Stockholm University

Unpacking the Value of Emerging Technologies

Experimentation, Communication and Knowledge Brokering

Gulnar Nussipova

Doctoral Thesis in Business Administration at Stockholm University, Sweden 2023

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Abstract

While many emerging technologies are making significant strides in the marketplace, others are developing at a slower pace. Historical experience has shown that their success can vary widely, from outright failure to becoming indispensable to daily life. The creation of value associated with emerging technologies has become a focal point for CEOs, business leaders, policymakers, and global forums such as the World Economic Forum. They actively explore opportunities for value creation using these technologies. Yet, the value of emerging technologies often remains uncertain since their adoption in new contexts and usage may deviate significantly from providers' intended use cases. The commercialization of emerging technologies presents a profound challenge due to the uncertain value and complex landscape of innovation.

This thesis aims to investigate the processes that help unpack the value of emerging technologies to customers in a B2B context, with a focus on processes that recognize the evolving, dynamic nature of value. The thesis contends that co - creation processes help customers in unpacking the value of emerging technologies. Given the constantly evolving nature of emerging technologies, it is important to adopt a comprehensive perspective in order to fully comprehend their complex nature. In order to address the challenges presented by the uncertain value of emerging technologies in B2B settings, this thesis proposes a framework that focuses on three co-creation processes - experimentation, communication, and knowledge brokering - that may assist customers in unpacking the value of emerging technologies for their businesses. Finally, the thesis concludes with a discussion of its contributions, both theoretical and practical implications, and recommendations for further research.

Keywords: *commercialization of emerging technologies, unpacking the value, value co-creation, experimentation, communication, knowledge brokering, framing of emerging technologies, value proposition.*

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To all the curious minds
whose quest for
knowledge has inspired
my own.
Not all those who
wander are lost.

Acknowledgments

As Gregory Bateson aptly remarked about the social sciences, "There are the hard sciences and then there are the difficult sciences." This quote resonates with my journey, emphasizing the inherent complexity in studying and comprehending the intricacies of the social world that I have personally experienced during this project. I would like to express my heartfelt gratitude to all those who played a role in supporting me throughout this dissertation project.

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Abstract

While many emerging technologies are making significant strides in the marketplace, others are developing at a slower pace. Historical experience has shown that their success can vary widely, from outright failure to becoming indispensable to daily life. The creation of value associated with emerging technologies has become a focal point for CEOs, business leaders, policymakers, and global forums such as the World Economic Forum. They actively explore opportunities for value creation using these technologies. Yet, the value of emerging technologies often remains uncertain since their adoption in new contexts and usage may deviate significantly from providers' intended use cases. The commercialization of emerging technologies presents a profound challenge due to the uncertain value and complex landscape of innovation.

This thesis aims to investigate the processes that help unpack the value of emerging technologies to customers in a B2B context, with a focus on processes that recognize the evolving, dynamic nature of value. The thesis contends that co - creation processes help customers in unpacking the value of emerging technologies. Given the constantly evolving nature of emerging technologies, it is important to adopt a comprehensive perspective in order to fully comprehend their complex nature. In order to address the challenges presented by the uncertain value of emerging technologies in B2B settings, this thesis proposes a framework that focuses on three co-creation processes - experimentation, communication, and knowledge brokering - that may assist customers in unpacking the value of emerging technologies for their businesses. Finally, the thesis concludes with a discussion of its contributions, both theoretical and practical implications, and recommendations for further research.

Key words: commercialization of emerging technologies, unpacking the value, value co-creation, experimentation, communication, knowledge brokering, framing of emerging technologies

Sammanfattning

Medan många framväxande teknologier gör stora framsteg på marknaden, utvecklas andra i en långsammare takt. Historiska erfarenheter har visat att deras framgång kan variera stort, från ett direkt misslyckande till att bli oumbärliga i det dagliga livet. Värdeskapandet i samband med framväxande teknologier har blivit en central fråga för VD:ar, företagsledare, beslutsfattare och globala forum som World Economic Forum. De undersöker aktivt möjligheter till värdeskapande med hjälp av dessa teknologier. Värdet av framväxande teknologier förblir dock ofta osäkert eftersom de används i nya sammanhang och kan avvika avsevärt från leverantörernas avsedda användningsfall. Kommersialiseringen av framväxande teknologier utgör en stor utmaning på grund av det osäkra värdet och det komplexa innovationslandskapet.

Denna avhandling syftar till att undersöka de processer som hjälper till att ta fram värdet av framväxande teknologier för kunder i en B2B-kontext, med fokus på processer som erkänner den föränderliga, dynamiska karaktären av värde. I avhandlingen hävdas att samskapande processer hjälper kunderna att förstå värdet av framväxande teknologier. Med tanke på att framväxande teknologier ständigt utvecklas är det viktigt att anta ett övergripande perspektiv för att till fullo förstå deras komplexa natur. För att hantera de utmaningar som det osäkra värdet av framväxande teknologier innebär i B2B-miljöer, föreslår denna avhandling ett ramverk som fokuserar på tre samskapande processer - experimentering, kommunikation och kunskapsförmedling - som kan hjälpa kunderna att ta reda på värdet av framväxande teknologier för deras företag. Avhandlingen avslutas med en diskussion om dess bidrag, både teoretiska och praktiska implikationer, och rekommendationer för vidare forskning.

Nyckelord: kommersialisering av framväxande teknologier, uppackning av värdet, gemensamt värdeskapande, experimentering, kommunikation, kunskapsförmedling, inramning av framväxande teknologier

Contents

List of Papers

I. G. Nussipova, F. Nordin, D. Sörhammar, 2020. Value Formation with Immersive Technologies: An Activity Perspective. Published in the *Journal of Business and Industrial Marketing*, 35(3), pp.483-494.

II. G. Nussipova, 2022. Framing Changes of the Value Proposition of Emerging Technologies in a B2B Context. Published in the *Journal of Business-to-Business Marketing,* 29(2), pp.99-118.

III. G.Nussipova, A. Yakhlef, 2023. Unpacking the Value of Emerging Technologies: The Role of Interactional Expertise. Submitted to the *Journal of Knowledge Management*.

Nothing is,
everything is becoming.
Heraclitus

New technologies are unrealized potentials
that may take a very large number
of eventual shapes.
Rosenberg 2009

1 INTRODUCTION

This chapter serves as an introduction to the thesis, providing an overview of the study's background and the specific research problem addressed through the collection of studies included in this work. The chapter also outlines the justification and aim of the study, along with the main research question that guides the investigation. Summaries of the research papers that form part of the thesis are included to offer a comprehensive understanding of the study's scope and contributions.

1.1. Emerging technologies

Emerging technologies[1] (ETs) are believed to contribute to economic growth (Groen and Walsh, 2013; McDermott and O'Connor, 2002) and provide productivity gains to businesses. Robotics and cloud computing are heralded to replace manual labor and traditional computing, while quantum computing, blockchain, and the Internet of Things (IoT) are hailed to fulfill their long-heralded promise (Grewal *et al.*, 2019). Such stories about ETs often evoke images from popular works of science fiction such as *The Matrix*, *Neuromancer*, and *Ready Player One*, painting a vivid picture of the deterministic future. Accordingly, there is a widespread belief that ETs are valuable per se, while the history has shown this is not always the case (Rosenberg, 2009). It can be tempting to view any ET as a solution to all problems, akin to a "silver bullet" as if the value of ETs is inherent.

In recent decades, the primary challenge for innovators has been not just creating innovations but also effectively commercializing[2] them (Sabatini *et al.*, 2020; Steenburgh and Ahearne, 2018). Many practitioners express

[1] By "emerging technologies" this thesis refers to technologies that are still in development and in early stage of adoption, and whose potential value has yet to be explored (see more in chapter 2.1.).

[2] Commercialization of ETs is defined as a multifaceted and continuous process, commencing in the early innovation stages and extending beyond the initial market launch.

concern that companies often lack a structured process to ensure that innovation has demonstrable commercial potential, leading to a disconnect between the promise of ETs and their perceived value to customers (Dhasarathy *et al.*, 2021; PwC, 2017). The saying, 'Good technologies do not usually sell themselves', from Smilor and Gibson (1991, p. 291) further highlights this disconnect. Technology providers often struggle to make the transition from ET breakthroughs to products that have value for the customer (Ostrom *et al.* 2015), defined as perceived value or the overall assessment of the benefits provided (Zeithaml, 1988). There are numerous historical examples of the remarkable inability to predict the value of ETs for customers and other stakeholders (Rosenberg, 2009).

While traditional approaches to understanding and communicating[3] the value of ETs have provided insights, they often fall short in capturing the dynamic and multifaceted nature of value. The complexity of the ETs and the evolving landscape of innovation call for a more nuanced exploration of how value is unpacked. Consider the epic failure of Google Glass, a futuristic eyewear, that flopped despite its breakthrough potential. There is, of course, much debate about the reasons why it failed, including geeky design and privacy issues. Remarkably, however, it lacked a clear value proposition and obvious viable applications (Altman, 2015). It seems that the company had relied on an assumption that the product would sell itself, following the "if we build it, they will come" philosophy. Google Glass solved the challenge of wearable computing but failed to articulate why people would want it. In a way, the media did them no favors by creating hype and raising public expectations. With a high price tag and no clear value for the customer, the product was officially pulled from the market after a media and public backlash. This example underscores the critical importance of unpacking the value of ETs to customers, a theme central to this research.

[3] In this thesis, the expression "communicating value" suggests a more traditional, one-way flow of information from providers to customers. It aligns with an "inside-out" perspective in which providers develop value propositions and then communicate them to potential customers.
The term "unpacking the value" implies a more interactive, two-way process. It suggests that the value of ETs is not just dictated by the provider but is co-created in dialogue with the customer. This aligns more closely with an "outside-in" perspective, where customer input is integral to shaping the value proposition.

One of my interviewees captured the essential complexity facing providers and potential customers of ETs by asserting that experienced practitioners are also puzzled:

> 'They are [emerging technologies] by nature still fairly new in the marketplace, and, in some respects, relatively unproven. The challenge in many respects is because they are relatively unproven, the business case around emerging technology doesn't have the level and depth and breadth of data points to support it, say, like an ERP or other legacy technologies or even cloud, as an example.'

This sparked my interest in the commercialization challenges of ETs due to their uncertain value (Haessler *et al.*, 2022), as the full impact and potential value of these promising technologies have yet to be explored (Kapoor and Klueter, 2021; Kumar *et al.*, 2021). As per Rotolo and authors (2015), the defining feature of ETs is that "[their] most prominent impact, however, lies in the future and so in the emergence phase is still somewhat uncertain and ambiguous". Although ETs are often hyped, thanks to the efforts of enthusiasts, marketers, and technology aficionados and others, customers face, what philosopher Dennis Gouler called, an "uncertain promise" (Gouler, 1977).

On the one hand, customers' uncertainty about the value of ETs negatively affects their incentive to buy, leading to potential biases against them (Hoppe, 2002; Walton *et al.*, 2002). On the other hand, the pressure of increasing competition forces business customers to embrace the latest technological advancements, despite the uncertain value and potential risks (IBM Institute for Business Value, 2021). This complex landscape underscores the profound issue that the value of ETs is uncertain, albeit promising. Despite the recognized importance of communicating value of ETs, the process remains poorly documented and understood (Kirchberger and Pohl, 2016; Probert *et al.*, 2013; PwC, 2017; Ye *et al.*, 2015). Ultimately, the commercial performance of any technology hinges on the perceived value by potential customers, a factor that transcends the chosen commercialization strategy chosen by a provider (Marx *et al.*, 2014). Therefore, unpacking the value is paramount to the commercialization of ETs. The commercialization of ETs presents profound challenges due to the uncertain value and complex landscape of innovation. This study seeks to explore the processes that unpack

the value of ETs to customers in a B2B context, focusing on processes that recognize the evolving, dynamic nature of value.

The subsequent sections will delve into the specific research need and present the research questions that guide this exploration.

1.2. Unpacking the value of emerging technologies

Technologies are not deterministic.
We can shape their pathways for good.
And we have an obligation to do it.

Shamika N. Sirimanne
Director of UNCTAD's
division on technology and logistics

Understanding the uncertainty of value

To better understand the issue why the value of ETs is uncertain let us open the aperture a bit. During one of my visits to industry events, the audience seemed to be at a loss in understanding what value the displayed gadgets could have for their businesses. The lack of rhyme or reason to the value of these ETs can be attributed to several factors. One reason for this uncertainty is that many ETs are often scientific research-based innovations. In these cases, inventors do not always know the potential applications, and thus the potential value of ETs to customers is unclear. As (Kapoor and Klueter, 2021) observe, the full potential of these applications might only be unearthed as time progresses. Furthermore, it is often unclear how potential customers would perceive the benefits associated with ETs. Thus, the ETs presented may seem like fancy gimmicks to potential customers, they may not know how to use them in their business, and they may lack a frame of reference/point of comparison (Veryzer, 1998). Another contributing factor for the uncertainty in the value of these technological marvels is the inability of technology providers to frame and communicate the value of ETs . All these factors contribute to the prevailing uncertainty about the value of these technological marvels.

Strategies for unpacking value

Traditionally, strategies for unpacking the value of ETs in a B2B setting have included technology demonstrations, pilots, quantifying benefits, and improving communication strategies (Chen *et al.*, 2007; Kirchberger *et al.*, 2020; Talke and Snelders, 2013; Thomke, 2003). These approaches, while valuable, often take a deterministic view, assuming that the value is inherent in the technology and can be objectively determined and communicated by providers. This perspective also may overlook the complexity and nuances of ETs' value and disregard the potential benefits of engaging in two-way communication with customers in co-creation (Ballantyne and Varey, 2006).

The deterministic approach to communicating the value of ETs has shown limitations. This approach may overlook the evolving nature of ETs (Kapoor and Teece, 2021), and the ways they can be adopted in new contexts, create new markets (Adner and Levinthal, 2002; Day and Schoemaker, 2000), or new product categories (Mark-Herbert, 2004). It often fails to identify unknown or underutilized applications because it presumes that the value of a given technology is largely inherent.

In contrast to traditional approaches, commercializing ETs may necessitate embracing a non-deterministic view[4] on value, recognizing that the full potential cannot be realized until it is used by customers in specific contexts. This outlook converges with the growing interest in value co-creation, especially from the lens of innovation and technology as evidenced by reviews (Galvagno and Dalli, 2014; Nájera-Sánchez *et al.*, 2020).

Prior literature has often conceptualized ETs as an operant resource, anchored in the Service-Dominant (SD) logic, becoming a critical resource for value co-creation (Lusch and Vargo, 2006). This perspective has led to a focus on

[4] A deterministic view on value assumes that the value of a technology is fixed and can be precisely determined through objective measures or existing conditions. It is based on the belief that given all the relevant information and context, the value is inherent and unchanging. This perspective might be aligned with more traditional economic theories where value is seen as intrinsic and quantifiable.
A non-deterministic view on value recognizes that value is not fixed and might change based on various influences, interpretations, and contexts. It accepts that the value of a product or technology might be co-created with customers, evolve over time, or vary across different applications. This perspective is more aligned with modern marketing and value co-creation theories where value is seen as dynamic and context-dependent.

technology-enabled co-creation (Breidbach and Maglio, 2016; Leone *et al.*, 2021; Stephen *et al.*, 2016), where technology is seen as a tool or facilitator, rather than exploring co-creation as a mechanism for understanding and unlocking the value of technologies themselves. In contrast, this study takes a different approach, recognizing that the commercialization of ETs requires a more nuanced understanding of value co-creation. Rather than viewing technology merely as an enabler, this research explores co-creation as a vital process that shapes the value of ETs, emphasizing the collaborative and dynamic nature of unpacking value in specific contexts.

In the realm of ETs, co-creation processes can enhance the understanding of benefits and applications of such technologies within distinct business contexts. In this paradigm, technology not only enriches the value proposition but also empowers customers to unlock its full potential. It emphasizes a collaborative approach where customers are not mere recipients of technology but active participants in shaping its value. While the co-creation theory has begun to reverberate in the literature, much of the research describes the process as a linear and singular sequence, as noted by (Friend *et al.*, 2020). That in the innovation lifecycle implies recognizing ongoing, iterative, and cyclical co-creation that continues even beyond the initial ideation phase (Rindfleisch and Fisher, 2023). On the other hand, several authors, such as (Payne *et al.*, 2008), (Grönroos and Voima, 2013), and (Powers *et al.*, 2016), underscore the importance of considering the iterative cyclical aspects of value co-creation that go beyond initial collaboration. This cyclical ongoing co-creation involves a continuous feedback (Meynhardt *et al.*, 2016), allowing the technology and its value proposition to be refined and evolve based on the users' needs and experiences. In the context of ETs, this ongoing co-creation process is crucial, as the value of these technologies often evolves as they are used, experimented with, and adapted to different contexts.

Furthermore, prevailing value co-creation theory often adopts a "zooming-out" approach, as elucidated by Leroy *et al.* (2013). This perspective concentrates on core elements, eschewing the finer details to offer streamlined understanding of the subject. While valuable, this approach might miss critical nuances in the context of ETs, such as the context in which ETs are used, how customers use them, and specific processes that contribute to unpacking of the value. Wang *et al.* (2019) have built upon this idea, arguing for the necessity of a "zooming-in" approach in value co-creation research. This perspective emphasizes a more detailed examination of the value co-creation processes,

shedding light on the subtleties and complexities that a "zooming-out" approach might overlook. This call for a closer look is in line with criticism of the value co-creation literature for being overly conceptual, without enough empirical research on the micro level of co-creation processes (Grönroos, 2017; Luotola *et al.*, 2017) making the study of co-creation more relevant for managers and practitioners.

Despite advancements in co-creation theory, certain aspects remain underexplored in the B2B context, leaving a fragmented understanding of how value is co-created (Saha *et al.*, 2022). The complexity of value co-creation in B2B scenarios is further heightened by the intricate interactions among various stakeholders (Grönroos, 2011; Lambert and Enz, 2012). This sentiment is reiterated by (Ramaswamy and Ozcan, 2018), who emphasize the intricacy of stakeholder interactions in the co-creation process. Among these stakeholders, intermediaries play a unique role, yet their contribution to the commercialization process remains underexplored (Haessler *et al.*, 2022). Commercialization is not a solitary process but often involves co-creation with various stakeholders. Intermediaries, in particular, act as bridges, facilitating the co-creation process and helping to translate technological potential into value for businesses. In the context of ETs, the role of intermediaries becomes even more challenging, as they must navigate the rapidly evolving technological landscape, facilitate collaboration between diverse stakeholders. This intricate role presents unique challenges and opportunities that warrant further investigation. Additionally, the role of intermediaries in co-creation is gaining attention in recent research (Nájera-Sánchez *et al.*, 2020; Ngongoni and Grobbelaar, 2017), signaling an area that appears particularly ripe for exploration.

