director of Business Development	Content creator - Gaming
Founder / CEO	Content creator - Gaming
Founder / CEO	Content creator – Entertainment/gaming
Business Director	Content creator - Fitness
CEO	B2B content developers
CTO	B2B content developers
New business consultant	Technology Consultancy
Researcher and Developer	Research
Research Engineer	Research
Senior Researcher	Research
CTO	HMD developers
Chief Strategy Officer	HMD developers
Strategy Manager	Connectivity infrastructure provider
Director Strategy Execution	Connectivity infrastructure provider
Senior Expert	Connectivity infrastructure provider
Director Global Partnering Strategy	Connectivity infrastructure provider
Expert Service Architecture & Use Cases	Connectivity infrastructure provider
Senior Advisor Advanced Technology Group	Connectivity infrastructure provider
Senior Expert – Monetization and Partner	Connectivity infrastructure provider

3.2.1.2 Interview execution

The interviews were conducted according to that of a semi-structured format, where there is a main list of questions prepared in advance from which the interviewers deviated occasionally with follow-up questions to enrich the material with more in-depth information (Patten 2017). The basis for the interview guides being used is visible in the appendix (sections 9.1 and 9.2). The interviews started with the interviewers giving an introduction to themselves and the purpose of the interview, this is supported by Brinkmann and Kvale (2018) who explain that the interviewee wants to get a sense of their interviewer before opening up about their experiences to someone previously unknown. They further stress the importance of attentive listening and showing interest from the interviewers' side which the interviewers tried to persist for the entire duration of the interviews.

According to Rowley (2012), some guidelines should be ensured in regard to how the questions in the interview are stated. The interviewer should make sure to not ask questions that are leading, include two questions in one, have a yes/no answer, are too vague or are invasive in any way. These guidelines were kept in mind while conducting the interviews to ensure the interviewees understood the questions.

Both thesis students were present at all the interviews, one being mainly in charge of following the interview guide and the other of notetaking. To allow for a transcription to be possible to make, the interviews were recorded through audio recording. After giving a briefing of the interviewers, the purpose of the interview, and asking if the use of recording devices was permitted, the interviews followed the logic of introductory questions (Brinkmann and Kvale 2018) to get to know the interviewer, thereafter questions relating to the main research areas, beginning with the relevant actors and relationships, followed by the main commercialization themes and ending with value capturing and some finalizing questions.

Thereafter the interviewee was thanked for taking the time to participate in the interview. As visible in the interview guides (9.1 and 9.2), follow-up questions (Brinkmann and Kvale 2018) were used when wanting to encourage depth (J.Rubin & S.Rubin 2005) in the discussion, and probing questions were used at times were thought necessary. In total, 21 interviews were conducted each with an approximate duration of one hour.

3.2.2 Documents

Document analysis involves a structured approach to examining and evaluating printed and electronic materials (Bowen 2009). Documents can be an alternative to other qualitative data sources such as interviews, observations, and questionnaires (Denscombe 2010). When using triangulation document analysis is commonly used as a complement to other data sources (Bowen 2009). Some examples of documents that can be used in research are books, journals, background papers, press releases, websites, organizational or institutional reports, and survey data (ibid.; Denscombe 2017).

The types of documents used in this thesis were mainly internal documents from Ericsson, in combination with websites, and press releases. The documents were collected through access from Ericsson, internet searches, and recommendations from the interviewees. Triangulation with interviews as a complement to the documents was used to prevent bias from the internal documents.

3.3 Data analysis

In this section, the process of data analysis that was used is described and motivated, aiming to increase the trustworthiness of this thesis.

After conducting the interviews there was a need to analyze the content in a systematic way, although Brinkmann and Kvale (2018) mean that there is no standard way to conclude the exact meanings or implications from interviews. To allow for easier analysis of written information, the interviews were transcribed meaning it was transformed from verbal interviews to written text (Halcomb & Davidson 2006).

The transcriptions were done through a built-in tool in Word on OneDrive, whereafter the interviewers went over the transcriptions while listening to the audio file making sure the transcription was correct and changing it if that was not the case. The reason for using aid in the transcription process was to decrease the time needed to complete the transcriptions. Transcriptions also allow for in-depth searches of the data and comparisons between the answers of interviewees (Denscombe 2017).

Unlike quantitative research, in qualitative research, there is no clear separation of the data collection phase and the data analysis phase according to Gibbs (2018), and therefore analysis starts already when data is collected. As previously shown in Figure 14, the analysis was done in parallel throughout the whole research process. The main method for analyzing the transcript materials was by the use of coding, which means that one or several keywords were used for longer text segments (Brinkmann & Kvale 2018). By doing this, the main themes or concepts that were touched upon in the interviews could easier be identified and compared, even though the interviewees may not have used the same exact words for the same concepts. Some examples of the codes used to analyze the transcripts are presented in Table 4.

Table 4. Excerpt of the codes used for interview analysis

Type of code	Code	Quote
Barrier	User friendliness	"friction for the users to actually get on the headset and run an app"
Barrier/important factor	Aesthetics	"sexy AR device"
Barrier	Comfortability	"It´s important with a balance so it doesn't become too heavy on your head"
Barrier	Content	"entertainment"
Actor	Operating system	"googles version of android for those headsets"
Actor	Content store	"Occulus store or steam"
Actor	Software development tools	"Platforms to build this VR or AR experience and that is Unity and NReal"
Actor	HMD developers	"Meta" "Pico" "Hardware developers"
Strategy & commercialization	Chicken or the egg	"To sell hardware good software is necessary […] to sell software good hardware is necessary"
Strategy & commercialization	Killer app	"Find the problem it solves"

The use of both documents and interviews as data collection methods when studying the same phenomenon of XR is a type of triangulation (Denzin 2007). It was thus a within methodology triangulation since both document and interview studies are of qualitative nature. The use of triangulation enables more completeness and the ability to confirm findings from one method to the other (Thurmond 2001).

3.4 Trustworthiness

In this section, the subject of trustworthiness is addressed. Specific attention will be paid to the role of researcher subjectivity and the measures that can be taken to enhance the credibility, transferability, dependability, confirmability, and reflexivity of the research findings.

It is essential that research meets the standard of being trustworthy for it to be relevant (Adler 2022). Traditionally, trustworthiness in qualitative research has been judged based on the four criteria of *credibility, transferability, dependability,* and *confirmability* (Guba 1981; Korstjens & Moser 2018; Adler 2022). Korstjens and Moser (2018) propose an additional criterion, *reflexivity*, which should be considered when assessing the trustworthiness of a study.

According to Adler (2022), transparency is the most important aspect of the trustworthiness of qualitative research. He stresses that in addition to providing clear documentation of the research method, researchers should also explicitly articulate the theoretical underpinnings of the study. To ensure trustworthiness, the theoretical framework that is used as guidance to answer the posed research questions is presented and clarified. To further ensure trustworthiness in this study, the approach of this thesis will be evaluated using the criteria of credibility, transferability, dependability, confirmability, and reflexivity as the basis.

Credibility concerns internal validity and the extent to which the research is done in accordance with good practice (Shenton 2004; Denscombe 2017). According to Denscombe (ibid.), researchers need to demonstrate the appropriateness and accuracy of their data. Some ways of doing so are triangulation, random sampling, iterative questioning, frequent debriefing sessions, and member check (Shenton 2004; Denscombe 2017; Korstjens & Moser 2018).

In this thesis, credibility has been achieved by using frequent debriefing sessions, member check, and triangulation. A member check was done by having a dialogue with the interviewees after the interviews, as well as discussing theories and ideas that came up during the interviews with the interviewees. The findings from the interviews were triangulated with information from the documents. The documents provided background, and although most of the documents were collected from Ericsson, they were validated through interviews. Lastly, the credibility of this thesis was enhanced by interviewing several different types of actors and getting viewpoints from multiple angles.

Transferability relates to the extent to which the results of the research can be transferred to other contexts (Shenton 2004; Korstjens & Moser 2018). In the case of this study, the scope has been limited to solely looking at the consumer market. There are multiple similarities between the business and consumer markets, and in the case of XR, there are many crossovers between the two ecosystems. Therefore, it is likely that many of the findings of this study can be transferred to the B2B case as well. According to Denscombe (2017), transferability requires the relevant information to be provided in a way such that other researchers can use it as a base of comparison to their setting. Thus, to enhance transferability the studied phenomenon is thoroughly described in section 1.1, and the interview guide is provided in the appendix (sections 9.1 and 9.2) together with an anonymized list of the interviewees.

Dependability concerns the extent to which the findings of the study can be obtained by another researcher, given the same information and methodology (Shenton 2004; Denscombe 2017). It also relates to consistency and whether or not the analysis process is done in line with accepted practices (Korstjens & Moser 2018). According to Shenton (2004), to address to issue of dependability, researchers should provide a detailed report of the processes used in the study. The procedures and research process of this thesis are outlined and motivated in this section. Furthermore, the interviews have been transcribed and documented for the purpose of auditing.

Confirmability refers to the degree qualitative research can generate findings that are not influenced by the ones conducting the study (Denscombe 2017), i.e., relates to the objectivity of the study (Shenton 2004). It is worth mentioning that no qualitative research can be completely independent of the researchers conducting it, as qualitative data are always subject to interpretation and are not objective facts (Denscombe 2017). To ensure a high level of confirmability, it should be clear that the findings are derived from the data (Korstjens & Moser 2018). Another important factor that enriches the confirmability is that the authors provide information regarding their biases and be open-minded (Denscombe 2017). In this thesis, the data collection is described in section 3.3 to assure objectivity. To avoid biases from the authors the coding, interpretation, and analysis of the collected data have been discussed by both authors. In addition, a critical review has been done by an objective supervisor for the university.

Finally, reflexibility is described as the process of engaging in critical self-examination, reflecting on biases, preferences, and self-concepts (Korstjens & Moser 2018). This section (0) is one of the ways in which the authors have increased the reflexibility of this study. Through the examination of credibility, transferability, dependability, and confirmability the authors have engaged in self-reflection. Furthermore, the authors have proactively engaged in ongoing discussions and reflections about their potential biases throughout the process of writing this thesis. Continuous dialogues have been maintained between the authors and with the university supervisor, aiming to mitigate any potential biases.

4 Findings

In the coming section, the findings of the interview and documents are presented in short. A combination of tables, figures, and some in-depth descriptions gives an overview of the findings.

To give a brief summary of the interviewees' insights, Table 5 has been assembled to showcase a selection of questions from the interview guide and their corresponding summarized responses categorized by actor segment. It is an aggregation of a larger table that was used during the data collection phase to summarize all the interviewees' answers in one place. This table aims to increase the transparency.

The subsequent sections will provide an overview of the interview themes that are pertinent to addressing the research questions. This will be achieved by presenting tables, figures, and further descriptions. The findings from the different themes covered in the interviews will be discussed and analyzed in more depth in the coming sections.

Table 5. Overview of interviewee responses by actor segment

Actor Segment	Who are the actors in the ecosystem?	Which are the strongest actor/actors?	What is your own role in the XR-environment?	How can the ecosystem change?
Research	Graphic card manufacturer, platforms, cloud solutions, content creators, content store providers, HMD developers, software development tools, end-user, libraries, publishers, governments, and EU	End-user, companies who own a larger part of the chain e.g., both device maker and content store	Investigate new areas of application, be a bridge between research and business, raise questions about standards, norms and ethics	Follow the same path as other digital markets e.g., consoles or smartphones. As the technology becomes more mature there will be more actors in the ecosystem.
Content Creation	HMD developers, chipset manufacturers, content creators, brands, content store providers, software development tools, specialized third party hard- and software developers, publishers,	Content store providers, Device developers	Provide applications and experiences	May look like the smartphone ecosystem. Mention of push towards more open but risk of closed ecosystem. First larger players will dominate, then room for startups.
Connectivity	Network infrastructure providers, CSPs, cloud rendering companies, HMD developers, chipset & graphics developers, content creators, content store providers, operating system, software development tools providers.	If wanting to reach content creators the software development tools are strong, when reaching end consumers device developers are strong.	Enabling XR on the go by 5G, provide communication infrastructure, innovate in areas such as latency and in collaborations with other actors.	Will become more standardized.

Actor Segment	Who are the actors in the ecosystem?	Which are the strongest actor/actors?	What is your own role in the XR-environment?	How can the ecosystem change?
HMD developer	HDM developers, chipset manufacturers, Content store providers, Content creators, Operating system providers, Cloud service providers, retail, entertainment industry.	HMD providers and chipset manufacturers.	Developing high quality HMDs, cloud provider.	Medium sized companies can enter the market, will look similar to the smartphone ecosystems with a dozen HMD providers with a main operating system. May get divided into a few separate ecosystems.
Technology Consultancy	Software, hardware, content creators	Actor who provides both HMD and content stores.	Making sure the tech is not hyped. Shift focus away from gaming to more useful applications.	The current players will not break through, new actors will emerge.
B2B content developers	HMD developers, content store providers, content developers, operating software system developers, cloud service providers, media companies, education companies.	HMD providers.	n/a	Will look similar to the smartphone ecosystem. Content will not be limited to specific HMDs.

Actor Segment	What potential does XR have in the future?	Important factors to reach a broad consumer market?	Barriers to commercialization?	Use cases with largest potential?
Research	May become a technology used in our everyday life.	Improved technical aspects and user friendliness, compatibility with other products, a lower price of devices and content, more opportunities to try out the technology.	No killer app[1], technical aspects	Gaming and education/training
Content Creation	In the near future be more like a smartwatch, a complementary device to a phone. Longer run AR will be used in day-to-day accessibility and VR/MR more gaming, fitness and entertainment.	Lower prices, better user friendliness, better understanding among consumers of how the technology can be used, aesthetics, better technology.	Technical, mental barriers for consumers such as resistance to change and unfamiliarity with the technology, legal aspects, no killer app.	Entertainment, gaming, education.
Connectivity	May replace smartphones, provide new future and environments.	Social acceptance, aesthetics, user friendliness, more content, killer app.	Geopolitical, macroeconomic, privacy issues, technological hardware barriers.	Social media, meetings, shopping, navigation, education, experiences.

[1] A "killer app" is an exceptionally compelling application that generates strong customer demand for both the product itself and the required infrastructure needed to fully utilize it (Juola 2008).

Actor Segment	What potential does XR have in the future?	Important factors to reach a broad consumer market?	Barriers to commercialization?	Use cases with largest potential?
HMD developer	May have a big impact especially MR, likely 2nd generation that will have meaningful volumes for consumers. Together with AI it has a big potential. Can end up somewhere between the level of a smartwatch or a smartphone.	Improved technical and user friendliness aspects. Need for killer app and subsidization of HMD to reach a broad market.	Too many digital devices already present in our lives, technological barriers, and social acceptance	Entertainment, productivity, physical and digital purchases
Technology Consultancy	Huge potential especially in education. Good complement for other things we use.	Aesthetics	Lack of utility content, user friendliness, attitude of users who tried it too early.	Education, training, workspace.
B2B content developers	Will replace or complement smartphones. May have bigger potential since it opens up for new commercial models from which value can be captured.	Technical aspects, user friendliness, aesthetics.	Physics aspects such as optics.	Shopping, education, gaming

Actor Segment	Where lies the customer value in XR?	How may end consumers pay for XR?	Additional ways to monetize on XR?
Research	Novelty and innovativeness of the technology. New ways to communicate and interact.	Leasing of headsets with content, prosumer model (basics free but all add-ons cost)	The selling of user data and ads.
Content Creation	Seamless accessibility (AR), access to new realities, immersive and interactive storytelling capabilities, and social connections in a new way.	Pay for the device, subscription with CSP, purchasing of digital items, subscriptions for content, up-front purchases of content	Selling ads.
Connectivity	Digital support while interacting with things, more immersive experiences.	Depends on the use case. Most likely pay for HMD up-front (or lease), and then up-front, sponsored or subscription payments for the content, digital purchases similar to NFTs.	Ads, product placements, and the possibility to monetize similar to Pokémon Go by physically moving people to locations e.g. near fast food chains.
HMD developer	Immersion together with new types of experiences.	Software sales.	Ads. Percentage of sales made through XR will go to the ecosystem.
Technology Consultancy	Limits physical travelling.	HMD and content purchases.	Ads
B2B content developers	Immersion, creating a natural/seamless connection between the digital world and the reality/ integration between the digital and the everyday life.	Pay for the technology as a service, purchase of HMD similar to smartphone model.	Pay to get rid of ads, selling user data, digital currencies.

4.1 Industry landscape

In this section, the findings related to the XR landscape are presented. The actors presented in Table 5 *are described in detail, and different perspectives from different types of actors are acknowledged.*

As visualized in Table 5 there is no clear consistency in identifying the actors involved in the ecosystem. Although, interviewees from the same actor segment answer more similarly, the differences between actor segments are larger. In addition, the majority of the interviewees have difficulties distinguishing between different roles and rather mentioned companies that often have more than one role in the ecosystem.

As can be seen in Table 5, all interviewees make the distinction between hardware and software providers, and most distinguish further by splitting up the two categories into additional subcategories of actors. Among these subcategories, the interviewees see different ones. However, most see HMD developers and content or application creators as two distinct types of actors. Noticeable in Table 5 is that the only actor segment that mentions the role of connectivity infrastructure providers and CSPs are the interviewees from the connectivity actor segment themselves. Other interviewees had to be prompted to even discuss the role of connectivity infrastructure providers.

The infrastructure providers justify their perspective by referring to when Apple and the iPhone disrupted the mobile industry and started the smartphone era. One interviewee draws parallels to the iPhone by pointing out similarities in the flexibility of the technology. The iPhone achieved a full-screen display by eliminating the keyboard, while the emerging XR technology holds the potential to entirely overcome the limitations of the screen. Another interviewee lifted the importance of "…three vertices, one is network, the other is device and the third one is applications". According to them, if applied to XR technologies, 5G would be a critical component in the success. The connectivity infrastructure providers point out that one of the enabling factors for this "iPhone moment" was the advancement of 4G.

To create a comprehensive picture of the ecosystem, the answers from the interviewees are combined, as visualized in the research process overview in Figure 14. This resulted in the XR landscape that is visualized in Figure 16. These actors and their roles are described in more detail in Table 6 below.

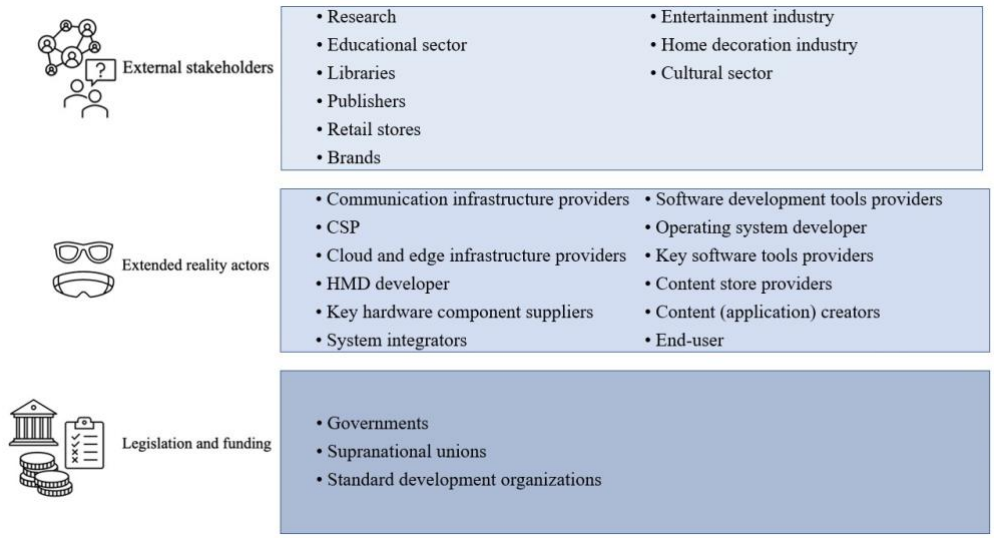

Figure 16. Visualization of the XR landscape

The actors in Figure 16 have been divided into three different categories. Figure 16 visualizes how legislation and funding set the base for the extended reality actors. Adner (2017) and Zhang et al. (2022) defines the actors in the ecosystem as those interdependent actors who collaborate to achieve a core value. As per the synthesized framework, the definition of innovation ecosystem by Adner (2006) and that of adoption networks by Dell'era, Frattini, and Ghezzi (2013) is used to find the actors in the core ecosystem. These have been noted as "Extended reality actors" in Figure 16. External stakeholders are thus actors who are mentioned by interviewees to have an indirect influence on and are interested in the development of XR technologies. These actors are often B2B2C actors that are mentioned as players that will help consumers get familiar with the technology.

