THE ELUSIVE NATURE OF EMERGING TECHNOLOGIES

UNIVERSITY OF GOTHENBURG

THE ELUSIVE NATURE OF EMERGING TECHNOLOGIES

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ABSTRACT

Emerging technologies fundamentally transform society, with this process gaining ever more momentum as the digital era unfolds; however, the early innovation processes interwoven with them remain poorly understood. The dissertation clarifies these processes considerably by examining the nature of emerging technologies and how the latter influence the early stages of innovation in organizations. The research behind it addressed two questions: *How can emerging technologies be conceptualized*, and, given this conceptualization, *how do emerging technologies shape the conditions for early digital-innovation processes?* The work drew from an interpretative, qualitatively oriented case study of public-sector organizations engaged in early innovation processes involving blockchain technology. A study at a government agency served as an especially rich data source, informing two-phase analysis wherein separate analyses were conducted and presented in four research articles, then more general case analysis addressed the overarching research questions.

Two central contributions to current theory emerged. Detailing the *elusive nature* of emerging technologies draws attention to vital facets of their ambiguity; they lack clarity both in their material structure (how they are technically constituted) and in the purposes articulated for them (what problems can be solved). Secondly, the dissertation presents elaboration on the *framing paradox* of emerging technologies, which is an outgrowth of their elusive nature. This explicates how grappling with the ambiguities requires a strategy to reduce the complexity bundled with the dual ambiguity. It also highlights key tensions: legitimacy-linked ones and tensions between innovation ambitions and responsibilities for existing structures.

The research's findings hold significant practical utility. An organization that acknowledges the "dual ambiguity" and the framing paradox is better equipped to guide its planning and execution of digital innovation processes. For government, one implication of understanding the ambiguity-rife nature of emerging technologies is development of more precise targeting of innovation funding. Also, in society at large, the power game of new technology development requires a corresponding focus on the labeling processes brought into play.

SVENSK SAMMANFATTNING

Ny teknologi förändrar samhället i grunden. Detta är en ständigt pågående process som har intensifieras i takt med framväxten av allt mer integrerade digitala teknologier. I denna avhandling studeras ”framväxande teknologier” (*emerging technologies*), alltså teknologier som ännu befinner sig i ett tidigt skede men som har potential att påverka samhälle, ekonomi och kultur i grunden. Avhandlingen fokuserar på två forskningsfrågor. Den första rör hur framväxande teknologier kan förstås i organisatoriska innovationssammanhang – vilka egenskaper de delar och hur de skiljer sig från etablerad teknik. Den andra frågan handlar om vilken påverkan dessa teknologier har på innovationsarbete, särskilt hur olika grupper och roller i organisationer tolkar deras potential och nytta. Avhandlingen bygger på en kvalitativ fallstudie med tolkande ansats, där offentliga organisationer analyserats. Gemensamt för dessa är att de initierat innovationsarbete kring idén att blockkedjeteknik (*blockchain*) kan skapa nytta i organisationen. En särskilt viktig del av datainsamlingen bestod av nära observationer av ett innovationsprojekt vid en statlig myndighet där idéutvecklingen delvis var framdriven av föreställningar om blockkedjans potentiella nyttor.

Avhandlingens slutsatser bygger på resultatet från de fyra bilagda forskningsartiklarna, samt på övergripande konceptuella resonemang kring framväxande teknologier och deras inverkan på innovationsprocesser. Två teoretiska bidrag presenteras. Det första är en beskrivning av framväxande teknologiers ”svårfångade natur” (*elusive nature*) med fokus på den ”dubbla mångtydighet” (*dual ambiguity*) som karaktäriserar dem. Dels är en framväxande teknologi mångtydig i sin tekniska del, dvs hur den är uppbyggd, dels i sin nyttodel, dvs för vilka syften teknologin kan användas. Dessa aspekter diskuteras ofta i globala sammanhang, och slutsatserna går inte sällan isär. Detta förstärker teknikens dubbla mångtydighet och gör det svårt för organisationer att avgöra vilka lösningar som faktiskt är möjliga och lämpliga för dem. Denna svårfångade natur utgör grunden för avhandlingens andra kunskapsbidrag – den så kallade ”formuleringsparadoxen” (*framing paradox*). Den innebär att en organisation behöver hantera den komplexitet som den dubbla mångtydigheten medför, genom att utveckla en strategi för att minska antalet alternativa tolkningar som teknologin ger upphov till. I sin tur kan detta leda till spänningar, dels kring innovation-

sarbetets legitimitet, dels i relation till de roller som ansvarar för etablerade strukturer, såsom IT-infrastruktur.

Forskningsresultaten har betydande praktisk relevans. En organisation som aktivt beaktar den dubbla mångtydigheten och formuleringsparadoxen står bättre rustad att planera och genomföra digitala innovationsprocesser där framväxande teknologier ingår. I avhandlingens avslutande kapitel presenteras teoretiska och praktiska implikationer, samt vägledande principer för innovationsarbete i organisationer.

ACKNOWLEDGMENTS

As I look back today on my long doctoral-study journey, I can conclude that it has been a very challenging one yet also deeply rewarding. It has required an endurance that would not have been possible to maintain had it not been for several people around me. I will not be able to name them all. Nonetheless, I want to extend a collective "thank you" to everyone who in some way has supported me, encouraged me, and in other ways contributed to me feeling at home in the research environment – which I certainly have. I will, however, also express gratitude specifically to particular individuals and groups.

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To my fellow PhD students: I have spent many hours with several of you, in the office working alongside you and outside it as we've shared our burdens and joys. Mikael Gustavsson, I cannot express how grateful I am for all your support. You have been immensely generous with your time, and your advice has truly helped me craft my journey, from the start through to the end. That, on top of this, we can have endless deep talks about the philosophy of technology and beyond, makes me especially glad to be your friend. Nadia Ruiz Bravo, it has been a joy to share nearly the entire path to a doctorate with you. We have had a lot of fun while supporting each other throughout these years. Thank you! Frida Ivarsson, it feels like only yesterday, but now it has been some time since your defense. I am very glad that I have gotten to know you. Your strong ethical drive has encouraged me greatly. I hope you continue on that solid path, and that we stay in touch. Lu Cao, it has been some time since we last saw each other. I will continue to value and miss that constant contagious smile of yours. Jabbar Hussain, thanks for your positive spirit, for always being so

friendly and always making sure to ask how things are with me and my family. I wish you great success as you complete your own doctoral-studies journey.

My thoughts turn next to the executive PhD students at the research consortium Digital Government. Some of you I have met only briefly and/or online, but every interaction with any of you guys has been full of kindness and spurred inspiration, partly because I share your interest in the school's overarching theme, public-sector digitalization. With a few of you, I have spent more than a little time talking and socializing at conferences and courses: Kristian, Leman, Per, Mäjt, Petra, Robert, Antonio, Malin, Christina, Marcus, Carl, and Andrea, thanks for all of the great discussion and laughs.

Some of the time in the office was devoted to student-union work – the time spent on issues related to the doctoral council. Although partly a matter of duty, this work has had social importance too: reflecting on and discussing such vital concerns as the work environment for PhD students draws people together. So, I want to thank everyone who has worked alongside me for this common aim. Thank you, Bahram, John, Izabella, Nadia, Malin, Jabbar, Frida, Christina, and Karin. Special thanks go to Anita, who established the council back in 2021.

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There are a few people who merit a special "thank you" for contributing specifically to my dissertation's final materialization as the volume you hold in your hands (if you are reading the PDF version you will have to imagine). Richard La Bontee, at the unit for academic language, your guidance was very helpful. Anna Shefl, thank you for the excellent language service you provided. I learned a lot through this process. Mattias von Feilitzen, I'm profoundly grateful for the assistance with the book layout. And Claes Alm, my long-time friend, I am so glad you wanted to create the cover illustration. Thank you so very much!

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I conclude these thoughts with my deepest thanks to my closest family: my partner Karin and my daughters Matilda and Klara. Karin, you have been so incredibly supportive through all my tough times, and always with a selfless attitude. My dearest daughters, I have tried hard over these years to maintain a sound balance between work and my family so that I can be a good father. I know that at times it has been hard. I genuinely hope you understand this. You mean so much to me, with my whole heart: jag älskar er!

Mikael Lindquist
Gothenburg, August 2025

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Part 1

THE ELUSIVE NATURE OF EMERGING TECHNOLOGIES

CHAPTER 1
INTRODUCTION

1.1 THE SITUATION MOTIVATING THE RESEARCH PROJECT

This thesis is about *emerging technologies*, interpreted as discursive entities that organizations' actors – such as practitioners, entrepreneurs, and public servants – encounter and that refer to novel technological innovations that appear promising. They are identified by labels, such as "blockchain," "AI," or "the internet of things." Each such label is important because it functions as a "portal" to a community discourse that contains information on various aspects of the emerging technology, with its proposed material components being among these (Alexander et al., 2012; Miranda et al., 2022; Swanson & Ramiller, 1997). Material components denote the underlying technical structure that the technology exploits for its purpose. These components are particularly important in that they both enable and constrain what the technologies can do, consequently circumscribing what purposes they can fulfill (Leonardi, 2010). Hence, the relation to material components is a property of technological discourses that decisively distinguishes them from other types of discourse.

The information held in discourses surrounding emerging technologies can be described as both fluid and ambiguous (Rotolo et al., 2015; Swanson & Ramiller, 1997). A clear challenge arises from this fact for organizational actors involved in innovation processes. One could consider the perspective of a digital strategist who has been assigned the task of staying abreast of novel technologies and continuously evaluating whether these might suit the local organization. This entails encounters with labels wherein the strategist tries to access whatever information lies behind those labels and consider that information in light of local needs. I argue that this encounter arena encompasses an under-theorized phenomenon, which the thesis addresses by offering a new theory of emerging technologies. It 1) approaches them as labels that refer to both material components (how are technical resources leveraged in new ways?) and purposes (why are these new ways interesting?) and 2) examines organizations' digital-innovation processes in relation to emerging technologies.

The term "emerging technology" is well established across industries and sectors (yet not well defined, as elaborated below). The associated labels for technologies that are currently considered emerging often get presented in lists or diagrams. Offering some continuity, industry consulting firm Gartner introduced its famous "hype cycle" in 1995[1] as a mapping tool for emerging technologies and has been publishing frequent updates ever since (Pollock et al., 2022). Wikipedia followed suit with its entry providing a dynamic list of emerging technologies since 2008.[2] Government attention to emerging technologies is evident also. For example, web pages specifically addressing the phenomenon have been published by the OECD[3] and EU[4].

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[1] Chronicled at https://www.linkedin.com/pulse/first-hype-cycle-origin-story-jackie-fenn/ as accessed on April 8, 2025.