This section has identified a research need for further research into the co-creation of ETs with a more nuanced understanding of value co-creation. It has underscored the evolving, dynamic nature of ETs' value and the importance of ongoing, iterative interactions in shaping that value. In doing so, it aims to contribute insights to both theory and practice, enhancing our ability to unpack the value of ETs and offering a more comprehensive understanding of how businesses can leverage co-creation in the evolving field of ETs.

1.3. The aim of the study and RQs

Given the identified need in the existing literature for a more nuanced understanding of value co-creation processes in B2B contexts, there is an evident need to delve into these areas, especially in the field of ETs. Value creation in the context of ETs is on the agenda of CEOs, business leaders, policymakers, and organizations like the World Economic Forum, which actively explores opportunities for value creation with these technologies (Paschen *et al.*, 2019). Given the evolving nature of ETs, it is vital to adopt a nondeterministic perspective on their value to better grasp its complex and nuanced nature. recognizing that value creation can be a complex and interactive process. This perspective recognizes that value is not created solely by the technology provider, but jointly through the collaboration of customers and other stakeholders. Adopting this broader perspective can help in aligning the development and commercialization of ETs more closely with customer needs, anticipating potential challenges and opportunities, and shaping strategies or processes that help unpack the value creation. Recognizing that value creation is a complex and interactive process, shaped by processes through which value is co-created, the contexts in which it's applied, and the users, sets the stage, the aim of this thesis is as follows:

"To develop a framework of co-creation processes that help customers unpack the value of ETs for their businesses."

To achieve this aim, the study will address the following research questions: a) How is value created by the customers through the experimentation process? b) How is the value of ETs framed in value propositions and how has framing changed over time? c) How do knowledge brokers facilitate the value of ETs? (see Table 1).

What is clear from previous research is that there is a need to examine value co-creation more closely, "zooming in" on nuanced aspects such as co-creation processes, contextual factors, and the unique dynamics of the B2B environment. In light of aforementioned theoretical considerations, this research applies a qualitative, theory-building approach to develop a framework that articulates and integrates *experimentation, communication, and knowledge brokering* processes, both theoretically derived and empirically grounded, to help customers unpack the value of ETs in B2B

contexts. Together, these processes form a comprehensive framework that can guide both academic exploration and practical application.

	Article 1	Article 2	Article 3
Title	Value Formation with Immersive Technologies: An Activity Perspective	Framing Changes of the Value Proposition of Emerging Technologies in a B2B Context	Unpacking the Value of Emerging Technologies: The Role of Interactional Expertise
Contribution	authors contributed equally	single author	main author
Outlet	Journal of Business and Industrial Marketing, 35(3), pp.483-494.	Journal of Business-to-Business Marketing, 29(2), pp.99-118.	Previously presented at PDMA Inspire Innovation Conference and JPIM Research Forum, 2022. Submitted to the Journal of Knowledge Management.
Processes	Experimentation	Communication	Knowledge Brokering
Research objectives	How is value created by the customers through the experimentation process?	How is the value of ETs framed in value propositions and how has framing changed over time?	How do knowledge brokers facilitate the value of ETs?
Theoretical framework	Activity theory, Customer-Dominant Logic	Value proposition theory	Interactional expertise theory

Table 1 Summary of the Articles

This thesis seeks to explore the processes of co-creation whereby helping customers unpack the value of ETs that are still in development and in the early stages of adoption. In the context of ETs, this research investigates the specific processes of co-creation, where providers, customers, and other stakeholders actively engage in unpacking of the value of ETs. The insights derived from this study have broad implications for those seeking to foster collaborative processes that bridge the gap between technological potential and customer value in the evolving landscape of ETs.

This thesis contributes to the co-creation literature on ETs by developing a framework of processes that help customers unpack the value of ETs, which seeks to answer the calls for a better understanding of value co-creation in the context of ETs (Mele *et al.*, 2018; Weingarden, 2018). Grounded in the empirical data obtained from qualitative case studies and interviews, this thesis suggests that value emerges in a co-creative process of interaction of various stakeholders, including providers of ETs, customers, and knowledge brokers. This contrasts with the deterministic way of thinking that views value of ETs as inherent and predetermined by provider. The findings have implications for the commercialization literature by outlining a comprehensive framework for understanding how *experimenting, communicating and knowledge brokering* work together to facilitate the spread and commercialization of ETs. The results also support the view that commercialization is a process that evolves over times. Finally, this thesis contributes to the marketing literature by clarifying the value proposition change and how this change takes from the *vision* frame to *network*, and then to the *use*.

The proposed framework, undergirded by empirical material elicited from case studies and interviews in B2B settings, can aid managers in both large companies and startups deal with uncertainty about value by applying value co-creation processes. On a practical level, managers may recognize the significance of the synergistic role of these three processes - experimentation, communication, and knowledge brokering - and leverage them to their advantage as they navigate the complex landscape of value creation for ETs. These processes, acting in concert, provide a roadmap for understanding and unlocking the potential value of ETs within various contexts. The insights derived from this thesis offer valuable perspectives not only for technology developers and marketers but also for policymakers and scholars. These

stakeholders can collectively benefit from the presented framework, as it emphasizes a collaborative and adaptive approach to value creation in the uncertain technological environment.

1.4. Empirical context

In this section, I will delve into the empirical context that briefly outlines the development and the unique features of AR/VR technologies, as notable examples of ETs. By illustrating it, I aim to provide a better understanding of the increasingly complex, dynamic, and uncertain environment of ETs. Additionally, the historical context demonstrates that ETs need not be an absolute novelty to be recognized as such, as some technologies can take decades to gain acceptance.

AR/VR technologies as ETs

It should be emphasized that the context arose from my initial curiosity and deep interest in the phenomenon of ETs. Specifically, this thesis explores the processes facilitating unpacking the value of ETs in business markets. The various empirical cases are selected primarily in the context of different perspectives on value that have been studied: customer, provider, and knowledge broker. Research focus is shifting from a specific focus on AR/VR technologies in the first and second studies to ETs in general in the third. Often ETs are considered in combination, this referred to as convergence or bundling of several complementary technologies. Technological convergence is a term used to describe the bringing together of previously unconnected technologies, often in a single application. For example, Artificial Intelligence (AI) is a broad term that describes a set of technologies that function without explicit human guidance. At the core of AI are automation and machine learning, which support applications such as natural language processing, computer vision (e.g., Tesla Autopilot), and optimization and decision support (e.g., Google Maps). The complexity of AI is predefined by the premise that ETs are regarded as part of 4th industrial revolution (Schwab, 2017), and as last trend suggests, are essential for metaverse[5] touted as next big thing, which promise to blur the lines between the physical, digital and biological spheres of global production systems. Technologies are becoming more and more

[5] The metaverse is a single, shared, immersive, persistent, virtual space where people experience life in ways they could not in the physical world. It is a vision of what many believe to be the next iteration of the Internet.

complicated and interconnected. The study of how to "explain" technologies such as artificial intelligence or the Internet of Things has become a separate area of research (Gunning and Aha, 2019). Thus, the unique characteristic, convergence, distinguishes ETs from new technologies introduced decades ago. Innovation and uncertainty go hand in hand and that it is the very essence of ETs that impedes their commercialization.

AR/VR technologies possess characteristics expected of ETs – potential yet largely unrealized practical application, and being in early adoption stage. These technologies are currently evolving, with VR being slightly more advanced than AR. The convergence of these technologies is anticipated to create a 'merged' or 'extended' reality, enhancing our interactive experiences. Gartner and other consulting firms (e.g., PwC, Deloitte, Accenture) consistently recognize AR/VR in their evaluation of ETs, describing specific technologies through a lifecycle of phases.

In attempt to simplify, some researchers sometimes categorize VR or AR as part of “virtual worlds”. This umbrella term includes virtual games and virtual-related experiences. As Bell (2008) posits “virtual worlds” as a “synchronous, persistent network of people represented as avatars, enabled by networked computers” (p.2). Taylor and colleagues (2013) go further, suggesting that 'virtual worlds' are 'places of imagination'. Hence, AR/VR are not strictly imaginary, as they are not separate from existing physical forms, so the context influences the experience further. AR/VR have more in common, as they both hijack our ability to perceive the world around us, fooling the brain into believing another alternate reality.

The AR /VR phenomenon aligns with the Azuma’s continuum, spanning from virtual reality, a wholly immersive digital experience, to augmented reality (AR), a blend of the real and digital worlds, and finally, to actual reality. VR creates a fully artificial environment, AR is the midpoint between the real and virtual world, and actual reality is our day-to-day experience (Milgram, 2011). The main differentiator in VR and AR is the ability to see natural surroundings.

Immersive technologies, an umbrella term for technologies that blur the line between the physical and digital realms (Lee *et al.*, 2013; Witmer and Singer, 1998), have also been referred to as mixed reality, digital reality, or extended reality. These varying terms mirror the dynamic evolution and transformative

progression of the technologies. Initially, the term "virtual reality" sufficed to describe the field, however, as the technology advanced and diversified, new terminologies were coined. The shift from 'virtual reality' to a spectrum of realities indicates the increasingly nuanced understanding of these technologies, acknowledging their diverse potential beyond gaming or entertainment. These novel terms serve to articulate new dimensions and applications that were not encapsulated by the original vocabulary, thereby attesting to the expanding conceptual scope of the field. Moreover, these terms are anticipatory. They foresee how we might interact with digital content in the future, highlighting the transformative potential of AR and VR. Therefore, the dynamic nature of these terms indeed parallels the dynamic and transformative nature of these technologies. For instance, when we use terms like "extended reality", we acknowledge that the field of reality-altering technologies is expanding beyond just AR and VR. Importantly, it's a term that anticipates the creation and adoption of new technologies that blend the digital and physical worlds in ways we've yet to fully realize or conceptualize.

Historical overview

Virtual reality is not a modern invention: its precursors can be found in the stereoscope or stereograph of the 19th century. As early as 1838, Charles Wheatstone invented the stereoscope to create a 3D image. In 1900, an Irish telescope manufacturer, Sir Howard Grubb, invented a device to help align projectile-firing weapons. The 1960s paved the way for virtual reality with the 'Sensorama Simulator', invented in 1957, and the 'Sword of Damocles', invented in 1966. The Sword of Damocles was invented by Ivan Sutherland and is considered the first VR/AR head-mounted display system.

When VR came out of the research labs in the 1990s, it was believed that VR was a revolutionary technology that would take the world by storm. The term 'virtual reality' was coined by Jaron Lainer in 1989 and 'augmented reality' was coined by a researcher from Boeing Thomas P. Caudell in 1990. VR has long been placed in the realm of entertainment due to popularity in gaming, albeit different market segments emerged much later. The VR has seen a second resurgence following the launch of Oculus in 2012, which has led to much more competition in the industry. Oculus was a Kickstarter-funded project with a head-mounted virtual reality display in pre-production, aimed primarily at immersive video gamers. The rejuvenation of VR led to the entry of a wide array of new players in the market, all contributing to the growth of technology and the decreased costs of devices. Beginning in the 2010s, Oculus

(Rift), HTC (Vive) and Sony (PlayStation VR) released next-generation commercial headsets, launching a new wave of development. AR became recognizable with the overnight success of the Pokémon Go app when AR Gaming took off. Investors and developers were buoyed by 10 million+ downloads in the first week. Thus, ubiquitous penetration and use of mobile devices serve the AR community. Smartphones are becoming a dominant AR delivery platform today driving consumer adoption, since AR is available on every phone. This is creating revenue as there are about 3.4 billion smartphones worldwide, most of which are compatible with web AR. That is followed by intervention of Facebook's Spark AR (including Instagram and Messenger), ARKit, ARCore, and Snapchat. The AR/VR category has yet to gain widespread consumer acceptance. Unfortunately, some hyped projects have flopped, such as the infamous Magic Leap, which raised $3 billion in venture capital in 10 years while lurching from one vaporware announcement to the next. A similar example is Google Glass, which was launched in 2013 but was discontinued two years later because customers quickly realized that it could do only a handful of things as well as the iPhone.

Unlike VR, AR is still in the process of finding the right *form factor*. The 'form factor' is a term for hardware design that defines and prescribes the size, shape, and other physical specifications of components. Inasmuch, AR now comes in a variety of forms: smartglasses, headsets, tablets, smartphones, projectors, and heads-up displays (HUDs). This slows down product and ecosystem development and makes it harder to communicate its value. More recently, wearable contact lenses have also become available. It is possible that none of these shapes is the right or final form factor and that a different design will come to market. From the perspective of the social construction of technology, this means that closure is not achieved because alternative designs are needed.

It has been argued that AR/VR could reshape the world the way mobile phones or computers did before, thanks to breakthroughs in wearables, optics, and sensors. VR and AR move processes into immersive environments that do not exist in the real world, but allow interaction with them due to a number of insightful features. These features are described as immersion, interaction, sense of presence, involvement, vividness, and embodiment, which make the technology special and differentiated. They are created by incorporating various cues (smell, touch, taste, sound, sight) that deceive the human senses. The feeling of "presence" is "the sense of being in an environment" (Gibson,

2014), “the subjective experience of being in one place or environment, even when one is physically situated in another”(Witmer and Singer, 1998). There is evidence that presence experienced in VR might surpass reality depending on the context (Villani *et al.*, 2012). Involvement happens with a focus and attention on coherent stimuli and varies according to how well the activities and events attract the viewer’s attention. The feeling of interaction occurs when a user is able to interact with the environment naturally through the use of input controllers in VR, or manipulating virtual objects with bare hands in AR (Suzuki *et al.*, 2014). Immersion or immersiveness has been described as the “sensation of being surrounded by the virtual environment” (McMahan, 2013) or being enveloped by the multisensory representation of the virtual world (Arsenault, 2005). Vividness is the richness of an environmental representation expressed in visibility, audibility, touch, smell, and quality, fidelity (Van Kerrebroeck *et al.*, 2017). Due to involvement of these sensations, this technology is described as “a technology with which you could see more than others see, hear more than others hear, and perhaps even touch, smell and taste things that others cannot” (van Krevelen and Poelman, 2010) .

Due to the pandemic, the world has begun to migrate to the virtual world in 2020. This forced companies to make changes in record time and accelerated the development of innovations that took place in many fields. For many companies, the pandemic was a good time to launch virtual and augmented reality systems, affording companies to innovate and co-create value (Cooper, 2021). The VR/AR industry, feeling the momentum, has started promoting its agenda, suggesting that this technology is a solution for social distancing and remote work. Here are just several examples, signifying their attempts to outline the benefits of technologies for: remote work, learning/ training, on-site virtual assistance, and home entertainment. Thus, the adaptation of AR/VR has taken on new urgency due to recent events, bringing the unique features of hands-free interactive smart glasses to the forefront. The push to implement immersive technologies quickly highlighted the uncertainties and risks involved, but still provided more evidence of value creation.

1.5. Overview of the thesis

As noted above, three articles were written as part of the research project, each with separate, though complementary research objectives to underlie the overall aim of the thesis. Table 1 lists the objectives of each article as well as the research questions posed, the publication outlet, and the theoretical framework. This research study is structured into five chapters. Chapter 1 includes the background of the study, the statement of the problem, the aim of the study, the significance of the study, the definition of terms, the theoretical framework, the research questions and the assumptions of the study. Chapter 2 presents a review of the literature, including matching processes. Chapter 3 describes the methodology used for this research study. It includes the research paradigm, data collection, and data analysis procedures. Chapter 4 summarizes the main findings, contributions, and implications of each article. Chapter 5 provides a concluding discussion of the findings, implications of the thesis, recommendations for further research, and conclusions.

2 THEORETICAL FRAMEWORK

Recognition of value as emerging from interaction has become a more recent focus of marketing researchers. In the context of turbulent and uncertain environments of ETs, with the increasing role of the customer in co-creation, the importance of value that co-created in interaction and evolving over time has assumed increased significance. In response to this complex landscape, this thesis employs an abductive reasoning approach to develop a nuanced framework that explores the interconnected processes of experimentation, communication, and knowledge brokering. Specifically, Chapter 2 offers a comprehensive overview of the concept of ETs, highlighting various definitions, perspectives, and nuances associated with the term. The chapter also provides a well-reasoned rationale for using the term "emerging technologies", highlighting that it offers a more nuanced and inclusive understanding, avoiding deterministic assumptions about the inherent value of technologies. The chapter also delves into commercialization, and matching processes and concludes with the presentation of the framework. This framework serves as a guiding structure for the subsequent exploration and analysis, bridging empirical observations with theoretical insights to unpack the value of ETs for customers.

2.1. Defining emerging technologies

The phenomenon of “emerging technologies” has been defined and conceptualized in different ways by scholars since it first appearance in the 1960s (Cozzens *et al.*, 2010). Some researchers consider technology emerging based on its potential significance and impact on the economy (Archibugi, 2017; Hung and Chu, 2006; Porter *et al.*, 2002; Rotolo *et al.*, 2015). Others, like Day and Schoemaker (2000), emphasize the expansion of the knowledge base and the inherent complexity and uncertainty of ETs. While others, such as (Millea *et al.*, 2005) highlight the market dimension by stating that "a technology is still emerging when it is not yet a must have". Despite the varying definitions, most scholars agree that ETs are characterized by their novelty, growth, coherence and conceptual autonomy, salient impact, and

uncertainty. They have the potential to create new markets or transform existing ones (Adner and Levinthal, 2002; Day and Schoemaker, 2000), and they also pose a threat to some firms (Srinivasan, 2008). An insightful perspective by (Bailey *et al.*, 2022) enrich our understanding of the "emerging technologies" term. Their view acknowledges that a technology is not just "emerging" because it is new, but also because its impacts and uses are still evolving and have not yet solidified into well-defined patterns. This is an important distinction because it explicates the definition of "emerging technology" beyond simply the novelty of the technology.