Table 6. A brief explanation of the different types of actors in the ecosystem

Actor	Description
HMD developers	HMD developers are the hardware actors who develop and assemble the final HMD. Some examples that have been mentioned are Meta, Pico, HTC, Nreal, Xiaomi, and Varjo.
Communication infrastructure providers	Communication infrastructure providers are the actors who supply the CSPs with infrastructure for wireless communication. One example that has been mentioned is Ericsson.
Software development tools providers	Software development tool providers are companies that supply software applications and/or -frameworks used by developers to create applications or experiences for XR. Some examples are different game engines and webXR platforms.
CSP	CSP is a company that provides communication services to customers. In the XR ecosystem, CSPs are the ones who provides the connectivity in the form of 5G or Wi-Fi. Some examples that have been mentioned is AT&T, Bell, and Telia.
Operating system developer	Operating system developers are the ones who provides the operating system for the XR technologies. I.e., it would be the equivalent to iOS and Android in the smartphone world.
Cloud and edge infrastructure providers	Cloud and edge infrastructure providers are companies that offer computing resources and services for organizations to host and manage their applications, data, and other digital assets. In doing so they provide cloud rendering capabilities. Some examples that have been mentioned are AWS, Microsoft Azure, and Equinix.
Key software tools providers	Key software tools providers are companies that provide additional key software technology such as eye tracking and different APIs.
Content store providers	Content store providers are the ones developing and supplying the online distributing store in which users can download software applications. I.e., the equivalence to Google Play Store and Apple's App store of the smartphone world.

Key hardware component suppliers	Key hardware component suppliers are the ones providing additional key hardware components to the HMDs. Some examples that have been mentioned is Qualcomm and Nvidia.
Content (application) creators	Content providers are mainly software developers who develop the experienced to be used in XR, similar to application developers for smartphones or game creators for consoles or PC.
System integrators	System integrators are the actors who specializes in working across the value chain, combining and configuring different hardware, software, and networking components into a complete system. They provide security, consulting and project management services.
End-users	The end-users are the consumers who use the XR technologies.
Governments and supranational unions	Governments and supranational unions are national government like the UK, and unions like the EU, who provide legislation that companies and tech-developers need to adhere to. Some of them also fund project, e.g. EU innovation fund for low carbon technologies.
Standard development organizations (SDOs)	SDOs provide guidelines and specifications that ensure products and services are safe, reliable, and compatible with each other. They play a critical role in promoting interoperability, standardization, and innovation across industries. Some SDOs that were mentioned are 3GPP and OpenXR.
External stakeholders	External stakeholders include retailers and other sectors who may see a future where XR is used to purchase their products or experiences. Other stakeholders are research and education who want to investigate the possibility of using XR in their fields.

When it comes to additional hardware components there is a myriad of different types. Some key ones that are mentioned by most interviewees are chipset manufacturers and graphic card developers. Especially chipset manufacturers are mentioned by multiple interviewees in different parts of the ecosystem as can be seen in Table 5. The chipset is mentioned as a vital part of the HMD that sets limits to what is possible to do with the HMD and how the different HMD actors can differentiate from each other. Some interviewees consider governments and supranational entities, such as the EU, as significant actors. These entities were mentioned in relation to funding, and more prominently in relation to legislation.

One insight that is prevalent from the discussion with interviewees outside of the connectivity infrastructure provider segment is the perception of connectivity being an assumed resource. The majority of the interviewees take connectivity for granted and do not discuss that XR technologies require connectivity without being prompted. They assume consumers have internet access, and that the development of connectivity will mainly be driven outside of the XR ecosystem. When discussing connectivity requirements one interviewee expresses:

> "I haven't thought about it […] but I guess that governments will build the [connectivity] infrastructure." [Head of Publishing]

Similarly, some of the interviewees from the connectivity infrastructure providers see a dependency between content creators and connectivity providers whereas other interviewees do not see this dependency. The connectivity infrastructure actors justify their belief by arguing that the characteristics of the connectivity, e.g., latency, sets boundaries for what experiences are possible to create for consumers, which implicates a dependency between the two. One interviewee from the connectivity infrastructure sector expresses:

> "Connectivity characteristics plays a central role […] and is vital for the experience, e.g., getting a low and predictive latency performance" [Strategy manager]

Although the same interviewee is not convinced everyone else in the ecosystem share this belief.

One interviewee from the content creation sector emphasizes the importance of designing content that appeals to and is accessible to a larger audience. Another interviewee, outside of the content creation sector, suggests that

content creators may prefer to use lower-quality connectivity in order to reach a broader customer base, rather than creating advanced experiences that require high-quality connectivity. They believe that connectivity does not set that large of a barrier and are of the view that content creators are able to adapt their applications to the constraints posed by connectivity without encountering significant limitations. To summarize, the view outside of the connectivity sectors is that good connectivity is not viewed as critical, and in general connectivity is taken for granted.

4.1.1 The developing XR landscape

When discussing the XR landscape the majority of the interviewees stress the newness and immaturity. The views on the future of and the interdependencies in the landscape are varied.

One viewpoint that is brought up by almost all interviewees, is that there is a prevalent interdependency between the HMD developers and the content creators. The common view among the interviewees is that HMD developers and content creators are dependent on each other to deliver value to the consumer. One expresses it as HMD developers need content to sell their devices and the content creators need consumers to own HMDs to be able to sell their content. Another view that is lifted is that the chipset manufacturers are dependent on HMD developers to use their chipsets in their devices. To mitigate this dependency, one of the leading chipset manufacturers has developed a reference design for HMDs. This reference design is pointed out by the interviewees as important.

Although there is somewhat of a consensus regarding the existence of an interdependency between HMD developers and content creators, there are conflicting views on the power dynamics between the two. Some interviewees argue that there is a lack of skilled content creators and that the content is what is generating value to the consumers, making content creators stronger actors. In contrast, other interviewees argue that there is an abundance of content creators, and the HMD developers are much fewer and stronger actors.

Another common view is that what decides which actor is the strongest is determined by which actor has the most resources, who owns the relationship with the consumer, or a combination of the two. As visualized in Table 5, the only actor segment that mentions the end-user or the consumer as an actor in the ecosystem is research. However, findings show

that multiple interviewees from different sectors indirectly discuss end-users as a player by reflecting on this relationship with the consumer, and or discussing the need and demands of consumers. One interviewee from the research sector argues that the strongest actor in the ecosystem is the end-user since "they are using the technology and creating the demand for it". According to them, the rest of the ecosystem has to oblige to the end-users' needs.

Table 5 also shows that some of the interviewees from the gaming sector of the content creators see the content store providers as one of the strongest actors. They are of the view that content store providers own the relationship with the customer and therefore become gatekeepers. One interviewee articulates their perspective by saying "Everyone is dependent on the content store providers […] and they own the consumer relationship".

Numerous interviewees across almost all actor segments mention Meta when reflecting upon the strongest actor. One interviewee highlights the large market share and delivery volumes of Meta. Other interviewees emphasize the size of Meta's investments in the market and the many acquisitions of up-and-coming actors in the XR field. One interviewee justifies their stance by referring to their "deep pockets" and "the important content store platform". Although several interviewees mention Meta as strong, some among them also question their duration as the strongest actor. One interviewee shared their thoughts on this by saying "At the moment Meta is the strongest actor, but it hasn't always been like that, and it will not stay that way forever either".

One interviewee from the content creator sector weighs in on the view of Meta's position in the ecosystem by referring to their vertical integration, and especially the control of both the device and content store. They further emphasize that this combination of owning and controlling both the device and content store is common and that stand-alone content stores are an exception.

This lack of consensus regarding power dynamics, the strongest actor, and thus what drives the future might open up for a "chicken or the egg problem". One interviewee from the research sector highlights this by saying:

> "There is not yet a 'killer app' that is making the general public run and buy the devices to be able to experience this […] which results in a small user base, which in turn means that there is not an incentive to develop the content" [Researcher and developer]

They further emphasize that this "chicken or the egg problem" has left the ecosystem standing still and unaware of where the future is heading.

Concerning the future of the ecosystem, a consensus among most interviewees suggests that changes will inevitably happen due to the early stages of the technology. One interviewee further develops their thought by saying:

> "The ecosystem will change because the world is never static. With that said, if someone is able to create a certain ecosystem leadership, those systems tend to be long-lasting." [Chief strategy officer]

They justify this belief by referring to how Apple's iPhone and its app ecosystem disrupted the smartphone industry and how after a while the ecosystem became self-reinforcing.

In line with the aforementioned interviewee's reasoning, the majority of the interviewees draw parallels to the ecosystem of smartphones and some to the one of gaming consoles, reasoning it will be configured in a similar way. One interviewee supports their assertions by saying "There is a playbook from the smartphone area, and I don't see any reason why this wouldn't work here [XR area]". Another interviewee asserts that several actors operating in the XR field are also involved in the smartphone ecosystem and that this increases the likelihood of the XR ecosystem taking a similar form to that of smartphones.

In addition, several interviewees from different actor segments have identified Apple as a potential disrupter in the field if they decide to enter. One interviewee refers to Apple as a "market mover" and states that whatever direction they choose, the rest of the market will shift towards that direction. Another interviewee weighs in on this topic, offering the insight that it is plausible that the XR ecosystem may not be dominated by a single player, and multiple ecosystems could emerge, with one revolving around Apple, similar to the current situation in the smartphone industry.

In February this year, Qualcomm announced a partnership together with Samsung and Google to build the next XR experience together (Samsung 2023, 51:06). This is another possible disruption that some interviewees mention as possibly important for the future of the XR ecosystem.

Another view that is brought up by one interviewee is that the first few cycles of development in the ecosystem will be dominated by the big players, but over time there will be room for smaller players to grow and take over. Several interviewees in the content creator sector of the ecosystem express a wish for the ecosystem to be more open. One of the interviewees expresses an aspiration for the ecosystem to adopt the structure of web browsers rather than smartphones, despite holding the belief that it will take a similar form to that of smartphones.

4.2 Value Capturing

In this section, the findings concerning value capturing are presented. Firstly, an overview of the consumer value of XR technologies is given, and then applicable revenue models are presented.

Value capturing is the area the majority of the interviewees have the most difficulties answering the questions posed during the interview, and there are a lot of different views. To be able to capture value, the first step is to define the value of the technology. Values the interviewees believe are important from a consumer perspective are presented in Table 7, and some are discussed in more detail below.

Table 7. Summary of values in XR technologies

Value of XR technologies	Short description
Immersive experience	Consumers value immersive experiences that are interactive, captive, and blur the line between reality and digital environments. Immersive experiences often involve elements that stimulate multiple senses.
Novel experiences and storytelling capabilities	Consumers value new and inventive experiences that are enabled by the storytelling capabilities of XR. The term "novel" in this context refers to experiences that are new and unique, and which could not be created or replicated without the use of XR technologies.
Personal expression in online environments	Consumers value being able to express themselves in online environments. This could for instance be in the form of having an avatar that resembles them and expresses their personality.
Seamless connection between digital and real world	Consumers value the seamless integration of digital content into their daily lives, and not being interrupted.
Visualization	Consumers see value in the visualization capabilities of the technology. Especially 3D visualizations that appear to be real-life and in real-time.
Communication	Consumers see value in the new ways of communication that XR technology enable.
Social connections	Consumers see value in the interactive elements of the technology that enables social connections. Especially less self-focused social connections.

When discussing the value of XR technologies, most interviewees lift the immersive experience, and the new type of experiences that the technology makes possible. In addition to the immersive experience, both interviewees from the gaming part of the content creator sector and documents discuss how people increasingly value personal expression in online environments.

Multiple interviewees from different actor segments point out communication in a new way as another value for the consumers. One interviewee from the content creator sector lifts the value of social connections in a new way by saying that the social and shared elements of the technology will be part of the killer app. The same interviewee also notes that with XR social connections can be much less self-focused, and more interactive than what we see today on social media.

Another interviewee from the B2B content development sector emphasizes the value of the technology by saying that the most important value in the technology lies in the smooth connection between the digital world and reality, and how XR technologies have the potential to be much less interruptive than today's technology. They lifted that, similar to what the name implies, XR has the potential to extend and enhance reality. Additionally, other interviewees recognize the advantages of hands-free interaction in contrast to smartphones, and the benefit of no longer being confined to a screen.

In general, when discussing monetary flows in the ecosystem, the majority of the interviewees believe these will not change. Most believe they will continue to resemble the monetary flows in the smartphone ecosystem. This belief is also backed up by documents. Some interviewees are either not sure or believe it will continue looking like it does today. An interviewee who shares this perspective highlights that, while certain players and internal cashflows may undergo alterations, the end-users' experiences are unlikely to be impacted.

When asked about monetization the majority of the interviewees separate between revenue models for the device and for the content. Most are of the view that the consumers will pay for the device themselves, either fully or with the HMDs being partly subsidized. As of now, some of the HMDs are subsidized by the HMD developer who regains this money through application sales in their content stores. When it comes to the content the views are a bit more varied, some believe the content will be paid for by the

consumers, some believe it will be paid for by a third party, through for instance ads, and other believe it will be paid for through a mix between these two. These different revenue models will be described in further detail in section 4.2.1.

4.2.1 Applicable revenue models

The revenue models that have been mentioned in the interviews and documents to capture value for the XR ecosystem are shown in Table 8 below. The two columns furthest to the right show if the revenue model was found in the interviews, documents or present in both.

Table 8. Relevant revenue models for XR technologies

Revenue model	Description	Interviews	Documents
Up-front HMD sales	Consumers directly purchasing HMD from a reseller.	X	X
Technology-as-a-service	The HMD is paid with a monthly subscription making it possible to update when new improved versions of the HMDs are available.	X	
Up-front content sales	Consumers pay for the content in form of an application or a functionality as a one-time fee.	X	
Subscription content sales	Consumers pay for their content either monthly or yearly.	X	
Renting of headsets with content	The consumer could rent for a limited time the HMD including a set of applications to run on it.	X	
Digital item sales	Consumers pay to receive items they can use or see in their XR environment, an example often given of this is NFTs.	X	

Sales of add-on functionality	For this revenue model, all basics would be provided for free, but the consumer would have to pay for all add-ons to the XR experience.	X	
Percentage of physical purchases made through XR	Consumers buy items through the XR environment, from which a certain percent is given to the XR environment.	X	
Ads	Third party companies pay to have their products shown in the XR environment, product placement was mentioned as the most important type of ad income.	X	X
User data sales	The users themselves or the actors owning user data would sell their data to third parties.	X	
Location sponsorship	Third party companies would pay content creators to physically move people near certain locations, e.g. near shopping malls or fast-food chains.	X	
Subscription sales for connectivity	The consumer would pay a monthly fee to the CSP to enable their HMD to be connected.	X	X
Data volume upgrade	A consumer who already has a data plan for another device such as a mobile phone, would upgrade this plan and pay a higher fee to have their XR HMD connected in addition.		X

Quality of Service (QoS)	Consumers pay for higher quality connectivity for either all or some specific content.		X
Device embedded connectivity	The connectivity cost is indirectly paid through the device, making the price of HMD devices slightly higher. E.g. Kindle		X

When discussing revenue models, almost all interviewees describe that end consumers will be responsible for purchasing HMDs. This could be either from device manufacturers or a third-party reseller. The most common revenue model for this was to pay an up-front cost for the HMDs. This is also confirmed by the documents. The documents discuss the possibility for other actors in the ecosystem, for example, CSPs to resell these. Most interviewees express that this purchase will probably be a one-time, up-front cost similar to how it is today.

In addition to an up-front cost for the HMD, one interviewee sees the opportunity for HMDs to be sold as so-called !technology-as-a-service", similar to some phone subscriptions where no up-front cost is paid but instead, a higher monthly subscription covers the cost of a phone which can be exchanged every year as long as the phone that is given back is fully functioning. The interviewee describes that by doing this, the consumers could update their HMDs every so often to keep up with any technical improvements needed for an optimal experience.

The opportunity to rent HMDs including some content is proposed by one interviewee working in research concerning XR. They explain that consumers might find it too expensive to purchase the HMD device, and additionally buy the content applications needed to experience XR. Renting is also lifted for the purpose of enabling users to try the technology before making the purchasing decision.

Content sales are also frequently mentioned in the interviews and backed by company documents. Both up-front costs for applications, subscriptions, and free-to-download but monetized through advertisements and in-app purchases are revenue models for content sales that were discussed. A founder and CEO of a company within the content creation sector highlights

the possibility of the majority of the content being paid by a third party. They emphasize that there is potential for "it [the XR world] to be a marketing base and platform", thus allowing for the content to be free and paid for with new forms of advertisement or brand recognition etc.

The sale of digital items is mentioned in many of the interviews. The examples ranged all the way from digital paintings visible on your walls when wearing XR HMDs, to accessories on personal avatars in virtual meetings. One interviewee stresses that people like to express themselves by looks and there will be a willingness to pay for items that show personality in a case where virtual hybrids would replace for example physical meetings. Another expert brought up the fact of the increasing world population leads to smaller living spaces, which would create a market for virtual living environments.

Another thing that is commonly mentioned is sales of add-on functionality. This can be either software functions, such as the described digital items, or functions related to the hardware such as the opportunity to receive haptic feedback or other sensory functions. The interviewee opens up for these add-ons to be made in-house by the HMD developers themselves, or third-party developers entering the ecosystem, building upon the basis provided by the HMD developers.

When it comes to additional ways to monetize, ads are mentioned by almost all interviewees and is also present in company documents. Some interviewees believe ads will not work since people are "sick of it". Others believe ads in XR will become much better than in smartphones today and more seamless, which would make them have an even bigger impact and with the possibility of generating even more revenue than today. Many interviewees see the possibility of new ways of advertisement that the technology would enable, although they were not entirely sure what it would be.

Another alternative way to monetize that often is mentioned in interviews is sales of user data. However, most interviewees see it as problematic and lifted both ethical and legal aspects of it. With many HMDs having video cameras, and the ability to track hand or eye movements, some interviewees express concerns regarding the likelihood of XR being able to track more user data than smartphones or other digital devices.

While some interviewees open up for the possibility of individuals owning their own data and choosing what to share in return for content or applications, others believe the user data would be different actors in the XR ecosystem who could sell the data to third-party companies such as insurance companies. However, several interviewees raise the concern about the privacy issues that may come with the sales of user data, and describe how regulations would come to interfere, although delayed. This concern is also backed by the documents.

One opportunity that is lifted by some interviewees is to capture value from purchases of physical products through the XR environment. Products would be visible in the XR environment and consumers would be able to purchase these directly through the HMDs, from which a smaller percentage of the purchase would be earned by the XR ecosystem. It is described by one interviewee in the hardware sector that in the case of a subsidized HMD, a couple of large purchases such as interior, have the potential to quickly gain back the subsidized part of the HMD. The interviewees emphasize the compatibility of this with the visualizing functionalities of XR technologies.

A director of strategy execution lifts the opportunity for XR content creators to monetize by creating features and content within their applications that would make users physically relocate to specific places. The example given was near fast-food places, where the fast-food place would pay to have people relocate near them in the hopes that they would enter the restaurant. They back their belief by referring to that this revenue model has been used by mobile AR content creators in the past and cannot see why not this type of value capturing can become more common in future XR applications.