[2] Presented at https://en.wikipedia.org/wiki/List_of_emerging_technologies (most recently accessed on April 8, 2025), with the number of updates made as of the time of retrieval (totaling 2,617) attesting to the dynamic nature of such lists.

[3] See https://www.oecd.org/en/topics/emerging-technologies.html, as accessed on April 8, 2025.

[4] For instance, https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/221-emerging-technologies-could-shape-europes-future-2025-02-17_en, most recently accessed on April 8, 2025.

1.1.1 THE PROBLEM AFFECTING PRACTICE

Understanding of emerging technologies has strong practical relevance from at least three problem-sensitized perspectives: public funding, innovation-process interpretation, and societal future-shaping. Firstly, the relationship to *public funding* demonstrates importance as government entities channel public resources to research and innovation projects aligned with emerging technologies. For example, by April 2018 cumulative spending of 200 million euros had been reported for blockchain technology alone, only one such technology.[5] The sentiment behind these expenditures is captured well in the abstract of a recent European Commission report: "Detecting emerging technologies is crucial for policymaking as it helps to anticipate future trends and address their potential societal, economic, and security impacts [and hence allows] policymakers to support strategic industries, orient research and innovation," etc. (Eulaerts et al., 2025, p. 1).

Secondly, government programs, alongside external expectations from actors such as civic associations, citizens at large, and firms' shareholders, put pressure on organizations to engage in and adapt emerging technologies (e.g., see Mergel et al., 2019). Therefore, from the perspective of *innovation processes*, organizations must find ways to interpret these emerging technologies and plot them against local needs (Swanson & Ramiller, 2004). This is challenging in that emerging technologies are fraught with ambiguity (see Rotolo et al., 2015) and surrounded by diverse market interpretations, fueled partly by inflated expectations (Swanson & Ramiller, 1997).

Thirdly, the importance of emerging technologies, and how the technologies get interpreted and acted upon, can therefore be addressed from a *societal* perspective. Since the landscape of emerging technologies shares ground with what is still being shaped, the interpretations of those technologies and also the related choices made in organizations' micro settings ultimately decide the socio-technical future of our society (Chiasson et al., 2018; Hovorka & Peter, 2019), where "socio-technical" refers to the reciprocal relations between social needs on one hand and technical

[5] At https://digital-strategy.ec.europa.eu/en/news/european-countries-join-blockchain-partnership, as accessed on April 8, 2025.

advances on the other (Leonardi, 2011b). One contemporary example of the importance of interpretation, which is greatly simplified here for ease of explanation, is the perceptual aspect of generative AI in various domains. For instance, tensions can be identified between interpretations in the education sphere that acknowledge potential and that acknowledge the risks. In conclusion, since the future gets realized "through the actions and policies of human actors [...] in relation to the interests and values brought to bear in technology design and implementation" (Chiasson et al., 2018, p. 372), the settings in which new technologies are developed, and wherein they are interpreted and adopted, play a pivotal role in the formation of tomorrow's society.

1.1.2 THE THEORY-RELATED PROBLEM

Connecting tomorrow with the past, a highly relevant question to ask oneself is whether the problems that the aforementioned perspectives highlight are new. New technologies have always emerged over time. There are clear indications, however, that we are experiencing an acceleration in the development of new technology, one due to digital technologies (Arthur, 2009; Yoo et al., 2012). With the advent of the internet and further digital platforms, the recombination possibilities heralded by technology development are multiplying at high speed. Other properties of digital technology add to this acceleration, such as its addressability and its homogenized, layered structure (Kallinikos et al., 2013; Yoo et al., 2010). In consequence, problems visible from each of the three angles demand solid theory-anchored understanding of the related dynamics. By possessing such understanding, we as a society increase our chances of, if not controlling, at least probing and affecting those dynamics. Furthermore, given the role of digital technologies in the contemporary technology landscape, coupled with the need for comprehending the material components of emerging technologies as a part of this new understanding, the information-systems (IS) discipline should take responsibility for advancing theory in these areas of concern.

The scope of the thesis is necessarily narrower than the vast terrain outlined above. As the project took shape, I formulated the phenomenon that I would study as *the early stages of organizations' digital-innovation pro-*

cesses wherein the enabling technology is an emerging technology (such phrasings below as "early innovation processes related to emerging technology" refer to the same phenomenon). The following paragraphs outline how this phenomenon has gone under-theorized from two angles. Those angles supplied the pair of theoretical-domain problems I set out to address. The first is bound up with how to conceptualize emerging technologies, which one must do before being able to understand their role in innovation processes, and the second question pertains to theorization about the early stages of organizational digital-innovation processes related to emerging technologies.

Conceptualization of emerging technology

The term "emerging technology" has been rather popular in academic discourse ever since the 1990s yet has seldom been defined (Cozzens et al., 2010). Still, two categories of definition can be distilled from the few conceptualization efforts. One is related to research that, by promoting ways to identify general properties of emerging technologies, can inform classification of technologies (*ibid.*; Halaweh, 2013; Rotolo et al., 2015). This category can be viewed as taking a context-agnostic approach to analyzing emerging technologies from their "exterior" properties. In an attempt to bring various conceptualizations together, Daniele Rotolo and colleagues (2015) identified the following properties: novelty, fast growth, coherence, impact, and uncertainty/ambiguity. They went on to discuss how these properties could be measured in a manner that enables bibliographic analyses of science and technology texts in high volume (i.e., "scientometric" analysis). Since these taxonomies focus on identifying properties common to all emerging technologies (e.g., as presented in scientific and academic literature), they manifest restricted utility in discussion of idiosyncratic details of any specific emerging technology under study, such as its material components – discussion that proved pivotal for the dissertation project.

One finds the second category of conceptualizations in recent literature that adds a relational-ontology perspective to allow for better understanding of how today's technologies emerge in tandem with their adoption and use in real-world practice (Bailey et al., 2022; Faraj & Leonardi, 2022). Putting focus on "describing and explaining the interdependencies between emerging technologies and organizing," Diane Bailey and colleagues posited that a relational perspective can "offer fundamentally new research questions" (2022, pp. 13–14). Rather than view technologies as fairly stable entities made up of material components, they have advocated acknowledging that emerging technologies "generate myriad new types of possible relations between people, technology, and organizing" and posited that "technologies are increasingly enacted – they come into being and have meaning in the world – through these relations" (p. 5). Therefore, such conceptualizations of emerging technologies can be viewed as being sensitive to context: they focus on technologies as enacted in practice, what have been called technologies-in-use (Orlikowski, 1995). In doing so, however, they devote less attention to technologies as abstracted entities that incorporate common knowledge, which might be perceived as objective, across contexts (Arthur, 2009; Popper, 1978).

The difference in perspective between these two groups of conceptualizations regarding the notion of emerging technology plays out on at least two dimensions. The first extends between interpreting technologies as abstract entities related to objective knowledge and as social objects enacted in practice. The second dimension is that of how the conceptualizations open attention to contexts such as the material components of technologies under study. The review I conducted of literature related to emerging technologies uncovered two thorny issues. The first, which has extensive consequences, is that the variation in uses of the term "emerging technology" makes for an unclear concept. The second issue is that none of the conceptualizations found were suitable enough to guide the inquiry in my project, which dealt with innovation processes related to emerging technologies that are perceived as abstract entities communicated through labels.

The first theory-related problem can be summarized thus in relation to the dimensions pinpointed above: the conceptualizations available are inadequate for guiding understanding of the phenomenon under study; they either fail to attend to contextual details or focus on technologies at a level of analysis different from what is needed (whether abstract entities or enacted objects). Hence, I identified a need to create clarity of theory among the preexisting conceptualizations, then develop a new type of conceptualization, one that better supports understanding emerging technologies in the context of early innovation processes. Any such conceptualization must be sensitive to the peculiarities of individual emerging technologies yet still treat these technologies as abstract entities, because emerging technologies are discussed in global communities, with mediation through technology labels (Alexander et al., 2012; Miranda et al., 2022; Swanson & Ramiller, 1997). Said discussions encompass both material components and related methods central to the emerging technologies, alongside the purposes for which the emerging technologies might show potential.

The early stages of organizations' emerging-technology-related digital-innovation processes

The settings studied in the doctoral project revolve around organizational innovation processes in which the enabling technology is an emerging one. My work concentrated on those processes' early stages. I chose to focus on processes wherein technologies or products that are new to the organization get explored as potential enablers of new ways of working, also referred to as organizational innovation processes (Swanson, 1994), to home in on organizations' perspective rather than take the perspective of technology providers or inventors by applying a product-development view of innovation processes. Research into innovation processes often uses stages or phases to depict stepwise progression from early scanning of problems/needs and/or solutions, which in turn evolve into formulated innovation ideas, as input to later decisions on potential adoption and implementation (Kohli & Melville, 2019; Rogers, 1995; Swanson & Ramiller, 2004). My scoping for early innovation processes in relation to this view is similar to what Everett Rogers (1995) referred to as the initiation sub-process, involving activities such as identification of problems and needs, the search for solutions, and conceptual matching between said problems and solutions. Among the other notions available are discovery (Fichman et al., 2014) and front-end innovation (Tate et al., 2018).

By confining my study of innovation processes to settings that bring in digital technologies, I aimed for a thesis that contributes to the digital-innovation research stream. This stream, largely flowing from within the IS discipline, can be broadly defined as examining innovation in which the outcome is enabled by digital technology (Fichman et al., 2014; Kohli & Melville, 2019). In this connection, I identified two dimensions as under-studied from the standpoint of organizations' digital innovation. I sought to cultivate new knowledge of both: 1) early stages of innovation and 2) emerging technologies as enabling technology. Innovation research in the IS field has traditionally focused on adoption, diffusion, and acceptance of information and digital technologies, thereby concentrating on later stages in the innovation process (Fichman et al., 2014). Accordingly, several reviews have reported that early stages are poorly studied (Fichman et al., 2014; Kohli & Melville, 2019). Digital-innovation-focused research into the distinct characteristics of emerging technologies is similarly scarce, though scattered work exists, from various vantage points, such as an institutional stance (Swanson & Ramiller, 1997, 2004) and a design view (Gregor & Hevner, 2015). This thesis contributes to scholarship on digital innovation by accounting for early digital innovation related to emerging technology.

1.1.3 THE RESEARCH APPROACH

The empirical study covered several settings, together constituting the research case. All presented early innovation processes in public-sector organizations that involved blockchain technology.[6] The latter technology fits the emerging-technology category well if one follows Rotolo et al.'s definition cited above. For example, it has repeatedly been posited to offer revolutionary impact, as when Don and Alex Tapscott (2016) anticipated that it would upgrade the internet from an "internet of information" to an "internet of value" or when *The Economist* published a special issue with the title "The trust machine: How the technology behind bitcoin could change the world," in 2015. Indeed, in the case-study contexts, ambitions and reflections pertaining to new socio-technical environments surfaced that had been inspired by blockchain stories.