The crux of most definitions of ETs is their uncertain potential, which means that the future outcomes and applications of ETs are not yet defined (Litvinski, 2018). By definition, ETs are uncertain, immature, and unproven, but promise significant value (Rosenberg, 2009; Rotolo *et al.*, 2015). In reviewing the definition of ETs, Cozzens *et al.* (2010) summarize what most studies agree on and define the characteristics of ETs as: growth, transition or change to something new, market or economic potential, and science-based innovation. Considering the potential, some scholars prefer the term “radical technology”, which focuses on the potential for delivering dramatically better product performance or lower production costs (Utterback, 1996). ETs can sometimes be defined as radical as they have potential to displace or make obsolete current technologies and/or creating entirely new product categories and markets. At the same time, however, not all ETs are necessarily radical. Although some scholars refer to ETs as "new technologies", i.e. "those that are early in the adoption cycle for firms and/or consumers", this term misses the point of their potential (Weingarden, 2018). Meanwhile, it was noted that different conceptualizations of ETs have made it difficult to identify common underlying mechanisms and to apply earlier findings to new commercialization challenges (Haessler *et al.*, 2022).

Other scholars use the term "disruptive" technologies (Li *et al.*, 2018), while this thesis is of the view that "disruptive" is a misunderstood and overused term (Markides, 2006). Contrary to its common usage, "disruptive" is not just another way of saying "truly innovative." According to the definition of Clayton Christensen and collaborators (2015), disruptive innovation is an innovation that overtakes an existing market by applying a different set of values and creating an entirely new market. For example, digital photography was a disruptive innovation that overtook chemical photography; Wikipedia was a disruptive innovation that overtook traditional encyclopedias. Few ETs

can be truly called disruptive, but rare is the one that is not touted as "disruptive". This is not to say that ETs cannot be disruptive, but not all ETs are disruptive, which is not always obvious. In the same vein, not all disruptive innovations are necessarily radical, nor are all radical innovations necessarily disruptive (Govindarajan and Kopalle, 2004). Therefore, the more inclusive term of ETs is used in this context, which highlights the uncertain value or "promise" of a technology without the need to focus on whether it is disruptive or not. This notion circumvents the deterministic assumption that technologies possess value inherently.

In this thesis, I focus on ETs that are currently in the developmental phase and in in the early stages of adoption. The potential value of these technologies, encompassing both practical applications and more extensive societal implications, remains largely unexplored. This approach aligns with a consensus within the broader scholarly discourse concerning the definition and significance of the subject (Adner and Levinthal, 2002; Bailey *et al.*, 2022; Chiarello *et al.*, 2021; Kapoor and Klueter, 2021; Kapoor and Teece, 2021).

2.2. On the commercialization of emerging technologies

While the term commercialization is frequently used in the literature on innovation, it is only generally defined and applied. In many cases commercialization has been assumed to be part of innovation and clearly distinguished as a final separate phase focused on launch (Koen *et al.*, 2001; Malecki, 1997; Mansfield, 1988). There are also others who argue that commercialization begins much earlier, at the conception stage rather than at the end (Aarikka-Stenroos and Lehtimäki, 2014; Cubero *et al.*, 2020). While it may suggest a sequence of ordered phases, in fact, the innovation process outlines essential types of activities for innovation (Bessant and Francis, 1999). In practice, it can be highly iterative and context-dependent (Gurcaylilar-Yenidogan and Aksoy, 2018), influenced by various factors such as needs, technological state, and organizational obstacles (Tidd and Bessant, 2020).

This thesis shares the view that commercialization of ETs is a multifaceted and continuous process, commencing in the early innovation stages and extending beyond the initial market launch. As outlined by Aarikka-Stenroos and Lehtimäki (2014), the commercialization process begins in a subtle

manner at the inception of innovation, and gradually intensifies in accordance with the progression of the technology. Furthermore, when viewed through the lens of provider-customer interaction perspective, commercialization is seen as the commitment of providers in helping customers to realize the full benefits of innovation (Athaide *et al.*, 1996). In this sense, it includes processes that contribute to unpacking of the value of ETs for customers. These processes span the gamut of development, testing, refinement, and even continue through to the post-product launch stage. Thus, commercialization occurs long before the market launch and continues long after its initial release. Many decisions made in the early stages of the development process impact the overall commercialization and success of a technology . For example, front end visioning and early market and concept decisions influence further activities (Markham, 2013; Reid and de Brentani, 2012). Research has shown that processes in innovation are interconnected and evolve simultaneously (Aarikka-Stenroos and Lehtimäki, 2014; Eldred and McGrath, 1997; Prebble *et al.*, 2008). Importantly, this nested complex interaction of the processes implies that an innovation process should include a notion of a customer from the outset (Harrison and Waluszewski, 2008; Oudshoorn and Pinch, 2003). This is consistent with the work of (Blank, 2018) and (Ries, 2011), who argue that the process of "customer development" should parallel the process of "product development." Commercialization and product development are, thus, integrated in iterative learning loops where planning for commercialization occurs while the product is still being developed, allowing the market to inform product development. Increasingly, research has moved toward considering commercialization not at a later final stage, but rather influencing the early stages of innovation (Cubero *et al.*, 2020, 2021). For example, (Cooper and Kleinschmidt, 1988) considered commercialization as "the 'back end' of the process", which includes market launch, production start-up, trial sell, and trial production. Later, however, the notion of continuous feedback loops was incorporated and suggested that the market launch planning should begin early in the development process.

Importance of Commercialization for ETs

It goes without saying that commercialization is critical for ETs providers due to significant investment and efforts required for their development. Without commercialization, companies and investors may not receive a return on their investment. As noted earlier, historical experience shows that attempts to

commercialize ETs can vary widely, from outright failure[6] to a major phenomenon like the Internet or smartphones becoming part of daily life. Some technologies are making great strides in the marketplace, but many of them are only developing at a glacial pace. For example, nuclear magnetic resonance, laser, impedance analysis, GPS, and optical spectral analysis had no clear practical application and no obvious commercial potential even after their technical feasibility was established (Gross *et al.*, 2018; Rosenberg, 2009). Companies that bring ETs to market must surmount many challenges, including recognizing new technological possibilities, organizing the human and financial resources needed, and carrying out the research and development activities (Hall *et al.*, 2014), along with finding the market, and proof of value. Mindful of the limitations, one must fully appreciate the origins and wide array of uncertainties attached to commercializing ETs. Technical, market, and organizational uncertainties associated with these kinds of projects are much higher than for incremental improvements (Burgelman and Sayles, 1988). In this context, commercializing ETs is complicated and risky (Frattini *et al.*, 2012; Hung and Chu, 2006) against the backdrop of high failure rates (Datta *et al.*, 2015). These difficulties are underpinned by historical cases showing that commercialization of technologies can take several decades (Gross *et al.*, 2018; Rosenberg, 2009) and the outcomes are still uncertain. The examples of computers, lasers, and telephones illustrate the difficulty involved in predicting how ETs would develop and create value (Rosenberg, 2009). Evidently, not all technologies demonstrate commercial performance and generate profits (George *et al.*, 2002; Markham and Lee, 2013). To be sure, some are rejected (Burton-Jones and Hubona, 2006) or partially accepted (Vishwanath and Scamurra, 2007). Meanwhile, some researchers assert that a significant number of market failures of newly developed technologies are attributed to commercialization (Chiesa and Frattini, 2011; Eldred and McGrath, 1997; Gans and Stern, 2003; Michel *et al.*, 2008), not the innovations themselves. Indeed, as (Laird and Sjoblom, 2004) note, “promising technology is no guarantee of commercial success”. To translate promise into value for customers, inventions need to be transferred to the market through the process of commercialization (Adams, 1990; Spann *et al.*, 1995).

The existing literature asserts that commercialization of ETs necessitates matching with market opportunities (Bond III and Houston, 2003; Hellman

[6] https://museumoffailure.com/

and Boks, 2006; Jolly, 1997; Maine *et al.*, 2012; O'Connor and Veryzer, 2001). A significant challenge for ETs providers lies in identifying and understanding the potential and discerning the markets that would be receptive to them (Gruber *et al.*, 2008). As Tesar (1974) suggested, the role of marketing in introducing ETs is akin to "bridging the gap that lies between the technology and the consumer" (p. 643). A variety of terms are employed in this context, such as technology-market coupling, bridging, matching, or linking. Some perceive it as "the degree to which technology can be matched to customer demand" (Bond III and Houston, 2003), while others envision it as the combination of technological knowledge with information about market demand(Gruber *et al.*, 2008). The "technology-market matching" is a descriptive and expressive collocation encapsulating the key concern for providers seeking competitive advantage by matching ETs to market opportunities with the view to creating customer value (Harmon and Laird, 1997). Furthermore, the idea of matching implies that the value of ETs is not given, but co-created as a result of the process. Indeed, the process of matching technology and market can be described as a collaborative quest wherein actors jointly co-create the value of ETs. It's worth noting that demand and markets for such technologies may not exist initially, necessitating their creation. Some authors believe that this matching should be structured and disciplined (Laird and Sjoblom, 2004) guided primarily by the value: where the technology will be used and where it will add the most value. In a related manner, (Probert *et al.*, 2013) point out to the key questions, namely, that are what is the value of this technology and how can this value be communicated.

2.3. Technology-market matching as value co-creation processes - an abductive approach

Despite its recognized potential, evidence suggests that co-creation has not always yielded positive outcomes. In some instances, it has resulted in co-destruction (Lintula *et al.*, 2018; Rindfleisch and Fisher, 2023) and its adoption among companies remains limited (Loughlin *et al.*, 2020). These challenges may be attributed to a lack of clarity on how to effectively implement co-creation processes, particularly in the evolving field of ETs. The complexity of these technologies, coupled with the dynamic nature of the markets they serve, calls for a more tailored approach to co-creation. Furthermore, recent scholarly works have underscored the need for a more profound understanding of value co-creation within the realm of ETs (Mele *et*

al., 2018; Weingarden, 2018).This emphasize the importance of exploring co-creation not just as a theoretical concept but as a practical tool for unlocking the value of ETs in specific business contexts. In response, this thesis presents a framework, conceived through abductive reasoning, to illuminate the intricacies of value co-creation in B2B settings with a focus on ETs. Abductive reasoning, characterized by crafting the best plausible explanations from observations, guided the synthesis of three processes: *experimentation, communication, and knowledge brokering.*

In developing the framework for unpacking the value of ETs for customers, the significance of *experimentation* emerged as a central theme. This emphasis on experimentation finds resonance with established theories and methodologies. For instance, Experiential Learning Theory (Kolb, 1984, 2014) underscores the importance of learning by doing through hands-on experience and reflection. Similarly, Popper's philosophy of falsificationism (Popper, 1959) emphasizes rigorous testing and real-world validation, principles that align with the framework's focus on experimentation. The Lean Startup methodology (Ries, 2011) with its emphasis on rapid, iterative testing, and pivoting based on customer feedback, further supports the centrality of experimentation in the framework. For instance, the design thinking concept (Brown, 2008) includes a phase of prototyping and testing solutions.

The next theme of *communication* is justified by developing a value proposition in accordance with Anderson *et al's* (2006) work on customer value propositions. Their research emphasizes the importance of understanding customer needs and preferences, co-creating value, and tailoring offerings to meet specific customer requirements. This literature offers a theoretical basis for comprehending the development, refinement, and co-creation of value propositions between customers and providers as the core for the communication element of the framework. Bakhtin's model of dialogic interaction (Bakhtin, 1981), highlighting the essential role of continuous feedback and interpretation, underscores ongoing and dynamic nature of dialogue, where meaning is constantly negotiated and co-created. In the context of ETs, this can be applied to the way value propositions are framed and communicated. Rather than a fixed or one-sided message, the value proposition becomes something that is co-created through interaction with various stakeholders, including customers and others.

This inclusion of *knowledge brokering* emerges as abductively justified through the various theoretical lenses. The concept of knowledge translation, as explored by authors such as Wenger (1999), emphasizes the crucial role of bridging gaps between complex technical information and specific contexts, a role that knowledge brokers often fulfill. The work of Nonaka and Takeuchi (1995) provides additional support for the integration of knowledge brokering by highlighting the importance of converting tacit knowledge into explicit forms and facilitating its dissemination. Additionally, the literature on boundary-spanning roles (Tushman and Scanlan, 1981) underscores the significance of individuals or entities, who can bridge disparate domains, fostering collaboration and alignment, a function that knowledge brokers perform. These theories collectively provide a strong theoretical grounding for adding the knowledge brokering in the framework, reflecting its essential role in the unpacking of ETs' value.

These theoretical underpinnings establish a robust foundation for a framework comprised of three processes – *experimentation, communication, and knowledge brokering* – which are suggested as helping unpacking the value of ETs to customers, thereby potentially enhancing the commercialization. The subsequent sections will provide detailed discussion and evidence supporting the importance of these processes.

While there exist other theories and perspectives related to these themes, the selected focus areas have been chosen for their direct relevance to the research objectives and the specific dynamics of value unpacking in the context of ETs. The following sections 2.3.1.-2.3.3 will provide a detailed exploration of these themes, further justifying the choice of focus, and elucidating their contributions to the overall framework.

2.3.1. Experimentation

Role of Experimentation

The process of co-creation through experimentation serves as a critical mechanism for unpacking the value of ETs to customers. By engaging customers in the experimentation process, businesses not only gain valuable insights into customer needs but also empower customers to explore the value of ETs for themselves. This mutual exploration process is at the heart of co-

creation, ensuring that the technology developed is not just innovative but also closely aligned with customer needs and preferences.

To begin with, matching ETs to the market is not merely a straightforward task, but a creative process (Dougherty and Heller, 1994) that involves co-creation between providers and customers. This co-creative endeavor requires experimentation with various features, close collaboration with customers, and simultaneous pursuit of multiple development paths. In essence, providers make assumptions about the possible applications of a given technology (Bourreau *et al.*, 2012). Experimentation is one of the processes identified in the literature that helps customers unpack the value of ETs, which involves the 'learning by doing' approach (Minniti and Bygrave, 2001). Moreover, this process allows providers to gain valuable insights into customer needs, preferences, and behaviors. It can also identify new market opportunities and test the viability of different hypotheses on perceived value. To add some nuances to the term, methods such as testing, prototyping, mock-ups, pilot projects, and "trial and error" approaches are considered significant building blocks of experimentation process.

Mitigating Uncertainty and Uncovering Latent Needs

Moving on, experimentation is critical for ETs to determine their application, as noted by various scholars (Chesbrough, 2020; Galende, 2006; Mahdavimazdeh *et al.*, 2020). It is often the initial step in identifying areas where the new technology can be applied. The study by Lyly-Yrjänäinen and authors (2019) found that uncertainties about customer preferences as well as uncertainty about value to customer are significantly mitigated by using mock-ups early in the development process. Similarly, Anderson and Wynstra (2010) stressed that experimentation is an effective tool for reducing uncertainty about the value of high-value purchases in business markets.

However, while traditional marketing research methods are instrumental in understanding known customer needs, they may not always uncover unexpressed or latent ones. Experimentation with ETs, instead, offers an alternative approach. Through experimentation, businesses can introduce these technologies to customers, potentially revealing latent and unmet customer needs—those needs that consumers may have but are not yet aware of or have not expressed. Furthermore, these ETs have the potential to not just reveal these latent needs, but also fulfill them (Rocafort, 2017). Once these

latent needs are identified, the technologies can be developed and adjusted to meet these newly discovered needs, thus opening up new market opportunities (Zhou *et al.*, 2005).

Predicting the use of ETs is challenging (Gillier and Piat, 2011), as many innovations often have unexpected applications. Therefore, providers should not overlook the discovery of new application areas (Narver *et al.*, 2001), as experimentation can reveal previously unknown applications (Galende, 2006; Mahdavimazdeh *et al.*, 2020). This implies that ETs may have applications very different from those envisioned by providers. For example, Isa and Liem (2021) demonstrates how LEGO uses physical prototypes as a tool to facilitate the co-creation of ideas and design solutions, as well as the anticipation of future customer needs. This illustrates the potential for ETs to serve unexpected purposes and meet previously unrecognized needs when used in an experimental context.

Instead of analyzing the market and carefully selecting the best alternative, some companies introduce an early prototype of an innovation to the market, learning from users' feedback and making appropriate changes based on this real-world input. This strategy can be risky, potentially revealing a company's plans to its competitors, but the insights gained can be invaluable. For example, one strategy to effectively displace an existing solution that is approaching maturity on its "S-curve" is to introduce a technology that is still under development (Nordin and Ravald, 2023). This involves familiarizing potential customers with the technology while it is still developing, testing whether it could potentially replace existing, outdated solutions. In this way, it is easier to understand the real needs of users and find out where the value lies during the testing phase (Laird and Sjoblom, 2004). By conducting pilot projects, good and well-grounded hypotheses can be obtained about what customers might value. In other words, providers make assumptions about possible applications of a particular technology and considers which markets would be interested in the technology in its current, often inferior, form, due to it being in still in an early stage (Wouters *et al.*, 2018). An apt example of this approach is Netflix's transition from DVD rentals to online streaming. Despite their success in the DVD market, Netflix boldly experimented with the new and underdeveloped streaming technology. This proactive strategy, refined through user feedback, allowed Netflix to smoothly shift from the maturing DVD market to the burgeoning streaming industry, illustrating the effectiveness of such a strategy.

Co-creation and Shared Understanding

Beyond that, experimentation plays a crucial role in developing a shared understanding of the value of ETs, particularly when there are multiple and conflicting perceptions of value. One of the primary challenges related to the value of ETs lies in addressing these differing perceptions (Ruiz *et al.*, 2007). The process of co-creation offers a solution, as it emphasizes the joint creation of value among stakeholders, ensuring better alignment with the needs and preferences of customers who use these technologies. The social construction of technology approach further reinforces this notion, positing that all members of a group must have the shared meaning for the artifact (Pinch and Bijker, 1984). Carlile (2002), for one, used prototypes to examine how specialists from different functions who held different views could come to a common understanding of the final design. By engaging in a continuous dialogue and incorporating feedback from other perspectives, providers can enhance the co-creation process and ensure a higher degree of alignment with the target audience's needs (Prahalad and Ramaswamy, 2004).