Concerning connectivity, some interviewees describe how the users of XR technologies will pay for the internet connectivity of these said devices. The customer having a separate subscription with the CSP is the only option for this mentioned by interviewees when prompted to discuss it. Internal company documents mention further ways in which the consumer can pay for their connectivity of XR HMDs, such as data plan upgrades and quality of service. Indirect models for connectivity revenue are also mentioned in these documents, such as the Kindle model, which is called device-embedded connectivity. Here the connectivity is paid indirectly by the consumer through their purchase of the HMD.

Although the interviewees lifted many possible revenue models, almost all of them stressed the newness of the technology. A few interviewees mention that XR will create opportunities for new commercial models through which new value can be captured. They accentuate the uncertainty of how XR will be used in the future and say that how value can be captured from this is difficult to say since we as of now do not know exactly how the technologies can and will be used. However, revenue models is one area where some interviewees believed the level of innovation needed is low. One interviewee in the content creation sector expresses it as:

> "Although there will be lots of advancement and innovation in the field of the technology, value capturing is the area in which there needs to be least innovation. There are already good enough models for value capturing, so this is not where we need to focus our innovation" [CEO and founder].

4.3 Commercialization

This section aims to present the findings from interviews and documents that are relevant to answer the overall RQ "How can XR technologies be commercialized to reach the broader market". This is done by providing general insight regarding commercialization, use cases, important factors to reach the mass market, and barriers to commercialization.

The interviewees see multiple values in XR technologies (see Table 7). When asking about the prospective outlook of XR in the future, the interviewees envision a substantial potential. The majority of the interviewees believe XR technologies will become everyday tech. Most of them believe it will eventually replace smartphones, and some believe it will become a complement to the smartphone.

One interviewee highlights that XR technologies will likely first become a complement to the smartphone and then later on when the technology is more mature, replace the smartphone. Another interviewee further mentions the possibility that XR technologies may continue to serve as a supplementary device to smartphones, rather than a replacement, despite having a positive outlook on the technology's potential for expansion.

In contrast, one interviewee from the content creator actor segment argues that XR technologies could have a greater potential than smartphones. This is due to the possibility of exploring new commercial models that enable the capture of untapped value. In addition, two of the interviewees from different actor segments note that the potential of XR technologies may be greater than initially anticipated when integrated with artificial intelligence.

A lot of other players in the market also believe in the future of XR. As mentioned in the introduction in section 1.1.4, there is a belief that the XR market will grow a lot in terms of revenue. Meta announced in 2021 that they would invest 50 million USD in their XR program and research fund (Anon. 2021). In 2022 Qualcomm announced that they expand their investments in XR by opening up a European XR lab (Anon. 2022).

4.3.1 Use cases

Part of the commercialization strategy is choosing the use cases deemed to have the most potential. The interviewees describe several areas which they believed XR will have great potential to be successfully applied in. The use cases that are mentioned in the interviews are categorized and described in Table 9 below.

Table 9. Use cases for XR technologies in the consumer market

Use Cases	Description
Gaming	Similar to current console or PC gaming, like current VR gaming but wider use and with MR devices accessible to the consumer market
Sports	Either in the form of fitness training through XR or at sports-related events to enhance the experience providing live stats of the game etc.
Entertainment	Entertainment in the form of virtual concerts or other experiences
Social media	Social interactions similar to how social media is used today, with increased interactivity
Education/Training	Both school education, training on the job and training for occasions like driving exams

Communication/collaboration	Virtual work spaces, immersive meetings
Shopping	Being able to purchase physical items through the XR experience, or as guidance when in physical stores

4.3.2 Important factors to reach mass market

When queried about which factors of the technology are the most important to consider in order to reach the broader market, the interviewees discuss a myriad of different aspects. These aspects are gathered in Table 10 below.

Table 10. Aspects of XR technologies that the interviewees lift as important in reaching the broader market

Aspect	Short description
User friendly	The technology should be intuitive and easy to use for consumers
Affordable	The price point needs to be set at a level where consumers find the technology affordable, considering both the device and the content.
Content	There needs to be a sufficient amount of content, and also a killer app
Aesthetics	The HMD should be designed with sufficient attention to contemporary fashion trends so that its visual aesthetics are appealing to consumers. This is of extra importance since the consumers need to be willing to wear them throughout the day. One important factor of this is that they need to be made less chunky
Technical	The technical elements of XR needs to be in place. Latency, battery time, and processing power, etc. need to be sufficiently good. The device also needs to weigh much less. In summary, the technology should work seamlessly
Comfortability	The device needs to be ergonomic; the consumers should not feel discomfort when using the technology
Social acceptance	It needs to be socially accepted to wear the HMDs in public places

Compatibility with other products	The XR technologies need to be compatible with other everyday tech
Consumer insight	The consumer needs to understand what the technology is about, how to use it, and to get an understanding of the XR space in full
Opportunities to try the technology	There needs to be opportunities for the consumers to try out the technology and get familiar with it

4.3.3 Barriers to commercialization

The topic of what factors may hinder commercialization to the broader market was discussed in all interviews. The mentioned barriers range all the way from technical barriers to social acceptance and privacy issues. An overview of the barriers described by each interviewee sector is visible in Table 5, and an aggregation and categorization is found below in Table 11. The barriers are described as factors that might limit the opportunity for XR to reach a wide user base.

Table 11. Barriers to commercialization to the broad market

Barriers	Description
Technical	Technical limitations connected to both the connectivity (latency and bandwidth etc.), as well as other things such as the weight of the device and battery performance
Optics	Limitations with optical see through such as backlight interfering with digital objects and difficulties of creating dark objects
Content	Lack of good content to run on the HMDs, lack of utility content and no killer app
User friendliness	Not intuitive enough to use and friction for users to start the HMD and run a content application
Comfortability	Difficulties with wearing HMD for longer periods of time, people getting motion sickness and chunkiness of the device

Aesthetics	HMDs being chunky and not aesthetically good looking, people are unwilling to wear them
User attitudes & Social acceptance	People being unwilling to adopt XR technologies because of unfamiliarity with the technology, resistance to change, privacy concerns or other personal attitudes
Price	Some consumers may believe the price of HMD devices and content is too high
Geopolitical	Uncertainties concerning relationships between countries with important actors in the XR landscape
Privacy & legal issues	Concern about privacy of users and user data and how this will be handled by regulatory institutions
Macroeconomic	Concern by companies regarding the financial situation in the world which creates hesitation to invest in new technology

The technical barriers are described by many of the respondents. Some of these include heat dissipation, battery time, processing power and performance. The display being too small was often raised in relation to AR. Technical aspects related to connectivity such as latency and bandwidth are described mainly by the interviewees operating in the connectivity sector.

Two of the interviewees went beyond technical aspects and are concerned of HMDs, especially AR devices, being hindered by basic physics, namely optics. They see difficulties with AR glasses, with optic see-through, being used outdoors with the sun, and acknowledged the difficulties of creating digital objects with black elements.

The third category of barriers that is heavily discussed in the interviews is that concerning content. One interviewee claims that “we need a lot more utility applications”, and the lack of a so-called killer app that makes people wanting to buy the technology is stressed by many of the interviewees.

The lack of user friendliness in current HMDs is described as a barrier to mass adoption. Interviewees lift that XR experiences “need to be easier, faster and more intuitive to use” which together with another statement “it needs to be simple with not so many steps” underpin the friction for users to actually use the devices and applications.

Adjacent to user friendliness, several interviewees also express the issues with HMDs concerning their comfortability to use. Other than simply describing the HMDs as uncomfortable to wear, the weight and chunkiness are also lifted as reasons for this. One interviewee also describes it as being “unpleasant for the eyes to use them for a longer period of time” further strengthening the aspect of comfortability. Although multiple interviewees address the challenge with some users’ experiencing motion sickness when using HMD devices, one interviewee stresses the improvement of this aspect over the past few years.

The aesthetics of the current HMDs is mentioned as a possible barrier to commercialization. The interviewees describe them as bulky, looking similar to a brick and not something you would want to wear on the street. Several interviewees believe that the devices have to become trendy and fashionable for people to be willing to wear them in public. This barrier is related to the area of social acceptance described below, but has been mentioned separately and as a barrier of special importance for HMDs.

Another area of concerns is that of user attitudes and social acceptance that is mentioned as a barrier to commercialization to the broader market. Different themes are raised on this topic, all the way from people being unfamiliar with the technology to there being a backlash because of people already trying the technology when it was very immature and are not willing to try it again because of the previous unsatisfactory experience. One interviewee in the hardware sector mentions that there may be a digital saturation among consumers, claiming that consumers may feel that “do I want one more digital device in my life messing up my already far too digital busy lifestyle”, and that this may be a barrier for the adoption of XR amongst consumers.

The price of the XR experience is especially stressed as a barrier by the interviewees in the research field and the content creation field. One interviewee highlights that the XR devices and content need to be at a "reasonable price point" so that people are prepared to buy them. Other interviewees however believe that since people pay a high price for smartphones, they are willing to spend a similar amount on an HMD.

One interviewee in the connectivity infrastructure sector sees a risk that geopolitical uncertainties may come to affect the commercialization of XR. They specifically mention USA and China as countries to look out for, since they both have actors developing technologies used for XR. These two are mentioned to be developed in parallel and having potentially different actors in their ecosystems.

There are concerns raised connected to privacy and integrity, if people will actually be willing to walk around with devices that essentially have cameras and microphones on at all times. The amount of sensitive user data possibly being able to be collected is also a concern mentioned by many interviewees, and while some find it concerning, others mention that many of the devices used by consumers today also collect this data. The data falling into the wrong hands or the possibility of people being used is mentioned as a concern. Many interviewees agree upon that regulatory institutes need to take a stand and adjust or introduce new laws, but they also mention that it will lag behind the technological development.

The macroeconomic barrier is not mentioned as a barrier for consumers, but for the willingness of companies to invest in new technology in an economic downturn. This is described as a barrier delaying the XR development, not hindering it completely.

4.3.4 Strategies for commercialization

How to commercialize a new technology in the most effective way strategically is no easy question, especially will all the just mentioned barriers in mind. When asked, one actor in the content creator sector says, "If I only knew", and several others answer similarly. Instead, most interviewees reflect on what aspects of commercialization would be important to ensure its success.

Most interviewees stress the importance of content when commercializing XR technologies. The need for a killer app is expressed several times during the interviews and listed as an important factor for commercialization. A

couple of the interviewees lift the need for a utility use case, and one actor in the content creator (gaming) expressed the need to find behavioral patterns with XR that work in people's everyday lives. An example that is given by an interviewee as a use case that will make a consumer buy a product for the use case is “if you want to make a smoothie you are willing to buy a mixer”, and they believe a use case like this will be needed for XR as well. Another interviewee expresses the importance of needing to start with the consumer and try to create value and content based on their needs.

The second aspect of commercialization that is considered very important by interviewees is reaching good, well-functioning HMD devices, and thus overcoming many of the previously mentioned technical barriers. Some of the important aspects mentioned are commercializing with HMDs that are aesthetically appealing, ergonomic and comfortable. One interviewee is positive that by continuously improving the technology and making it more user friendly it will be successfully commercialized. An actor in the HMD developer sector believes MR devices should be the way to go when commercializing to the broader consumer market. This same interviewee thinks volumes should be driven by subsidizing the HMDs, similarly to how Meta subsidizes their headsets.

Commercializing with good use cases and good technology go hand in hand with timing, which is stressed by an interviewee in the connectivity infrastructure sector. They mean that it is important to go to market when the market is mature, the technology and content are mature and the whole ecosystem around it as well.

Another aspect of commercialization that is mentioned by a few of the interviewees is the importance of making people familiar with XR technologies. One interviewee in the content creator sector who currently focuses on mobile AR, believes a good way to introduce people to XR is by doing it through their smartphones first. They believe that since a smartphone is something almost everyone has, starting in this form will make people comfortable with the technology and give people a preview of what can be done, like a proof of concept. Additionally, showing that XR is an extension of the smartphone, not a replacement, and that the combination can give another level of interaction between people that you cannot get without the XR technologies.

An interviewee from the research sector proposes to increase the opportunities for people to try out XR, such as testing opportunities or leasing of devices. They stress the importance of making people familiar with the technology without a high economic commitment. Other ways to mitigate the social acceptance barrier that is mentioned by some interviewees is the usage through B2B2C actors such as retail and education. One interviewee also mentions libraries might also be a place for trying the technology, similar to how it was when PCs were adopted.

An interviewee working in the HMD developer sector anticipates that what will work for businesses will ultimately work for consumers. Saying that if a method for business use enables to save a lot of money or make the technology happen faster or with better quality, once that is scaled it becomes affordable to the consumers as well. Thus, XR technologies built for businesses or industries will be able to benefit the consumer market as well.

With this said, if the clear distinction between VR, MR, and XR remains, the commercialization strategies may differ due to different user motivations. One interviewee says that the nature of VR being more isolated will result in it being used in more specialized applications.

5 Analysis

In this section, the findings from the interviews, which have been triangulated with the document, are analyzed using the synthesized theoretical framework presented in Figure 13.

The analysis proceeds in four stages: the innovation ecosystem is initially mapped along with an analysis of the actor interdependencies, then an analysis of the future of the XR ecosystem is carried out. This is followed by an examination of value capturing in the ecosystem. Finally, this culminates in an analysis of the overall research question regarding how XR can be commercialized to reach the broader market.

5.1 Ecosystem layout

This section aims to present a visualization of the XR ecosystem and its layout and structure.

According to existing literature, it is important to analyze the ecosystem in order to understand the development of industries (Takeishi & Lee 2008). A way to map and analyze an innovation ecosystem is presented in Figure 3, the ecosystem pie model created by Talmar et al. (2020). The extended reality actors (presented in the middle section of Figure 16) are mapped into this model which is visible below in Figure 17 (the model can be found in a larger format divided into two halves in appendix Figure 18 and Figure 19).

The center of the model presents the value proposition of the ecosystem, namely the XR experience that is possible because of the collective value creation of the actors stated as pieces of the pie. The targeted user segment of the ecosystem in this case is the consumer segment visible in the top left position with red post-its. The actors involved in achieving the complementary value chains of the ecosystem are color coded accordingly with post-its.

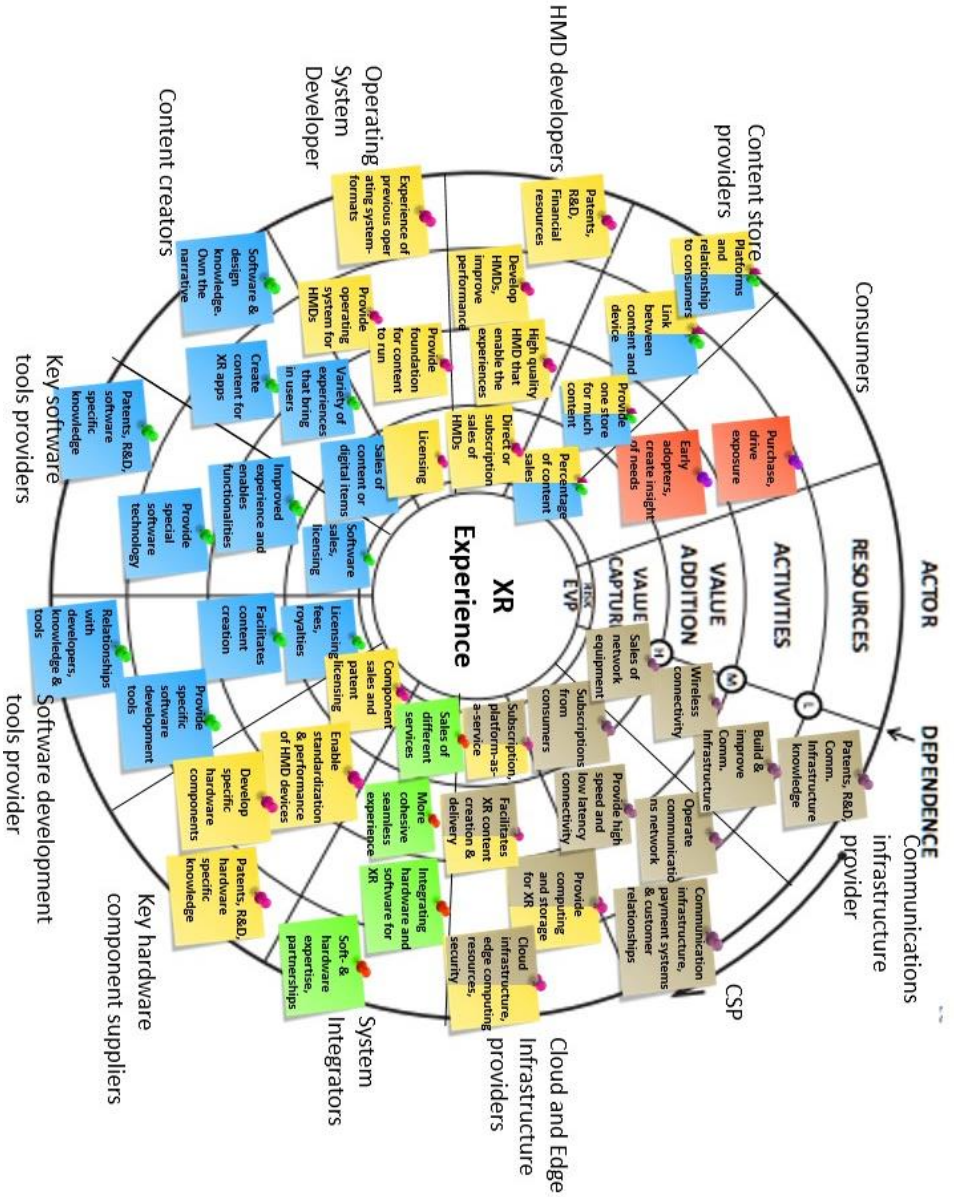

Figure 17. The XR ecosystem presented in the Ecosystem pie model

The color coding of the post-its follows the following logic: the brown notes are attached to the actors that are mainly connected to the connectivity value chain, i.e., the communications infrastructure providers and the CSPs. The yellow post-its represent the actors that are mainly part of the device value chain, thus the HMD developer, the key hardware component suppliers, and

the operating system developers. The cloud and edge infrastructure providers are partly included in the connectivity value chain and the hardware segment because of the offloading potential from the HMD devices to the cloud. It is however worth noting that these actors are not completely excluded from the content/software value chain.

The blue post-its were given to actors mainly involved in the content/software value chain, these include the content creators, key software tool providers, and software development tool providers. The content store providers were given both a yellow and blue color because this role is where the device and content come together to stream the XR experience, this actor is thus closest to the consumers. Finally, the system integrators are represented in green because of the overarching nature of these actors. The ecosystem can be further analyzed in the ecosystem pie model by specifying the risk of actors not contributing to the ecosystem and the actor dependence on the success of the ecosystem.

As stated earlier, the interviewees had difficulties distinguishing between different roles in the ecosystem and tend to refer to specific companies instead of delineating the distinct functions. One interviewee says:

> "There are lots of start-ups, but the dominant actor is Meta […] there is HTC […] and lots of people hope that Apple will come with an iconic device." [New business consultant]

A common denominator for Meta, HTC, and Apple is that they are all vertically integrated. For instance, they all own and control the device and content stores[2].

Vertical integration's efficiency in new markets such as the one for XR is backed up in the theory. Vertical integration is efficient to use in new emerging markets with market uncertainties and where the customers want an all-in-one solution and makes it easier to align goals (Cacciatori & Jacobides 2005; Cho, Qiu & Bandyopadhyay 2020; Liang et al. 2022). According to Frattini et al (2012), the mainstream market is looking for a solution that works seamlessly.

[2] Apple is as of now (May 2023) not active in the emerging XR ecosystem, but are active in that of smartphones.