The sets of data from the case settings were analyzed in two phases. Analyses in the first phase led to four research-report articles, the papers integral to this dissertation. One element of this phase was to direct focus

[6] Blockchain is a contested concept. A simple way to think about it is that it is the underlying technical architecture of the cryptocurrency Bitcoin. Also see Section 2.3 where this is discussed at greater length.

to the envisioned digital artifacts enabled by blockchain technology, as cast within the innovation processes. The second phase, in turn, corresponds to the integrative, dissertation-level theorizing. Here, during the part of the project whereby the theoretical problem of emerging-technology conceptualization was addressed, a need to zoom out and "unthink" the digital domain emerged. That enabled capturing emerging technologies as a general phenomenon. In consequence, the dissertation is able to articulate theorization on emerging technologies, highlighting distinctive aspects of these technologies that have become much more important to acknowledge amid the innovation processes of the digital era.

1.2 THE PROJECT'S AIM AND QUESTIONS

Keenly aware of the need to advance IS theory for emerging technologies and related digital material, I undertook to analyze case-study data so as to develop a theory of emerging technologies as labels, thereby helping explain their role in early-stage digital innovation.

Part of the analysis involved grappling with how practitioners who engage in innovation processes carry out the complex task of interpretation and then acting on their interpretations while engaging with emerging technologies. Understanding this necessitated deeper investigation of what emerging technologies really are. Therefore, two research questions, together addressing the problematizations presented in the previous section, guided the project. The following two questions, which intersect and informed attention to each other throughout the project, were formulated:

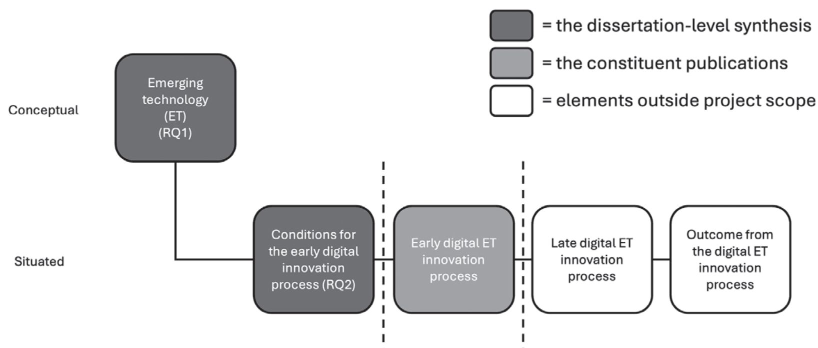
- *How can emerging technologies be conceptualized?*
- *Given this conceptualization, how do emerging technologies shape the conditions for early digital-innovation processes?*

Answering these questions enriches research into emerging technologies by expanding conceptual understanding, particularly through nuanced handling of the "technology" part of the concept, and advances research into organizational digital-innovation processes by deepening scholarly understanding of the early stages in encounters with emerging technologies. While further advances to IS research are still needed, these contributions should form an important step toward theory-informed understanding of emerging technologies in the digital world, which are expected to play pivotal roles in the shaping of our society.

1.3 THE DISSERTATION'S STRUCTURE AND APPROACH

Figure 1 illustrates the boundaries for the project, also in relation to the research questions. These boundaries grew out of a developmental journey. My early exploration that yielded the four published papers studied early innovation processes related to emerging technologies; however, contemplating the unifying theme for the dissertation illuminated a pressing need to conceptualize those technologies so as to afford discussing their influence on the innovation process. The synthesis here therefore does not center on the innovation process *per se*; it zooms in on analysis of the influencing elements instead.

Figure 1. The scope bounding the research



The dissertation is built upon the four research papers (see Table 1), found in their entirety in the second part of this publication, which comes after the synthesis material. The first part, the framing synthesis, is structured such that the present introduction to the thesis and to the project's aim and research questions is followed by a chapter that supplies background through which I both review related research into emerging technologies and early innovation processes and present an overview of the case technology considered in the research, blockchain, by summarizing historical developments and common interpretations. With the third chapter, I discuss the theoretical foundations, with emphasis on emerging technology, its relationship with technology in general, the ways in which it is perceived, and the discourse surrounding it. Chapter 4 then lays out how I conducted the research during the doctoral project that led up to the published papers and ultimately to the synthesizing manuscript, with special attention to methodology and ethics considerations. The following fifth chapter provides an overview and summaries of the four papers, outlining how they slot into the project as a whole. After that, Chapter 6 synthesizes and discusses the findings articulated in the individual papers, for coalescence of insight. With the concluding chapter, I summarize the main contributions of the research, its implications for practices, and avenues for future study.

Table 1. Published papers within the dissertation project

#	Title	Authors	Research question	Outlet
1	Need–Solution Pairing and the Role of Emerging Technology in a Public Sector Innovation Process	Mikael Lindquist, Livia Norström, and Juho Lindman	What are the characteristics of early innovation search processes as a public sector organization approaches emerging technologies?	31st European Conference on Information Systems (ECIS 2023)
2	Navigating Landscapes for Digital Innovation: A Nordic Government Agency Case	Mikael Lindquist, Livia Norström, and Juho Lindman	How can a government agency carry out innovation processes involving emerging decentralized technologies?	57th Hawaii International Conference on System Sciences (HICSS 2024)
3	Innovation Frames: Governments Making Sense of New Decentralizing Technologies	Mikael Lindquist	How can government organizations frame their innovation work differently in their early engagement with new decentralizing technologies?	23rd IFIP WG 8.5 International Conference (EGOV 2024)
4	Emerging Technology and Futures: Purpose vs Material Engagement	Mikael Lindquist, Livia Norström, and Juho Lindman	How do innovation teams engage with emerging technology for future systems?	15th Scandinavian Conference on Information Systems (SCIS 2024)

CHAPTER 2

BACKGROUND ON RELATED RESEARCH AND THE CASE TECHNOLOGY

To elaborate further on the central problematization introduced in the previous chapter, I present background, including description of relevant related research, on emerging technologies and early digital-innovation processes, in sections 2.1 and 2.2, respectively. These also represent areas in which I sought to contribute with my research findings. Following these two sections is a presentation of the project's case technology, blockchain technology. The presentation is provided here to assist in illustrating the characteristic properties of an emerging technology – its ambiguities in particular.

2.1 EMERGING TECHNOLOGIES

"Emerging technology" has operated as a descriptor in academic output since at least the mid-20th century (Cozzens et al., 2010). In the intervening decades, it saw occasional use, but the notion started gaining momentum in in the 1990s, and its use in news and research articles has since then increased steadily (Cozzens et al., 2010; Rotolo et al., 2015). This burst in popularity coincides with the popularization of the internet and digital technologies overall. It was also around this time, in 1995, that industry-analyst firm Gartner released its first "hype cycle" report, which grouped emerging technologies under five phases.[7] The categorization work of Gartner and other analysis firms is far from scientific, but its impact is nevertheless substantial. It has even been suggested that companies such as Gartner have led the way in defining labels for speculative technologies that with time enter and leave the moment's bucket of emerging technologies (Pollock et al., 2022). One example is Gartner's introduction of the category label "enterprise resource planning" (ERP) in 1998 (*ibid.*).

In social-science research specifically, the use intensity of the emerging-technology concept has largely adhered to this pattern; however, the increase started somewhat later, and the number of publications involved is not as large as that in hard-science journals (Cozzens et al., 2010; Rotolo et al., 2015). Again, increased use notwithstanding, only a few papers have engaged in conceptualization of the notion. Generally, it is fair to state that in much of the literature the concept serves more frequently to describe a phenomenon identified in the practical domain; in the words of Munan Li et al. (2018), this literature "uses ET [emerging technology] as an operational concept rather than a theoretical one" (p. 286).

The papers that do embark on defining the concept take several approaches (see Li et al., 2018; Rotolo et al., 2015). Working in the scientometrics domain, in 2014 Henry Small's team focused on novelty and growth for identifying emerging technologies and topics in scientific literature. Meanwhile, literature in the discipline of science and technology studies often highlights the ambiguity and uncertainty of emerging technologies (Cozzens et al., 2010; Stahl, 2011). Most definitions stress the feature of emerging technologies' potential significance and impact on the

[7] This development is documented well online (see Note 1).

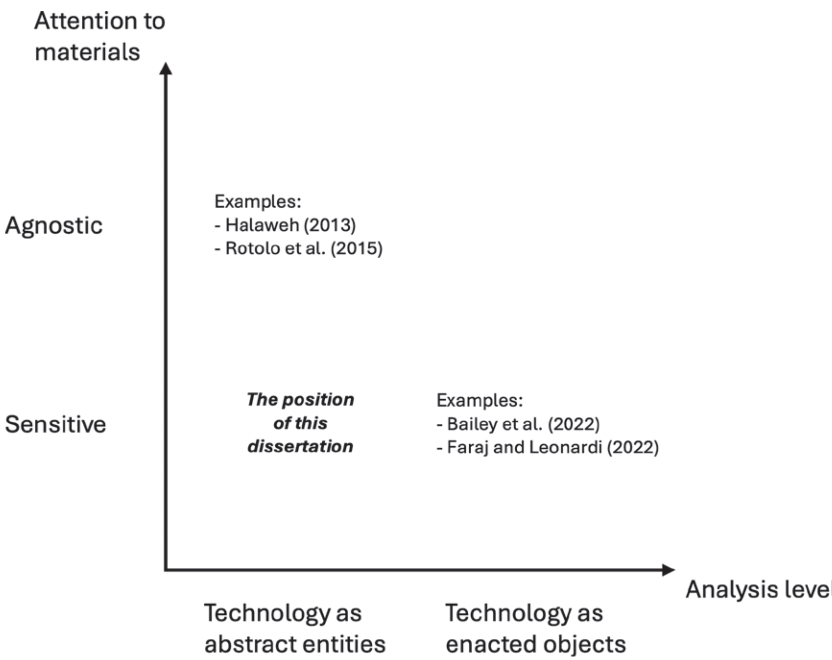
economy and on society at large (Porter et al., 2002) from, for example, transforming markets or creating new ones (Day & Schoemaker, 2000; Hung & Chu, 2006). Taking another approach, Jeffrey Alexander et al. (2012) pointed to expert communities that engage with the given technology's underlying concepts and constructs, with the effect that the emerging technology gains sufficient coherence to hold it together. Though the definitions highlight different aspects of the emerging-technology concept, generally they are not mutually contradictory. Also, they show commonality in viewing emerging technologies as abstract entities normally identified through technology labels, and the authors aim to pinpoint properties shared by those entities. Rotolo et al.'s extensive review synthesizes many of these properties into a single, unified definition (2015, p. 1833; emphasis on the contributing attributes added):

> a *radically novel* and *relatively fast growing* technology characterised by a certain degree of *coherence* persisting over time and with the potential to exert a considerable impact on the socio-economic domain(s) which is observed in terms of the composition of actors, institutions and patterns of interactions among those, along with the associated knowledge production processes [while its] most *prominent impact*, however, lies in the future and so in the emergence phase is still somewhat *uncertain* and *ambiguous*

More recently, some conceptualizations of emerging technologies have been proposed that are not consistent with the above synthesis (Bailey et al., 2022; Faraj & Leonardi, 2022). Seeking to theorize on the relationship between emerging technologies and organizing, Bailey et al. emphasized that "the technologies themselves are, by design, always changing and adapting" (2022, p. 1). At the heart of their analysis is the emergence that happens around technological objects as they are enacted in practice. Correspondingly, the authors developed a relational perspective approaching emerging technologies "not as stable entities, but as a set of evolving relations" (p. 1). A comparison of the emerging-technology concept's operationalization between conceptualizations of the latter nature and in the first category reveals a difference in ideas of what constitutes a technology. Work in the first category treats a technology as an abstract entity related to objective knowledge maintained in expert communities, whereas work in the second regards a technology as a social object enacted in practice.