Context of Use

Moreover, the context of use is also important in shaping the perceptions and applications of technology by different user groups. One of the biggest challenges lies in the fact that customers often do not recognize the value of a product until they have experienced it in use (Lanning, 2000; Woodruff, 1997). This perception of value can evolve from practical experience with new technologies (Orlikowski, 1996, 2000). The exploratory behavior of the customer within their specific contexts can lead to the discovery of new applications or usage scenarios. One example is Stadsbiblioteket, the Stockholm Public Library, inadvertently discovered during VR testing that smart glasses are highly effective for conducting visitor surveys. The library received a higher response rate and more thoughtful feedback because respondents were actively engaged in the process (from a personal meeting). Another example of co-creation with customers through experimentation is General Electric (GE), which launched a "Wearables Challenge" for its employees to test AR headsets in their workplace and name their best use scenario. This resulted in three use cases: assembly instructions and metrics, field service applications to call an expert, and packaging (Jackson, 2017). As ETs continue to develop and be integrated into various aspects of our lives, it is crucial to explore the novel activities and experiences that they create. Mele,

Spena, and Peschiera (2018) emphasize the need to investigate new activities that emerge from the use of ETs.

Ethical concerns

It is important to note that ethical considerations become particularly significant in B2B settings involving ETs. Given the high stakes (e.g., potential financial loss, reputational damage, or operational disruptions) and unpredictable nature of these technologies, conducting experiments without the full awareness and consent of customers can lead to significant risks. As such, transparency about the nascent state of ETs and their associated risks is not merely an ethical obligation; it is a practical necessity for establishing and sustaining trust in long-term business relationships. This transparency is especially crucial because experimentation with ETs can occasionally lead to 'value co-destruction,' particularly when the results fall short of customer expectations (Lintula *et al.*, 2018). Therefore, a more in-depth discussion on ethics, including potential frameworks or guidelines for ethical experimentation, would add value to this discourse (Brey, 2012). Given the complexities and potential pitfalls, ethical guidelines for experimentation with ETs in B2B settings are essential. Such guidelines could serve as a roadmap for companies navigating the uncertain terrain of ETs, thereby adding substantial value to this discourse.

Continuous Experimentation

Finally, continuous experimentation is important for the ongoing co-creation. By constantly iterating and involving customers in the iterations, companies can dynamically adapt to changing needs and preferences. In particular, Lindgren and Münch (2016) note that continuous experimentation has not yet reached maturity in practice, but it plays a crucial role in driving ongoing improvement of ETs and fostering innovation. For example, technology providers can continually experiment to discover new use cases or applications for their technology beyond the initial development scope, as illustrated by practical examples above (e.g., Stadsbiblioteket and General Electric). In support of this, the results of the study by Yaman *et al.* (2017) found that software development companies responded positively to continuous experimentation, as it helped them systematically collect data on customer value, better understand their products' value and address user needs. Day and Schoemaker (2000) emphasized the importance of embracing

this strategy for companies to remain agile and responsive to changing market conditions. However, it should be noted that continuous experimentation comes with its own set of challenges. Some scholars have expressed concerns that this approach may lead to an "over featuring" in new products, potentially causing a divergence from the original purpose (Marzi, 2022). Additionally, Auer *et al.* (2021) describe the challenges span various aspects including cultural, organizational, business, technical, statistical, ethical, and domain-specific issues. However, the insights gained through this process can outweigh these drawbacks, making it a valuable, though not unproblematic, strategy for co-creation.

Research could provide further insights by exploring different methods for engaging customers in the continuous experimentation process, such as crowdsourcing ideas, collecting real-time feedback, or involving customers in the discovery of new use cases via workshop sessions. Of particular relevance is how customers participate in the process of co-creating value in the context of continuous experimentation by contributing their resources, knowledge, and skills, and how this participation impacts the overall value co-creation process. Furthermore, the call by Medberg and Grönroos (2020) for empirical studies of value-in-use underscores the need to understand how users derive value from products and services in real-world contexts, and it can guide experimentation with ETs. By focusing on what users actually value, this approach ensures that the development and implementation of ETs are aligned with user needs, enhancing their relevance and potential for successful adoption.

In conclusion, this section has underscored the role of experimentation as a co-creation process aimed at helping customers unpack the value of ETs. Co-creative experimentation is essential for revealing value of ETs, aligning providers and customers in a mutual discovery process. This approach serves not only as a tool for mitigating the inherent uncertainties surrounding these technologies but also as a mechanism for uncovering latent customer needs. The importance of continuous adaptive experimentation was emphasized, highlighting its real-world implications and the need for empirical validation. These insights contribute to the broader themes of this literature review by offering a nuanced understanding of how value can be co-created in the complex and evolving field of ETs.

2.3.2. Communication

Role of communication

In this thesis, the communication process is a strategic approach to effectively unpack the value of ETs to potential customers through value propositions. A value proposition can be defined as a strategic tool that articulates the unique benefits and advantages of a product or service to customers (Payne et al., 2017). In the context of this thesis, it is crucial to understand that value propositions are not crafted by companies in isolation. They evolve through a co-creative process involving ongoing dialogue and feedback loops with potential customers (Ballantyne *et al.*, 2011; Ballantyne and Varey, 2006; Park and Lee, 2015; Terho *et al.*, 2012).

Communicating the value of ETs poses a significant challenge that has been emphasized by various researchers. Therefore, ETs are demanding in terms of providing early information to avoid harsh criticism from the market. Here, the failure of Google Glass serves as a cautionary tale. For instance, Chen *et al.* (2007) and Kambil *et al.*(1996) advocate improved strategies to inform and educate potential customers. The importance of the effective communication of value of ETs is further underscored by several authors (Hindle and Mainprize, 2006; Probert *et al.*, 2011; Schmitz and Ardilio, 2011), who note that customers may not have access to all the information held by providers. This difficulty in understanding the value propositions of ETs by customers can hamper their adoption, as highlighted by Korte *et al*. (2020). Therefore, the technology industry faces unique challenges in developing value propositions for ETs that genuinely resonate with customers (Wouters *et al.*, 2018; Young, Laurie and Burgess, 2015). This constitutes the rationale as to why the role of effective value propositions becomes crucial in addressing the challenges associated with communicating the value of ETs.

Crafting an Initial Value Proposition

Value propositions are central to why customers engage with one company over another, gravitating toward offerings perceived as having higher value. Market leaders often attain their status not merely through superior products, but by delivering value propositions that are perceived as superior (Sales *et al.*, 2017). This is particularly relevant for novel ETs, where the design of value propositions can influence the customer value of novel technologies

(Khan and Bohnsack, 2020). However, as pointed out by Doganova and Eyquem-Renault (2009), the "prospective nature" of innovations makes it difficult to design a concrete value proposition. Innovations, particularly ETs, are inherently about the future; they are about creating something new that does not yet exist. This makes it challenging to articulate the specific value that they provide. This is a significant challenge because, without a clear value proposition, it can be difficult to secure the necessary investment and customer interest.

Traditionally, research on value propositions in the B2B context has emphasized the quantification of monetary value as a crucial communication strategy (Anderson *et al.*, 2006; Kirchberger *et al.*, 2020; Patala *et al.*, 2016; Wouters and Kirchberger, 2015). However, although useful, this approach faces challenges with ETs, where novelty often leads to a lack of comprehensive performance data and real-world usage experiences, making it difficult to quantify in monetary terms (Wouters *et al.*, 2018). This lack of information often translates into a limited understanding of the ETs' functionality and potential value compared with alternatives. As a result, ETs require alternative strategies to develop value propositions that recognize their unique characteristics and the complexity of conveying their value.

Framing Value Proposition

This leads us to the concept of framing, which plays a crucial role in communicating the benefits and value of technology, particularly in enhancing success in the marketplace. Framing refers to the active and dynamic construction of messages that guides the interpretation and processing of information (Goffman, 1974). More than just a rhetorical tool, framing can be understood as a processual interpretive meaning-construction mechanism (Benford and Snow, 2000), where frames are used as socially constructed mental representations to simplify complex phenomena. These frames act as interpretive lenses, helping recipients contextualize intricate messages (Snihur *et al.*, 2018). In essence, framing is an ongoing negotiation of 'what is going on' (Goffman, 1974, p. 8), where selective emphasis on certain aspects guides the recipient's understanding, influencing interpretations, evaluations, and recommendations (Entman, 1993). The importance of framing goes beyond mere interpretation of information; it plays a vital role in shaping cultural resonance. Frames are integral to determining which meanings are associated with ETs, especially given their

novelty and complexity. The critical role of framing technologies through language (Cornelissen and Werner, 2014) has particular implications for providers, who must facilitate an understanding of the value of technologies, especially when it comes to ETs.

Cognitive Biases and Customer Understanding

It is equally important to understand the cognitive biases that may affect how these messages are received. The uncertainty of ETs is related to the cognitive biases and limitations of human thinking, (Day and Schoemaker, 2000), as customers often lack a frame of reference to understand new phenomena (Veryzer, 1998). Current norms, concepts, or ideas can provide a solution by giving customers "the appearance of familiar ideas" (Hargadon and Douglas, 2001) to initially frame the value of innovation (p.478). Of particular interest is the challenge of introducing ETs without losing their intrinsic novelty while invoking an existing understanding. The challenge lies in balancing the new and unfamiliar aspects of ETs with existing frameworks to which customers can relate, thereby facilitating a smoother adoption process.

Providers might frame the value of ETs by referring to familiar symbols or product, “embedding observed events in a context that gives them meaning” (Beach and Connolly, 2005, p. 16). For example, the way Edison created similarities between the light bulb and kerosene lamp facilitated understanding of the new technology, prompting the market for electrical energy (Hargadon and Douglas, 2001). This strategic use of frames allows providers to ascribe meaning to the ETs and relate them to everyday experiences, whether painting a technology as “environmentally friendly,” “modern,” or "job-creating" (Geels and Verhees, 2011; Rosenbloom *et al.*, 2016). Historical examples, like bicycles, were initially framed as racing devices and "macho" status symbols further illustrate the power of framing (Bijker, 1987). It was not until the framing changed to "safety bikes" that the innovation gained widespread legitimacy. It follows from these examples that providers might attempt to impose their framing by shaping perceptions of ETs in the market, thereby influencing not only consumer decisions, but also broader public discourse.

Hence, providers should exercise caution when framing value propositions. The challenge lies not in imposing benefits predetermined by the provider (Woodruff and Flint, 2006), but rather in conveying the value that the

technology provides to the customer. Notably, providers tend to think about what they offer their customers rather than what their customers value (Bower and Christensen, 1995; Christensen and Overdorf, 2000). According to Vishwanath (2009), the emphasis on technical attributes may contribute to the failure of technological innovation in the marketplace. To counter this bias, Day (2020) encourages companies to adopt an "outside-in" perspective to the value proposition, focusing on the customer's needs and value to the customer. By integrating customer perspectives, providers can frame their value propositions in a way that resonates more effectively with their target audience. Day asserts that the 'outside-in' perspective is not a one-time effort but an ongoing, iterative process that continually refines the value proposition based on customer feedback.

Co-creation plays an essential role in this shift by broadening the perspective on how value propositions are developed. It moves the focus from a company-centric view to an interactive, dynamic process between companies and customers, ensuring that the value proposition aligns with what the customer value rather than what the company presumes they want. However, while co-creation offers a more dynamic and customer-centric approach to developing value propositions, it's worth noting that the ideal of reciprocal value propositions is not always achievable in practice. For instance, Truong *et al*. (2012) argued that various constraints can limit the effectiveness of a co-creative approach by adding another layer of complexity to this process.

Ethical Dilemma

Navigating the promise of ETs introduces a new layer of ethical dilemma for providers. The temptation to exaggerate the benefits or capabilities for market advantage can mislead customers and raise ethical concerns. Importantly, the ethical implications of value propositions for ETs are often underestimated. Lehoux *et al*'s (2012) study is noteworthy for using an empirical ethics approach to examine the value proposition of healthcare innovations. This approach combines empirical research with ethical analysis to provide a more nuanced understanding of ethical implications.

However, the paradox surrounds the very concept of value propositions, which lies in the disconnection between the promised value proposition and reality. On the one hand, scholars regard them as the company's single most important organizing principle, central to strategy and alignment with market

needs (e.g.,Webster (2002). However, as noted by Lanning (2020) and Eggert *et al*. (2020), this concept is often casually used, poorly understood, and inadequately executed in practice. Businesses may make promises through their value propositions, but fail to take these promises seriously, ultimately undermining the core purpose of having a value proposition.

Changing Value Propositions

As it was shown, it is crucial to establish an initial value proposition for ETs, but it is equally important to acknowledge that the value proposition may require adaptation over time. As the technology landscape and market demand evolve, providers must adjust their value propositions to remain relevant and appealing to their target audience. Reframing the value proposition can help companies overcome the technical inferiority often associated with disruptive ETs (Bohnsack and Pinkse, 2017). Doganova and Eyquem- Renault (2009) view the value proposition not as a static statement but as a "test" or "trial, aimed at building a consensus between the provider and the potential customer. This is an interesting conceptualization because it emphasizes the experimental and uncertain nature of innovation. In this view, the value proposition serves as a hypothesis to be tested in the marketplace. Viewing the value proposition as a "test" also recognizes the inherent risks and uncertainties involved in bringing innovation to the market. In this view, it is not about getting it perfect for the first time, but about continuous testing, learning, and refining.

Consequently, providers need to carefully consider how they frame their value propositions for ETs and make the necessary adjustments. As scholars (Athaide *et al.*, 1996; Lehtimäki *et al.*, 2009) have noted, the value of a product or service is context specific, and providers need to communicate its value in a manner that resonates with the customer. This process requires a constant review of the ability to answer why customers would choose their offerings over competitors (Anderson *et al.*, 2006).

Guided by the idea that value is always contextually specific, the process of how value propositions adapt to context requires further investigation (Payne *et al.*, 2017). The importance of reviewing and modifying value propositions over time has been underscored by numerous studies (Covin *et al.*, 2015; Lindgreen *et al.*, 2012; Lusch *et al.*, 2010; Maglio and Spohrer, 2013; Norton and Pine, 2013). Additionally, Covin *et al.* (2015) found that changing value

propositions can positively affect company performance compared with companies whose value propositions remain unchanged. Existing research on how a value proposition can change over time remains relatively limited (Frow *et al.*, 2014; Lindgreen *et al.*, 2012; Ostrom *et al.*, 2015; Payne *et al.*, 2017), with a few exceptions (Kowalkowski, 2011; Leroi-Werelds *et al.*, 2021). Therefore, this study goes some way to address this limitation by obtaining longitudinal data on the evolution of the value proposition of ETs.

This section has explored the role of value propositions in unpacking the value of ETs. It highlights the challenges in communicating the value of ETs and suggests that ethical considerations and cognitive biases must be considered. Through a co-creative approach, companies can develop and adapt value propositions that resonate with customers more effectively, thereby facilitating the successful introduction and adoption of ETs. It concludes by emphasizing the need for the ongoing adaptation of value propositions and calls for further research in this evolving field.

2.3.3. Knowledge brokering

Role of Knowledge Brokering

Compared to experimentation and communication, knowledge brokering is another process that unpacks the value of ETs to customers. Knowledge brokering involves engaging knowledge brokers, people, or organizations with expertise that facilitates the exchange of knowledge and creates connections between domains. As organizations increasingly acknowledge the importance of bridging the gaps between different knowledge domains to promote innovation, the role of knowledge brokers in innovation has gained increasing attention in the literature (Akram *et al.*, 2011; Hargadon, 2002; Hsiao *et al.*, 2012).

ETs are often complex and fraught with uncertainties, that can hinder business users from fully understanding their potential value (Korte *et al.*, 2020; Rindova and Petkova, 2007), let alone leveraging them effectively. Consequently, customer companies may lack insight into how and why they should use ETs and integrate them into their processes(Govindarajan and Kopalle, 2004). Additionally, it may be challenging to find internal specialists who can understand the complexities of ETs and how customers can benefit from them. In the face of such challenges, business customers who lack in-

house expertise to decipher the value of ETs can turn to knowledge brokers who help unpack ETs and devise technology strategies aligned with business goals, ensuring that companies fully capitalize on ETs (Pawlowski and Robey, 2004). Organizations could potentially build internal expertise to leverage ETs, making the role of external knowledge brokers less critical. However, the lack of specialized talent is consistently cited as the biggest barrier to ETs adoption (Gartner, 2021), further highlighting the importance of knowledge brokers in overcoming these obstacles. Knowledge brokers fill this gap by providing specialized expertise that may not be readily available in-house.

Similarly, technology providers can enlist the help of knowledge brokers to accelerate or propel commercialization (Denoo *et al.*, 2021). For example, knowledge brokers can play an instrumental role in creating proof-of-concept to test technologies with the potential to evolve from initial R&D into major breakthroughs (e.g., surgical robotics) (Ismail, 2022). ETs typically involve the integration of knowledge from diverse fields and their potential applications can span different sectors and markets. As such, companies that develop ETs often need to draw on knowledge from various internal and external sources including academia, industry, customers, and other stakeholders. Consequently, knowledge brokerage exemplifies co-creation through knowledge and skills (Prahalad and Ramaswamy, 2004) in a context where companies recognize the limitations of their internal expertise and proactively facilitate external contributions to complement their knowledge base. Additionally, knowledge brokerage can assist providers in crafting product roadmaps that cater to the needs of consumers in the industrial ecosystem or devising go-to-market strategies. This is particularly valuable because, as Mohr, Slater, and Sengupta (2006) note, technology providers often possess greater technological expertise than marketing acumen. In this capacity, knowledge brokers can serve as intermediaries between providers and customers, helping manage expectations by facilitating communication, clarifying goals and objectives, and negotiating mutually acceptable outcomes. By providing customers with essential information and insights about ETs, knowledge brokers help build confidence in providers' ability to fulfill their commitment.

Knowledge Brokers as Interdisciplinary Connectors

The knowledge brokering process acts as a bridge, translating complex technical information into specific contexts (Hsu and Lim, 2014) and enabling

the transformation of technologies into commercial successes (Islam, 2017). In this context, bridging refers to the boundary-spanning nature of brokers' work as well as the development of their specific expertise. According to Hargadon (1998, p. 57), knowledge brokers innovate by "innovate by brokering knowledge from where it is known to where it is not, " combining existing technologies in novel ways to generate new solutions(Hsu and Lim, 2014). This ability is rooted in their experience working on comparable technology projects in the pipeline and applying structured frameworks to address challenges (Rasiel *et al.*, 2001). Such complex projects demand interdisciplinary collaboration and integration of diverse types of knowledge across professional and organizational boundaries. Furthermore, as described by Burgess and Currie (2013), these actors leverage their distinctive intermediary vantage points to foster innovation by connecting, recombining, and transferring previously disconnected pools of ideas to new contexts. This intermediary position allows them to bridge gaps between different areas of knowledge, ultimately promoting creative and innovative solutions.