As per the findings, vertical integration is common, and some interviewees argue that the reason for Metas strong position is due to their vertical integration. Although vertical integration is not shown to have a significant impact on market power in specific cases by some scholars (Díez-Vial 2007; Basant & Mishra 2019), Harrigan (1984) shows that one of the main reasons for bargaining power is product specificity. By controlling both the device and content store, the product specificity increases, which in turn increases the bargaining power. According to Díez-Vial (2007) which stages in the value chain are being integrated is an important factor that affects the efficiency of the vertical integration. Seeing that the combination is the rule rather than the exception, it is possible that the combination of owning and controlling both the device and content store is an efficient vertical integration in the case of XR.

Findings indicate, the opportunity of several parallel XR ecosystems is a possibility if multiple actors manage to gain a strong enough position. For instance, if Apple enters the XR market and are able to get a significant market share and the mentioned collaboration of Samsung, Qualcomm and Google also becomes successful, these can become parallel competing ecosystems. This idea of multiple ecosystems is backed by the theory of vertical ecosystems, where they partly compete and partly cooperate (Cacciatori & Jacobides 2005).

5.1.1 Actor interdependencies

Different types of complementarities underpin an ecosystem (Jacobides, Cennamo & Gawer 2018), which is also applicable on the XR ecosystem. HMD and content are mentioned as resources being two-way dependent and with a strict complementarity, since the device does not function without the content and the content cannot function without an XR device to run on.

Supermodular complementarity is also evident for the content store providers and the content creators, since an increase in the number of applications made by content creators that are published on the content stores, make the content store more valuable. These also have somewhat of a two-way strict complementarity, however the conflicting view on the abundance or scarcity of content could mean the content could also be considered a generic complementarity.

There are also examples of one-way strict complementarities, for example the cloud and edge infrastructure is needed for XR, but the cloud does not need XR in order to function. The same can be said for system integration and the software development tools.

A conflicting view highlighted in the findings is that some interviewees believe that in order for mobile XR to function, broad-reaching high-performing connectivity infrastructure is necessary, displaying a one-way strict complementarity (ibid.). Others did not share this view and described the willingness to develop content not dependent on a high-performing connectivity network. There is thus a discrepancy in the view of what complementarities underline this relationship. This exacerbates the collaboration and alignment of goals in the XR ecosystem.

Business and organizational networks are similarly described as actors related to each other with certain relationships which can be classified as hierarchical, affective, market or referential (Håkansson & Ford 2002; Ahuja, Soda & Zaheer 2012). All actors presented as extended reality actors (seen in Figure 17) can be said to have hierarchical ties to the governments and supranational unions seen in the bottom section of Figure 16, and referential ties to the standard development organizations since they can provide certifications of standard.

The relationships between the extended reality actors and the external stakeholders differ. Some can be said to have no direct network ties, some extended reality actors have transactional market ties, and some create partnerships and thus have affective ties e.g. a content creator forming a partnership with a retail store to create an XR application.

There are several actors who have created partnerships to each other and thus have affective ties, and some firms have taken this a step further by vertical integration. As reflected in the findings, content applications and HMD device are vital together to an XR experience which increases the incentives for these types of actors to create affective ties to each other. Many of the actors belonging to the same value chain have transactional market ties to each other, e.g. communication infrastructure providers and CSPs.

Findings indicate that the relationship to the consumer is key. It has been suggested that owning this relationship gives a stronger position. The actor who will handle the transactions to the consumer will have transactional market ties to said consumer. Other actors may have a type of affective ties to the consumer, if they actively work with them and thus form a partnership. Finally, the different firms belonging to the same actor segment have competitive market ties to each other.

5.2 Value Capturing

This section discusses the importance of consumer value, and with the base in theory highlight revenue models mentioned in the findings.

A non-well-managed monetization strategy can backlash, leading to a decrease in the money consumers are willing to put into the ecosystem (Salehudin & Alpert 2021). This highlights the importance of orchestrating monetization and revenue models in order to optimize the value-capturing capability.

The first step in choosing revenue model is to determine the value proposition (Dmitriev et al. 2014). Thus, interviewees were asked where the customer value in the technology lies. As visualized in Table 7, there are a myriad of different values in XR technologies that the interviewees believe consumers will derive value from. The majority of the answers evolve around the immersive experience, but there is no consensus regarding where the key consumer value lies.

From the interview answers regarding the consumer value of XR technologies, one discrepancy is prevalent. Namely the view on willingness to pay and how much the devices will cost. Although most interviewees believe the willingness to pay will be similar to the willingness to pay for smartphones, some interviewees see the price point as critical and emphasize the need to lower the price of the devices. This is especially prevalent in the research and content creator sector. Despite this, the interviewees outside of the connectivity infrastructure sector are convinced that enough money will come into the system and be captured for the ecosystem to be self-sustaining in due time. Thus, they are not concerned with the investment gap for 5G. When prompted to consider the investment needs for connectivity, these interviewees did not see a problem. They believe that connectivity issues will be solved by the connectivity sector, and with funding from governments, etc.

5.2.1 Relevant revenue models to capture value

In regard to value capture within the ecosystem, several ideas are identified from the interviewees, as demonstrated in Table 8. Some of the revenue models that the interviewees discuss resemble one another. Similarly, the revenue models discussed in the theoretical background are interconnected and share elements.

The technology-as-a-service model from the findings can be viewed as a form of subscription. According to Cheng Lu Wang et al. (2005), the willingness to pay for subscriptions increases inter alia with service rate, quality, convenience, and added-value. Thus, the technology-as-a-service model will be more efficient, if the consumers perceive the subscription as convenient and of high quality. In addition, it is essential for the subscription to be perceived as providing considerable benefits compared to the non-subscription alternative.

Some interviewees believe applications would be free to use, and revenue would be generated by in-app purchases or by advertisements, which is equivalent to the free-paid and free-free model (Roma & Ragaglia 2016; Numminen, Sällberg & Wang 2022). In-app purchases are more efficient in the free-paid setting rather than paid-paid (Salehudin & Alpert 2021). This is further reflected in the findings as one interviewee rationalized their stance on the necessity for in-app purchases or advertisements as the primary means of monetization, by referencing to consumer expectations for free content as established by social media and gaming platforms.

The sales of add-on functionality is another revenue model that is highlighted by multiple interviewees. One way of monetizing from add-on functionalities is though in-app purchases. The revenue model of in-app purchases is a preferable strategy to price discriminate when the customer base is heterogeneous, and especially in pairing with free basic content (Roma & Ragaglia 2016; Salehudin & Alpert 2021). So, since the consumers expects free content, in-app purchases either in the form of digital goods or add-on functionalities is one potentially efficient way of monetizing from the content and still allowing the users to feel as if it is free.

Another revenue model that could be employed for the sale of add-on functionality is the freemium model. In the freemium model the free version of the app brings down the trialability barrier allowing for trying the content before committing to the paid version (Roma & Ragaglia 2016). Similar to in-app purchases, the freemium model works well when the customer base is heterogeneous, and in addition the willingness to pay should in general be high (ibid.; Numminen, Sällberg & Wang 2022). Thus, depending on the willingness to pay, the freemium model may work better than in-app purchases.

Concerning other additional ways to monetize, ads is the most commonly mentioned method. Although there is clear dissension among the interviewees regarding the potential of it. The belief in the potential of advertisement is backed up by the theory. Ads is a very common revenue models in areas where the consumers except the content to be free (Enders et al. 2008). In addition, the fact that the global mobile ad spend in 2022 is equal to a 14 percent year-on-year growth (Data AI 2023), indicates that the revenue model seems to work well in the smartphone area. The view of people expecting free content is often expressed, and seeing that the majority of the interviewees believe the monetary flows will resemble those of smartphones and, this would indicate that ads will be an important revenue model for XR as well. The possibilities of new and less invasive advertisements, as brought up by many interviewees, further enhances the possibilities of ads as an important revenue stream.

One specific alternative of advertisement that is lifted by a director of strategy execution can be seen as a form of location sponsorship (Dunham et al. 2022). The compatibility with XR capabilities and boosting physical locations makes this revenue model extra interesting in the XR ecosystem. In addition, other types of LBA that allow for a real-time personalized advertisement (Bauer & Strauss 2016; Cheng et al. 2022) also provide an opportunity. Different ones that are mentioned by the interviewees are for instance personalized billboards through the XR glasses, and individually tailored storefronts.

Another additional monetization strategy that is mentioned is to capture value from physical purchases made through the XR environment. This could be done similar to how content store providers charge a fee for in-app purchases. Thus, the business model with a consignment contract with revenue sharing (Avinadav et al. 2022) may be applicable. This allows for the ones creating the experience to keep ownership, and for both parts to monetize.

To summarize, there is no consensus regarding where the key consumer value lies. In addition, there are numerous different revenue models brought up in the findings that can be more or less efficient in the case of XR technologies. Businesses will often have multiple revenue sources Kim (2018), meaning several of the presented revenue models can be combined, both where the paying customer is the same, e.g. digital item sales and subscription, or two different paying customers types, e.g. up front content sales and location sponsorship. Which combinations will be preferable is yet to see. Nevertheless, insufficient implementation of monetization strategies can backlash and result in a lower willingness to pay (Salehudin & Alpert). Thus, monetization strategies are vital for an economically sustainable ecosystem and cannot be ignored.

5.3 Commercialization

This section presents the analysis on commercialization, and the overall research question on how to reach the broader market.

The market opportunity for XR technologies was touched upon in the introduction section with an estimated consumer market size in 2027 of 52 billion dollars (Statista 2022a) and stated as having the potential to disrupt the digital world (McKinsey & Company 2022). Also, a majority of the interviewees saw large potential for XR being included in consumers everyday lives with various opportunity spaces and values for consumers. In order to realize this potential a successful commercialization is of uttermost importance.

Some of the important factors for commercialization highlighted by the interviewees (see Table 10) can be associated with the five critical characteristics of innovation that influence the adoption rate (relative advantage, compatibility, complexity, trialability, and observability (Rogers 2003; Oyelana, Kamanzi & Richter 2021). For instance, compatibility with other products, customer insights, and opportunities to try the technology

can be mapped to compatibility, observability, and trialability respectively. Thus, they can be deemed to be of especially high interest for actors in the XR landscape.

5.3.1 Barriers to commercialization

In some cases, rather than communicating reasons for adoption, it is more important to focus on and mitigate adoption barriers (Claudy, Garcia & O'Driscoll 2015). When examining the interviewees' answers to important factors to reach the broader market (see Table 10) and the barriers to commercialization (see Table 11 & Table 12), there are a few overlaps. Technical, content, user-friendliness, comfortability, aesthetics, and social acceptance is found in both categories. Further, consumer insight and opportunity to try the technology can be linked to user attitudes. Given that these aspects are mentioned as both important for commercial success, and barriers to commercialization simultaneously, these barriers can be especially important to mitigate.

Table 12. Barriers from findings mapped to the theoretical barriers categorized by Joachim, Spieth, and Heidenreich (2018)

Barriers	Description	Type of diffusion of innovation barrier
Technical	Technical limitations connected to both the connectivity (latency and bandwidth etc.), as well as other things such as the weight of the device and battery performance	Functional risk
Optics	Limitations with optical see through such as backlight interfering with digital objects and difficulties of creating dark objects	Functional risk
Content	Lack of good content to run on the HMDs, lack of utility content and no killer app	Co-dependence
User friendliness	Not intuitive enough to use and friction for users to start the HMD and run a content application	Complexity and usage

Comfortability	Difficulties with wearing HMD for longer periods of time, people getting motion sickness and chunkiness of the device	Personal risk
Aesthetics	HMDs being chunky and not aesthetically good looking, people are unwilling to wear them	Social risk
User attitudes & Social acceptance	People being unwilling to adopt XR technologies because of unfamiliarity with the technology, resistance to change, privacy concerns or other personal attitudes	Trialability, visibility, social risk, information, and norm
Price	Some consumers may believe the price of HMD devices and content is too high	Economic risk
Geopolitical	Uncertainties concerning relationships between countries with important actors in the XR landscape	Image
Privacy & legal issues	Concern about privacy of users and user data and how this will be handled by regulatory institutions	Personal risk

All barriers can be mapped to the theoretical barriers of Joachim, Spieth, and Heidenreich (ibid.), which verifies the findings. The technical barrier is classified as a functional risk because of the risk of an unproperly functioning XR experience. The optics barrier is similarly classified as a functional risk. The content barrier is categorized as a co-dependence barrier where there is a significant need for additional parts/services for the experience to be considered complete. This is a significant barrier forcing the entire ecosystem to cooperate.

The lack of user friendliness is classified as a complexity barrier because of some users finding it too difficult to use, as well as a usage barrier for possible disruption of established user patterns. One of the five critical characteristics that determine the rate of adoption of an innovation (Oyelana, Kamanzi & Richter 2021) can be directly linked to the user friendliness barrier, namely complexity, meaning this barrier is critical to mitigate to increase the adoption rate of XR.

Comfortability is classified as a personal risk since it is a potential threat to the user's personal well-being. Because of the many themes connected to the barrier of user attitudes and social acceptance this can be classified as trialability, visibility, social risk, information or norm barriers. For example, one interviewee speaks of user attitudes concerning the novelty of the product by saying "they've never done this before and so it takes a lot to get people into something new" which is also backed in theory by Talke and Heidenreich (2014) who claim consumers are not always interested in new things and thus resist innovations.

Price is naturally classified as an economic risk barrier since some consumers may believe the HMD device and additional content is too expensive. The geopolitical barrier is an image barrier since the country of origin may have an effect on the commercialization of the technology. The privacy and legal aspect is classified as a personal risk barrier since users may believe it as a risk to their personal well-being or possessions.

Through an understanding of the various types of innovation resistance present in the market, strategies can be formed to mitigate them. When reflecting upon the barriers described by the interviewees, there seems to be both situational and cognitive passive resistance to XR technologies. To address cognitive passive resistance, the learning process should be facilitated and the perceived complexity reduced, while for situational passive resistance, the product's superiority over the status quo should be emphasized (Heidenreich, Kraemer & Handrich 2016). Thus, to effectively address passive resistance towards XR, it is important to demonstrate the superiority of XR technologies over existing alternatives such as smartphones and gaming consoles, while also enhancing consumers' comprehension of the technology.

5.3.2 Maturity of XR technologies

The hype curve was in the theory section described as a model representing the hype or attention a new technology or innovation receives by the public (Fenn & Raskino 2008). One interviewee from the content creation sector mentions the hype curve in relation to XR. They believe XR technologies are currently right before the first peak of inflated expectations. Although, other interviewees have expressed that XR has been through a period of overexcitement around 2016 leading to high expectations from consumers. However, the technology did not meet these expectations, causing disappointment in the market. These characteristics would indicate that the technology is in the trough of disillusionment phase in Gartner's hype cycle which comes after the peak of inflated expectations (ibid.).

The fact that XR is an umbrella term for VR, AR, and MR makes it more complicated to pinpoint where the technology overall is positioned in the hype cycle. For instance, some interviewees mention that VR has come further than both MR and AR in terms of technology development and customer adoption. However, common for both the peak of inflated expectations and the trough of disillusionment phases is that they occur in the early stages (ibid.). Several other interviewees mention they believe the financial economic situation in the world will delay the development and commercialization strengthening the argument that XR technologies are early in their technological development and adoption.

Interviewees also describe the current consumers as being excited about new innovations and having an interest in technology, which aligns with the traits of innovators and early adopters in the technology adoption lifecycle (Dedehayir et al. 2017; Cirus & Simonova 2020). Some interviewees even refer to the users today as being early adopters. However, as with the challenge of determining XR's precise position on Gartner's hype cycle, it is unclear whether the technology has transitioned from the innovators' phase or not. Nonetheless, it is evident that XR has not yet penetrated the early majority, and thus, crossing Moore's chasm is still necessary for widespread adoption.

In the theory of diffusion of innovation it is also lifted that, in contrast to the early adopters who are driven by the newness of the technology, the mainstream consumer is looking for a complete solution (Frattini et al. 2012). Due to the unresolved technological and user-friendliness barriers, the solution lacks seamlessness, thereby indicating that the technology is not yet ready to cross the chasm.

5.3.3 Commercialization Strategies

When reflecting commercialization strategies, the findings give some interesting insights that can be applied to the theoretical framework. The importance of timing highlighted in the findings is also backed by the theoretical framework. One of Rogers' (2003) four key components of innovation diffusion is timing. Similarly, according to Frattini et al. (2012), two of the most critical dimensions of high-tech commercialization are timing and whole product configuration. Therefore, the timing in combination with whole product configuration, in this case sufficient content with well-functioning HMDs and low latency connectivity, will be of high importance for reaching the broader market.

There are five critical characteristics highlighted in theory that determine the rate of adoption of an innovation, namely relative advantage, compatibility, complexity, trialability and observability (Oyelana, Kamanzi & Richter 2021). The commercialization strategy mentioned in the findings that stresses the importance of increased testing opportunities and making people familiar with the technology can be directly linked to the trialability characteristic and is thus critical to the rate of adoption. These increased familiarity and testing opportunities may also have an impact on the observability characteristic of XR. The importance of perceived value by consumers is also stressed by Kirchberger and Pohl (2016) and testing opportunities may open the eyes of the consumer to experience this value without a large financial commitment.

The theory of diffusion of innovation lifts that, in contrast to the early adopters who are driven by the newness of the technology, the mainstream market is looking for a complete solution that seems easy to use (Frattini et al. 2012). Thus, this aspect of timing and maturity of the ecosystem are key components in efficient commercialization. The theory of diffusion of innovation also highlights the importance of early adopters. Among other functions, they play the role of encouraging or discouraging others to adopt the innovation (Chiesa & Frattini 2011).

The role of early adopters is something that should be used to the technology's advantage. According to Bianchi et al. (2017), commercializing firms can influence the behavior of early adopters by actively working with them. So, by interactively working with the early adopters and listening to their feedback it is possible to use the early adopters to be able to cross the chasm. Their feedback can be helpful in both improving content and the devices and reaching a broader audience. Thus, both content creators and HMD developers should actively work with their users. By making sure they are pleased with the product they can advocate for it and encourage more people to try it out. In general, the relationship with the consumer has been highlighted as especially important, and these transactional market ties should thus be carefully nurtured.

When applying the framework of Nieto Cubero, Gbadegeshin, and Consolación (2021) to XR as the focal point the technology can be said to be in the iterative phase between discovery and incubation. I.e., with the focus of concept and value proposition validation, and business validation and market creation (ibid.). Accordingly, in this stage for XR technologies some of the key priorities are to emphasize the value proposition and find the right price point, build the ecosystem, find and overcome adoption barriers, and build an awareness and credibility for the technology.

In the incubation phase Nieto Cubero, Gbadegeshin, and Consolación (ibid.) emphasizes the importance of the adoption network. Similarly, Chiesa and Frattini (2011) and Cubero, Gbadegeshin, and Segura (2020), stress that the support from the adoption network is a success factor for commercialization. Therefore, the collaboration in the adoption network, and consequently the "Extended reality actors" in the XR landscape, are pivotal for a successful commercialization. To be able to reach the broader market it requires an orchestrated joint effort. This is further backed up by Frattini et al. (2012) who argue that for discontinuous, such as XR, an adoption configuration network strategy, including partnerships and alliances is key.

6 Discussion

This section further discusses the findings with the support of the analysis. The section is divided in three sections, each reflecting one of the research questions, firstly RQ1, secondly RQ2 and lastly the overall research question.

6.1 The system of actors and its development

This section aims to discuss the topics related to RQ1, involving the actors involved in the development of XR.

The findings and analysis indicate that there are a large number of actors involved in the XR ecosystem and there exist complex relationships between them. In addition, vertical integration is also common. Although there are question marks regarding exactly how the ecosystem will evolve, many parallels in the findings have been drawn to that of the smartphone ecosystem. This may be a likely scenario, since one of the three main drivers of network dynamics are relational factors (Chen et al. 2022), where previous network ties shape new ones. Thus, the actors that have certain ties to each other since before may be likely to create new ones for the XR market.