With this groundwork laid, I now proceed to delineate among prior conceptualizations at greater length, for two reasons: 1) I intended to contribute to scholarship by enhancing conceptual clarity, and 2) this opens room for positioning a new conceptualization that addresses my first research question and that complements the preexisting conceptualizations outlined above. I developed this conceptualization to accentuate how technologies as abstract entities identified through labels can be unpacked in a manner that affords studying the idiosyncratic material details of a specific emerging technology of interest.

Figure 2. Conceptualizations of emerging technologies



The diagram in Figure 2 illustrates my delineation system. It plots the concepts' level of analysis against attention to case-specific elements such as material components. This ties in, firstly, with my conclusion that prior reviews in management and science and technology literature (e.g., Halaweh, 2013; Rotolo et al., 2015) manifest commonality in identifying properties of emerging technologies viewed as abstract entities while, from another perspective, scholars behind recent strategy and organization publications have proposed conceptualizations of emerging technologies viewed as enacted objects employing a relational ontology (Bailey et al., 2022; Faraj & Leonardi, 2022).

The *y*-axis, representing *attention to materials*, refers to whether the conceptualization employs constructs that aid in picking out material details unique to a specific emerging technology under study. Material-agnostic conceptualizations direct very little, if any, attention to the materiality of the technologies. Instead, they focus on technologies' measurable properties that support classifying them as emerging (e.g., coherence). In those conceptualizations sensitive to materials, the material details of the given technology are important. Typically, these conceptualizations are developed from, or illustrated by, contextualized cases.

For *analysis level*, along the *x*-axis, the diagram highlights two types of work. Under concept systems that focus on technologies as abstract entities, technologies are typically associated with labels and surrounded by shared knowledge and community discourse (Alexander et al., 2012; Miranda et al., 2022; Swanson & Ramiller, 1997), though this classification does not rule out conceptualizations of this kind covering technology objects that function in constituting the abstract entity. In conceptualizations that tend to technologies as enacted objects, "technologies" means the technologies as used in practice (Orlikowski, 1995, 2000), though conceptualizations in this class may still apply technology labels as abstractions of particular enacted technology objects.

Another way of thinking about the analysis-level dimension is to view technology emergence as something that plays out in parallel on two levels. While technologies as abstract entities emerge via technology development and discourse in which ideas and experiences are shared throughout, for example, an industry, new technologies simultaneously emerge as technology objects are enacted in use, because of the generative nature of modern technologies. Bailey and colleagues expressed the latter notion in an alternative manner – "the data-intensive and intelligent technologies that are proliferating across organizations today are entwining human participants in more intimate and complex relations [.…] [t]hus, today's technologies emerge through a set of expanded relations and continue to emerge in new ways as those relations evolve" (2022, p. 2).

This thesis will help contribute to a wider set of conceptualizations of emerging technologies by offering concept clarity and by suggesting a new conceptualization for contexts of organizational innovation processes. All theoretical perspectives that underpin a phenomenon's conceptualization offer utility to some extent. By the same token, no perspective ever can account for all aspects of the phenomenon. Depending on what is salient from the perspective adopted, some aspects stand out while other facets are obscured. With this awareness, I acknowledged previous conceptualization efforts, while striving for balance in my own.

2.2 EARLY STAGES OF DIGITAL-INNOVATION PROCESSES

As a broad concept, innovation is probably one of the most researched topics in business and administration research. Raghu Garud et al. (2013) reported that more than 7,000 business/economics research articles with the word "innovation" in the title had been published between 1956 and 2012, and that in 2012 these constituted 2.5% of the articles published. The vast numbers indicate that the phenomenon has many facets and can be studied from many, very different vantage points. An especially large divide is visible between innovation as an outcome and innovation as a process (Fichman et al., 2014; Garud et al., 2013; Swanson, 1994). In the process camp, various stage-based models have been popular historically (Kohli & Melville, 2019; Rogers, 1995; Swanson & Ramiller, 2004). They come in various shapes and reaches, but in general they depict stepwise progression from early scanning of problems/needs and/or solutions to formulated innovation ideas, which, in turn, might later get chosen for adoption, development, and implementation. Some scholars question stage models, whether because these presume a process following a series of well-bounded stages in a set manner, thereby implying that managers can control the innovation process (Gregor & Hevner, 2015; Van de Ven, 2017; Van de Ven et al., 2008), or because the "boundaries on what is or is not an innovation outcome have become more porous and fluid" in the arena of contemporary digital technologies (Nambisan et al., 2017, p. 225). Nevertheless, many branches of research converge in finding value in the idea of early stages of innovation (mirroring the aforementioned initiation sub-process), encompassing such activities as identifying problems and needs, searching for solutions, and undertaking conceptual matching of such problems and solutions. Among similar notions are discovery (Fichman et al., 2014) and the "front end" of innovation (Tate et al., 2018).

The main mechanism that prior innovation literature associates with early stages of innovation is recombination (Garud et al., 2013). This refers to knowledge, skills, and resources – across domains (residing within and/or outside the firm) undergoing review and being conceptually combined (Fagerberg, 2009; Garud et al., 2013), thereby forming a base that "'sets the stage' for 'acts of insights' regarding possible recombinations" (Garud et al., 2013, p. 779). Because of the many ways that these factors may be combined, innovation is strongly linked to complexity (Fagerberg, 2009; Garud et al., 2013). For dealing with complexity, it is essential for the early stages to allow for openness to new ideas and solutions (Fagerberg, 2009). Also fundamental is finding strategies for locking ideas into collective frames of reference before subsequent stages commence (Garud et al., 2013; Leonardi, 2011a; Spieth et al., 2021). Conflicting with this open attitude in some respects is another reduction of complexity, which comes about through division of labor in typical organizational structures. This often hampers innovation because comprehension issues among organizational actors who focus on day-to-day business can readily encourage inertia and resistance (Garud et al., 2013).

Innovation research in IS has been popularized under attention to "digital innovation" (Kohli & Melville, 2019). Several definitions exist. Youngjin Yoo et al. (2010) focused on product innovations in light of the generative nature of digital platforms (see also Yoo, 2013; Zittrain, 2006) while both Robert Fichman et al. (2014) and Rajiv Kohli and Nigel Melville (2019) chose broader definitions, to encompass all innovation in which the outcome is enabled by digital technology. One important distinction that arises from employing a broad definition is demarcation between the supply side and the demand side of innovation (Fichman et al., 2014). A supply-side stance aligns itself with innovators behind new digital products whereas demand-side approaches stress organizational innovation that adopts technologies/products new to the firm, either by selecting an already existing, usually commercialized IT artifact or by arriving at something new through a creation process incorporating a technology found in the external environment, one that requires subsequent interpretation and extensive integration with other elements, whether technical, social, or organizational (Fichman et al., 2014; Kohli & Melville, 2019).

Literature concentrating on the demand side of digital innovation has paid little heed to two dimensions of organizations' innovation (thus creating crucial gaps that I set out to fill): early stages of innovation and emerging technologies as enabling technology. With regard to the first, several studies have found that the early stages receive insufficient focus in IS (Fichman et al., 2014; Kohli & Melville, 2019); the major streams of the IS field's innovation research have traditionally concentrated on adoption, diffusion, and acceptance. However, Kohli and Melville (2019) point to some tentative findings in the nascent, not yet consolidated research addressing early stages. One of these is that organizations' capabilities of sensing the external environment, so as to find opportunities in technological advancements, are vital to the early-stage efforts. They include identifying and applying organization-internal and external knowledge alike. Another relevant finding is that isomorphic pressure can influence initiation (DiMaggio & Powell, 1983): legitimization may be drawn from "organizing visions" discussed in global communities (Swanson & Ramiller, 1997) while variety in local mindfulness can affect the risk of falling prey to fads and fashions (Baskerville & Myers, 2009; Swanson & Ramiller, 2004).

Attending to the second under-studied dimension, that of emerging technology, is motivated by the premise that it matters greatly whether the enabling technology in an organizational innovation process is an emerging one vs. an established technology. According to E. Burton Swanson (1994), innovations can be classified in various ways – for example, into administrative vs. technical innovations – and "[i]nnovation types are significant in part because research findings suggest that facilitation factors vary among them" (p. 1071). Even though Swanson did not mention the distinction between established and emerging technologies, there are reasons to believe that the above statement holds for that discrimination too. One supporting argument is that the knowledge needed for combinatorial innovation (see Fagerberg, 2009; Garud et al., 2013; Yoo et al., 2012) depends in part on technical knowledge whereas emerging technologies exhibit high levels of ambiguity in that regard (Rotolo et al., 2015).

In sum, scholarship offers no research stream that clearly draws together examination of early innovation processes and of technologies that are new, immature, or in their emergence phase, although a few isolated attempts to do this, from various vantage points, are visible. Taking an institutional view, Swanson and Neil C. Ramiller (1997) presented their theory of organizing visions, designed to explain how innovation ideas are both discussed in field-level communities and reciprocally used in organization-level processes for interpretation, legitimization, and mobilization. Their ideas did not gain traction; since their paper's publication, expansion of their theory has proved modest, as has been noted both by Swanson (Baskerville et al., 2014) and in Inchan Kim and Shaila Miranda's paper "20 years old but still a teenager? A review of organizing vision theory and suggested directions" (2018). In another effort, from a design perspective, Shirley Gregor and Alan Hevner (2015) introduced a 2×2 matrix of innovation types. Looking at the maturity of the technology and the maturity of the application area both, they strove to show that patterns in early innovation activities depend on the type of innovation pursued. Via my research, I sought to extend these efforts to offer new theory that highlights the conditions created by emerging technologies for the early stages of innovation processes.