Knowledge Brokers as Communication Facilitators

Knowledge brokers play a vital role in understanding the value of ETs when there is a disconnect between technology providers and customers (Lewin, 2021; Ye *et al.*, 2015). This communication challenge often arises from misaligned objectives (Ye *et al.*, 2015), where business professionals tend to prioritize problem-solving and return on investment (ROI) (Finkelstein (Finkelstein *et al.*, 2009), while technical professionals from the provider side focus mainly on technology's functionalities and performance metrics (Antoniou and Ansoff, 2004; Lynn and Heintz, 1992). One could argue that these communication challenges could be addressed through enhanced internal communication strategies within provider organizations, thereby reducing the need for external knowledge brokers. However, while internal communication is undoubtedly important, the specialized expertise of knowledge brokers uniquely positions them in bridging these communication gaps. They possess the ability to understand both technical and business perspectives, making them invaluable for facilitating effective communication between providers and customers.

Technically trained experts from provider sides often struggle to convey the value of ETs to business customers (Naegle and Ganly, 2020), and the specific competencies required to unpack the value of ETs have not been fully

clarified. Heusinkveld *et al*. (2009) suggest that this expertise of "in-between" knowledge brokers (Lomas, 2007) is often taken for granted and further research into the details of knowledge that enable these knowledge brokers to bridge the gap between providers and business customers is needed. This is not to negate their current effectiveness but to acknowledge that there is room for further research to optimize their role. Existing studies have provided empirical evidence supporting their effectiveness in various contexts (Naegle and Ganly, 2020).

Knowledge Brokers as Ethical and Neutral Parties

While knowledge brokers are generally viewed as facilitators who bridge gaps and enable co-creation (Mariano and Awazu, 2017), there are some potential limitations to consider. For example, one significant concern raised in the literature is the potential for knowledge brokers to act as gatekeepers (Parker and Hine, 2014), thereby limiting access to valuable knowledge and affecting the outcome of co-creation. Building on this, it is crucial to note that knowledge brokers may not always be neutral and may have vested interests that may not align with those of customer companies or technology providers. To illustrate, an recent ethnographic study on the Dutch police's use of a learning algorithm for crime prediction offers a case in point (Waardenburg *et al.*, 2022). Contrary to the traditional view of knowledge brokers as neutral entities, the study found that these brokers could even substitute machine outputs with their own judgments. Subsequent studies could focus on creating ethical frameworks or guidelines to ensure the impartiality and ethical integrity of knowledge brokers, particularly within the field of ETs.

In summary, further research is necessary to explore the complexities surrounding the multifaceted role of knowledge brokers and the potential for biases or conflicts of interest. Specifically, studies could examine the knowledge of knowledge brokers, the ethical implications of their neutrality, the extent to which they act as gatekeepers, and how this impacts co-creation. Understanding these aspects could offer new insights into optimizing the role of knowledge brokers in fostering innovation and facilitating effective co-creation.

The review of the literature integrates existing insights into a theoretically grounded framework that can guide this research (see Figure 1). I believe that these three processes are components of the integrated model and they are

interrelated, but more data are needed to explain the relationships between them. This preliminary framework serves as a starting point for a more detailed exploration of the processes that help unpack the value of ETs, and will be refined based on the findings in the articles:

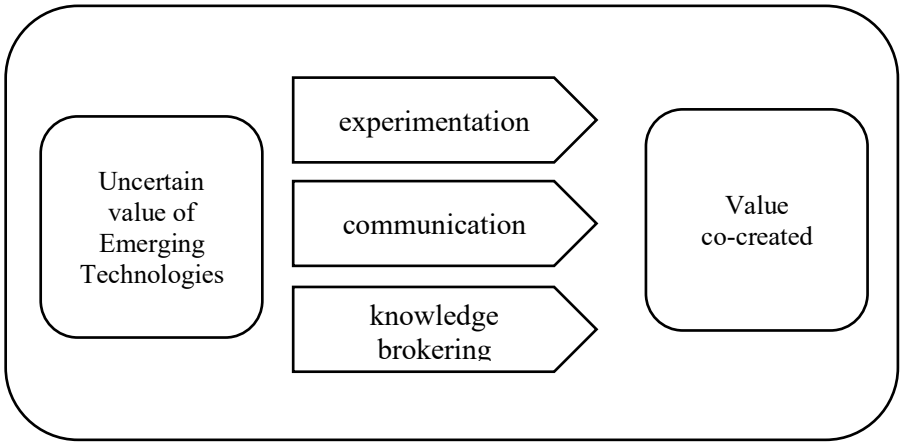

Figure 1 Theoretical framework: Three processes of unpacking the value of ETs

3 METHODOLOGY AND METHOD

Chapter 3 elucidates the overall approach and research design of this study. The purpose of research design is to find and describe a strategy that allows the researcher to gather the information needed to answer the research questions in the best possible way. It provides a framework for accomplishing the research including what kind of data is collected, how it is collected and how it is analyzed. The chapter is organized into four sections: (a) research design, (b) data collection, and (c) data analysis, (d) mode of analysis, and (e) the empirical context.

3.1. Research design

I must admit that when I started my Ph.D. project, as a technology enthusiast, I was absolutely convinced of the power and possibilities of technology. This initial position was very close to technological determinism on the edge, and my research now speaks more to the social construction of technology (Bijker, 2009), as I believe that human agency can shape the future, if only within certain limits. I am still a techie, but my perspective has been influenced by my journey and has shifted towards the socially constructed view. The argument is based on my empirical work, but also on my awareness of the simplistic and uncritical acceptance of technology, which can be summarized as 'the belief in technology as a key governing force in society' (Smith and Marx, 1994). The development of my knowledge, based on empirical studies, has led me to view technologies as socially shaped, and technological determinism as problematic because humans create technology and, to a large extent, choose how to use it. Technology does not force people to use it, rather the decision to use technology is in the hands of the individual. I contend with Raymond Williams's (2003) perspective that technological determinism fails to recognize the importance of the power of social relationships, interaction, and circumstances. I agree with his assertion that the emergence and evolution of technology are primarily driven by human needs, structures, and ambitions

rather than the technology itself. He astutely recognizes that it is people who wield power over technology, shaping it to address our challenges and meet our aspirations. This understanding highlights the diverse applications and outcomes of technology because it is shaped by the diverse needs, goals, and circumstances of individuals and groups in society.

As elaborated on in the beginning of the thesis, the view that technology as socially constructed[7] has influenced my thinking. Based on that, technology being socially constructed means that the producers of technology do not have complete control over how customers will use the technology. This is one among several constructivist ways of studying science and technology that emerged in the 1980s. It is difficult to predict the unlimited number of practical applications of technology to which history is a witness (Rosenberg, 2009). The value of technological artefacts is not primarily determined by their technical features or functions (Parker and Mainelli, 2001), but by customers' engagement with them (Bijker and Law, 1994; Woolgar, 1990). In other words, the value of a technology is not given a priori; it evolves in practice as users interact with it (Orlikowski, 1996, 2000). In this sense, the value of a technology is situated and emerging in interaction rather than inherent. It aligns well with Holbrook's (1994) argument that value is "an interactive relativistic preference experience", which involves recognizing a customer must interact with an object for customer value to occur. Similarly, according to (Woodruff and Gardial, 1996) customer value is not inherent, "but it is experienced by the customers" (p.7) as a result of using the company's services for their own purposes. It appears that customers do not perceive the value of the technology until they experience it in use (Lanning, 2000; Woodruff, 1997), which brings forward the relevance of value that is created during use (Grönroos and Gummerus, 2014; Grönroos and Voima, 2011; Macdonald *et al.*, 2011).

In this thesis, I investigated the phenomenon of unpacking the value of ETs using several single case studies and interview materials with a purposive sampling approach. With the goal of gaining a deep understanding within a natural setting, "case study is a research strategy that focuses on understanding the dynamics within individual settings" (Eisenhardt, 1989, p. 534). Case studies are rich and empirical descriptions of specific instances of

[7] The phrase "social construction" was first used by Berger and Luckmann (1966) in their "Treatise in the sociology of knowledge".

a phenomenon based on a variety of data sources (Yin, 2014). As has been acknowledged, the case study method allows for in-depth inquiry (Feagin *et al.*, 2016), as well as a holistic view of a phenomenon (Gummesson, 2000). Single case studies are valuable for creating understanding in situations where the context has been properly chosen. It has also been argued by Dubois and Gadde (2002) that learning from a single case should be seen as a strength rather than a weakness. This contrasts with the prevailing view, which tends to be biased towards favoring a multiple case studies approach based on a notion of statistical significance.

3.2. Abductive reasoning

In undertaking this research, I've been guided by the approach of abductive reasoning, or what (Harman, 1965) referred to as "inference to the best explanation". This term is often attributed to Charles Sanders Peirce, yet he credits its origin to Aristotle, suggesting it stemmed from a mistranslation and should be instead referred to as retroduction (Peirce *et al.*, 1934).

Throughout my research journey, the intriguing phenomenon I observed in the realm of ETs – unpacking the value of these technologies when the value was initially uncertain – led me to delve into theoretical exploration and formulate a hypothesis. The abductive approach that I employed has been useful but it was not without challenges. The process of abduction opened the door to a myriad of theoretical frameworks, creating a landscape that was both exciting and at times overwhelming. The challenge lay not just in navigating these diverse theories but in synthesizing them into a cohesive and nuanced understanding. As a result, I hypothesized that the processes of experimentation, communication, and knowledge brokering help customers unpack the value of ETs, when that value was initially unclear. This hypothesis emerged from a fusion of empirical observations, theoretical explorations, and the guiding principles of abductive reasoning.

Notably, the abductive approach is neither inductive nor deductive, since neither the empirical nor the theoretical data overlap the other (Dubois and Gadde, 2002). Abduction aims to find a middle ground between inductive and deductive (Coffey and Atkinson, 1996; Tavory and Timmermans, 2014), since abductive research is neither data-driven nor hypothesis-driven but is equally engaged with empirical data and existing theoretical understanding (Rinehart, 2021). In this case, the researcher examines when the empirical data deviate from what is expected based on current theoretical understanding

(Schwartz-Shea and Yanow, 2013) and identifies where existing theoretical frameworks are unable to explain the empirical findings (Alvesson and Kärreman, 2007; Rinehart, 2021). The pattern of abduction refers to the common experience of observing an unexpected, anomalous, and strategic datum that becomes the occasion for developing a new theory or for extending an existing theory. However, there is no information or anomaly in our environment (Von Foerster, 1974). Therefore, if a certain phenomenon seems strange (Andreewsky and Bourcier, 2000), it only means that the theoretical framework used to interpret it needs to be revisited. The revisiting cognitive process of rethinking is called abduction and aims at "normalizing" anomalies.

Abduction, or making a probable conclusion from what we know, is often used unrecognized in everyday reasoning: "the phenomenon is enormously more widespread than [one] might, at first thought, have supposed" (Bateson, 1979, p. 142). For example, physicians often use abductive reasoning to hypothesize how to treat a patient with an information on hands. Hence, it has also been argued that abduction is a cornerstone of scientific reasoning (Boyd, 1981, 1984; Harré, 1988; Lipton, 2017; Psillos, 1999) as scientific reasoning frequently involves it. The existence of Neptune, for example, was hypothesized when it was discovered that the orbit of Uranus, one of the seven planets known at the time, deviated from the orbit predicted on the basis of Newton's theory of universal gravitation and the additional assumption that there were no other planets in the solar system. One possible explanation, of course, was that Newton's theory was wrong. But that did not seem to be a very good explanation. Two astronomers, John Couch Adams and Urbain Leverrier, suggested instead, independently but almost simultaneously, that there was an eighth, undiscovered planet in the solar system, which they believed offered the best explanation for Uranus' divergent orbit. Not much later, this planet, now known as Neptune, was discovered (Douven, 2022). In contrast to deductive reasoning, the abductive process provides a plausible conclusion, but it is not positively verified. It is used in science to test competing theories for explanatory power (Thagard, 1989, 2000). Importantly, while this reasoning was lauded as "the abductive methodology is the best science provides" (Williamson, 2017), and "the inference that makes science" (McMullin, 2013), the conclusions yielded are plausible. It is never quite certain whether an abductive conclusion is actually true, but that does not prevent Rozeboom (2016) from claiming that "good science is abductive, not hypothetico-deductive".

Project	Data collection	Data sample	Data analysis
Article 1	Semi-structured interviews and observations	3D artists, quality engineer, design engineer, designer and UX designer.	Content analysis
Article 2	Archive documents	482 press releases, 11 annual reports, 1 annual report of the previous shareholder, 28 earnings and special calls, 7 shareholder letters, 4 secondary materials from interviews with the CEO of the case company, 16 corporate presentations, and website pages in retrospect, old magazines	Content analysis
Article 3	Semi-structured interviews	13 Intermediating knowledge brokers	Thematic analysis

Table 2 Data collection, sample and method of analysis

3.3. Data collection

In order to gain a more comprehensive understanding of ETs commercialization, I have participated in industry events: several VR SCIFEST exhibitions organized by KTH, Vive Developer Meetings, the 4th International AR and VR Conference, gatherings organized by the Stockholm Virtual Reality association, and events organized by Tobii (a technology company that develops and distributes eye-tracking products); and by the Product Development and Management Association (PDMA). It also included observations and interviews at a large manufacturing company and interviews with knowledge brokers. The main purpose of attending such events was to gain an understanding of the challenges and difficulties in commercializing ETs in terms of value and how they are being addressed. It was of great value to ask the practitioners involved in mediating between technology providers and business customers to describe and discuss their views on the phenomenon of the uncertain value of ETs and what helps them explain it. Throughout the process, MaxQDA software (VERBI Software, 2021) was used to organize and code data, switching back and forth between data collection and data coding.

Semi-structured interviews

Semi-structured interviews served as the cornerstone of my data collection, primarily utilized in two studies, while in the study 3, interviews were conducted via Zoom conferences. For all research projects, I developed an interview guide. This guide, rather than being a rigid set of questions, was designed to be flexible, reflecting the principles of abductive reasoning. The abductive approach impacted the interview guide in several ways. Firstly, it encouraged flexibility in the questions. The guide started with predefined questions based on the existing theory but was open to incorporating new questions that emerged during the interview process. Secondly, it promoted iterative refinement of the guide. As new insights emerged, the guide was modified to better explore these findings in subsequent interviews. Finally, the guide was designed to highlight and explore anomalies - aspects that didn't quite fit with the existing theory - as these areas are of particular interest in abductive reasoning.

Both purposive (Palys, 2008) and snowball sampling were employed for respondents recruitment. My selection was purposeful, seeking out experts with unique expertise in the area (Weiss, 1994), and snowball sampling facilitated a chain of referrals, each leading to the next. Following each

interview, in line with the abductive reasoning approach, while I took time to reflect on my technique as an interviewer, I also remained open to the emergence of new concepts that might challenge or expand our existing theoretical understanding. These new concepts, rather than being anomalies, were seen as potential avenues for further exploration in subsequent interviews or discussions with the co-author. All interviews were recorded, transcribed verbatim, and coded using MaxQDA software. The transcriptions were then reviewed in light of the existing theory, with any deviations being noted as potential prompts for theory refinement or development.

Interviews are a powerful tool to capture rich perspectives, experiences and interpretations of the respondents in their own voices. Qualitative interviews serve as "a construction site of knowledge" (Kvale, 1996, p. 2), yielding generally rich, detailed data and good for in-depth understanding of new and complex social phenomena (Van Maanen, 1998). The flexibility of the semi-structured interview method, combined with the openness and adaptability fostered by abductive reasoning, enhances the interview process, making it more responsive to emergent themes and unique contexts (Denzin and Lincoln, 2011; Folkestad, 2008).

Observations

Participant observations method was applied in the Article 1 at large manufacturing company to study the users' use ETs in industrial settings. The use of observations provided valuable insights into how users engaged with ETs in an industrial setting. Employing an abductive approach, these observations allowed us to uncover new themes and generate additional interview questions, further enriching the data collection process. In this context, abductive reasoning influenced the participant observation method by encouraging us to remain open to unexpected findings and to continuously re-evaluate and refine their understanding of the phenomena under study. Schensul and colleagues (1999) defined participant observation as "the process of learning through exposure to or involvement in the day-to-day or routine activities of participants in the researcher setting" (p.91). The main advantage of observation is the systematic study of events as they occur (Marshall and Rossman, 2014), while allowing researchers to learn about the activities of the subjects under study in the natural environment by observing them.

Hence, sometimes a researcher not only observes but also participates in activities, which imposes an obligation to maintain a sense of objectivity through learning from a distance. The researcher needs to learn how to blend (Bernard, 2017), which means to be a careful observer and a good listener while being open to the unexpected. In our case, to avoid observer bias, objectivity was achieved by an intercoder reliability (Kurasaki, 2000) procedure in which conclusions were compared.

Secondary data

In the second study, I collected archival data and as recommended for single-case studies, data were triangulated with multiple sources of data to increase robustness and quality (Yin, 2014). These archival data included annual reports, press releases, earning and special calls transcripts, letters to shareholders, secondary interviews, corporate presentations, and website pages in retrospect. Table 2 explains in detail the composition of the data. This rich, thick empirical evidence (Geertz, 2008) was collected with the aim to provide a deeper understanding of the phenomenon.

Material collection of the case company's content was particularly challenging due to the various names under which the company existed. In 1997 it was renamed to VR Acquisition, which acquired all the assets of Forte Technologies. Thereafter, the name was changed to Kaotech Corporation in 1997, to Interactive Imaging Systems, Inc. in 1998, to Vicuity Corporation in 2004, and to Icuiti Corporation in 2005. The current name Vuzix Corporation was registered in 2007. Therefore, I employed complex search strategies to retrieve data from various databases such as Seeking Alpha, the U.S. Patent and Trademark Office, and the Internet Archive. The Internet Archive is the largest historical web archive since 1996, which "keeps all retrieved copies of Webpages … so that changes in a page over time can be tracked and old pages … can still be found" (Thelwall and Vaughan, 2004).