This reasoning also makes the scenario of parallel ecosystems a likely possibility. Since many of the actors that are and are expected to operate in the XR market are currently operating other markets e.g. the smartphone market. It will thus be natural for these actors to seek partnerships with already known actors, and parallel ecosystems can thus emerge with the actors who already have relationships.

Among the actors there is currently a “chicken or the egg” problem, where there is not enough good content or good and affordable devices. This makes less people buy XR devices which in turn reduces the incentive for creators to produce content for XR experiences and for the HMD providers to increase the performance of their devices. This leaves actors being passive and rather waiting for someone else to make the move. Hence it is unclear who will be responsible for the commercialization process and it will take a lot of commitment of the actors who choose to push the technologies forward.

Aligning goals and objectives of several parts of the ecosystem, through for example vertical integration or partnerships, may mitigate this "chicken or the egg" problem, thus enabling XR advancements. The increased exit barriers caused by vertical integration (Harrigan 1984) may also be an incentive for highly vertically integrated firms to actively push the ecosystem forward.

The findings indicate that there is a general belief that the most powerful actors are those with significant financial resources, and thus investment power, owning several parts of the ecosystem. Hence, it may be necessary for these players to make the first moves and show commitment in order for other actors to gain the confidence to commit and thus follow the first movers. Another source of strength indicated in the findings are the closeness and relation to the consumer. By owning the relationship with the consumer, the actor can get valuable consumer data, brand loyalty and repeat business opportunities. This can be leveraged to create the whole product configuration that could cause consumers to adopt the technology. By doing this, the position in the ecosystem can be strengthened and the ecosystem can be stabilized through the whole-product configuration.

The potentially important vertical integration of controlling both the device and content store, as per the analysis, may be undermined through the emergence of alternative content stores. One such example is SideQuest (SideQuest n.d.), which is an alternative content store to Meta's Quest store that allows for installing content on Quest headsets via sideloading. These kind of players decreases the gatekeeper role otherwise kept by actors controlling both the device and content store. They also raise the question of the degree of openness of the ecosystem. Many content creators hope for a more open ecosystem, where there is room for more small players to emerge and find it economically sustainable to contribute to the XR experience in different ways.

The Ecosystem Pie Model illustrates the importance of all actors involved in the XR ecosystem. Removing one of these players results in a missing piece of the pie, and a value addition component lost. The risk of taking connectivity for granted can be visualized using this model. By removing all the pieces of the pie with brown post-its (i.e., removing the role of connectivity actors), there is a clear absence of the wireless connectivity needed for the XR experience.

Although governments and supranational unions are not considered key actors in the XR ecosystem, their role should not be disregarded. Their regulatory and funding power may still have a significant impact on the development of XR technologies, and actors in the ecosystem should therefore try to inform these institutions of the opportunity space for XR in society. By doing this, actors can secure funding for research projects in the field and ensure beneficial regulations.

The findings from both the interviews and documents indicate that privacy will be a big concern and an area needing attention in the future, both by actors of the XR ecosystem, regulatory institutes, and end users. The impact of ads is also something deemed to have a large potential in XR, with the possibility of having an even greater impact on consumers than in current digital markets. Although multiple interviewees deemed these two areas to have a large influence on XR in the future, no interviewees considered the possible implications of this and how the structure of the ecosystem might be impacted by either of these factors.

Further, in other contexts, it was raised that there were opportunities for the ecosystem to evolve and that there would be room for new actors to emerge. Taking these findings into account collectively, it becomes apparent that the privacy challenges and the emergence of new types of advertisement create opportunities for new actors to enter these segments. Most likely, someone will see this opportunity and will enter. Consequently, the potential emergence of actors in the privacy and advertising domains may shake things up in the ecosystem and should be monitored.

6.2 Capturing value without consensus of what value to capture

This section aims to discuss the topics related to RQ2, discussing the value-capturing opportunities for XR.

Prior to identifying effective revenue models within the XR ecosystem, it is essential to determine the consumer value proposition (Dmitriev et al. 2014). As highlighted in the analysis, there exists a notable lack of consensus regarding the key consumer value. However, the majority of the interviewees' responses revolve around the immersive experience. The notion of the immersive experience encompasses a broad range of aspects, thus necessitating further specification to identify the core consumer value. If an alignment in where the key consumer value lies can be obtained, the

capturing of this said value will be easier to achieve, subsequently leading to monetization of other additional values. Hence, this study indicates that initial emphasis should lie on finding this key consumer value.

However, the findings and analysis still provide some insight to which revenue models may be applicable, and how value could be captured to reach economic sustainability. Whether the technology is at the peak of inflated expectations, or if it is in the trough of disillusionment, it is inevitable that the initial hype surrounding the technology will diminish over time. Consequently, this declining enthusiasm may result in decreased investments being made in the XR ecosystem. In order to ensure the long-term viability of the ecosystem, it is important to establish economic sustainability.

Currently, this is not the case. As previously raised in both the introduction and findings, the market is experiencing significant stimulation through substantial investments made by larger companies. These companies are leveraging their existing products or services to drive growth in their XR business. However, this approach is not sustainable in the long term. It will take a joint effort to ensure this economic sustainability, and collaboration among industry players will become crucial. By working together, the actors can pool their resources and expertise to drive innovation and create mutually beneficial opportunities.

In addition, economic sustainability will not happen unless value capturing becomes more of a focus. Better value-capturing mechanisms are required for firms to generate sufficient revenue streams to sustain their operations and investments in the long run. Insufficient work regarding monetization strategies can backlash and result in consumers being less willing to pay (Salehudin & Alpert 2021). Therefore, the actors in the XR ecosystem need to explore and develop viable revenue models and monetization strategies that align with the characteristics and needs of the XR market. There has been a discussion of which revenue models may be relevant (see Table 8), but which these will be will depend on the specific situation. Similar to the situation with content store revenue models (Roma & Ragaglia 2016), which revenue model is best suited will depend on the specific situation and may, due to the early stages of the XR ecosystem, be difficult to distinguish.

However, given the characteristics of the emerging ecosystem and the highlighted barriers, some of the mentioned revenue models may have greater potential. For instance, initially when the trialability barrier is higher, subscription models such as the addressed technology-as-a-service model may be efficient. By signing up for a subscription requiring lower up-front costs and assuring opportunities to change device, the trialability barrier may be lowered. For subscription models to be efficient, the subscription needs to be deemed convenient, of high quality, and value-adding (Cheng Lu Wang et al. 2005). It is possible, that with the quickly evolving XR technologies, this kind of subscription will be perceived to have these characteristics as the devices quickly become outdated, and new improved versions are released. Therefore, this model might be appropriate for the initial stage of rapid technological progress.

The findings and analysis highlight the similarities in XR with smartphones and gaming. This may indicate that revenue models that work in these landscapes will work for XR as well. Although, they would probably need to be adapted to the specific situation of XR. Nevertheless, new ways of capturing value and the need to modify existing revenue models should not be disregarded. For instance, although ads have been an important source of revenue for smartphone applications, findings and analysis highlight the belief that consumers exhibit a growing discontent with ads. This may indicate the need to innovate within ads. The notion of ads in a new way is backed up in the findings, and the characteristics of XR open up for innovation in the area. If ads can be made less intrusive, they can continue to serve as big money pool. One already tested approach is location sponsorship, and similar innovations may be beneficial.

Findings regarding the view on connectivity indicate that it is often overlooked, and the importance of good connectivity is not recognized. This may result in a low willingness to pay for the connectivity. Hence, using indirect monetization models, such as device-embedded connectivity, could be a suitable approach to address this issue. By finding alternative ways to generate revenue without directly charging for connectivity, the barrier of a low willingness to pay for connectivity may be mitigated. Alternatively, another approach could be to educate and convince both other actors in the ecosystem and end customers about the value and benefits associated with reliable and fast connectivity. By emphasizing the importance of good connectivity, the willingness to pay for it may increase. This may also help other actors see the investment gap for 5G.

The findings visualize there is a conflicting view regarding innovation in value capturing. On one hand, there is a belief that there is not that big of a need for innovation when it comes to value capturing since the already existing revenue models are deemed sufficient. On the other hand, there is a contradicting belief that there is room for innovation in value capturing and that this may be very beneficial. However, one important factor to keep in mind is that people of this view may have a focus on technology and may thus oversee other business aspects.

Although, innovation may not be necessary, it may be beneficial. For instance, if advertisement will be done in a completely new way, and the discussed potential new actors emerge, then new possible value-capturing opportunities may arise consequently. There is also potential for other similar new value-capturing opportunities, such as the proposed strategy to capture value from physical purchases made through the XR environment, to arise. This illustrates the potential for identifying new unexplored value capturing opportunities.

6.3 Reaching the broader market

Related to the overarching research question, this section aims to discuss subjects related to which factors are deemed important to reach the mainstream market beyond the early adopters.

It is evident that many factors are necessary for broad commercialization and there is no one single recipe for success. As stated in the introduction, the area of commercialization of high-tech innovations is fragmented and understudied (Chiesa & Frattini 2011; Datta, Reed & Jessup 2013; Nieto Cubero, Gbadegeshin & Consolación 2021). However, the findings of this thesis in combination with previous theory gives important insight to what may be significant for the commercialization process for technologies such as XR. Thus, this thesis contributes to closing the research gap concerning commercialization of high-tech innovations. Many of the key factors for commercialization stated in literature are also crucial in the studied case such as trialability, compatibility and observability.

Other than many well-known factors for commercialization, there are innovation-specific factors considered especially relevant for the XR commercialization process. The evolvement and maturing of the ecosystem and attractive aesthetics are believed to facilitate the commercialization process. Because of the currently immature ecosystem surrounding XR, the

role of the adoption network is also deemed especially important for successful commercialization. The relevance of the adoption network may not only be important for the commercialization of XR, but also for similar innovation ecosystems where there is not one sole actor owning the innovation.

The mainstream market is looking for a frictionless and complete solution (Frattini et al. 2012). Consequently, strategic commercialization decisions concerning timing and whole product configuration hold particular importance in reaching the broader market. The timing aspect needs to be aligned with the whole product configuration and in extension, the mitigation of the technical barriers. There is no point in aiming commercialization efforts towards the broader market before the whole product configuration reaches this frictionless and complete solution. Otherwise, a failure in timing may inhibit mass market adoption due to negative evaluations (ibid.).

The adoption network is also of particular importance to ensure this complete whole product configuration. They play a role in both contributing to develop the innovation itself, and also developing complementary product and services which increase the perceived experience around the innovation. In addition, feedback from early adopters can help steer the ecosystem towards a complete whole product configuration.

The role of early adopters has also been stressed throughout the thesis. Early adopters can play a role in crossing the chasm (Chiesa & Frattini 2011). According to Bianchi et al. (2017), it is possible to actively shape the behavior of early adopters by iteratively interacting with them. So, by realizing the importance of the consumer, and especially the early adopters, the relationship to them can be used, not only to strengthen the position in the ecosystem, but also to use their inputs in finding the key consumer value. Subsequently, when the key consumer value is identified, it will be easier to find a killer app.

By finding one area in which XR technology is superior to existing alternatives, more consumers will be willing to adopt the technology. Once individuals have experienced XR and begun utilizing it for this specific purpose, their usage may naturally expand to encompass a wider range of applications. Therefore, by initially prioritizing the development and monetization of a killer app that showcases the full potential of XR,

subsequent use cases consequently emerge, resulting in an expanded scope of XR utilization. This expansion, in turn, creates broader opportunities for value capturing and enhances the efficiency of the commercialization process.

The findings and analysis show there are still many barriers yet to be overcome or mitigated. The identification of barriers, such as trialability, compatibility, and observability in the specific case of XR contributes to the understanding of how adoption of new technology and commercialization can be hindered. By being aware of this, these can actively be mitigated, enabling an adoption of the technology, and the reaching of the broader market. By mitigating these barriers, the value of the technology is not overshadowed by the barriers.

In addition to ensuring the whole product configuration and a well-functioning XR experience addressing technical barriers can also bring further benefits. Focusing on improving the technical aspects may help overcome other barriers in the process. User friendliness is vital for the mainstream market and can be improved when the technology is improved. Similarly, the comfortability and aesthetics barriers may be combated by improving the technology, resulting in lighter, more attractive HMDs and a more comfortable experience.

Also increasing the testing opportunities for consumers may help solve additional barriers in the process of increasing trialability. Making devices available for use can make people more familiar with the technology, and thus increase the social acceptance and reduce negative user attitudes, making XR seem less strange or foreign. This may also help combat the economic risk related to the price barrier, where consumers may learn how they would most benefit from the use of XR and thus be convinced the investment is worthwhile.

Gaming is mentioned as a sector often taking the lead with new technologies, and XR alike, not only by the interviewees from the gaming sector. However, when asking about potential commercialization strategies there is instead an abundance of interviewees stressing the importance of finding utility use cases to reach mass market. Thus, this indicates a contradiction of the importance of the gaming industry for the general commercialization of XR.

7 Revisiting research questions and stating the contribution

This section summarizes the findings, analysis, and discussion by providing answers to the posed research questions. The academic and practical contributions of the thesis are highlighted.

7.1 RQ1

RQ1: Who are the actors, what roles do they play, and what are the interdependencies?

All of the identified actors influencing XR and its commercialization are visible in Figure 16 (p. 64) and further described in Table 6 (p. 64). The roles of the most important XR actors in the XR ecosystem are presented below. Other than these the actors are external stakeholders and regulatory institutions (legislation and funding in Figure 16).

Communication infrastructure providers – Suppliers of infrastructure to ensure wireless communication for XR devices. Their role is to innovate in areas such as latency and bandwidth for a seamless XR experience.

Communication Service Providers – Operating the communication networks. Their role is to ensure low latency connectivity for the XR experience.

Cloud and edge infrastructure providers – These actors provide computing and storage for XR.

HMD developers – Provide the devices which the XR experience is run on. Innovate in areas such as weight, performance and battery life. Their role is also to make XR devices that consumers want to buy.

Key hardware component suppliers – Provide additional key hardware components to the HMDs such as graphics cards and chipsets. They set limits to what can be done with the XR device.

System integrators – Integrate the hardware and software for a more seamless XR experience.

Software development tools providers – They facilitate the content creation for XR.

Operating system developer – They provide the operating system for HMDs that becomes the foundations for the XR content to run.

Key software tool providers – Provide software technology for XR such as APIs and eye tracking. They enable functionalities that improve the XR experience.

Content store providers – Provide one marketplace for XR content. Have a close connection to the customers.

Content creators – Provide content or experiences to be run on the XR devices. Their role is to make experiences that draws people in to use XR technologies.

End users – The consumers using the XR technologies for one or several use cases. They create the demand, and early adopters are seen as especially important for a successful commercialization.

Room for new actor segments – As the ecosystem continues to evolve, there is also room for new actors to emerge.

The interdependencies between actors are described by the ecosystem complementarities and network ties. Concerning the complementarities of the ecosystem of the above-mentioned actors, there are examples of strict two-way complementarities, strict one-way complementarities and supermodular complementarities. The study indicates that the most important ones are the two-way strict complementarity between the HMDs and content.

With regards to network ties, all of the above-mentioned actors have hierarchical ties to governments and supranational unions, and referential ties to standard development organizations. To the external stakeholder they either have no direct ties, transactional market ties or affective ties. Amongst themselves, the actors have affective ties and referential or competitive market ties.

Research has shown that it is important to analyze the ecosystem to understand the development of industries. This thesis analyzed the emerging and developing XR ecosystem and thus contributes to the understanding of the ecosystem which may be of value both for XR research, ecosystem research, and for the involved XR actors, making it both an academic and practical contribution. Previous research argues that there is a need for more

studies of what non-economic factors influence the development of ecosystems. In the case of XR, some of the factors that can cause the ecosystem to evolve have been mentioned in the findings and discussion, and include the increased privacy concerns, new ways to monetize through ads, and the existence of previous relationships between actors affecting the development of the XR ecosystem.

7.2 RQ2

RQ2: How can value be captured from XR technologies?

XR technology is in its early stages, and there is yet to figure out where the key consumer value lies. This thesis indicates that once this key consumer value is found, it will be easier to develop a killer app, after which efficient revenue models can be established. Consequently, other value-capturing opportunities will follow. Suggesting that it is beneficial for the initial focus to lie on figuring out what the key consumer value is. However, this thesis has identified multiple relevant value-capturing opportunities and revenue models that display promising potential. These have been compiled and are presented in Table 8 (p. 74).

The study further suggests that these revenue models should be adapted and aligned with the characteristics and needs of the XR landscape and experiences. In addition, the study indicates that multiple different revenue sources will be combined, with either the same or different paying customers. Some revenue models that have been deemed important for XR is that of ads in a new way, which can become better and more compelling in XR, technology-as-a-service, which mitigates the trialability barrier and lowers initial economic commitment, and the opportunities for physical goods sales through XR.

The many similarities with the smartphone and console gaming market in combination with many actors being active in these markets as well, makes it likely the revenue models will be similar to those of smartphone- and or console gaming content. However, the study suggests that the room for new and innovative revenue models should not be overlooked. Additionally, the results of this thesis reveal that this should preferably be determined by using feedback from early adopters.

According to previous research, it is difficult to generate a sustainable business model for 5G. This thesis provides some contributions towards finding a sustainable business model for 5G by investigating different

revenue models to capture value from one of its use cases. In addition, one practical implication of this thesis is an attempt to identify how enough money can come into the XR ecosystem to make it economically sustainable. This is done by discussing where the value in the technology lies, providing a comprehensive overview of possibilities for value capturing via revenue models, and discussing their relevance. Further, other practical implications of this thesis are the highlighting of the importance of value capturing, the need to adapt existing revenue models to the XR ecosystem, and opportunities for finding new untapped value capturing possibilities.

7.3 Overall research question

*RQ: **"How can XR technologies be commercialized to reach the broader market?"***

This thesis shows that there is no simple formula to reach successful commercialization of XR technologies, although several aspects are deemed especially significant. The results indicate that to reach the mainstream market, the XR solution needs to be complete and frictionless, implying the need for whole-product configuration, which for XR can be achieved by the support of an adoption network and a maturing ecosystem. Further, the timing of commercialization has been revealed to be important, and needs to be aligned with a sufficient whole-product configuration.

Moreover, the study indicates that it is beneficial for the XR ecosystem to actively work with early adopters. The results demonstrate that by listening to the feedback of early adopters, the content and devices can be improved, social acceptance and observability can be increased and the development of a 'killer app' facilitated. The study further offers insights that barriers deemed especially important to overcome are the technical barriers and the trialability barriers, because of the several other barriers that can be overcome in the process of fixing these.

The thesis thus contributes with a more holistic study of commercialization of XR technologies, specified as a research gap for disruptive innovations, and gives further insights into the commercialization phase of a high-tech technology. Additionally, the study contributes to commercialization theory by, in addition to focusing on the technology itself, also highlighting the importance of the ecosystem and adoption network, and value capturing. The thesis also contributes with barriers that can inhibit adoption for XR

technologies, which is another research gap highlighted by previous research for high-tech innovation. How XR technologies can reach the broader market is also highlighted as an important practical contribution.

7.4 Further research

This section describes some areas where further research may be necessary that have been come across through the process of this thesis. By highlighting these areas, this chapter aims to inspire future researchers to further explore these topics and create a deeper understanding.

The thesis contributes to an understanding of the XR ecosystem. However, when analyzing the interdependencies via ties in the business network and complementarities in the ecosystem most of the focus was directed at specifying these. To a limited extent, this thesis has shown that power structures possibly play a vital role in driving the ecosystem development. Thus, further research could focus on investigating power structures, how ties and complementarities affect power structures, and how these should be treated.