2.3 THE CASE TECHNOLOGY: BLOCKCHAIN

Concretizing a concept central for this thesis, that of emerging technologies, my empirical research cohered around a specific emerging technology, which provided a basis for my theory development: blockchain technology. This section gives an overview of what "blockchain" is and sets it in the context of reasons pointing at the time of study to why it might be useful.

It is important to bear in mind throughout my discussion both that there were and are many accounts of what this or any other emerging technology is (or could be) and of what purposes it might be able to fulfil (now or in the future) and that those accounts show both variety and, often, conflict. The associated vital constellation of issues is examined extensively both in the theory-oriented chapter and later, in the discussion of findings. To handle the ambiguity straightforwardly here, this chapter is arranged around what seems to be the one aspect common to all accounts of blockchain – namely, that it started with Bitcoin (even this is only nearly true, as there are actors that contend that they engaged in design of blockchain systems before the advent of Bitcoin; e.g., the Estonian company Guardtime[8]).

To afford clarity in presenting what blockchain is, I divide my account into two parts. The first offers a walkthrough of the developments from a technical perspective, or at least orients attention toward the communities that have engaged closely with technical ideas related to blockchain. This story starts with developments leading up to Bitcoin's introduction and continues with further advancements of the technology. The second part of the picture involves how the wider community interpreted blockchain and its potential. To present this, I address important events (news releases etc.) that contributed to the "buzz," various writers' ways of speculating about the benefits and use cases of blockchain, and how particular key industries have engaged with the technology.

As new technologies naturally trigger new technological developments, any such presentation must be selective. In deciding which changes my treatment should encompass, I followed the guiding principle of sticking to what has been proposed under the label "blockchain."

2.3.1 TECHNICAL DEVELOPMENT: FROM THE CYPHERPUNKS TO MULTIPURPOSE

The origins of blockchain

The historical developments pre-dating what is called blockchain revolved around notions of cryptographic currencies. Those ideas, in turn, had roots in a movement initiated by the "cypherpunks," an informal group

[8] For a corresponding perspective, consult https://e-estonia.com/wp-content/uploads/faq_estonian_blockchain_technology.pdf, as accessed on August 4, 2025.

of people interested in building tools to protect individuals' freedom and privacy. The interest of the cypherpunk movement, born in 1992, cohered around cryptography and privacy-enhancing technologies, which had only recently reached prominence outside the military domain (Judmayer et al., 2017; Preukschat & Reed, 2021). Inspiration came also from the first attempt at a "digital cash" solution, made a few years earlier by David Chaum's company DigiCash. In the years that followed, the desire to build an anonymity-enabled digital currency led to several endeavors in this field, among which were Wei Dai's 1998 initiative b-money and the same year's "bit gold," introduced by Nick Szabo; Hashcash, presented formally in 2002 by Adam Back; and the Reusable Proof of Work system, created in 2004 by Hal Finney. Each of these attempts can be seen as taking development one step closer to what was later released as Bitcoin (see Judmayer et al., 2017).

Bitcoin

The digital currencies that came before Bitcoin fell short of their intent in several important respects. Firstly, they all relied to some extent on a centralized intermediary. This dependence proved hard to avoid because, even though known algorithms existed that could manage a decentralized network comprising a fixed set of nodes (involving Byzantine fault-tolerant multiparty consensus), a single attacker could create thousands of simulated nodes to take over the network in the absence of some central authority empowered to dictate who may operate as a node (Buterin, 2014). Another problem proving hard to solve was the "double-spending" problem: the risk of the same digital money ending up used in two separate transactions. Blockchain developer Vitalik Buterin has explained that timestamping forms a part of the problem: "There is no intrinsic way of determining from two transactions which came earlier, and for decades this stymied the development of decentralized digital currency," until Bitcoin arose as "the first credible decentralized solution" (2014; p. 1). In 2008, a white paper titled "Bitcoin: A Peer-to-Peer Electronic Cash System" was published by the pseudonymous author Satoshi Nakamoto (the person or group of people responsible for the paper has never been revealed). Shortly after it entered print, the Bitcoin network was launched via open-source software.

Especially those readers unfamiliar with blockchain technology, as implemented in the Bitcoin network, will benefit from a brief walkthrough. Therefore, I precede my description of the important components by an introduction to two cryptographic mechanisms that are fundamental for Bitcoin and to blockchain technology in general. The first is the hashing algorithm. In short, an algorithm taking any bitstring (i.e., any data – whether a text-based document, an image file, or some other sequence of characters) as input produces as output a new bitstring, of a fixed length, referred to as the file's hash value or just its "hash." The strength of this processing, hashing, lies in the fact that the hash value for any given input string is easily created and the resulting bitstring will always be the same, while it is practically impossible for someone who gets hold of a hash value to find out which input string was used on the input side, to produce that value.

The second pivotal cryptographic mechanism is public-key cryptography, also known as asymmetric cryptography. This technique involves a set of keys, one public and one private. For an illustrative example, we can consider the RSA algorithm, one of many algorithms applied in this technique. It makes use of the mathematical fact that if a large number n is the product of two large prime numbers p and q, obtaining n is very easy when these two prime values are known yet it is nearly impossible to find p and q purely on the basis of knowing n. In the parlance of public-key cryptography, the value n is the public key and primes p and q together constitute the private key. Accordingly, there is no way to get to the private key from a known public key, while access to the private key allows one to know the public key. Furthermore, knowing the private key that is linked to a given public key lets the user create a digital signature for any bitstring which will be attached to that string. Any outside actor aware of the associated public key can then securely confirm that the bitstring was indeed signed by the user in question and not altered at any point after the signing. This protocol for signing and verification is crucial for Bitcoin and related blockchain systems.

We are now ready to look at the main building blocks of Bitcoin. Worth noting is that these components were technologies known to the cypherpunk community long before it arrived on the scene and were investigated in earlier strivings toward digital currencies. The novelty lay, on the other hand, in Bitcoin's groundbreaking configuration of components:

- A peer-to-peer network: The system relies on a decentralized any-one-can-join network wherein communication is broadcast across the network. A computer participating in the network is called a node.
- Addresses: Consisting, in essence, of a public key in an asymmetric-cryptography setting, an address corresponds to a "wallet." All Bitcoin tokens are held by an address, and all public keys are coupled with a private key as described above. Knowing the private key grants access to the tokens and permission to transfer them to other addresses by producing a digitally signed transfer statement.
- A distributed ledger: All transactions that have ever transferred Bitcoin tokens from one address to another get stored in a ledger distributed across all interacting nodes – every fully participating node maintains a copy of the ledger. Transactions are bundled into blocks, with all data in a block feeding into a full-block hash integral to the next block generated. Every subsequent block retains the block hash of the previous block. Carrying the block data forward in this way keeps all blocks chained all the way back to the very first block (called the genesis block).
- A proof-of-work consensus algorithm: Nodes can participate in competition to add the next block to the chain. Among the nodes that take part, called mining nodes, the one that wins receives a reward (measured in Bitcoin tokens). In theory, the "miner" with the most CPU power has the highest chance of winning, thanks to randomization of the process. The technical task is to find a four-byte bitstring that in combination with the rest of the proposed block data yields a hash with a specified number of trailing zeroes. The only way to succeed in this is via brute force (i.e., trying new bitstrings constantly, one after another).

Drawing together all these elements, the Bitcoin protocol marked a true revolution. Its introduction unveiled a solution to a quest initiated nearly two decades earlier, to build a viable digital-cash system that does not require a central authority.

Further developments

The Bitcoin family of inventions spawned many other new ideas in the years that followed its launch. These are the most consequential ones:

- Altcoins: As with all open-source software, copying the Bitcoin source code is easy. This enabled simple creation of new "coins" with functionality either identical to Bitcoin's or with some configuration tweaks and facilitated developing new ideas for decentralization-based use cases built on the same foundations as Bitcoin. Numerous cryptocurrencies were spun off thus from Bitcoin in the early days of blockchain.
- The general-purpose blockchain: One specific development arising from Bitcoin that merits attention of its own is the general-purpose blockchain, equated for the most part with the Ethereum network. Established by Buterin in 2013, the Ethereum project was based on the same principles as Bitcoin yet represented more than a mere configuration adjustment. At its heart, it was designed to be not just a currency: enabling all sorts of decentralized applications, it ushered in "smart contracts" as one key enabler opening the door to more complex, flexible programming logic than was possible with either Bitcoin or the altcoins (in technical terms, it met the threshold of being a Turing-complete blockchain system).
- Permissioned blockchains: An aim behind one class of blockchain implementations was to avoid giving up control over which nodes may participate yet retain as much as possible of the decentralization of blockchain. The control required is achieved by employing a central control node in place of the proof-of-work consensus algorithm. Among the best-known initiatives to advance blockchain systems following this enterprise-aligned logic, are the open-source project Hyperledger initiated in 2015 by the Linux Foundation and with IBM, Intel, and SAP as large contributors and Corda, released by the company R3 in 2016 to support the financial services industry. This development spurred considerable debate within the developer communities surrounding the permissionless blockchains, such as Bitcoin and Ethereum. The Corda platform has even been accused of not being a blockchain at all as it lacks many of the characteristic attributes.[9]

[9] See https://www.gtreview.com/magazine/volume-15issue-3/r3s-corda-uncovered-not-blockchain/, as accessed on April 8, 2025.

Additionally, the generative nature of Bitcoin and the other advances mentioned above have triggered several other important technological advancements. Below, I will briefly present a few that are sometimes referred to as blockchains or as parts of blockchain ecosystems.