Reading corporate documents, including interviews with the CEO, transcripts of earnings announcements, and letters to shareholders were particularly informative to me in understanding the challenges the company faced in the emerging industry and the strategies laid out. The information disclosed in press releases can be considered accurate and complete so as not to mislead (Trautmann and Hamilton, 2003) because of the antifraud requirements of federal law. This transparency in a company's public disclosures offers the opportunity to provide insight into the company's current affairs and strategic

decisions. Annual reports and press releases are commonly used as a source of data to answer the question of how a company communicates with its key stakeholders (Chapman, 2020). Transcripts of earnings announcements were added as a supplemental source of data to provide insight into the minds of executives and a better perspective on the corporate strategies and expectations. These transcripts are a detailed record that includes prepared remarks by management, questions, and discussions with analysts.

Secondary data help to bring findings from different sources into dialogue (Fielding, 2012) and help with "converging validation" (p. 127). However, it is important to remember that secondary data are produced with a specific audience in mind and have multiple intended purposes and should not be taken out of context (Bryman and Bell, 2015). Thus, in examining hundreds of quarterly earnings press releases, (Mahoney and Lewis, 2004), found that the language in press releases can range from "straight-forward recitations of numbers to being quite promotional" with the information either a "fact-based, no-frills-added manner or cast in positive-to-superlative terms" (p. 2004). Being aware of these variations, I compared the data and cross-checked them with other sources.

3.4. Data analysis

Content Analysis

To identify patterns for material analysis in study 1 and study 2, I applied qualitative content analysis, the method that allows for systematic, reliable, and objective examination of previously published material (Kracauer, 2022). According to (Guthrie *et al.*, 2004), content analysis is a method of codifying text into various groups or categories based on selected criteria. Its essence lies in the subjective interpretation of content through systematic coding and identification of themes or patterns. This type of design is usually appropriate when existing theory or research literature on a phenomenon is limited (Hsieh and Shannon, 2005).

In study 1, we built a preliminary framework as a set of physical and emotional activities, using abductive reasoning to inform our understanding of the themes emerging from the data. The abductive reasoning process wasn't linear but iterative. As new themes emerged or existing ones evolved, our hypotheses were continuously refined. This involved going back to the data, comparing it with our hypotheses, adjusting these hypotheses as necessary, and then returning to the data again. This back-and-forth process ensured that

our hypotheses remained grounded in the data, enhancing the rigor and credibility of our analysis. Abductive reasoning played a crucial role in informing our understanding of the themes that started emerging from the data. This reasoning process allowed us to go beyond the observed data and start formulating explanations for the patterns we were noticing. For example, we noticed that "remote interaction" was a recurring theme in the data, we used abductive reasoning to hypothesize why this theme was so prevalent. Was it more a reflection of company work mode, or perhaps a response to immersive environment? The use of abductive reasoning also fostered a collaborative environment among us as it facilitated in-depth discussions before, during, and after the coding process, helping us reach a consensus on the codes. These discussions were not just about what codes to use, but also about the underlying reasons and implications of these codes. This collaborative interpretive process, informed by abductive reasoning, ensured that our coding scheme accurately captured the essence of the texts and conveyed their true meaning.

In Study 2, similar to Study 1, a preliminary framework was established at the outset. This framework, informed by the research questions and pre-existing theoretical knowledge, provided a broad structure of three phases for the coding and categorization of the data. To organize content into time periods and enable processual research, I dated and tagged each document so that changes can be tracked over the years. This enabled me to create a chronological sequence of critical events that occurred during specific time periods, constructing a timeline following the recommendations of Pettigrew (1997) and Langley (1999). Analyzing the value proposition change in this study, I applied a processual approach, which acts as a meta-method, greatly assisting my investigation. It empirically examines how and why an evolving phenomenon unfolded over time. Uncovering time-based themes and overarching patterns of value proposition change over a long duration was crucial, as change is inconceivable without time (Sztompka, 1993). Events such as major milestones (e.g., IPO, inclusion in the Russell 2000 Index, new product launch), embracing strategy changes, and key partnerships were central to identifying VP change. This allowed me to emphasize the complexity within a longitudinal processual design, leading to a rich understanding of the phenomenon over an extended period. The identified patterns revealed specific dynamics of value proposition when technologies evolved. This became particularly useful during the analysis, visualizing the

value proposition change shown, based on codes calculations by periods (see Figure 3).

After a close reading of the documents to gain a deeper understanding of the industry specifics and obtain a sense of the whole (Tesch, 1990), I coded collected materials through several rounds. In the first round of coding, I used theoretical coding (Saldaña, 2021) to keep track of codes that were "the terms used by [participants] themselves" (Strauss, 1987, p. 33). While this produced a long list of first order concepts elicited from the interviews, it allowed to participants' own language to stay close to the data, which can provide valuable insights into the participants' perspectives. The examples of first round codes derived from data were: big future, commitment to innovate, dominant technology, investment base, resource integration, channel initiatives. I used these codes developed through theoretical coding as the observations to inform my abductive reasoning process. In the iterative process of abductive reasoning, I, thus, constantly revisited these codes, reassessed my hypotheses, and made necessary adjustments. This combination allowed to stay grounded in the data while also generating and refining explanations for the patterns I observed, which allowed "theoretical sensitivity" (Glaser and Holton, 2004). Further, coding was performed until theoretical saturation (Saunders *et al.*, 2018) was reached, which is determined by when researcher is noticing to go "through the same network of ideas" (D'Andrade, 1991, p. 281). During data analysis, the goal was to generate new theoretical insights (Timmermans and Tavory, 2012) by iterating between the emerging conceptualizations and empirical data (Gioia *et al.*, 2013).

Data were analyzed using MaxQDA software, with field notes from observations, transcribed interviews, public records, and collected documents (Eisenhardt, 1989). MAXQDA is qualitative data analysis software designed for computerized qualitative and mixed methods data. Once the analysis was complete, the codes were counted to compare the differences between the three time periods. This confirmed the prevalence of frames in each phase, as it is possible to analyze data qualitatively while quantifying it in content analysis (Grbich, 2012).

Thematic Analysis

In Study 3, I used an abductive approach, guided by a preliminary theoretical framework, and draw inspiration from Braun and Clarke's (2006) six-step

thematic analysis. This procedure consists of: 1) familiarization; 2) data coding; 3) generating initial themes; 4) reviewing and developing themes; 5) refining, defining and naming themes; 6) writing the report. First, I studied the data extensively by making transcripts myself and then reading and re-reading them line by line, with the first codes noted in a column next to the transcripts. It was very helpful to jot down the initial ideas in memo in MAXQDA software during this process so that I would not forget them.

Thematic analysis is a method for analyzing qualitative data that entails searching across a data set to identify, analyze, and report repeated patterns (Braun and Clarke, 2006). It is a method for describing data, but it also involves interpretation in the processes of selecting codes and constructing themes. I transcribed interviews myself to engage with the depth and breadth of the corpus to search for meaning and understanding behind narratives and the context in which things occur.

After first familiarization with the data, I read interviews thoroughly, making notes about something said by interviewees, or a recurrent theme in what one interviewee has to say. For example, the theme of "systemic thinking" emerged from the interviews as crucial in respondents' ability to unpack the value of ETs. The systemic perspective allowed them to see how ETs could fit within companies' existing structures and systems, and how they could potentially disrupt or enhance these systems. Based on abductive approach, we expected to find the categories relating to explicating value of ETs, and interaction "in between" providers and customers, communicative strategies used, their background. These categories became 'themes' that I used to analyze interview data once collected from respondents. Eventually, based on findings from the thematic analyses, we constructed a framework in the final part of our paper.

Applying content and thematic methods in this dissertation, I had a chance to reflect on differences and similarities. In my opinion, this subject of the similarities and differences between thematic and content analysis deserves more "airtime" in academic discussion. It's a natural predicament that any researcher stumbles upon, unless it was specified in the method course. It seems a dilemma for the researcher to choose between them and depends on how much one wants to be descriptive or interpretive in the analysis, which guide the method choice. Another way to understand the difference is to think

of them in the continuum of qualitative methodology (Vaismoradi *et al.*, 2013).

Gauging the quality of qualitative research may be somewhat an intricate task. It is important to recognize that the criteria promulgated by positivist researchers - generalizability, validity and reliability (Maxwell, 2012) are not readily compatible with qualitative research. Yet, it is the contention of this study that these concepts can still hold substantial merit within this research milieu. Indeed, generalization is often couched in statistical terms, but in the context of this study, it is not the aim to generalize the findings. Instead, this research adopts the conceptualization of analytical generalization (Halkier, 2011). In this way, findings from qualitative research should be assessed for their transferability; its potential application to other cases and contexts (Maxwell, 2012). When viewed in conjunction with the results of other studies, these findings may yield more general theories. Similarly, the concept of validity can also be adapted to suit to the qualitative research. While quantitative research often provides clearer benchmarks for validity, qualitative research navigates a more intricate landscape due to inherent ontological and epistemological differences (Dieronitou, 2014; Hammarberg *et al.*, 2016). In the field of qualitative research, the versatility in understanding of validity is reflected in the myriad of terms used to describe it (Golafshani, 2003). When construed as reflection of an objective truth, validity may not appear relevant. However, when defined in terms of trustworthiness (Riessman, 1993) and verisimilitude (Bruner, 1998), validity becomes significantly more pertinent. Trustworthiness demands the meticulous data collection and interpretation, while verisimilitude requires to present findings in authentic, meaningful way to resonate with the realities of the studied phenomena. Lastly, the concept of reliability in traditional understanding as a consistency, whether repeated application of a technique yields the same result (Babbie, 2021) is not congruent with qualitative research in which human participants are the focus of analysis. However, conducting a repeated study with other participants can generate similar results and reinforce the original findings, enhancing the reliability (Polit and Beck, 2010).

In general, to ensure quality, I followed a set of measures for data collection and analysis, which should increase the reliability of the findings. I used multiple sources of data aimed at enhancing descriptive validity (Yin, 2014) and multiple informants to triangulate perspectives (Eisenhardt, 1989). As

Patton (1999) observed, triangulation allows for the comparison and cross-verification of data, ensuring that the information I gather from different sources remains consistent over time. In the first and the third studies, each transcript was analyzed independently by each researcher, and the codes were compared and re-evaluated by the researchers to ensure analytic rigor (Guba and Lincoln, 1994). I also had an extended engagement in the research field during which data were collected in real time to become familiar with the context and data (Lincoln and Guba, 1985). In addition, I wrote detailed descriptions and received feedback from informants to capture rich context and ensure the quality and validity of interpretations (Langley, 2012).

I discussed my observations and emerging findings with other researchers, allowing for further insights, opportunities for additional clarification, and alternative explanations for initial findings (Corley and Gioia, 2011). To determine the consistency and accuracy of the text with the assigned codes, I also used MaxQDA software for code grouping and word frequency.

4 FINDINGS AND CONTRIBUTIONS OF THE ARTICLES

This chapter summarizes each article and discusses its major contributions and place in this research. Each article contributes to the overall purpose of the thesis to develop a framework of processes that help customers unpack the value of ETs. Specifically, the first article contributes by emphasizing how experimentation helps industrial users unpack the value of ETs in their specific context in routine activities. The second article shows how value proposition of emerging technology evolved over the years in the process of commercialization. The third article acknowledges the role of knowledge brokers in intermediating between providers and customers, translating, interpreting and co-creating value of ETs in tandem with business customers.

4.1. Article 1

Article 1, published in the *Journal of Business and Industrial Marketing*, aims to improve our understanding of how experimentation help customers unpack the value of immersive technologies in industrial context. The pilot study was conducted by a manufacturing company seeking to test immersive technologies for industrial design applications.

In recent years, scholars have increasingly focused on the various benefits and impacts of immersive technologies (Borsci *et al.*, 2015; Boyd and Koles, 2018; Hilken *et al.*, 2017). However, there is still a need for more fundamental explanations regarding how the value is formed by users through testing these technologies in industrial settings. As (Suh and Prophet, 2018, p. 77) noted, "relatively little research has been conducted to better understand what we know and what we need to know about immersive technology and how users experience these technologies". This observation aligns with calls for more research on immersive technologies in general (Rauschnabel *et al.*, 2015) and on value creation from a user perspective in particular (Tscheu and Buhalis, 2016). In depth research on how such technologies can contribute to its customer value has been limited.

Given the growing prevalence of immersive technologies in various aspects of our lives, it is essential to conduct more research on the physical and emotional activities associated with their unique features. Such research can help us understand and address potential risks, improve user experiences, and ensure the responsible development of these transformative technologies, particularly in industrial context. This adds to the point that the sense of presence in virtual reality can have both positive and negative implications. Furthermore, this feeling of being fully immersed in the virtual environment can blur the line between the virtual and real worlds. For instance, immersive experiences can elicit strong emotional responses or lead to cognitive overload. In industrial settings, understanding the physical impact of immersive technologies is essential for ensuring workers' safety and comfort. By focusing on activities, this research responds to the call to investigate new activities that emerge from the use of ETs (Mele *et al.*, 2018).

Through the lens of an activity-centric view on value creation and customer-dominant logic, the study suggests a framework to explore how value is co-created by users of immersive technologies in an industrial setting. In accordance with the view, this empirical study focuses on what industrial users do with immersive technology; that is, the value formation is realized through physical and emotional activities enabled by deploying immersive technology. Since the focus of this paper is on *how* the use of immersive technologies enables value creation for individual industrial workers, we use the value-in-use (Macdonald *et al.*, 2011; Vargo and Lusch, 2012), which results from the use of immersive technologies. In this study, value is conceptualized as value-in-use, focusing on the process of creating value rather than the outcome. This approach emphasizes the ongoing interactions and experiences that users have with immersive technologies, acknowledging that value is derived from the continuous engagement with the technology rather than just the end result.

In activity theory, the relationship between “subject” (the human agent/doer) and “object” (the thing that is done) constitutes as the core of an activity. The activity theory acknowledges the complexity of studying people and provides tools for understanding the complexity in everyday practice. By taking activity as the unit of analysis, it provides a means to develop a set of new ideas to explain the value created during use. This study shows the robustness of “activities” to demonstrate to users the value of ETs while testing, as better accommodated to perform complex tasks. In immersive technology, the

"subject" remains the same, but the "object" and the "outcomes" can be different, as VR represents new forms of activities that reshape the ordinary routine. By experimenting with ETs thus, the customer could create value, while performing routine activities.

In accordance with customer-dominant logic (Heinonen *et al.*, 2013), customers are active participants in value creation and value is co-created through interactions between customers and service providers. This perspective emphasizes the importance of understanding customers' needs, preferences, and experiences in order to create value for them. Once the case study was completed, all core value-forming activities enabled by immersive technology were identified, along with the actions, users, and objectives associated with each activity:

Table I Core value-forming activities enabled by immersive technology

Activity	Actions	Users	Objective
Conducting a design review	Evaluating properties of a full-size model Assembling/disassembling the model Adding annotations Detection of errors	Engineers Designers	Securing technical requirements
Assessing design and market feasibility	Walking around and through a model Experiencing a full-scale model Comprehending complex information Comparing different design concepts Giving feedback	Managerial decision-makers	Ensuring a good market potential for a product
Remote collaboration	Walking together around and through the model Adding annotations Giving and receiving instant feedback Discussing and resolving design issues	Internal and external users	Enabling efficient and naturalistic interaction
Emotional responses	Feeling uncertain Feeling immersed Feeling excited Feeling discomfort Feeling belonging	All users	Guiding individual user behavior

The framework developed suggests that value is formed through three physical activities and their resulting emotional responses, which can be illustrated graphically see Figure 2.

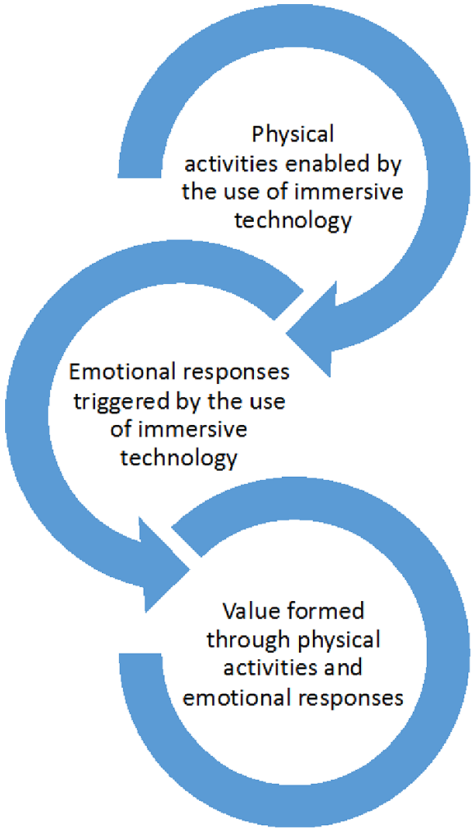

Figure 2 Value formation as a coalescence of physical activities and emotional responses

Contribution and implications of Paper 1

This paper contributes with a framework that explains how value is *formed* during the usage of immersive technologies in industrial contexts. The case study results illustrate how value is formed by users in the context studied through three physical activities (conducting a design review, assessing design and market feasibility, and collaborating remotely) that consist of a series of actions and are reflected in five emotional responses (sense of uncertainty, immersion, excitement, discomfort, and belonging). Physical activities and emotional responses are the essence of our basic tentative framework and the assumption that prompted and guided this study. Therefore, this framework articulates a more nuanced perspective on how value emerges for the user through physical activities and his/her emotional

responses. By focusing on activities, this research adds knowledge to the literature on commercialization of ETs about new activities that emerge from the use of ETs (Mele *et al.*, 2018). The next contribution is that the study provided empirical evidence that as a result of use of immersive technologies, physical activities trigger the emotional responses of users which can cause negative implications, particularly for novice users who may be less familiar with the technology and its potential effects. This supports the literature that suggests that value co-creation may sometimes lead to the co-destruction of value (Echeverri and Skålén, 2011; Lintula *et al.*, 2018). By understanding the potential negative implications of emotional responses, researchers and developers can work to mitigate these effects through improved design, user education, and support. A third contribution of this study is that it clearly verifies the relativistic nature of the value realized of ETs (Holbrook, 1994). This means that value is formed in relation to an individual user's previous experiences and depends on the specific context. The study's findings, therefore, highlight the importance of considering the diverse backgrounds and experiences of users. Interestingly, the study's empirical observations also shed light on the unexpected role of bystanders in the value formation. Bystanders, who are not directly using the technology but are present during the user's experience, can influence the user's perception of value. This finding emphasizes the importance of considering the broader social context when evaluating the impact and value of immersive technologies. The theoretical contribution of this study lies in its application of activity theory, a cultural approach, to analyze value-in-use. By using activity theory as a lens, researchers can better understand how the complex interplay between users, immersive technologies, and the surrounding social and cultural context influences the formation of value. This approach enables a more comprehensive understanding of the factors that contribute to the value of immersive technologies, and it can guide the development of more effective, inclusive, and responsible applications.