The thesis increases the understanding of XR commercialization. However, the delimitations of the thesis are somewhat broad, and the whole consumer market is considered in the thesis investigation. In order to get a more detailed picture of a specific consumer segment further research can be limited to investigating some specific future use cases for XR or specific consumer target groups.

Additionally, the thesis focuses on XR as a whole, including both VR, MR and AR to ensure sufficient data. Future research can focus on how commercialization can differ between these technologies, and in more detail investigate aspects such as differing barriers, value propositions or other commercialization aspects. This may be of interest both for the research community to understand key differences and applications, but also for actors involved in developing either VR, AR or MR technologies.

Although multiple actors involved in different aspects of XR were interviewed, there are still several actor segments that were not interviewed. These actors could contribute with further insights that may provide additional elements to the results. The study can thus be extended to include a more complete representation of the ecosystem from the compiled list of actors in Figure 16.

This study indicates that there exist consumer related aspects connected to adoption barriers, such as user attitudes and social acceptance. Zarantonello and Schmitt (2022) state that the studies done on the adoption of XR mainly focus on variables related to efficiency and functionality, and that there lacks a focus on consumer related variables. Thus, this study further reflects the need for research on this topic.

AR applications in mobile phones were early on excluded from the scope of this thesis, however both these applications and comparisons to smartphones were often occurring in the data. Data from the interviews also indicate that mobile AR applications may be of importance to lower the trialability barrier. Therefore, mobile AR applications can have an impact on commercialization of XR as a whole and a study regarding this may be of interest for all of the XR ecosystem.

The risk of XR technologies ending up being a complement to smartphones instead of replacing them is reflected in this thesis. Therefore, an additional inquiry that holds potential significance and can contribute valuable insights to the advancement of the XR ecosystem and technologies, is an investigation into the underlying reasons why certain technologies merely serve as supplements while others replace previous innovations. Thus, further research on why innovations become supplements rather than substitutions may provide valuable lessons and insights for future advancements in this field. One such area of study is the path of smartwatches. Since smartwatches became a supplement to smartphones, this pathway may be of particular interest for and more generalizable to the XR case.

This thesis provides additional evidence supporting the notion that the B2B sector, and particularly the B2B2C sector, holds significant potential in driving the widespread adoption of XR technologies among consumers. The insights gathered from interviews conducted during the data collection phase indicate a belief that the B2B sector should take the lead in this domain. As a result, conducting a similar study focusing on either the B2B or the B2B2C sector would yield valuable insights not only for those sectors but also for the B2C sector. Such a study would provide a deeper understanding of the dynamics and opportunities within the B2C sector by leveraging the experiences and practices observed in B2B and B2B2C contexts.

8 References

Aarikka-Stenroos, L. & Lehtimäki, T. (2014). Commercializing a radical innovation: Probing the way to the market. *Industrial Marketing Management*, 43(8), pp. 1372–1384, doi:10.1016/j.indmarman.2014.08.004.

Adler, R. H. (2022). Trustworthiness in Qualitative Research. *Journal of Human Lactation*, 38(4), pp. 598–602, doi:10.1177/08903344221116620.

Adner, R. (2006). Match Your Innovation Strategy to Your Innovation Ecosystem. *Harvard Business Review*.

Adner, R. (2017). Ecosystem as Structure: An Actionable Construct for Strategy. *Journal of Management*, 43(1), pp. 39–58, doi:10.1177/0149206316678451.

Adriana Cárdenas-Robledo, L., Hernández-Uribe, Ó., Reta, C. & Antonio Cantoral-Ceballos, J. (2022). Extended reality applications in industry 4.0. – A systematic literature review. *Telematics and Informatics*, 73, p. 101863, doi:10.1016/j.tele.2022.101863.

Adu, J., Owusu, M. F., Martin-Yeboah, E., Pino Gavidia, L. A. & Gyamfi, S. (2022). A discussion of some controversies in mixed methods research for emerging researchers. *Methodological Innovations*, 15(3), pp. 321–330, doi:10.1177/20597991221123398.

Ahuja, G., Soda, G. & Zaheer, A. (2012). The Genesis and Dynamics of Organizational Networks. *Organization Science*, 23(2), pp. 434–448, doi:10.1287/orsc.1110.0695.

Akyildiz, I. & Guo, H. (2022). Wireless communication research challenges for Extended Reality (XR), 3, p. ITU Journal on Future and Evolving Technologies (ITU J-FET), doi:10.52953/QGKV1321.

de Almeida, I. B. F., Mendes, L. L., Rodrigues, J. J. P. C. & da Cruz, M. A. A. (2019). 5G Waveforms for IoT Applications. *IEEE Communications Surveys & Tutorials*, 21(3), pp. 2554–2567, doi:10.1109/COMST.2019.2910817.

Alriksson, F., Kang, D. H., Phillips, C., Pradas, J. L. & Zaidi, A. (2021). *XR and 5G: Extended reality at scale with 5G networks*. https://www.ericsson.com/en/reports-and-papers/ericsson-technology-review/articles/xr-and-5g-extended-reality-at-scale-with-time-critical-communication [2023-01-26].

Andrews, C., Southworth, M. K., Silva, J. N. A. & Silva, J. R. (2019). Extended Reality in Medical Practice. *Current Treatment Options in Cardiovascular Medicine*, 21(4), p. 18, doi:10.1007/s11936-019-0722-7.

Anon. (2021). Building the Metaverse Responsibly. *Meta*. https://about.fb.com/news/2021/09/building-the-metaverse-responsibly/ [2023-04-25].
Anon. (2022). *Qualcomm Expands Investment in XR and the Metaverse with the Formation of XR Labs Europe – an XR R&D hub in Europe | Qualcomm*. https://www.qualcomm.com/news/releases/2022/02/qualcomm-expands-investment-xr-and-metaverse-formation-xr-labs-europe-xr-rd [2023-04-25].
Anon. (2023). *commercialization*. https://dictionary.cambridge.org/dictionary/english/commercialization [2023-02-03].
Artto, K., Ahola, T., Kyrö, R. & Peltokorpi, A. (2017). Managing business networks for value creation in facilities and their external environments: A study on co-location. *Facilities*, 35(1/2), pp. 99–115, doi:10.1108/F-07-2015-0049.
Auh, S., Bell, S. J., McLeod, C. S. & Shih, E. (2007). Co-production and customer loyalty in financial services. *Journal of Retailing*, 83(3), pp. 359–370, doi:10.1016/j.jretai.2007.03.001.
Avinadav, T., Chernonog, T., Meilijson, I. & Perlman, Y. (2022). A consignment contract with revenue sharing between an app developer and a distribution platform. *International Journal of Production Economics*, 243, p. 108322, doi:10.1016/j.ijpe.2021.108322.
Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S. & MacIntyre, B. (2001). Recent advances in augmented reality. *IEEE Computer Graphics and Applications*, 21(6), pp. 34–47, doi:10.1109/38.963459.
Baggott, A. (2023). *Every Apple App Store fee, explained: How much, for what, and when*. AppleInsider. https://appleinsider.com/articles/23/01/08/the-cost-of-doing-business-apples-app-store-fees-explained [2023-04-17].
Bansal, P. (Tima), Smith, W. K. & Vaara, E. (2018). New Ways of Seeing through Qualitative Research. *Academy of Management Journal*, 61(4), pp. 1189–1195, doi:10.5465/amj.2018.4004.
Barthel, M. (n.d.) Despite subscription surges for largest U.S. newspapers, circulation and revenue fall for industry overall. *Pew Research Center*. https://www.pewresearch.org/short-reads/2017/06/01/circulation-and-revenue-fall-for-newspaper-industry/ [2023-05-09].
Basant, R. & Mishra, P. (2019). Impact of Vertical Integration on Market Power in Indian Manufacturing Sector During the Post-Reform

Period. *Journal of Industry, Competition and Trade*, 19(4), pp. 561–581, doi:10.1007/s10842-019-00294-4.
Batyashe, T. & Iyamu, T. (2021). Operational Architecture Framework for Information Technology Solutions: Diffusion of Innovation Perspective. In: *2021 IEEE/ACIS 20th International Fall Conference on Computer and Information Science (ICIS Fall)*. Presented at the 2021 IEEE/ACIS 20th International Fall Conference on Computer and Information Science (ICIS Fall), pp. 83–90.
Bauer, C. & Strauss, C. (2016). Location-based advertising on mobile devices. *Management Review Quarterly*, 66(3), pp. 159–194, doi:10.1007/s11301-015-0118-z.
BCG & ETNO (2021). *Connectivity and beyond: How telecos can accelerate a digital future for all*. ETNO. commissioned report by ETNO.
Bekh, A. (2020). Advertising-based revenue model in digital media market. *Ekonomski Vjesnik*, 33(2), pp. 547–559.
Bhangu, S., Provost, F. & Caduff, C. (2023). Introduction to qualitative research methods – Part I. *Perspectives in Clinical Research*, 14(1), pp. 39–42, doi:10.4103/picr.picr_253_22.
Bianchi, M., Di Benedetto, A., Franzò, S. & Frattini, F. (2017). Selecting early adopters to foster the diffusion of innovations in industrial markets: Evidence from a multiple case study. *European Journal of Innovation Management*, 20(4), pp. 620–644, doi:10.1108/EJIM-07-2016-0068.
Björn, M. (2023). Meeting with Head of Research, Consumer Labs Ericsson.
Bowen, G. A. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal (RMIT Training Pty Ltd trading as RMIT Publishing)*, 9(2), pp. 27–40, doi:10.3316/QRJ0902027.
Bower, J. L. & Christensen, C. M. (1995). Disruptive Technologies: Catching the Wave. *Harvard Business Review*, 73(1), pp. 43–53.
Bowman, C. & Ambrosini, V. (2000). Value Creation Versus Value Capture: Towards a Coherent Definition of Value in Strategy. *British Journal of Management*, 11(1), pp. 1–15, doi:10.1111/1467-8551.00147.
Brinkmann, S. & Kvale, S. (2018). *Doing Interviews*. SAGE Publications Ltd.
Budde, B. (2015). *Hopes, hypes and disappointments: On the role of expectations for sustainability transitions. A case study on hydrogen fuel cell technology for transport*.

Cabiddu, F., Moreno, F. & Sebastiano, L. (2019). Toxic Collaborations: Co-Destroying Value in the B2B Context. *Journal of Service Research*, 22(3), pp. 241–255, doi:10.1177/1094670519835311.
Cacciatori, E. & Jacobides, M. G. (2005). The Dynamic Limits of Specialization: Vertical Integration Reconsidered. *Organization Studies*, 26(12), pp. 1851–1883, doi:10.1177/0170840605059160.
Cambridge Dictionary (n.d.). *subscription*. https://dictionary.cambridge.org/dictionary/english/subscription [2023-05-03].
Camps-Aragó, P., Delaere, S. & Ballon, P. (2019). 5G Business Models: Evolving Mobile Network Operator Roles in New Ecosystems. In: *2019 CTTE-FITCE: Smart Cities & Information and Communication Technology (CTTE-FITCE)*. Presented at the 2019 CTTE-FITCE: Smart Cities & Information and Communication Technology (CTTE-FITCE), pp. 1–6.
Chen, H., Mehra, A., Tasselli, S. & Borgatti, S. P. (2022). Network Dynamics and Organizations: A Review and Research Agenda. *Journal of Management*, 48(6), pp. 1602–1660, doi:10.1177/01492063211063218.
Cheng Lu Wang, Yue Zhang, Li Richard Ye, & Dat-Dao Nguyen (2005). Subscription to Fee-Based Online Services: What Makes Consumer Pay for Online Content? *Journal of Electronic Commerce Research*, 6(4), pp. 304–311.
Cheng, P., Lian, X., Chen, L. & Liu, S. (2022). Maximizing the Utility in Location-Based Mobile Advertising. *IEEE Transactions on Knowledge and Data Engineering*, 34(2), pp. 776–788, doi:10.1109/TKDE.2020.2986198.
Chesbrough, H., Lettl, C. & Ritter, T. (2018). Value Creation and Value Capture in Open Innovation: Value Creation and Value Capture. *Journal of Product Innovation Management*, 35(6), pp. 930–938, doi:10.1111/jpim.12471.
Chesbrough, H. & Rosenbloom, R. S. (2002). The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. *Industrial & Corporate Change*, 11(3), pp. 529–555, doi:10.1093/icc/11.3.529.
Chiesa, V. & Frattini, F. (2011). Commercializing Technological Innovation: Learning from Failures in High-Tech Markets. *Journal of Product Innovation Management*, 28(4), pp. 437–454, doi:10.1111/j.1540-5885.2011.00818.x.
Cho, S., Qiu, L. & Bandyopadhyay, S. (2020). Vertical Integration and Zero-Rating Interplay: An Economic Analysis of Ad-Supported and

Ad-Free Digital Content. *Journal of Management Information Systems*, 37(4), pp. 988–1014, doi:10.1080/07421222.2020.1831769.
Christensen, C. M. (2016). *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. [Elektronisk resurs]*. Harvard Business Review.
Cirus, L. & Simonova, I. (2020). Rogers' Diffusion of Innovation Theory Applied on Primary Education: Case Study of Czech Teachers. In: *2020 International Symposium on Educational Technology (ISET)*. Presented at the 2020 International Symposium on Educational Technology (ISET), pp. 33–37.
Claudy, M. C., Garcia, R. & O'Driscoll, A. (2015). Consumer resistance to innovation—a behavioral reasoning perspective. *Journal of the Academy of Marketing Science*, 43(4), pp. 528–544, doi:10.1007/s11747-014-0399-0.
Cramer-Petersen, C. L., Christensen, B. T. & Ahmed-Kristensen, S. (2019). Empirically analysing design reasoning patterns: Abductive-deductive reasoning patterns dominate design idea generation. *Design Studies*, 60, pp. 39–70, doi:10.1016/j.destud.2018.10.001.
Cubero, J. N., Gbadegeshin, S. A. & Segura, C. C. (2020). Commercialization Process of Disruptive Innovations in Corporate Ventures and Spinoff Companies: A Comparison. *Advances in Science, Technology and Engineering Systems Journal*, 5(2), pp. 621–634, doi:10.25046/aj050278.
Dahlman, E., Parkvall, S. & Sköld, J. (2021). Chapter 1 - What Is 5G? In: Dahlman, E., Parkvall, S., & Sköld, J. (eds.) *5G NR (Second Edition)*. Academic Press, pp. 1–5.
Data AI (2023). *State of mobile 2023*.
Datta, A., Reed, R. & Jessup, L. (2013). Commercialization of innovations: an overarching framework and research agenda. *American Journal of Business*, 28(2), pp. 147–191, doi:10.1108/AJB-08-2012-0048.
DCF (2022). *The investment gap to full5G rollout*. Frontier economics.
Dedehayir, O., Ortt, R. J., Riverola, C. & Miralles, F. (2017). Innovators and early adopters in the diffusion of innovations: a literature review. *International Journal of Innovation Management*, 21(08), p. 1740010, doi:10.1142/S1363919617400102.
Dedehayir, O. & Steinert, M. (2016). The hype cycle model: A review and future directions. *Technological Forecasting and Social Change*, 108, pp. 28–41, doi:10.1016/j.techfore.2016.04.005.
Dell'Era, C., Frattini, F. & Ghezzi, A. (2013). The role of the adoption network in the early market survival of innovations: The case of the Italian mobile value-added services (VAS) industry. *European*

Journal of Innovation Management, 16(1), pp. 118–140, doi:10.1108/14601061311292887.
Denscombe, M. (2010). *Good Research Guide: For small-scale social research projects*. Berkshire, UNITED KINGDOM: McGraw-Hill Education.
Denscombe, M. (2017). *EBOOK: The Good Research Guide: For Small-Scale Social Research Projects*. McGraw-Hill Education (UK).
Denzin, N. K. (2007). Triangulation. In: *The Blackwell Encyclopedia of Sociology*. John Wiley & Sons, Ltd.
Díez-Vial, I. (2007). Explaining Vertical Integration Strategies: Market Power, Transactional Attributes and Capabilities. *Journal of Management Studies*, 44(6), pp. 1017–1040, doi:10.1111/j.1467-6486.2007.00693.x.
Dmitriev, V., Simmons, G., Truong, Y., Palmer, M. & Schneckenberg, D. (2014). An exploration of business model development in the commercialization of technology innovations. *R&D Management*, 44(3), pp. 306–321, doi:10.1111/radm.12066.
Donkin, C. (2023). Operators mull future of network replacement cycle. *Mobile World Live*, 26 April 2023.
Dunham, J., Xu, J., Papangelis, K. & Schwartz, D. I. (2022). Advertising in Location-Based Games: An Exploration in Pokémon GO. In: *Extended Abstracts of the 2022 CHI Conference on Human Factors in Computing Systems*. New York, NY, USA: Association for Computing Machinery, pp. 1–6.
Dunnewijk, T. & Hultén, S. (2007). A brief history of mobile communication in Europe. *Telematics and Informatics*, 24(3), pp. 164–179, doi:10.1016/j.tele.2007.01.013.
Enders, A., Hungenberg, H., Denker, H.-P. & Mauch, S. (2008). The long tail of social networking.: Revenue models of social networking sites. *European Management Journal*, 26(3), pp. 199–211, doi:10.1016/j.emj.2008.02.002.
Epic Games (n.d.). *Epic Games Store Offers App, Software and Game Distribution*. Epic Games Store. https://store.epicgames.com/en-US/distribution [2023-04-17].
Ericsson (n.d.-a). *Ericsson Company facts*. https://www.ericsson.com/en/about-us/company-facts [2023-02-09].
Ericsson (n.d.-b). *Ericsson Portfolio*. https://www.ericsson.com/en/portfolio [2023-02-09].
Fast-Berglund, Å., Gong, L. & Li, D. (2018). Testing and validating Extended Reality (xR) technologies in manufacturing. *Procedia Manufacturing*, 25, pp. 31–38, doi:10.1016/j.promfg.2018.06.054.