- Self-sovereign identity (SSI): This concept is expressed by a set of technologies built to enable individuals and other actors to control their digital identities. One may regard it as a digital equivalent of physical credentials (such as passports and other certificates with an issuing party). Its connection with blockchain technology resides in both often being proposed for use in decentralized systems. Also, SSI's development exhibited a strong coupling to the advancements made by Bitcoin and other cryptocurrencies (Preukschat & Reed, 2021).
- Web3: Not so much a technology as a vision for the next generation of the internet, the concept of Web3 is contentious, with many versions of detail-level meanings existing in parallel. One prevalent notion here involves a new architecture for the internet that increases users' centrality and places strong emphasis on privacy and user control. Accordingly, decentralization is regarded as vital, and blockchain technology often gets cited as a key enabler (e.g., Chohan, 2022).
- Decentralized autonomous organizations (DAOs): The idea of an organization represented by rules that are enforced by software preceded blockchain technology, but it grew in popularity only after the introduction of general-purpose blockchains. Today, it demonstrates intimate links wherein blockchain technology functions as underlying infrastructure.
- Non-fungible tokens (NFTs): Essentially, digital identifiers registered on a blockchain that indicate ownership of unique assets. Like DAOs, the concept of digital ownership predates blockchains, but NFTs gained widespread adoption in conjunction with the development of general-purpose blockchain platforms, which serve as their infrastructure layer. They illustrate one way that blockchain technology is used to manage and represent distinct digital items.

Having outlined the journey of blockchain technology from the perspective of its technical evolution, I now embark on the second part, about the discourse around the technology and why it is useful. This path follows the timeline accounted for above but with an alternative focus.

2.3.2 PUBLIC ATTENTION: IDEAS AND VISIONS OF WHAT BLOCKCHAIN CAN/SHOULD DO

Early engagements

In the early years of blockchain, in the wake of Bitcoin's launch, most discourse around the technology's possibilities remained internal to cryptographic and developer communities. When the popular press acknowledged it, the attention concentrated mostly on Bitcoin's potential as a decentralized digital currency (Miranda et al., 2022). Bitcoin was perceived as a genuinely novel innovation in this regard, in that it presented a clever solution to the double-spending challenge and, by displaying an attractively transparent anyone-can-join infrastructure, also solved the problem of trust in distributed systems without relying on any intermediary, such as the central banks behind fiat currencies (Jacobetty & Orton-Johnson, 2023). At this point, the technology's development had strong political underpinnings, tied to visions of a decentralized economy (Preukschat & Reed, 2021).

The initial applications of digital currency sparked ideas for further ways of exploiting the infrastructure. Soon Bitcoin was forked into multiple projects, for a whole host of purposes (Buterin, 2014; Judmayer et al., 2017). Two of the most well-known are namecoin, which extended the capabilities of Bitcoin to decentralized domain-name registration, and colored coins, which enabled people to create their own digital currencies or digital tokens with relative ease (Buterin, 2014). The various altcoins proved that blockchain possessed potential to serve as a multipurpose technology, moving into areas such as asset management, identity systems, and smart contracts.

The rise of Ethereum, after the approach's introduction in 2013 and its launch in 2015, became an important step in developing blockchain technology into a general-purpose platform (Antonopoulos & Wood, 2018; Buterin, 2014; Jacobetty & Orton-Johnson, 2023). While Ethereum shares the same principles as Bitcoin, being a permissionless network with certain associated pillars, it was developed to improve scripting so as to enable smart contracts with full computation potential. The result took the form of a decentralized platform that can run distributed applications similarly to how applications run on a single computer (the applications involved have been termed decentralized applications, or dApps; see Antonopoulos & Wood, 2018). In the white paper describing Ethereum for the first time, Buterin proposed several potential applications that could be built on that platform – for example, identity systems, decentralized file storage, decentralized marketplaces, and DAOs. The last of these opportunities highlights an intriguing avenue for "imprinting" organizations into smart contracts in conditions wherein shareholders must vote via the blockchain on any proposed change in the code.

Increasing attention

Around the time of the Ethereum launch, various reports and articles started to signal blockchain's potential to disrupt industries beyond the finance realm. Two pieces with especially wide reach were the special issue of *The Economist* titled "The trust machine: How the technology behind bitcoin could change the world" (2015) and the 2016 contribution to business literature *Blockchain Revolution*, by the Tapscotts. The messages expressed clear enthusiasm about the new technology; e.g., "it has the potential to transform how people and businesses co-operate" (The Economist, 2015, p. 13), and it "may even create the technological preconditions to reconciling some of our most vexing social and economic challenges" (Tapscott & Tapscott, 2016, p. 25). As time passed, blockchain technology started to attract more and more attention from a broader community, including the trade press, industry leaders, and academic researchers alike (Miranda et al., 2022; Preukschat & Reed, 2021). Public attention thus shifted from a narrow interest in decentralized currencies to broad-based fascination with blockchain's potential to transform entire industries, or even society.

By this time, heated debate had already arisen with regard to what constitutes a true blockchain (Casey, 2015; dinbits, 2015; Voorhees, 2015). That question was connected in particular to the arrival of permissioned blockchain, making use of centralized governance. For highly engaged Bitcoin enthusiasts, new configurations of such a nature could hardly be considered to employ blockchains. Others saw these modifications as necessary for dealing with the slow, computationally and financially expensive nature of permissionless blockchains (Greenspan, 2015).

Focusing on how blockchain-technology narratives have been articulated in broader spaces, one finds emphasis put on slightly different aspects. Although most do acknowledge the centrality of the technology letting data be shared and agreement be automatically executed between parties that do not necessarily know or trust each other, without any reliance on third parties or intermediaries (e.g., Nascimento et al., 2019; Ølnes et al., 2017; The Economist, 2015), varied metaphors have been articulated as its core (Jacobetty & Orton-Johnson, 2023). Tapscott and Tapscott framed this technology as the "Internet of Value," designed to move value, in contrast against the "Internet of Information" shaped over the preceding two decades. Another prominent notion featuring in descriptions of the essence of blockchain is trust. *The Economist*, for instance, called blockchain "a machine for creating trust" (2015, p. 13). Both publications present motivated positions, but they still evocatively demonstrate how richly the promises of blockchain may be molded into various metaphors.

Several industries began experiments with blockchain at this time, with a wide range of underlying objectives. In finance, for example, cost reductions, higher transaction speeds, and decreased error rates were anticipated in processes ranging from settlements and security swaps to high-level trading (European Commission, 2019; Nascimento et al., 2019; The Economist, 2015). For supply-chain management, blockchain was seen as offering an opportunity to replace heavily paper-based documentation in cross-border delivery chains while also bringing transparency and traceability benefits, for better compliance with sustainability standards, efforts to detect fraud (e.g., counterfeiting), work to improve overall efficiency, etc. (European Commission, 2019, 2020; Nascimento et al., 2019). Other industries that identified benefits were health care, land-registry management, the music industry, and various public-service fields (Lindman et al., 2020; Nascimento et al., 2019; Ølnes et al., 2017).

As numerous industries identified applications deemed worth pursuing in innovation projects, the increased interest in blockchain technology percolated to governmental structures, thereby attracting further attention. This reached for example the level of the European Union, which initiated several overarching initiatives to promote innovation via blockchain technology (European Commission, 2019, 2020). Among them have been calls for research, funding programs, and other undertakings, such as

Horizon 2020 and the EU AI/Blockchain Investment Fund. Meanwhile, organizational initiatives include the European Blockchain Partnership and the European Blockchain Services Infrastructure, aimed at developing blockchain infrastructure for cross-border government services. The latter proceeded from four use cases at the outset: 1) notarization to prove data integrity, 2) trusted data-sharing for secure sharing of data among customs and tax authorities, 3) an EU SSI framework to give users control over their data, and 4) certification of diplomas in support of trusted education credentials. Even this high-level set of use cases exhibits interesting patterns bound up with ambiguity and labeling, which my research helped to unpack. Against the backdrop of the stricter definitions of blockchain mentioned above, the last two stand out as powered primarily by SSI rather than blockchain technology (the EU has acknowledged that the latter is not required for decentralized identity functions; see European Commission, 2020, p. 47). Every action involves positioning; here, the scope of the definition for blockchain technology adopted at EU level can be said to lie toward the inclusive end of the scale.

Promised affordances

Blockchain technology has been widely heralded as holding promise in connection with claimed ability to deliver a rich range of affordances able to assist in resolving challenges posed to contemporary information systems and institutions across the board. The promises' vast variety notwithstanding, several affordances consistently get reiterated (marked with emphasis below).

Firstly, blockchain solutions are said to resolve *trust* issues. Statements that they create or enhance trust persist even though the original article by Nakamoto (2008) states explicitly that the proposed Bitcoin network was envisioned as replacing trust in central authorities with cryptographic proof; i.e., rather than promoting trust as *The Economist* indicated, payments would no longer rely on trust. In either case – whether trust is replaced or enhanced – there is a shared idea that, thanks to cryptographic validation and the transaction records' immutability, the parties need not trust each other when engaging in transactions.

Two additional pillars of blockchain systems are their *transparency* and their strong *security*. The former is a fundamental property of permissionless blockchains. Their networks render all transactions visible and time-stamped, which allows the various stakeholders to verify actions and trace histories (Jacobetty & Orton-Johnson, 2023; Yli-Huumo et al., 2016). With cryptographic techniques such as hashing incorporated as core components, blockchains also come with strong security (Jacobetty & Orton-Johnson, 2023; Xu et al., 2017). These techniques protect data integrity and prevent unauthorized changes of transaction data. Other labels placed on these benefits are "immutability" (Lagendijk et al., 2019) and "tamper-resistance" (Nascimento et al., 2019). In consequence of their transparency and strong security, blockchains allow for *auditability* (Casino et al., 2019) and *traceability* (Lagendijk et al., 2019).

Decentralization often gets cited as an affordance in its own right (Nascimento et al., 2019). By distributing the control throughout a network of nodes, blockchain avoids reliance on single points of failure or central authorities. This improves system resilience while also promoting open and fair access via anyone-can-join networks.

Anonymity and *privacy* too receive prominent mention alongside other benefits of blockchain solutions (Yli-Huumo et al., 2016). Although all transaction data are exposed in the blocks, these data are linked to addresses that function as proxies; they do not in themselves reveal the actor's identity (this is referred to as pseudonymity). In addition to pseudonymous transaction data, several further techniques have been added to blockchain applications in pursuit of enhanced privacy (Xu et al., 2017).

While the aforementioned affordances often get counted as inherent benefits of blockchain, Xiwei Xu and colleagues, writing in 2017, emphasized that actualizing them brings inevitable architecture-related tradeoffs. Accordingly, the enthusiasm so readily sparked in conjunction with considering blockchain technology for new areas of application might end up inflated when compared to what reality demands (Casino et al., 2019; Lagendijk et al., 2019; Ølnes et al., 2017). For instance, compromises might arise as increasing the decentralization reduces performance and scalability. Likewise, enhanced privacy may limit transparency. The most obvious example of an architectural decision that strongly affects the resulting affordances is that between permissionless and permissioned blockchains. A permissioned-blockchain system requires tradeoffs against several of the core principles that were behind the development of the Bitcoin architecture in the first place. Not least, they compromise the vision of decentralization subject to no central authority, wherein anyone can join the network, and the very strong security mechanism entailed by the proof-of-work consensus algorithm (Xu et al., 2017).