4.2. Article 2

Article 2, published in the *Journal of Business-to-Business Marketing*, aimed to develop a framework to explore the evolution of the value proposition of ETs evolves over time. Responding to calls for further research on the dynamic nature of value propositions (Ostrom *et al.*, 2015; Payne *et al.*, 2017), the study focuses on how technology providers frame the value of ETs in value propositions and change it in B2B market.

Employing a single case and process approach, the longitudinal study tracks changes in the value proposition of ETs over a 25-year period. Drawing on the theory of value proposition and the notions of frames and framing, this article identifies various frames that are invoked and become dominant in the value proposition as it evolves.

The study provides a nuanced account of how framing of the value proposition transitioned from *vision* to *network* and ultimately to *usage,* demonstrating synergetic relationships with customers as the firm progressed from a startup to a public company. The role of technology provider in the framing of value propositions is emphasized throughout this process.

Contrary to the preliminary assumption that frames would displace one other, the observed patterns indicate that the vision and network frames persist across all phases and play a supportive role in communicating the value proposition. In other words, the study reveals that an existing frame is not replaced by a new one; instead, the dominant frame changes. Figure 3 offers the visual comparison by displaying the frequency of occurrence of frames at each stage of development.

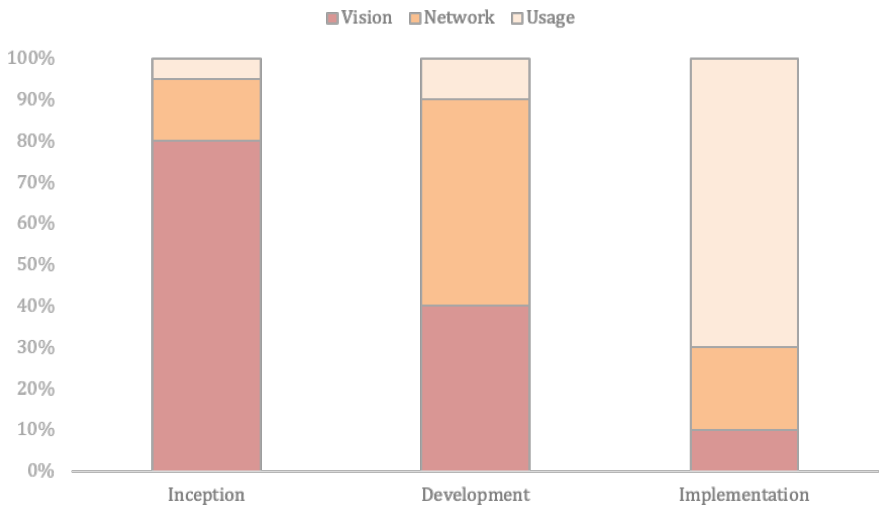

Figure 3 Overview of value proposition change

This study exemplifies that matching ETs with markets involves a diverse range of strategies, from pinpointing ideal markets to addressing specific

customer challenges. Framing an initial value proposition for ETs is a complex undertaking, as the technology value is uncertain and often there is lack of experience in developing value propositions.

This research aligns with Kowalkowski's (2011) assertion that effective communication of value propositions involves flexible shifts in focus at different stages. Such changes have been driven in this research by a combination of enhanced competitive strategies, technological advancement, and deeper customer focus, echoing insights from scholars like (Covin *et al.*, 2015; Lindgreen *et al.*, 2012; Lusch *et al.*, 2010; Norton and Pine, 2013). On this view, the value proposition emerges as a dynamic communication process that mitigates customer uncertainty about the value of ETs, leveraging company's resources and competencies. Moreover, this research demonstrates a dynamic and 'outside-in' perspective in the examination of value propositions, which is particularly needed in B2B markets Day's (2020). Day defines "outside-in" as perceiving solutions through the eyes of the customer rather than merely treating solutions as bundles of products and services.

Contribution and implications of Paper 2

The study's primary contribution is the development of a framework that illustrates how value proposition of ETs evolves over time. It captures the dynamic changes and adaptations that technology providers make to maintain relevance in the market. The secondary contribution offers a detailed analysis of how value proposition framing progresses from vision to network, and eventually to usage, while emphasizing close synergy with customers.

In the initial phase, the vision frame serves as a proxy, as newly founded businesses are typically driven by a grand idea of future. Subsequently, the network frame becomes more prominent, reflecting the company's extensive collaboration with partners due to lack of necessary resources. Finally, as adoption of the technology increases, there is an overarching focus on usage. The study not only illustrates the emergence of each frame, but also reveals that an existing frame is not replaced by a new one, instead the dominant frame changes.

Another contribution of this paper is the observation that highlights the role of vision in creating an initial value proposition that reflected public beliefs

about the emergent industry. The study confirms the importance of adapting the value proposition over time, allowing providers influence expectations by emphasizing specific benefits. This corroborate the assumptions of a great deal of the previous works that value proposition is dynamic (Covin *et al.*, 2015; Lindgreen *et al.*, 2012; Lusch *et al.*, 2010; Maglio and Spohrer, 2013; Norton and Pine, 2013). In doing so, this study dispels the doubt expressed by (Lindgreen *et al.*, 2012) if change in value proposition takes place at all. Further, it also corroborates the importance of taking a proactive approach to changing the value proposition. This research also makes a methodological contribution by utilizing data from Internet Archive, the largest historical web archive since 1996. This archive preserves retrieved copies of web pages, enabling researchers to track old pages that have been deleted (Thelwall and Vaughan, 2004).

This study underscores the significance of technology providers in framing the value of ETs by initially defining and conveying the potential value of ETs to customers and other stakeholders; by establishing a network of partners and customers, which further strengthens the value proposition through showcasing the technology's potential for widespread adoption and integration; and by collaborating closely with customers to co-create value-in-use, ensuring that the ETs fulfill their promises and satisfy customer expectations. This research corroborates the viewpoint of (Ballantyne and Varey, 2006) on the pivotal role of two-way communication in co-creation. They emphasized that engaging customers in conversation not only paves the way for innovative insights but also signals a shift in the dynamics of relationships between parties involved. This transition is aptly illustrated in the second study, where a company moved from a persuasion-heavy communication approach to a more dialogue-oriented one. This dialog supports co-creation and serves as advanced communication forms compared to persuasive and informing (Ballantyne and Varey, 2006) This shift enabled the provider to facilitate more meaningful interactions with their customers, sparking innovative ideas and leading to improved collaborative outcomes. It posits that two-way communication is a vital for value propositions. It enhances customer engagement, fosters mutual understanding, and facilitates the development of solutions that closely align with customer needs and preferences, thereby effectively conveying the value of ETs to potential customers. The findings underscore the necessity for providers to transition from a monologue-centric to a dialogue-oriented communication model,

which nurtures open-ended, discovery-oriented, and value-creating interactions.

4.3. Article 3

Article 3, presented in a previous version as a competitive paper at the PDMA Inspire Innovation Conference and JPIM Research Forum 2022. It aims to analyze the technological and business fluency skills that knowledge brokers possess so that are able to effectively communicate and jointly co-create the value of the ETs under consideration with customers. Despite the acknowledged role of knowledge brokers in the innovation, their precise contribution to value co-creation with customers remains somewhat unclear. Indeed, previous researchers have emphasized the role of cross-boundary communication but glossed over the required form of expertise that underlies effective and credibly persuasive communication, bridging two communities with their two different life worlds.

This study addressed the disconnect between business customers and technology providers regarding the ETs value, which continues to generate headlines in trade publications (Lewin, 2021). ETs' benefits for business customers are not always immediately apparent. Complicating matters further is the fact that ETs are a new phenomenon that has hardly been empirically studied. As a result, knowledge brokers are needed to operate at the boundary between the different communities in technology projects. Previous research has addressed this communication challenge between technologists and business professionals due to their different mindsets, cultural environments, and socialization processes resulting from their specialized disciplines.

To gain insights into expertise possessed by knowledge brokers to competently communicate and ultimately co-create value of ETs, the current study adopted and adapted the concept of "interactional expertise" (Collins, 2004), amplified by Goddiksen (2014). Originally, the concept of interactional expertise was suggested by Collins (2004) as a form of knowledge that facilitates effective communication and collaboration between people from different disciplines, or between experts and non-experts (Arsal *et al.*, 2021). This concept helps explain the type of expertise needed for knowledge brokers who lack experience in a particular area beyond formal knowledge. Extended the original definition of interactional expertise, our central focus remains unchanged: master the language of a specific domain to the extent of fluency. However, we propose an expansion of this concept,

particularly emphasizing the need to account for contributory expertise, i.e. technological knowledge, particularly within the scope of knowledge brokers. By promoting a more nuanced understanding of interactional expertise, we emphasize its scope beyond the mere ability to speak and understand the language of a domain, but rather about identifying and effectively communicating the intricate subtleties of ETs. This expertise equips knowledge brokers to mediate between different knowledge domains, bridging divides and facilitating meaningful cross-disciplinary dialogue. It could be argued that knowledge brokers with interactional expertise plays a critical role in the commercialization process of ETs, acting as a bridge between diverse stakeholders necessary for successful market adoption.

Through in-depth, semi-structured interviews with knowledge brokers, the study extends the concept of interactional expertise by outlining how it is acquired, the depth and breadth of technological knowledge, and the degree of linguistic socialization that underlie this form of expertise. The findings reveal that while technological knowledge and industry-specific experience contribute to credibility, mastering the languages of both technology and business communities is essential for knowledge brokers to be considered legitimate in the eyes of both sides. Knowledge brokers resort to devices such as experimentation, using prototypes and pilots, while also make extensive use of figurative language such as metaphors, analogies and storytelling to make complex ETs understandable. An interesting finding was that brokers with deep and extensive technological knowledge (acquired through formal training and experience) and deep linguistic socialization in the business world (acquired through practice) tended to use metaphorical, figurative, storytelling communication devices that stimulated their clients' minds and imaginations, often leading to the discovery of new uses of technology and innovative solutions. In contrast, less experienced knowledge brokers with basic technology skills, regardless of their level of business socialization, tend to rely on literal language ultimately offering more ordinary solutions.

Contribution and implications of Paper 3

The main contribution of the articles is a matrix framework that illustrates the nuanced nature of the expertise required to competently communicate the value of ETs. These findings provide food for thought about the varying levels of interactional expertise that knowledge brokers develop over the years. The more advanced a broker’s technological knowledge and business language

fluency, the "more elevated" innovative solutions for customers problems will be. The figure 4 visually demonstrates the relationships between these two dimensions - technological knowledge and business linguistic fluency:

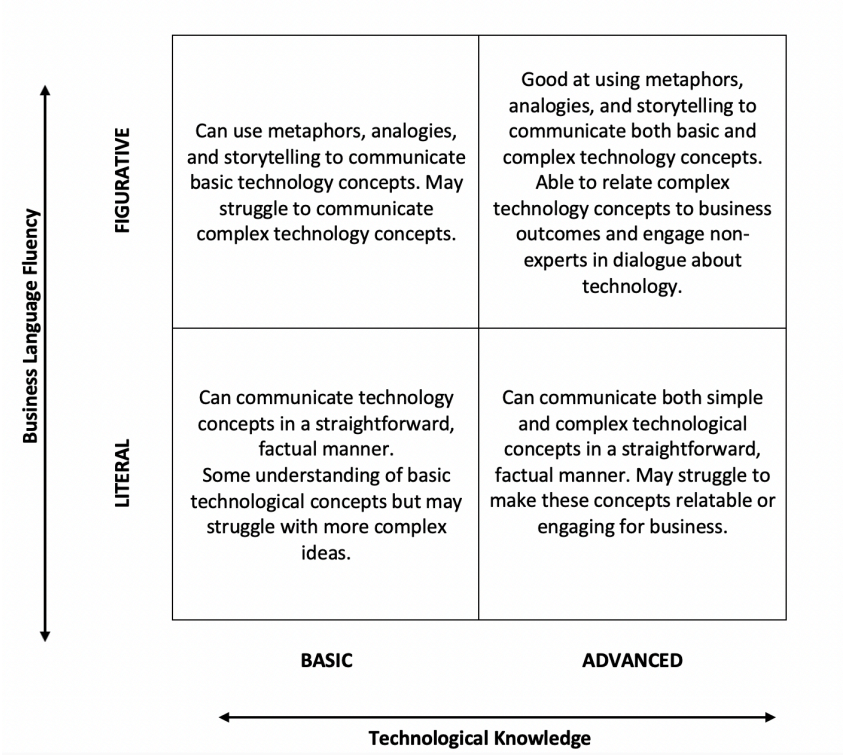

Figure 4 Degrees of interactional expertise

It is important to acknowledge that while many knowledge brokers strive to develop a degree of interactional expertise, the assumption that all consultants possess it is a simplification. The actual distribution of consultants across these categories may be more complex and nuanced. It's also possible for someone to improve their skills in one area (e.g., technical knowledge) without necessarily improving in the other (business language fluency). Therefore, it's important to use such degrees as a guide, rather than a strict classification system.

This study also advances the theory of interactional expertise, providing a more nuanced understanding interactional expertise that underscores the indispensability of both profound technical understanding and adept business fluency in effectively mediating the divide between technology and business.

In essence, we argued for a more comprehensive and sophisticated understanding of interactional expertise, by recognizing the significant role of technological proficiency. As it stands, knowledge brokers, through their ability to unpack the value of ETs and co-create innovative solutions to customer challenges through collaborative initiatives, propel the commercialization process of ETs. This study, therefore, accentuates the significance of comprehending and bolstering the role of knowledge brokers for both practitioners and policymakers, positioning them as key drivers of successful technology commercialization and adoption.

5 CONTRIBUTIONS, IMPLICATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

This chapter presents the results of the empirical research, relate its findings to previous research, and point out the implications of this thesis as well as suggestions for further research. The aim of thesis was to propose a theoretical framework of co-creation processes that help customers unpack the value of ETs for their businesses. This framework, based on a theoretical insights and reinforced with empirical evidence, highlights the significance of three processes helping unpack the ETs' value (see Figure 5) and their importance in commercialization. By and large, previous studies have recognized that main reasons for the uncertain value of ETs is due to their emerging and complex nature, as discussed in Chapter 1. The primary conclusions drawn from all three papers are systematically presented in Chapter 4. For an in-depth exploration of the findings, as well as a comprehensive discussion of their theoretical implications and contributions, readers are referred to the individual papers themselves, where each is examined in detail.

5.1. General discussion of the framework

This research aimed to propose a framework based on abductive approach that encompasses three distinct but mutually reinforcing co-creation processes to help customers unpack the value of ETs for their businesses. Building on the theoretical insights from Section 1.2, this research adopted a social constructionist approach to technology, focusing on three key processes: experimentation, communication, and knowledge brokering. These processes were identified as central to the unpacking of ETs' value, reflecting the theoretical framework that underpins this study. While a deterministic way of thinking implicitly underpins the part of claims in the literature on commercialization about ETs value, others view co-creation as a linear and singular sequence. This co-creation perspective challenges deterministic view on technology by acknowledging the role of social interactions between customers and other stakeholders in the process of creating the value of ETs. The critical vantage point is that value of ETs is not given a priori, as an idea

in the mind of the provider, but resulting from a continuous social process. By employing abductive reasoning, this research not only extends the understanding of ETs co-creation but also situates it within a broader theoretical landscape, providing a robust foundation for the interconnected processes described.

5.2. Main findings

This thesis contributes to the co-creation literature on ETs by developing a framework of processes that help customers unpack the value of ETs. This answers the calls for a better understanding of value co-creation in the context of ETs (Mele *et al.*, 2018; Weingarden, 2018).

This study contributes to the understanding of co-creation in the context of ETs by elucidating the interconnected processes of experimentation, communication, and knowledge brokering. It emphasizes the iterative and cyclical nature of these processes, highlighting their mutual reinforcement. The findings have significant implications for both academics and practitioners, offering a nuanced framework that can guide the commercialization of ETs. By recognizing the complexity and interdependency of these processes, organizations can foster a more dynamic co-creation, unlocking new opportunities and enhancing their competitive edge in an ever-evolving marketplace.

Moreover, this thesis sought to synthesize partial perspectives of each article into a comprehensive framework, which provides a holistic understanding of the co-creation processes involved. The framework suggests that three processes, *experimentation, communication*, and *knowledge brokering* help customers unpack the value of ETs, each studied in an article with findings discussed in Chapter 4. These three processes are intertwined and interdependent because they work together to unpack the value of ETs, constituting a circuit of value co-creation, as captured in (Fig. 5). They jointly contribute to a better understanding of the value proposition, improve customer engagement, and foster a collaborative environment for value creation. Through these three interrelated processes, represented by a cogwheel metaphor, technology providers can create an environment that facilitates customers to unpack the value of ETs for their businesses.

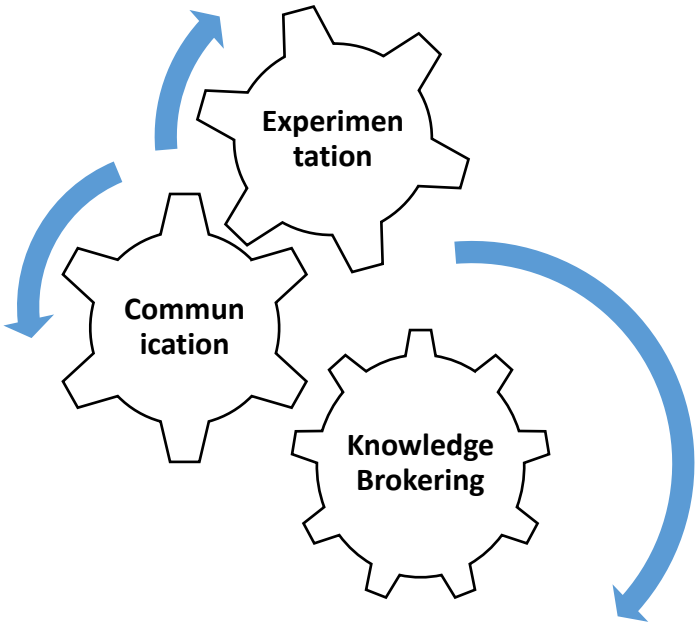

Figure 5 Processes helping to unpack the value of ETs

The results of the study reveal a complex interplay between experimentation, communication, and knowledge brokering in unpacking the value of ETs for customers, reflecting an interconnected and mutually reinforcing relationship.