Fenn, J. & Raskino, M. (2008). *Mastering the Hype Cycle: How to Choose the Right Innovation at the Right Time*. Harvard Business Press.
Fletcher, W. (2010). (page 1)p. 1What does Advertising Do? In: Fletcher, W. (ed.) *Advertising: A Very Short Introduction*. Oxford University Press, p. 0.
Ford, D. & Håkansson, H. (2013). Competition in business networks. *Industrial Marketing Management*, 42(7), pp. 1017–1024, doi:10.1016/j.indmarman.2013.07.015.
Frattini, F., Bianchi, M., De Massis, A. & Sikimic, U. (2014). The Role of Early Adopters in the Diffusion of New Products: Differences between Platform and Nonplatform Innovations. *Journal of Product Innovation Management*, 31(3), pp. 466–488, doi:10.1111/jpim.12108.
Frattini, F., De Massis, A., Chiesa, V., Cassia, L. & Campopiano, G. (2012). Bringing to Market Technological Innovation: What Distinguishes Success from Failure. *International Journal of Engineering Business Management*, 4, p. 15, doi:10.5772/51605.
Frith, J. (2017). The digital "lure": Small businesses and Pokémon Go. *Mobile Media & Communication*, 5(1), pp. 51–54, doi:10.1177/2050157916677861.
Gao, Y., Xue, S., Ding, M., Peng, J. & Pang, J. (2021). Exploring Extended Reality with Flexible Spectrum Access in Wireless Cellular Network. In: *2021 IEEE 32nd Annual International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC)*. Presented at the 2021 IEEE 32nd Annual International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), pp. 1–6.
Garcia, R. & Calantone, R. (2002). A critical look at technological innovation typology and innovativeness terminology: a literature review. *Journal of Product Innovation Management*, 19(2), pp. 110–132, doi:10.1111/1540-5885.1920110.
Gawer, A. & Cusumano, M. A. (2014). Industry Platforms and Ecosystem Innovation. *Journal of Product Innovation Management*, 31(3), pp. 417–433, doi:10.1111/jpim.12105.
Gibbs, G. R. (2018). *Analyzing Qualitative Data*. SAGE Publications Ltd.
Gillespie, B. & Joireman, J. (2016). The Role of Consumer Narrative Enjoyment and Persuasion Awareness in Product Placement Advertising. *American Behavioral Scientist*, 60(12), pp. 1510–1528, doi:10.1177/0002764216660136.
Gligor, D. M. & Maloni, M. J. (2022). More is not always better: The impact of value co-creation fit on B2B and B2C customer

satisfaction. *Journal of Business Logistics*, 43(2), pp. 209–237, doi:10.1111/jbl.12278.
Gomes, L. A. de V., Facin, A. L. F., Salerno, M. S. & Ikenami, R. K. (2018). Unpacking the innovation ecosystem construct: Evolution, gaps and trends. *Technological Forecasting and Social Change*, 136, pp. 30–48, doi:10.1016/j.techfore.2016.11.009.
Google (n.d.). *Service fees - Play Console Help*. https://support.google.com/googleplay/android-developer/answer/112622?hl=en [2023-04-17].
Gregory, R. & Muntermann, J. (2011). Theorizing in Design Science Research: Inductive versus Deductive Approaches. *ICIS 2011 Proceedings*.
GSMA (2023). European 5G Performance Trails its International Peers. *Membership*. https://www.gsma.com/membership/resources/european-5g-performance-trails-its-international-peers/ [2023-05-08].
Gu, M., Wang, Z., Li, X. & Liu, D. (2021). Location Sponsorship in Location-based Augmented Reality Gaming: A Game-Theoretic Model.
Guba, E. G. (1981). ERIC/ECTJ Annual Review Paper: Criteria for Assessing the Trustworthiness of Naturalistic Inquiries. *Educational Communication and Technology*, 29(2), pp. 75–91.
Guide Jr, V. D. R. & Van Wassenhove, L. N. (2007). Dancing with the Devil: Partnering with Industry but Publishing in Academia*. *Decision Sciences*, 38(4), pp. 531–546, doi:10.1111/j.1540-5915.2007.00169.x.
Hagiu, A. (2007). Merchant or Two-Sided Platform? *Review of Network Economics*, 6(2), doi:10.2202/1446-9022.1113.
Håkansson, H. & Ford, D. (2002). How should companies interact in business networks? *Journal of Business Research*, 55(2), pp. 133–139, doi:10.1016/S0148-2963(00)00148-X.
Halcomb, E. J. & Davidson, P. M. (2006). Is verbatim transcription of interview data always necessary? *Applied Nursing Research*, 19(1), pp. 38–42, doi:10.1016/j.apnr.2005.06.001.
Harrigan, K. R. (1984). Formulating Vertical Integration Strategies. *Academy of Management Review*, 9(4), pp. 638–652, doi:10.5465/AMR.1984.4277387.
Hart, O. & Moore, J. (1990). Property Rights and the Nature of the Firm. *Journal of Political Economy*, 98(6), pp. 1119–1158, doi:10.1086/261729.
Heidenreich, S. & Kraemer, T. (2016). Innovations—Doomed to Fail? Investigating Strategies to Overcome Passive Innovation Resistance.

Journal of Product Innovation Management, 33(3), pp. 277–297, doi:10.1111/jpim.12273.
Heidenreich, S., Kraemer, T. & Handrich, M. (2016). Satisfied and unwilling: Exploring cognitive and situational resistance to innovations. *Journal of Business Research*, 69(7), pp. 2440–2447, doi:10.1016/j.jbusres.2016.01.014.
Heidenreich, S. & Spieth, P. (2013). Why innovations fail — the case of passive and active innovation resistance. *International Journal of Innovation Management*, 17(05), p. 1350021, doi:10.1142/S1363919613500217.
Holm, A. B. & Günzel-Jensen, F. (2017). Succeeding with freemium: strategies for implementation. *Journal of Business Strategy*, 38(2), pp. 16–24, doi:10.1108/JBS-09-2016-0096.
Holm, D. B., Eriksson, K. & Johanson, J. (1999). Creating value through mutual commitment to business network relationships. *Strategic Management Journal*, 20(5), pp. 467–486, doi:10.1002/(SICI)1097-0266(199905)20:5<467::AID-SMJ38>3.0.CO;2-J.
Holmlund, M. & Törnroos, J. (1997). What are relationships in business networks? *Management Decision*, 35(4), pp. 304–309, doi:10.1108/00251749710169693.
Hortaçsu, A. & Syverson, C. (2007). Cementing Relationships: Vertical Integration, Foreclosure, Productivity, and Prices. *Journal of Political Economy*, 115(2), pp. 250–301, doi:10.1086/514347.
Institute, C. (2023). *Is the innovation (really) disruptive? These 6 questions can reveal the answer.* Christensen Institute. https://www.christenseninstitute.org/blog/is-the-innovation-really-disruptive-these-6-questions-can-reveal-the-answer/ [2023-02-20].
Jacobides, M. G., Cennamo, C. & Gawer, A. (2018). Towards a theory of ecosystems. *Strategic Management Journal*, 39(8), pp. 2255–2276, doi:10.1002/smj.2904.
Jarvinen, P. (2000). Research Questions Guiding Selection of an Appropriate Research Method. *ECIS 2000 Proceedings*.
Joachim, V., Spieth, P. & Heidenreich, S. (2018). Active innovation resistance: An empirical study on functional and psychological barriers to innovation adoption in different contexts. *Industrial Marketing Management*, 71, pp. 95–107, doi:10.1016/j.indmarman.2017.12.011.
J.Rubin, H. & S.Rubin, I. (2005). *Qualitative Interviewing (2nd ed.): The Art of Hearing Data*. SAGE Publications, Inc.
Juola, P. (2008). Killer Applications in Digital Humanities. *Literary and Linguistic Computing*, 23(1), pp. 73–83, https://doi.org/10.1093/llc/fqm042.

Kapoor, R. & Teece, D. J. (2021). Three Faces of Technology's Value Creation: Emerging, Enabling, Embedding. *Strategy Science*, 6(1), pp. 1–4, doi:10.1287/stsc.2021.0124.

Kaur Kapoor, K., K. Dwivedi, Y. & D. Williams, M. (2014). Innovation adoption attributes: a review and synthesis of research findings. *European Journal of Innovation Management*, 17(3), pp. 327–348, doi:10.1108/EJIM-08-2012-0083.

Khan, S. (2023). Chapter Fifteen - The future of XR-empowered healthcare: roadmap for 2050. In: Khan, S., Alam, M., Banday, S. A., & Usta, M. S. (eds.) *Extended Reality for Healthcare Systems*. Academic Press, pp. 265–275.

Kim, W. (2018). A practical guide for understanding online business models. *International Journal of Web Information Systems*, 15(1), pp. 71–82, doi:10.1108/IJWIS-07-2018-0060.

Kim, Y., Kwon, H.-J., Awoniyi-Oteri, O., Hande, P., Sundararajan, J. K., Tokgoz, Y., Luo, T., Mukkavilli, K. & Ji, T. (2021). UE Power Saving Techniques for Extended Reality (XR) Services in 5G NR Systems. In: *2021 IEEE 32nd Annual International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC)*. Presented at the 2021 IEEE 32nd Annual International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), pp. 1–7.

Kirchberger, M. A. & Pohl, L. (2016). Technology commercialization: a literature review of success factors and antecedents across different contexts. *The Journal of Technology Transfer*, 41(5), pp. 1077–1112, doi:10.1007/s10961-016-9486-3.

Kluge, M. G., Maltby, S., Keynes, A., Nalivaiko, E., Evans, D. J. R. & Walker, F. R. (2022). Current State and General Perceptions of the Use of Extended Reality (XR) Technology at the University of Newcastle: Interviews and Surveys From Staff and Students. *SAGE Open*, 12(2), p. 21582440221093348, doi:10.1177/21582440221093348.

Korstjens, I. & Moser, A. (2018). Series: Practical guidance to qualitative research. Part 4: Trustworthiness and publishing. *European Journal of General Practice*, 24(1), pp. 120–124, doi:10.1080/13814788.2017.1375092.

Kovacs, A. (1), Verhoeven, D. (1), van Looy, B. (1) & Marullo, C. (2) (2019). Radical, disruptive, discontinuous and breakthrough innovation: More or the same? In: *AOM 2019: Understanding the Inclusive Organization - 79th Annual Meeting of the Academy of Management*. Presented at the AOM 2019: Understanding the

Inclusive Organization - 79th Annual Meeting of the Academy of Management, Academy of Management.
Kovács, G. & Spens, K. M. (2005). Abductive reasoning in logistics research. *International Journal of Physical Distribution & Logistics Management*, 35(2), pp. 132–144, doi:10.1108/09600030510590318.
Lago, C. (2021). Will the EU's recovery package be enough to close the 5G gap? *Tech Monitor*. https://techmonitor.ai/technology/networks/5g-investment-eu [2023-04-14].
Laukkanen, T. (2016). Consumer adoption versus rejection decisions in seemingly similar service innovations: The case of the Internet and mobile banking. *Journal of Business Research*, 69(7), pp. 2432–2439, doi:10.1016/j.jbusres.2016.01.013.
Lee, S., Lee, S., Joo, H. & Nam, Y. (2021). Examining Factors Influencing Early Paid Over-The-Top Video Streaming Market Growth: A Cross-Country Empirical Study. *Sustainability*, 13(10), p. 5702, doi:10.3390/su13105702.
Lehdonvirta, V. (2009). Virtual item sales as a revenue model: identifying attributes that drive purchase decisions. *Electronic Commerce Research*, 9(1), pp. 97–113, doi:10.1007/s10660-009-9028-2.
Lekvall, P. & Wahlbin, C. (2001). *Information för marknadsföringsbeslut*. IHM Publishing.
Li, S., Luo, Q., Qiu, L. & Bandyopadhyay, S. (2020). Optimal Pricing Model of Digital Music: Subscription, Ownership or Mixed? *Production and Operations Management*, 29(3), pp. 688–704, doi:10.1111/poms.13131.
Li, Z., Wang, X. & Zhang, T. (2021). *5G+: How 5G Change the Society*. Singapore: Springer Singapore.
Liang, J., Yang, S., Huang, X. & Zhu, J. (2022). Forward or backward: The Impact of Vertical Integration Direction on the bullwhip effect. *International Journal of Production Research*, 60(22), pp. 6923–6944, doi:10.1080/00207543.2022.2051765.
Lin, Y.-T., Parlaktürk, A. K. & Swaminathan, J. M. (2014). Vertical Integration under Competition: Forward, Backward, or No Integration? *Production and Operations Management*, 23(1), pp. 19–35, doi:10.1111/poms.12030.
Linde, L., Frishammar, J. & Parida, V. (2023). Revenue Models for Digital Servitization: A Value Capture Framework for Designing, Developing, and Scaling Digital Services. *IEEE Transactions on Engineering Management*, 70(1), pp. 82–97, doi:10.1109/TEM.2021.3053386.
Linden, A. & Fenn, J. (2003). Understanding Gartner's Hype Cycles.

McKinsey & Company (2022). *Value creation in the metaverse*.
Milgrom, P. & Roberts, J. (1990). Rationalizability, Learning, and Equilibrium in Games with Strategic Complementarities. *Econometrica*, 58(6), pp. 1255–1277, doi:10.2307/2938316.
Mirza, N. A., Akhtar-Danesh, N., Noesgaard, C., Martin, L. & Staples, E. (2014). A concept analysis of abductive reasoning. *Journal of Advanced Nursing*, 70(9), pp. 1980–1994, doi:10.1111/jan.12379.
Moore, G. A. (2014). *Crossing the Chasm, 3rd Edition: Marketing and Selling Disruptive Products to Mainstream Customers*. 3rd ed. Harper Business.
Morimoto, T., Kobayashi, T., Hirata, H., Otani, K., Sugimoto, M., Tsukamoto, M., Yoshihara, T., Ueno, M. & Mawatari, M. (2022). XR (Extended Reality: Virtual Reality, Augmented Reality, Mixed Reality) Technology in Spine Medicine: Status Quo and Quo Vadis. *Journal of Clinical Medicine*, 11(2), p. 470, doi:10.3390/jcm11020470.
Nieto Cubero, J., Gbadegeshin, S. A. & Consolación, C. (2021). Commercialization of disruptive innovations: Literature review and proposal for a process framework. *International Journal of Innovation Studies*, 5(3), pp. 127–144, doi:10.1016/j.ijis.2021.07.001.
Nilsen, E. B., Bowler, D. E. & Linnell, J. D. C. (2020). Exploratory and confirmatory research in the open science era. *Journal of Applied Ecology*, 57(4), pp. 842–847, doi:10.1111/1365-2664.13571.
Nisiotis, L. & Alboul, L. (2021). Initial Evaluation of an Intelligent Virtual Museum Prototype Powered by AI, XR and Robots. In: De Paolis, L. T., Arpaia, P., & Bourdot, P. (eds.) *Augmented Reality, Virtual Reality, and Computer Graphics*. Cham: Springer International Publishing, pp. 290–305.
Numminen, E., Sällberg, H. & Wang, S. (2022). The impact of app revenue model choices for app revenues: A study of apps since their initial App Store launch. *Economic Analysis and Policy*, 76, pp. 325–336, doi:10.1016/j.eap.2022.08.010.
Overholm, H. (2015). Collectively created opportunities in emerging ecosystems: The case of solar service ventures. *Technovation*, 39–40, pp. 14–25, doi:10.1016/j.technovation.2014.01.008.
Owolabi Yusuf, M. & Mat Derus, A. (2013). Measurement model of corporate zakat collection in Malaysia: A test of diffusion of innovation theory. *Humanomics*, 29(1), pp. 61–74, doi:10.1108/08288661311299321.
Oyelana, O., Kamanzi, J. & Richter, S. (2021). A critical look at exclusive breastfeeding in Africa: Through the lens of diffusion of innovation

theory. *International Journal of Africa Nursing Sciences*, 14, p. 100267, doi:10.1016/j.ijans.2020.100267.
Paris, S., Pedersen, K. & Zhao, Q. (2022). Adaptive Discontinuous Reception in 5G Advanced for Extended Reality Applications. In: *2022 IEEE 95th Vehicular Technology Conference: (VTC2022-Spring)*. Presented at the 2022 IEEE 95th Vehicular Technology Conference: (VTC2022-Spring), pp. 1–6.
Patten, M. L. (2017). *Understanding Research Methods: An Overview of the Essentials*. Taylor & Francis.
PDMA (n.d.). *Glossary for New Product Development: I to S - PDMA*. https://www.pdma.org/page/glossary_access2 [2023-02-07].
Perez, J. & Kreinovich, V. (2018). Gartner's hype cycle: a simple explanation. *International Journal of Computing and Optimization*, 5(1), pp. 1–4, doi:10.12988/ijco.2018.832.
Perry, M. K. (1989). Chapter 4 Vertical integration: Determinants and effects. In: *Handbook of Industrial Organization*. Elsevier, pp. 183–255.
Pilinkienė, V. & Mačiulis, P. (2014). Comparison of Different Ecosystem Analogies: The Main Economic Determinants and Levels of Impact. *Procedia - Social and Behavioral Sciences*, 156, pp. 365–370, doi:10.1016/j.sbspro.2014.11.204.
Pratap, A. & Das, S. K. (2022). Stable Matching Based Resource Allocation for Service Provider's Revenue Maximization in 5G Networks. *IEEE Transactions on Mobile Computing*, 21(11), pp. 4094–4110, doi:10.1109/TMC.2021.3064047.
Råholm, M.-B. (2010a). Theory development and the logic of discovery. *International Journal for Human Caring*, 14(3), pp. 36–42.
Råholm, M.-B. (2010b). Abductive reasoning and the formation of scientific knowledge within nursing research. *Nursing Philosophy*, 11(4), pp. 260–270, doi:10.1111/j.1466-769X.2010.00457.x.
Ram, S. & Sheth, J. N. (1989). Consumer Resistance to Innovations: The Marketing Problem and its solutions. *Journal of Consumer Marketing*, 6(2), pp. 5–14, doi:10.1108/EUM0000000002542.
Ratcliffe, J., Soave, F., Bryan-Kinns, N., Tokarchuk, L. & Farkhatdinov, I. (2021). Extended Reality (XR) Remote Research: a Survey of Drawbacks and Opportunities. In: *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. Presented at the CHI '21: CHI Conference on Human Factors in Computing Systems, Yokohama Japan: ACM, pp. 1–13.
Rauschnabel, P. A., Felix, R., Hinsch, C., Shahab, H. & Alt, F. (2022). What is XR? Towards a Framework for Augmented and Virtual

Reality. *Computers in Human Behavior*, 133, p. 107289, doi:10.1016/j.chb.2022.107289.
Ritter, T., Wilkinson, I. F. & Johnston, W. J. (2004). Managing in complex business networks. *Industrial Marketing Management*, 33(3), pp. 175–183, doi:10.1016/j.indmarman.2003.10.016.
Robinson, O. C. (2014). Sampling in Interview-Based Qualitative Research: A Theoretical and Practical Guide. *Qualitative Research in Psychology*, 11(1), pp. 25–41, doi:10.1080/14780887.2013.801543.
Roche, R. (2019). Quants' Quandary: Crossing the Chasm.
Rogers, E. M. (2003). *Diffusion of Innovations*. 5th ed. The Free Press.
Roma, P. & Ragaglia, D. (2016). Revenue models, in-app purchase, and the app performance: Evidence from Apple's App Store and Google Play. *Electronic Commerce Research and Applications*, 17, pp. 173–190, doi:10.1016/j.elerap.2016.04.007.
Rowley, J. (2012). Conducting research interviews. *Management Research Review*, 35(3/4), pp. 260–271, doi:10.1108/01409171211210154.
Ryoo, J. & Winkelmann, K. eds. (2021). *Innovative Learning Environments in STEM Higher Education: Opportunities, Challenges, and Looking Forward*. Cham: Springer International Publishing.
Salehudin, I. & Alpert, F. (2021). To pay or not to pay: understanding mobile game app users' unwillingness to pay for in-app purchases. *Journal of Research in Interactive Marketing*, 16(4), pp. 633–647, doi:10.1108/JRIM-02-2021-0053.
Salih, A., Zeebaree, S., Abdulraheem, A., Zebari, R., M.Sadeeq, M. & Ahmed, O. (2020). Evolution of Mobile Wireless Communication to 5G Revolution. *Technology Reports of Kansai University*, 62, pp. 2139–2151.
Samsung (2023), *Samsung Galaxy Unpacked February 2023: Official Replay*. 1 February. YouTube. Available at: https://www.youtube.com/watch?v=gUM2wYKdxDA&ab_channel=Samsung [2023-05-08].
Santos, J. N. & Baptista, C. S. (2021). Development of dyadic relationships between competitors within multi-actor alliances. *Journal of Business & Industrial Marketing*, 36(7), pp. 1246–1260, doi:10.1108/JBIM-10-2019-0460.
Shah, E. D. & Rothstein, R. I. (2020). Crossing the chasm: tools to define the value of innovative endoscopic technologies to encourage adoption in clinical practice. *Gastrointestinal Endoscopy*, 91(5), pp. 1183–1186, doi:10.1016/j.gie.2020.01.009.
Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information*, 22(2), pp. 63–75, doi:10.3233/EFI-2004-22201.

SideQuest (n.d.). *SideQuest: Oculus Quest Games & Apps including AppLab Games (Oculus App Lab)*. https://sidequestvr.com [2023-05-19].

Siegel, R. A., Hansén, S. & Pellas, L. H. (1995). Accelerating the commercialization of technology: commercialization through co-operation. *Industrial Management & Data Systems*, 95(1), pp. 18–26, doi:10.1108/02635579510079425.