Demarcation of the blockchain technology

In the early days' engagement with blockchain technology, one could justifiably portray it as a "well-defined technological object with limited applicability applications" (Lagendijk et al., 2019, p. 1). Since then, however, the concept has expanded significantly, growing to encompass a wide array of configurations, applications, and interpretations (*ibid.*; European Commission, 2020). Therefore, what demarcates blockchain in any given context depends on the person conducting the analysis. Scholars and practitioners have engaged in debates between those advocating a conservative view (as expressed by Casey, 2015; dinbits, 2015; Voorhees, 2015) and authors who point to the utility of allowing room for broader views (e.g., Greenspan, 2015). From a technical perspective, blockchain systems can vary widely in their architecture design (Xu et al., 2017), so much so that, approaching this issue from the perspective of perceived utility, Arnoud Lagendijk et al. (2019) have argued that blockchain has evolved into a "hyperobject," representing a concept "so extensive and mutable, that common frames to characterise and grasp them comprehensibly are lacking" (p. 1).

In sum, the term "blockchain" now encompasses a wide, multifaceted spectrum of technologies and ideas. The richness of this spectrum can be exemplified by the narrow view of Bitcoin enthusiasts who claim that only proof-of-work-powered networks ought to be considered blockchains, on one hand, and, on the other, the European Union with its view of blockchain as an ecosystem with some very broad common goals. While the stretchability of the blockchain concept demonstrated by this definitional continuum demonstrates an ability to adapt, it also complicates efforts to evaluate, regulate, and standardize that concept. This means that any attempt to define blockchain must acknowledge its dynamic nature and inherent tradeoffs.

CHAPTER 3

UNDERPINNINGS FROM THEORY

With this chapter, I proceed from the position behind the research project as elaborated upon in Chapter 2, with particular regard to the two research areas outlined as closely related to the phenomenon of early stages of organizational digital-innovation processes wherein the enabling technology is an emerging technology. From that starting point, I present the theoretical foundations required for advancing the contributions to theory that are fleshed out in Chapter 6. The discussion here gives strong emphasis to technology as a multifaceted phenomenon and to how emerging technologies mesh with that phenomenon. Such elaborations are needed to grapple with the first research question dealing with emerging technologies' conceptualization. Further focus is devoted to interpretations of technologies, at local and global level, to help address the second question, how early innovation-processes are affected.

Semantically, emerging technologies are a two-part construct. The emphasis here lies on the technology part, while the other element, the indication of an emergent nature, falls outside the scope of my theorizing. The reason for this is that I approach the concept of emerging technologies as the discursive entity that the organization's actors encounter when engaged in innovation processes. That positioning renders the technology part extremely important, in that the emerging technologies are presented *as* technologies. In my interpretation, the emergence process to which the term alludes plays out on time scales that are larger than those of the innovation processes that interact with the emerging technologies. Hence, the dissertation is scaled for the process of innovation, not emergence (that being said, emergence is touched upon in Subsection 3.3.3).

Even though an emerging digital technology constituted the case technology for the doctoral project, the unpacking below emphasizes not digital technology *per se* but, rather, discussion of the technology concept, with examples from both the digital realm and other (more or less mundane) technologies. This decision stems from a need to establish some fundamental principles for how we can conceptualize technology. It does not imply that digital technologies are irrelevant. On the contrary, the properties of digital technologies, such as being editable, reprogrammable, and distributable (Kallinikos et al., 2013), contribute to spurring the development of new technologies toward even greater speed.

The chapter is organized to introduce my research's alignment with the concept of materiality and how I have worked with it, then elaborate to relevant extent on precisely what technology is, a factor that ultimately proves crucial for understanding the specifics of emerging technologies. Discussion of technology-related perception and discourse follows that. Key concepts are highlighted along the way. Laid out concisely in a dedicated subsection at the end of each section below, these serve as foundations for later discussion drawing together the dissertation project's essential contributions.

3.1 MATERIALITY, MATERIALS, AND MATERIAL CONFIGURATIONS

Social research has applied concepts of materiality/materials and semantic variants of these extensively. Several scholars have reported inconsistencies in their application (Kallinikos et al., 2013; Leonardi, 2017), with Jannis Kallinikos (2012) even asserting that the term "materiality" has expanded into "an inflating buzzword, an empty vessel able to contain an amazingly large and ambiguous web of significations" (p. 83). Their accounts indicate complexity plaguing these concepts' use in study of the social world. At this juncture, I find it sensible to clarify my position here, starting with the concept of materiality, since it has seen widespread discussion (for example, in connection with the introduction of digital technologies and in relation to the popular-interest broader theme of socio-materiality). I then take a look at various semantic alternatives. Against this backdrop, I can present the concepts I ultimately arrived at, to which the remainder of the dissertation adheres.

3.1.1 MATERIALITY

The foundational interpretation of materiality in technology-focused scholarship equates it with physicality, or matter (Gal et al., 2022; Kallinikos, 2012). Especially important features of materiality viewed through this lens are that it 1) endures, or exists through time (Faulkner & Runde, 2019; Leonardi, 2012); 2) behaves in a consistent way, in that it "do[es] not change, by [itself], across differences in time and context" (Leonardi, 2012, p. 29); and 3) supplies opportunities and limitations that are non-negotiable because they follow the laws of physics – e.g., glass does not burn (Leonardi, 2010, 2017).

When engaging with technologies that emerged before the advent of digital technology, we can adopt a straightforward understanding of technologies as physical matter formed into technological objects that perform a desired function (Kallinikos, 2012; Leonardi, 2010). For such a technology, matter and form, which together constitute its materiality (Leonardi, 2012), are closely related, jointly yielding the affordances and constraints connected with the object's physicality and, thereby, producing the functionality it provides (Kallinikos, 2012). As we move into the age of information/digital technologies, however, the weave between the function of a technology (such as a word processor) and the physical matter is becoming much more complicated. It might even be the case that the function at the technology's interface does not necessarily depend on the physical matter (Kallinikos et al., 2013). This is a consequence of layered modular architectures (Yoo et al., 2010) in which physical materials are important for lower layers that serve as "bearers" for the non-physical materials constituting higher layers (Faulkner & Runde, 2019; Leonardi, 2012). Awareness of this structure led Paul Leonardi (2010) to propose the concept of digital materiality, to consider not just physical materials but also those non-physical ones that exhibit the properties of durability, consistency, and non-negotiability (where these properties are rooted in laws of mathematics and logic rather than physics; see Kallinikos et al., 2012). Incorporating this understanding of materiality in the realm of technologies, one can define materiality as "the arrangement of a technological artifact's physical and/or digital materials into particular forms that endure across differences in place and time and are important to users" (Leonardi, 2013, p. 144). I find the latter definition useful in that it stresses the enduring aspect of technology, even with regard to non-physical technologies embedded in digital technologies. Therefore, this definition serves as a suitable starting point for my discussion.

Socio-materiality

A strong research tradition related to materiality has emerged in recent decades in such fields as organization studies and IS research: studies of "sociomateriality" (sometimes hyphenated; see Cecez-Kecmanovic et al., 2014). Researchers using this banner aim to account for the role of technology and materiality in social life by emphasizing that the social and the material are always contingent on one another, with neither being able to exist without the other. Spirited debate has arisen between those who claim that the two are analytically separable (Leonardi, 2011b, 2013; Mutch, 2013) and scholars seeing their separation as impossible (Orlikowski & Scott, 2008). Irrespective of such divergence of perspective, they all proceed from a common intention to "increase our understandings of the practices of contemporary organizational life" (*ibid.*, p. 467). Through this practice lens, studying materiality entails focusing on particular instances of artifacts and their uniqueness, alongside the entanglement of these with the social in the present, be it in technology in use (Orlikowski, 1995) or during (re-)design (Leonardi, 2011b). A socio-material perspective of this sort aided in the theorizing behind the dissertation by spotlighting the complex nature of material and social interaction, but at the same time it left room for an alternative view of materiality-facing relations. The reason was twofold: Firstly, my theorizing demanded a focus on situations wherein the materiality in question is speculated upon – as an assemblage enabled by the emerging technology – and hence genuinely exists in some possible future. Secondly, while socio-materiality research provides rich understandings of the uniqueness and situated nature of each socio material ensemble, it also shrouds "the universal common structures that give birth to those varieties that we observe" (Yoo, 2012, p. 151). Accordingly, my research does not build on socio-materiality so much as relate to it.

Shared knowledge

When materials are crafted into forms that as an assemblage perform functions, we can discern a certain type of knowledge coalescing around these materials and the multiple alternative formations possible (Åman et al., 2017; de Weck, 2022; Kallinikos, 2012; Kaplan & Tripsas, 2008; Thoring et al., 2022). Historically, that knowledge fell under the notion of craftsmanship and "developed around the mastery of specific materials such as wood, stone, clay, gold and iron, and textiles" (Kallinikos, 2012, p. 68). With modern technology and as the materials grow far more complex, crafting of technologies still requires knowledge of various materials, plus skills in creating with them. Sometimes referred to as design knowledge (Åman et al., 2017; Thoring et al., 2022), it is recognized by scholars of design research as comprising many facets (these encompass such commonly used concept pairs as declarative–procedural, tacit–explicit, and individual–collective; see Åman et al., 2017, p. 65). Aware that knowledge is a prohibitively large expanse for conceptual exploration, I focus the arguments in this dissertation on the *shared knowledge* accumulated over time that is "distributed throughout communities and carried out by entrenched educational and vocational institutions that transcend situated practice" (Kallinikos, 2012, p. 84).

3.1.2 SEMANTIC VARIATIONS

Literature dealing with materiality displays a wide range of semantic variants, with each of these words ("matter," "materialize," "materialism," and others) all meriting its own elaboration. Although that is outside the scope of the thesis, some of them deserve mention because they informed my work importantly: "material" as an adjective describing aspects of materiality and "material" or "materials" for a noun to refer to the material elements that constitute some technology. Digital materials form an important subset of these for my purposes. Such material elements that build up into digital technologies may be physical (such as servers and smartphones) or logical (such as protocols and software programs).