The three processes are not linear or isolated; they are part of an ongoing, iterative cycle of value co-creation. Experimentation feeds into communication, which in turn is facilitated by knowledge brokering. Together, they form a cohesive and interconnected framework that helps customers unpack the value of ETs. The synergy between these processes is essential, as without one, the others would be less effective. For example, without knowledge brokers (with their interactional expertise), the outcomes of experimentation may not be effectively unpacked (as shown in study 3), and without communication, experimentation alone would be insufficient. This interconnectedness underscores the complexity of the co-creation process and highlights the need for a holistic approach that recognizes the interdependencies and mutual reinforcement of these three key processes.

Experimentation (with its underlying physical and emotional activities) is often the starting point, where customers actively explore and test ETs,

gaining firsthand experience and understanding of the technology's potential applications, benefits, and limitations. A key aspect of this process is the discovery of customer needs through dialogue and feedback during pilots. Customers, as carriers of their own wants and needs (Tiberius *et al.*, 2021), can play a role of knowledge brokers, especially in the context of ETs where understanding user needs and preferences can be challenging. Experimentation also provides a platform for customers to offer feedback to technology providers, driving improvements to the technology and ensuring it remains relevant and valuable to customers over time. This process feeds into the other two processes, as the insights gained here drive the communication and knowledge brokering processes.

The process of communication is intertwined with experimentation as the process of communication is a continuous dialogue where customers' feedback influences the co-creation and customization of ETs (Ballantyne and Varey, 2006). The feedback from hands-on trials informs the development and refinement of the value proposition, supporting the scholars' observations that the value proposition is a co-created claim (London *et al.*, 2015). Communication is not a one-way street; it's a continuous dialogue where customers' feedback influences the co-creation and customization of ETs (Ballantyne and Varey, 2006). This process aligns with Bakhtin's model of dialogic interaction (Bakhtin, 1981), where continuous feedback and interpretation play a vital role.

The knowledge brokering process functions as a bridge, translating complex technical information into specific contexts as consistent with the literature (Burgess and Currie, 2013). Consequently, knowledge brokers assist companies in augmenting the knowledge companies possess. Knowledge brokers (through their interactional expertise) translate the outcomes of experimentation into understandable and pertinent information for customers (as shown in study 3). They act as a conduit between customers and technology providers, fostering collaboration and communication by bridging gaps in understanding and aligning expectations.

The three processes are part of an ongoing, iterative cycle of value co-creation. The synergy between them is essential, as without one, the others would be less effective. This interconnectedness underscores the complexity of the co-creation process and highlights the need for a holistic approach that recognizes the interdependencies and mutual reinforcement of these three key processes.

By engaging in these processes, customers, providers, and knowledge brokers all play a role in the value co-creation with ETs. For instance, customers co-create the value by experimenting with ETs, as they use them in everyday activities (as was the case in the first article). This experiment resulted in testing the customer's hypothesis and finding new use scenarios for design, which later led to the continuous use. Providers contribute to value unpacking of ETs by framing and changing value propositions in the second article. Customers feedback on pilot projects, in the second article, made a huge contribution to the current meaning of value of ETs. Knowledge brokers in the third article, contribute by providing advice and explaining technologies based on prior experience and expertise, also by co-creating value with their clients. Apart from these key actors, value was shaped by a set of other contributors such as bystanders in the Article 1; competitors, governmental bodies, exchange funds, analysts, shareholders, PR specialists in the Article 2 and subject expert matters in Article 3.

5.3. Theoretical contributions

This thesis augments the academic discourse by offering several key contributions to the current body of knowledge on co-creation with ETs (Galvagno and Dalli, 2014; Nájera-Sánchez *et al.*, 2020). The first major contribution is the development of framework, exploring interconnected processes of experimentation, communication, and knowledge brokering. Secondly, it underscores the iterative and cyclical nature of these processes, highlighting their mutual reinforcement. Lastly, the thesis extends the concept of co-creation in B2B with a specific emphasis on the role played by knowledge brokers.

Firstly, it introduced the framework comprising three interconnected processes - *experimentation, communication, and knowledge brokering*, that extends prior research on value co-cocreation in the context of B2B. In doing so, it provides a more intricate nuanced perspective on the concept of value co-creation, as according to the call "zoom in" (Wang *et al.*, 2019). The "zooming in" approach can be interpreted as a detailed, in-depth exploration of specific co-creation processes and their interactions within commercialization of ETs. The findings provide detailed insights by specifying each process; by highlighting the roles of multiple stakeholders such as customers, providers, and knowledge brokers that resonates with the view that these roles are complex and intricate (Ramaswamy and Ozcan,

2018); empirically studying value co-creation in context allows for a robust, nuanced understanding of how value is co-created with various stakeholders in real-world scenarios.

The second contribution is that research findings strengthen existing literature on co-creation, which suggests that co-creation is not a one-time interaction, but rather an iterative and cyclical process where feedback and continuous engagement between stakeholders are essential. This thesis emphasizes that the processes of *experimentation, communication, and knowledge brokering* are not linear or one-time activities. Instead, they are part of an ongoing, iterative cycle of value co-creation. This thesis confirms the notion that value of ETs emerges in a process of continuous, cyclical co-creation *in situ*. This view is supported by scholars who suggest the co-creation concept to move away from the firm-centric prism, such as (Grönroos, 2011; Prahalad and Ramaswamy, 2004; Vargo and Lusch, 2012). The findings suggest that iterative cyclical co-creation is particularly relevant in the context of ETs due to uncertainties and constant changes, which often necessitated closer and more extended collaboration with customers to ensure that the developed technologies align with market needs and preferences. This was crucial for fostering new ways of co-creating value with ETs that go beyond initial collaboration. The study demonstrates, namely, how continuous co-creation in experimentation facilitated the provider to iteratively refine and adjust the technology based on customer feedback and evolving requirements; allowed the provider to effectively update its value proposition to maintain a dialog and synergy with customers; and promotes the ongoing exchange of information and collaboration. Thus, this research emphasizes the significance of continuous co-creation as a vital aspect of these three processes and its importance in the commercialization of ETs. This, in turn, facilitates organizations to co-create value based on the latest market developments, industry trends, and customer preferences. This study offers empirical evidence that supports the view of iterative ongoing co-creation and illustrates the critical nature of continuous learning and iterative processes (Leask *et al.*, 2019) in the context of ETs.

Lastly, the thesis enriches the understanding of co-creation by casting the specific lens on the B2B context (Saha *et al.*, 2022) with a particular focus on the role of knowledge brokers. It reinforces their importance in the co-creation process within B2B contexts, emphasizing their essential role in facilitating collaboration among diverse stakeholders. As noted by Haessler *et al*. (2022),

the role of knowledge brokers in the commercialization of ETs is under-researched, while this thesis demonstrate their contribution in Study 3, highlighting how they identify customers problems, translate complex technical information, and adapt solutions to specific contexts. The findings reinforce the idea of knowledge brokers ability to apply knowledge from one domain to innovate in another (Hsu and Lim, 2014), a process that involves connecting, recombining, and transferring ideas (Burgess and Currie, 2013). This approach allows them to offer customized advice and recommendations, addressing issues related to ETs, and confirming their indispensable role in co-creation. The findings indicate that knowledge brokers possess a deep understanding of the industry landscape and the unique aspects of their clients' businesses.

5.4. Application of the framework

The proposed framework can also be applied to other technologies, showing they help unpack the value through these three processes. In the case of drone technology, also known as unmanned aerial vehicles, commercialization took several decades. In 1917, the first drone was tested in the United Kingdom, while the American aerial torpedo was first tested in 1918. The experimentation with unmanned aircraft continued, and in 1935 the first drones were used for military purposes. These early drones were rudimentary and had limited capabilities, but they paved the way for the development of more advanced drones in the years to come. Drone experimentation has involved many actors, from the military and government agencies to private companies and research institutions to hobbyists and enthusiasts. As the technology evolved, so its applications proliferated, opening new opportunities for value creation.

The value proposition of drones has evolved significantly over the years, reflecting changes in technology, use cases, regulation, and market demand. The first prevailing frame focused heavily on warfare, as military officials often emphasized the strategic and tactical benefits of drones for security and defense. As technology evolved and drones became increasingly available, providers focused more on promoting the potential benefits and applications

of their products. Parrot[8], for example, launched the AR quadcopter drone in 2010, which was cast in a positive light as an affordable, easy-to-use, innovative, and fun drone that was accessible to a broader audience of hobbyists and enthusiasts. Its introduction helped popularize the use of drones for recreational purposes and paved the way for the development of more advanced and powerful drones in the years that followed. Technology companies such as Amazon, UPS and Google have been vocal advocates for the use of drones in package delivery. In doing so, they are framing value proposition of drones as efficiency and cost reduction. Drones are increasingly being used for environmental monitoring and research, such as tracking wildlife or surveying landscapes. In addition, the United Nations (UN) has been using drones in its peacekeeping missions around the world for humanitarian assistance and protection (Karlsrud and Rosén, 2013). Customers are participating in the public discourse about drones by sharing their experiences and opinions on social media and online forums. Drone enthusiasts, for example, share photos and videos they have taken with their drones, while experts can provide insight and advice on the use of drones for specific applications. At the same time, privacy advocates express concerns about the use of drones due to their potential impact on privacy. The evolving framing of drones and the communications surrounding them reflect the growing recognition of their potential benefits, as well as the concerns and challenges associated with their use. This underscores the need for continued research, innovation, and responsible use of this technology.

There are different types of knowledge brokers that contribute to unpacking the value of drones. Knowledge brokers such as research organizations that provide insight and expertise on the development and application of drone technology. The Association for Uncrewed Vehicle Systems International (AUVSI), for example, is a leading industry association that supports the development and adoption of unmanned systems, including drones. They play a role in connecting stakeholders in the drone industry, providing information and resources, and promoting best practices. Government agencies facilitate the development and regulation of drone technology. For example, the Federal Aviation Administration (FAA) in the United States is responsible for

[8] Parrot is a French provider of commercial drones covering equipment and software.

regulating the use of drones in the national airspace and has developed guidelines and regulations to ensure safe and responsible drone use. Another example is consulting firms such as McKinsey, which provide strategic advice to companies and organizations looking to invest in or deploy drone technology. Other brokers such as trade journals as DroneLife provide news, analysis, and insight into the drone technology and industry, and serve as knowledge brokers among stakeholders in the drone ecosystem by providing information on trends, best practices, and regulatory developments.

5.5. Theoretical implications

From the constructionist view of value as emergent, we can comprehend commercialization as a complex process involving interactions among various stakeholders. This perspective acknowledges that both technology and the market are not given; rather, they are continuously evolving and being redefined through the interactions of different actors, providers, regulators, and customers. Under this framework, commercialization transcends the simple transfer of technology from the lab to the market. It becomes a dynamic, co-evolutionary process in which stakeholders jointly shape and redefine the technology, the market, and the value. This view emphasizes that commercialization is a continuous and cyclical process, rather than a one-off event, where the value of technology is continuously negotiated, constructed, and reconstructed through interactions among various stakeholders. In the context of ETs, this constructionist view aligns with the principles of continuous co-creation and systemic thinking. Continuous co-creation fosters an ongoing, collaborative relationship that enables organizations to exploit unknown and future opportunities, ensuring responsiveness to the ever-changing landscape. Systemic thinking provides a holistic view of the complex interdependencies within the market and technological ecosystem. Together, they form a synergistic framework that empowers organizations to proactively identify and exploit unknown and future opportunities in the commercialization of ETs, enhancing agility and positioning organizations at the forefront of technological innovation.

5.6. Managerial implications

From a practical standpoint, this study can furnish managers with valuable insights into the value co-creation processes, assisting them in the crafting of effective strategies that are firmly rooted in this concept. The synthesis

elucidated in this thesis further stands to benefit managers by endowing them with a comprehensive understanding into the processes that help unpack the value of ETs for practitioners. To effectively address the uncertainties inherent in ETs, a combination of three co - creation processes is recommended: *experimentation, communication, and knowledge brokering*. Providers may consider creating opportunities for relevant stakeholders in B2B market to motivate experimenting with ETs, which could help identify potential uses and benefits, as well as uncover any limitations. This hands-on experience can inform decision-making regarding technology ultimately driving adoption. In the face of uncertainty, hands-on trials offer tangible insights and allow business customers to understand implications, test assumptions, and pivot when necessary. It allows industrial users to actively explore and test ETs in their specific contexts, providing them with firsthand experience of the technology's potential applications, benefits, and limitations. Firsthand experience aids customers in overcoming doubt and uncertainty about the technology's functionality if they hesitate to embrace the technology as quickly as providers expect. This process facilitated users to validate the technology's performance in real-world conditions, identify use cases relevant to their specific needs, and therefore, gain a deeper understanding of its value. Moreover, managers could consider fostering ongoing co-creation with stakeholders to regularly re-evaluate, refine, and improve technology applications and solutions. This iterative approach would allow organizations to stay agile and responsive to changing needs and emerging opportunities. Feedback loops, in this case, are essential, as they allow for the ongoing exchange of information, insights, and ideas between stakeholders involved in the development and utilization of ETs.

However, experimentation alone is insufficient; it should be accompanied by communication of value proposition to the market. Developing an initial value proposition of ETs maybe challenging compared to established technologies due to potential customers' hesitance to adopt something new and unproven. Using a trailblazing AR/VR firm as an example, this research describes the iterative process of value proposition development over the years to help managers sift through the information. This research suggests that an initial vision may be helpful for crafting an initial value proposition, but it should be adjusted over time. Deepening the customer perspective by using value-in-use and reflecting it in value propositions can provide managers with valuable information to increase the success rate of technology commercialization. Providers who want to continue selling ETs may maintain close contact with

their customers to understand how value evolves over time. Managers could benefit from collaborating with knowledge brokers who can facilitate knowledge exchange and cooperation between various stakeholders. In light of the findings in this research, knowledge brokers can provide valuable insights into potential applications and benefits.

5.7. Limitations and future research directions

While this investigation provides valuable insights into the processes that help unpack the value of ETs, it is important to acknowledge its limitations. As with all methodological choices, single case research has its limitations in that it has limited generalizability and limited ability to search for commonalities among multiple cases (Yin, 2014). However, it allowed me to examine in depth the processes that help unpacking the value of ETs and to gain theoretical insights because the case study method allows for an in-depth investigation (Feagin *et al.*, 2016) of the phenomenon. In fact, as Dubois and Gadde (2002) suggest, learning from a single case can be a strength rather than a weakness, as it generates a rich, dense description. The study in the second article based on comprehensive data provided insights into how the value proposition is changing and, thus, provides food for thought on how providers can leverage value propositions over time in practice. While the study's findings may not be generalizable to all contexts, they offer a detailed and nuanced understanding of the phenomenon being studied. By providing a detailed and nuanced analysis, this thesis has theoretical and practical implications for those seeking to develop and commercialize ETs.

Semi-structured interviews and observations as research methods have some weaknesses and limitations. Far from being neutral and objective instruments for data collection, both suffer from the subjectivity of the researcher (Denzin and Lincoln, 2011) and the words captured through interviews inevitably introduce a degree of ambiguity. In addition, long transcripts produced require a great deal of time and effort to analyze, using qualitative method. Therefore, other research strategies can be used to conduct further research in this area.

A natural limitation is related to the use of content analysis itself. While the method is an appropriate means to reveal certain patterns in the communication behavior of companies (Kassarjian, 1977), it cannot give insights into the effects of the messages on customers, e.g., which message appeal is convincing. Future studies should therefore not only try to detect differences or similarities in the communication behavior but should also

focus on the effects (e.g., in an experimental setting) of specific contents and their influence on the decision-making process of customers.

Many perceive qualitative research as subjective due to its potential for bias. Rudestam and Newton (2014) point out that qualitative researchers intentionally select knowledgeable interviewees to enhance understanding of a phenomenon. Consequently, (Morse, 2007) claims, "qualitative research must be a biased activity"(p. 13), arguing that bias should be harnessed and used. Granted these considerations, this bias is necessary for advancing theoretical and practical understanding of the phenomenon. As these are the challenges faced by qualitative researchers, the metaphor that "qualitative researchers navigate treacherous waters" (Tavory and Timmermans, 2014) aptly captures the complexity and dangers of the field.

Despite the novel insights presented in this study, further research is necessary on unpacking of the value of ETs. The study also opens avenues for further research, exploring how these three processes might be applied in different contexts or industries. Pertinent issues for further research include how value of ETs can be reframed, when the first attempt has failed or technology reached maturity. For example, Ryan Raffaelli (2018) develops a theory of technology re-emergence, i.e. creating new value for old technologies. He shows how Swiss mechanical watchmaking, rather than being displaced by a new dominant design, was able to re-emerge and achieve new market growth.

Based on the insights gained from the study on value propositions, it would be intriguing to explore whether value propositions can remain effective without modification. To investigate this, research could be conducted from the customer perspective, assessing their perceptions of the value proposition's relevance and attractiveness. Ultimately, this line of inquiry would contribute to a deeper understanding of the factors that influence the effectiveness of value propositions over time and provide valuable insights for businesses looking to optimize their value proposition strategies in a dynamic and competitive environment.

Future research could explore the application of interactional expertise theory in reverse, focusing on how purchasing managers (from business community) acquire technological solutions while striving to learn the language of technology community and attain technological depth. This line of inquiry could provide valuable insights into the challenges and opportunities faced by

purchasing managers in understanding and evaluating technology-based solutions. Moreover, employing different research designs and methodologies could help to strengthen the validity and generalizability of the findings. This might entail quantitative approaches on how customers perceive interactional expertise. For example, a survey about the influence it has on customer satisfaction, trust, and decision-making processes. Furthermore, future avenue might potentially delve deeper into the specific contributions and impact of knowledge brokers in the ETs commercialization. Another potential question is to determine how knowledge brokers' level of interactional expertise can be utilized to ascertain their level of participation in co-creation with their clients.

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