Sjödin, D., Parida, V., Jovanovic, M. & Visnjic, I. (2020). Value Creation and Value Capture Alignment in Business Model Innovation: A Process View on Outcome-Based Business Models. *Journal of Product Innovation Management*, 37(2), pp. 158–183, doi:10.1111/jpim.12516.

Slater, M., Gonzalez-Liencres, C., Haggard, P., Vinkers, C., Gregory-Clarke, R., Jelley, S., Watson, Z., Breen, G., Schwarz, R., Steptoe, W., Szostak, D., Halan, S., Fox, D. & Silver, J. (2020). The Ethics of Realism in Virtual and Augmented Reality. *Frontiers in Virtual Reality*, 1.

Speicher, M., Hall, B. D. & Nebeling, M. (2019). What is Mixed Reality? In: *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. Presented at the CHI '19: CHI Conference on Human Factors in Computing Systems, Glasgow Scotland Uk: ACM, pp. 1–15.

Statista (2022a). *Topic: XR: AR, VR, and the metaverse*. Statista Inc. https://www.statista.com/topics/6072/extended-reality-xr/ [2023-04-13].

Statista (2022b). *Global: tablet revenue 2013-2026*. Statista Inc. https://www.statista.com/forecasts/1181766/revenue-tablets-worldwide [2023-04-13].

Statista (2022c). *Global app store commission rates 2022*. Statista Inc. https://www.statista.com/statistics/975776/revenue-split-leading-digital-content-store-worldwide/ [2023-04-17].

Statista (2023). *Smartphones - Worldwide | Statista Market Forecast*. Statista Inc. https://www.statista.com/outlook/cmo/consumer-electronics/telephony/smartphones/worldwide [2023-04-13].

Statt, N. (2018). *Valve's new Steam revenue agreement gives more money to game developers*. The Verge. https://www.theverge.com/2018/11/30/18120577/valve-steam-game-marketplace-revenue-split-new-rules-competition [2023-04-17].

Steam (2018). *Steamworks Development - Central de notícias do Steam*. https://store.steampowered.com/news/group/4145017/old_view/1697191267930157838?l=portuguese [2023-04-17].

Stentoft Arlbjørn, J. & Halldorsson, A. (2002). Logistics knowledge creation: reflections on content, context and processes. *International Journal of Physical Distribution & Logistics Management*, 32(1), pp. 22–40, doi:10.1108/09600030210415289.
Stewart, J. & Nickerson, C. (2021). Costs and benefits of 5G geographical coverage in Europe.
Stüber, G. L. (2017). *Principles of Mobile Communication*. Cham: Springer International Publishing.
Takeishi, A. & Lee, K.-J. (2008). Business Ecosystem and Reverse Salient: The Development of the Mobile Music Business in Japan and Korea. *All Sprouts Content*, 6(52).
Taleb, T., Boudi, A., Rosa, L., Cordeiro, L., Theodoropoulos, T., Tserpes, K., Dazzi, P., Protopsaltis, A. & Li, R. (2022). Towards Supporting XR Services: Architecture and Enablers. *IEEE Internet of Things Journal*, pp. 1–1, doi:10.1109/JIOT.2022.3222103.
Talke, K. & Heidenreich, S. (2014). How to Overcome Pro-Change Bias: Incorporating Passive and Active Innovation Resistance in Innovation Decision Models. *Journal of Product Innovation Management*, 31(5), pp. 894–907, doi:10.1111/jpim.12130.
Talmar, M., Walrave, B., Podoynitsyna, K. S., Holmström, J. & Romme, A. G. L. (2020). Mapping, analyzing and designing innovation ecosystems: The Ecosystem Pie Model. *Long Range Planning*, 53(4), p. 101850, doi:10.1016/j.lrp.2018.09.002.
Teece, D. J. (1984). Economic Analysis and Strategic Management. *California Management Review*, 26(3), pp. 87–110, doi:10.2307/41165082.
Teece, D. J. (2018). Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world. *Research Policy*, 47(8), pp. 1367–1387, doi:10.1016/j.respol.2017.01.015.
Teece, David J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy*, 15(6), pp. 285–305, doi:10.1016/0048-7333(86)90027-2.
Teixeira, J. M. & Peres, F. F. F. (2020). Analysis of XR Research in Brazil from 21 Years of SVR Publications. In: *2020 22nd Symposium on Virtual and Augmented Reality (SVR)*. Presented at the 2020 22nd Symposium on Virtual and Augmented Reality (SVR), pp. 220–231.
Thurmond, V. A. (2001). The Point of Triangulation. *Journal of Nursing Scholarship*, 33(3), pp. 253–258, doi:10.1111/j.1547-5069.2001.00253.x.

Timmermans, S. & Tavory, I. (2012). Theory Construction in Qualitative Research: From Grounded Theory to Abductive Analysis. *Sociological Theory*, 30(3), pp. 167–186.
Todeva, E. (2006). *Business Networks: Strategy and Structure*. London: Routledge.
Vergara, R. A. (2012). Samsung Electronics and Apple, Inc.: A Study in Contrast in Vertical Integration in the 21 st Century. *American International Journal of Contemporary Research*, 2.
Voštinár, P., Horváthová, D., Mitter, M. & Bako, M. (2021). The look at the various uses of VR. *Open Computer Science*, 11(1), pp. 241–250, doi:10.1515/comp-2020-0123.
Williams, C. (2007). Research Methods. *Journal of Business & Economics Research (JBER)*, 5(3), doi:10.19030/jber.v5i3.2532.
Wohlin, C., Aurum, A., Angelis, L., Phillips, L., Dittrich, Y., Gorschek, T., Grahn, H., Henningsson, K., Kagstrom, S., Low, G., Rovegard, P., Tomaszewski, P., van Toorn, C. & Winter, J. (2012). The Success Factors Powering Industry-Academia Collaboration. *IEEE Software*, 29(2), pp. 67–73, doi:10.1109/MS.2011.92.
Yaghmaie, P. & Vanhaverbeke, W. (2019). Identifying and describing constituents of innovation ecosystems: A systematic review of the literature. *EuroMed Journal of Business*, 15(3), pp. 283–314, doi:10.1108/EMJB-03-2019-0042.
Yavoruk, O. (2020). The Study of Observation in Physics Classes through XR Technologies. In: *Proceedings of the 4th International Conference on Digital Technology in Education*. New York, NY, USA: Association for Computing Machinery, pp. 58–62.
Yin, R. K. (2014). *Case study research : design and methods*. 5. ed. SAGE.
Zagury-Orly, I., Solinski, M. A., Nguyen, L. HP., Young, M., Drozdowski, V., Bain, P. A. & Gantwerker, E. A. (2023). What is the Current State of Extended Reality Use in Otolaryngology Training? A Scoping Review. *The Laryngoscope*, 133(2), pp. 227–234, doi:10.1002/lary.30174.
Zarantonello, L. & Schmitt, B. H. (2022). Experiential AR/VR: a consumer and service framework and research agenda. *Journal of Service Management*, 34(1), pp. 34–55, doi:10.1108/JOSM-12-2021-0479.
Zhang, H., Hu, Y., Shi, X. & Gao, Y. (2022). When and how do innovation ecosystems outperform integrated organizations? On technological interdependencies and ecosystem performance. *Industrial Management & Data Systems*, 122(9), pp. 2091–2120, doi:10.1108/IMDS-11-2021-0720.

Zhang, Y. & Zhang, J. (2021). Catch them all: Impacts of location-based augmented reality mobile applications on local businesses. *Information & Management*, 58(8), p. 103550, doi:10.1016/j.im.2021.103550.

9 Appendix

9.1 Interview guide in Swedish

Fetstilade frågor är prioriterade frågor

Intro:

[Tacka för att de tog sig tiden, presentera oss och examensarbetet]

Introduktionsfrågor:

- Kan du berätta lite om dig själv?
    - Vad är din roll på [FÖRETAGET]?
    - Vad är din bakgrund inom XR?
- Kan du berätta lite mer om [FÖRETAGET]?

Ekosystemet:

- **Vilka typer av aktörer är just nu involverade i att tillverka, stötta och sälja XR-teknik till konsumentmarknaden?**
- På vilka sätt är de olika aktörerna beroende av varandra?
    - Hur ser samspelen ut?
- Finns det några större samarbeten mellan olika typer av aktörer som du är medveten om?
    - Vad ser du för fördelar med dessa samarbeten?
    - Finns det några typer av samarbeten ni tror är särskilt viktiga för spridningen av XR-teknik?
- Vilka tycker du är de starkaste aktörerna?
    - Varför?
    - På vilket sätt?
    - Vad driver dem?
- **Vad är er egen roll inom ekosystemet?**
    - Vilka är ni beroende av?
    - Vilka är beroende av er?
- **Tror du att ekosystemet kommer fortsätta se ut som det gör nu framöver?**
    - Hur kan det komma att ändras?
    - Vad driver den förändringen?

Kommersialisering:

- **Vilken potential ser du att framtidens XR-teknik har?**
- **Vad tror du är viktigast för att XR ska nå en större grupp av konsumenter än den gör idag?**
- **Vilka hinder ser du just nu för att nå den breda marknaden?**
    - Hur kan de övervinnas?
    - Vilka aktörer är viktiga för detta?
- Vilka aktörer är relevanta för kommersialiseringen av XR-tekniken till den bredare marknaden?
- **Vilken/vilka aktörer tror du kommer vara drivande i kommersialiseringen av XR-tekniken till den breda marknaden?**
    - Var ligger den viktigaste kundkontakten?
- Inom vilka användarområden tror du det finns störst potential att nå den stora marknaden?
- **Hur tror du att XR kan kommersialiseras på det mest effektiva sättet rent strategiskt för att nå den breda marknaden?**

Value Capturing:

- Var ligger kundvärdet i XR-tekniken?
- Vad tror du att betalningsviljan ligger när det kommer till XR-teknik?
- **Hur tror du att slutkonsumenter kommer betala för XR-tekniken?**
    - **Vilka affärsmodeller tror du kommer vara bäst både ur konsument och företagsperspektiv?**
- **Hur kommer monetära flöden se ut mellan aktörer i ekosystemet?**
- **Vad finns ytterligare värden man kan hämta från tekniken som kan monetiseras på?**

Avslutande frågor:

- Har du något övrigt som du hade velat lyfta men som du inte känner att du har sagt?
- Har du andra kontakter du tror vi hade kunnat prata med?
    - Känner du till andra företag som jobbar med XR som du tror hade varit intressanta för oss att höra av oss till?

9.2 Interview guide in English

Questions in bold are priority questions

Intro:

[Express gratitude for taking the time, present us and the thesis]

Introductory questions:

- Can you tell us a bit about yourself?
    - Can you tell us a bit more about your role at [your company]?
    - What is your background concerning XR?
- Can you tell us more about [your company]?

Ecosystem:

- **What types of players are currently involved in producing, supporting and selling XR technologies to the consumer market?**
- In what ways are the different actors interdependent?
    - What does the interaction look like?
- Are there any major collaborations between different types of actors that you are aware of?
    - What do you see as the benefits of these collaborations?
    - Are there any types of collaborations you think are particularly important for the diffusion of XR technologies?
- **Who do you believe are the strongest actors?**
    - Why?
    - In what way?
    - What drives them?
- **What is your own role within the ecosystem?**
    - Who do you depend on?
    - Who is dependent on you?
- **Do you think the ecosystem will continue to look like it does now in the future?**
    - In what ways could it change?
    - What is driving that change?

Commercialization:

- **What potential do you see for the future of XR technologies?**
- **What do you think is most important for XR to reach a larger group of consumers than it does today?**
- **What barriers do you currently see for the commercialization towards the broad market?**
    - How can they be overcome?
    - Which actors are important for this?
- Which actors are relevant for the commercialization of the XR technologies to the wider market?
- **Which actor(s) do you think will drive the commercialization of XR technologies to the wider market?**
    - Where is the most important customer interaction?
- In which areas do you think there is the greatest potential to reach the broader market?
- **How do you think XR should be commercialized in the most effective way strategically to reach the broad market?**

Value Capturing:

- **Where is the main customer value in XR technologies?**
- What do you think the willingness to pay is when it comes to XR technologies?
- **How do you think end consumers will pay for XR technologies?**
    - Which business models do you think will be best from both a consumer and business perspective?
- What will monetary flows look like between actors in the ecosystem?
- **What additional values can be extracted from the technology that can be monetized?**

Final questions:

- Is there anything else that you would have liked to discuss but don't feel you have gotten the opportunity to?
- Do you have other contacts you think we could talk to?
    - Do you know of other companies working with XR that would be of interest for us to interview?

9.3 Ecosystem Pie Model

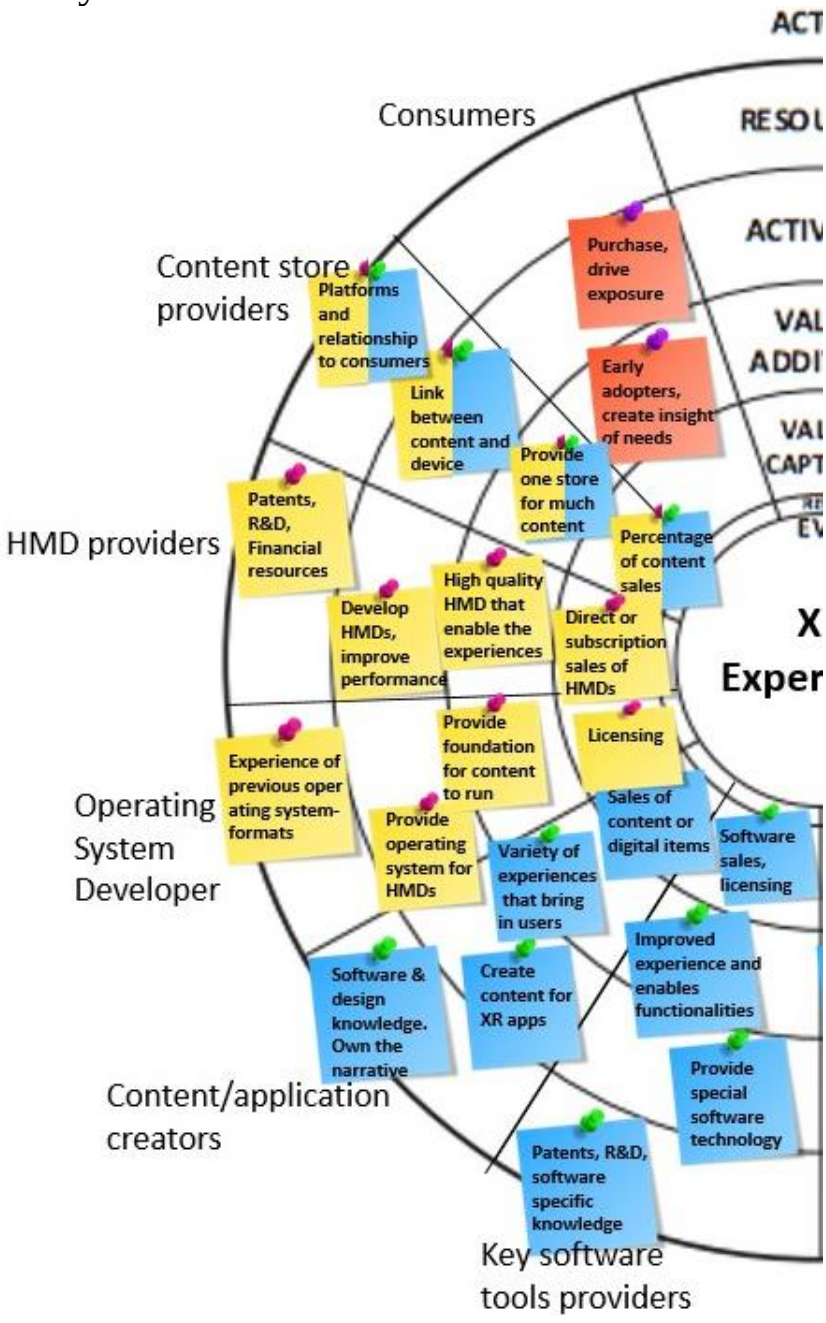

Figure 18. XR ecosystem modeled as the ecosystem pie model (left-half)

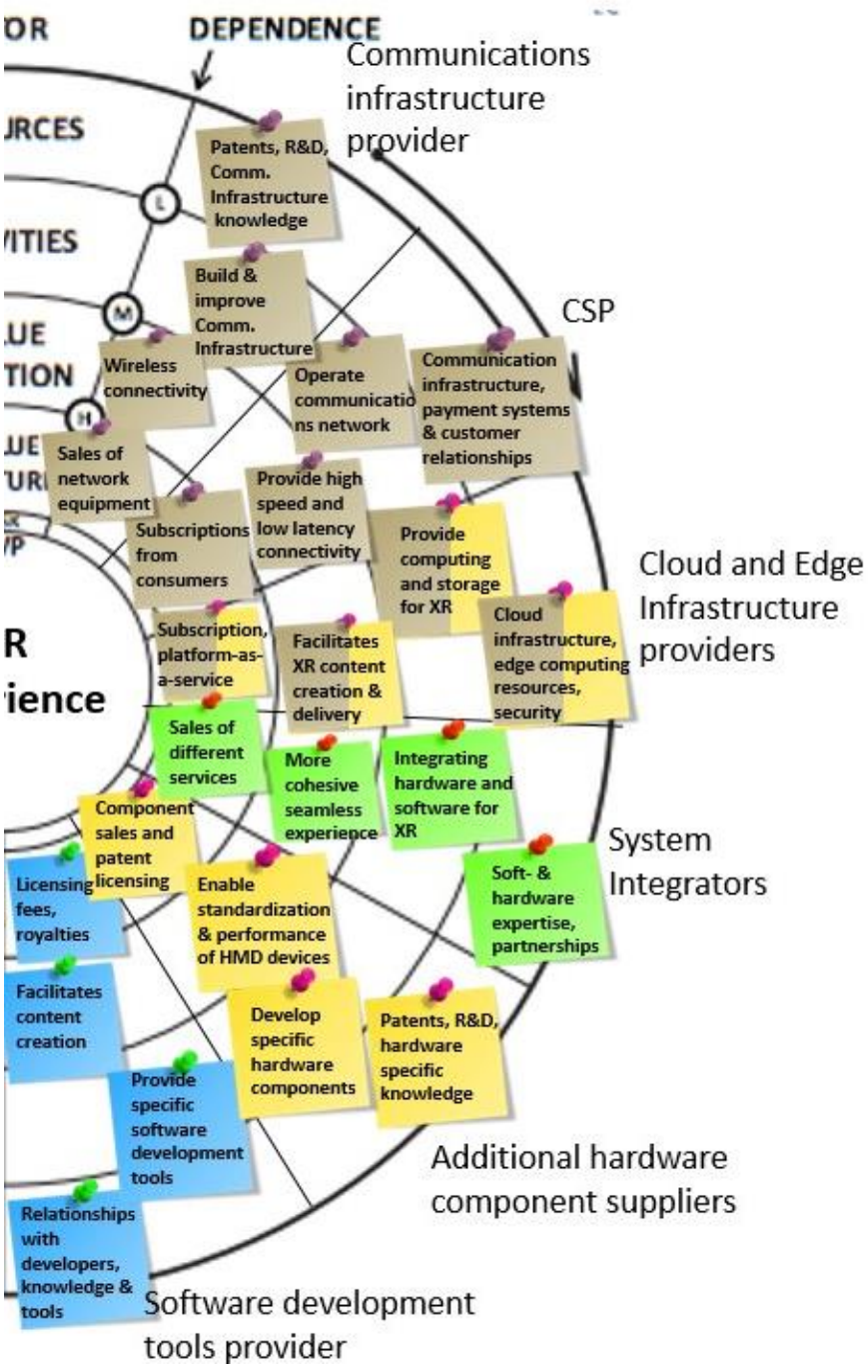

Figure 19. XR ecosystem modeled as the ecosystem pie model (right-half)