To choose suitable semantics for purposes of the discussion here, I proceed from Leonardi's definition of materiality as presented above. It serves the purpose of the dissertation especially well in emphasizing the fact that materials and their formation constitute properties of technology that endure beyond temporal and other context. Two issues remain to be handled, however. Firstly, as Yoo has pointed out (2012), the prevailing approach to studying materiality of artifacts has centered the discussion on the "unique and idiosyncratic artifacts" (p. 144) that are produced and consumed in organizations. This focus, on what he referred to as the phenotype, neglects the "universal common structures that give birth to those varieties that we observe" (p. 151), which are associated instead with the "genotype." Secondly, because the notion of materiality gets utilized mostly for studying technology as it is enacted in practice, there is an attendant risk of impairing discussion of circumstances wherein the formation of materials points to speculative arrangements of not-yet-developed technologies. In an example drawn from the empirical material I studied, a practitioner focusing on innovation might propose that the Ethereum network could be leveraged to construct an artifact that increases trust between citizens and their municipality. Such a statement does give regard to materials (digital ones) and hints toward a formation of them, but there are not yet any materials, physical or digital, with which users or developers interact.

To resolve both issues, in a manner that steers clear of loaded terms that might increase the likelihood of misreading, I have chosen "material configuration," employing this term to mean materiality as defined above but with the clarification that the formations of materials encompass abstract knowledge about these materials and ways of forming them, including possible speculation on ways in which materials and formations might develop in the future.

3.1.3 KEY CONCEPTS RELATED TO MATERIALS

At the beginning of Section 3.1, I emphasized that materiality and its semantic variants are concepts that are both loaded and used with multiple meanings in the literature. In clarifying my position above, I have distilled core concepts for my further theorizing laid out in later chapters. Going further, I found it vital to concentrate on the *material configurations* available for technology, as defined above. Also, I maintained focus on the *shared knowledge* amassed in relation to materials and their possible configurations.

3.2 TECHNOLOGY

The next step in the discussion is to problematize the use of the word "technology." As with the concept of materiality, that of technology has equivocal meanings, and the word's use differs across research traditions (Leonardi, 2012; Nightingale, 2014). Diverse meanings can even be found within disciplines. The IS field is no exception. Consider the following three examples from evidence I compiled from IS publications:

- "When competitors use a new technology (e.g., blockchain technology), […]" (Liang et al., 2021, p. 321)
- "The study investigated the implementation of a new information technology – a groupware system – into one large organization." (Orlikowski & Gash, 1994, p. 181)
- "Over the next three years, EMD developers worked with an external vendor to build a new technology called CrashLab." (Leonardi, 2011b, p. 159)

All three examples refer to "a new technology", but deeper analysis reveals that they differ in their use not only of the word "technology" but also of the word "new." The first extract refers to technology as an abstract entity, as opposed to the third example's specific technological object in a certain context. The second extract is situated somewhere nearer the middle of the continuum; though studied within a context, the technology can be interpreted as an instance of a certain technology product too (the article deals with Lotus Notes). As for newness, "new" in the first case can be interpreted in the "new-to-the-world" sense (Hevner & Gregor, 2022); here, the technology is novel not merely to the organization. In the other two examples, "new" refers rather more to newness of the technology in some particular organizational context. I interpret this flexible use of words as non-problematic, given the types of research questions that IS research typically tackles. Many streams of contemporary IS work place their focus on the design and use of information technology, so the technological objects have attracted the greatest interest; other levels then are abstractions from the object level of analysis. Since my research, on the other hand, cohered around interpretations of emerging technologies, I argue that it demanded more nuanced treatment of the levels of specificity of the technology concept.

This requires some explanation. For finding some stable ground for a suitable definition of technology, our first recourse could be to dictionaries. Querying the current online edition of the *Oxford English Dictionary* identifies several contemporary meanings for the word "technology": 1) the "branch of knowledge dealing with the mechanical arts and applied sciences," 2) "application of such knowledge for practical purposes," 3) a "product of such application [...] [in] a technological process, method, or technique," and 4) a "particular practical or industrial art" or "a technological discipline." The web site Dictionary.com defines it as both 1) "the branch of knowledge that deals with the creation and use of technical means and their interrelation with life, society, and the environment, drawing upon such subjects as industrial arts, engineering, applied science, and pure science" and 2) "the application of this knowledge for practical ends." Proceeding from a different angle, Wikipedia begins its entry by contextualizing technology as "the application of knowledge for achieving practical goals in a reproducible way" while noting also that "technology can also mean the products resulting from such efforts."

Turning next to academic literature, we find additional variations in application of the word. Sarah Kaplan and Mary Tripsas (2008) acknowledged it as covering both "knowledge from which products are elaborated" and "the physical manifestation of that" (p. 791). Stressing the element of reproducibility, Kallinikos (2004) pointed to the "essential characteristics which remain beyond the reach of the negotiating and reshaping capacity of local contexts and situated agents" (p. 266). We can see several important patterns in the elements here. Firstly, technology is depicted as about knowledge but also the products generated out of knowledge. Secondly, it is related to practical goals and purposes; accordingly, it is intentional. There is also a reproducibility element involved; that is, parts of the technology can be expected to yield similar outcomes across contexts. Furthermore, the word "technology" indubitably operates on several points along the continuum from general to particular. That continuum, which I conceptualize in terms of specificity levels, holds special importance for my use of "technology" in the dissertation.

3.2.1 SPECIFICITY LEVELS

Considering the span from the most general to the most specific, I identified several levels of technology. Table 2 provides an overview of the levels relevant for the project. The most crucial rows are presented in a heavier-weight typeface. While explanations for some intermediate levels (without highlighting) facilitate understanding, they are not referenced further in the thesis.

At the highest, most abstract level we find technology as referred to in its uncountable form. The research-discipline label "science and technology studies" offers an example. This general angle on technology can be framed as the *technology collective* of a society at a given point in time (Arthur, 2009), referring to "the entire collection of technical devices, methods and practices available to a culture" (p. 28). At the other end of the continuum is the *technology object*, where the materialized technological object resides (i.e., the level of technology that individual users interact with). The final example in the bulleted list above exemplifies the term's use at this level. Scholars of IS often refer to this level as the IT artifact (Benbasat & Zmud, 2003; Orlikowski & Iacono, 2001).

In the middle are applications more abstract than technology objects but more specific than the technology collective. I refer to this middle ground as the *technology class*. One could define it concisely as "a means to fulfil a human purpose" (Arthur, 2009, p. 28), with the computer being one instance of it. Among the other labels assigned to this specificity level are "technology-singular" (Arthur, 2009), "product class" (Faraj & Azad, 2012), and "genotype" (Yoo, 2012). The last is part of the analogy to biology, mentioned earlier on, that Yoo presented to help unpack the complexities of technology objects. He proposed that common structures in genotypes (technology classes) are the source of variety we observe when studying the phenotypes (technology objects).

Other intermediate levels can be identified. Between the technology object and technology class, one could add a level denoted as *technology configuration*. This level needs acknowledging because there are many cases wherein exactly the same material structure is copied to multiple instances (specific situations that hold research interest); for example, IS research has offered proof of how the material structure of a particular piece of software ripples into multiple usage patterns, hinging on differences between contexts (e.g., see, Barley, 1986). At another level, visible between technology collective and technology class, stands the *technology domain*, an "assemblage of practices and components." One example is electronics (Arthur, 2009, p. 28).

It should be pointed out that none of these are discrete levels; this is a smooth continuum from the general to the particular, rather than a ladder with steps or rungs. The three levels presented between its extremes allow particular richness for displaying hierarchies – for example, of domains vs. sub-domains or coarser and finer-grained configurations (such as yearly editions and customizable parts of a car model).

Table 2. Levels of technology conceptualization

Level	Arthur (2009)	Yoo (2012)	Example	Definition
Technology collective	**Technology-general**			**The entire collection of technical devices, methods, and practices available to a culture**
Technology domain	Technology-plural		Electronics	A cluster of practices and knowledge; a technological discipline
Technology class	**Technology-singular**	**Genotype**	**The smartphone**	**A means (method, process, or device) to fulfill a purpose**
Technology configuration	Technology-singular	Genotype	The Samsung S20	A specific work architecture (such as a product)
Technology object	**Technology-singular**	**Phenotype**	**My Samsung S20**	**A materialized object with which users interact**

One might ask oneself why, when technology can be interpreted at all these levels, academic publications seldom refer to the level explicitly. After all, researchers with an interest in technology are clearly sensitive enough to discern among them. The most plausible interpretation I found is that these levels are normally deemed self-evident, partly because of shared understandings within a certain field and partly since research tends to follow common trends. For instance, several decades ago, technology adoption was a popular theme, and that normally implies a technology-class perspective (e.g., ERP adoption). Today, many branches of IS are much more practice-oriented, focusing on technology in practice, and therefore imply a technology-object perspective (e.g., for examining how affordances are enacted at the time when a user interacts with a technology object). For my aims, however, explicitly distinguishing among the levels is vital. When interpreted as discursive entities, emerging technologies stand among technology classes, yet when fleshed out in the course of innovation work, they also involve technology objects that are envisioned.

Technology-class level

The level with greatest importance for the discussion here is the technology class. From this perspective, the focus on technology is specific in terms of what purpose is fulfilled and by what means but is general in the sense of not being situated in a certain context. While I could offer many examples of technology classes – e.g., from the more mundane to more complicated, the hammer, steam engine, telegraph, wristwatch, radio receiver, laser, hash function, and relational database – it is more pertinent to outline my definition for the technology-class level. To develop it, I drew on the work of Brian Arthur, who with the book *The Nature of Technology* set out to create an overall theory of technology that presents a "common logic that would structure technology and determine its ways and progress" (2009, p. 4). He defined a technology class in brief as "a means to fulfill a human purpose" (p. 28). Citing the examples of a computer, a diesel engine, and an electricity generator, he stated that these are expressed in abstract terms, as the idea or concept of the technology, rather than any specific instance of it, even though these instances are also of great importance for zooming in and out conceptually.

From the corresponding perspective, for technologies to persist and evolve into new ones, objective knowledge about their inner workings is indispensable. That is especially pivotal for the complex technologies of today. It is through this knowledge that new technologies are created. "Knowledge and technology in this way cumulate together" in Arthur's view (p. 65). This sits well alongside his condensed summary of his theory of technology (p. 203):

> Theories start with general propositions or principles, and we started with three: that all technologies are combinations of elements; that these elements themselves are technologies; and that all technologies use phenomena to some purpose. This third principle in particular told us that in its essence, technology is a programming of nature. It is a capturing of phenomena and a harnessing of these to human purposes. An individual technology "programs" many phenomena; it orchestrates these to achieve a particular purpose.

The aspects presented in this summary bear additional explanation. I will start with the third proposition, that technology is a programming of nature. All technologies make use of natural phenomena (physical and logical) in some clever way that fulfills a particular purpose – i.e., the reason sparking one's interest in that technology. The way a technology applies leverage to one or more natural phenomenon is also termed the "base principle" of the technology. For example, the base principle of a wristwatch is to exploit the physical property whereby certain quartz crystals oscillate at a steady frequency. In the digital domain, the base principle of the RSA cryptographic algorithm is to make use of the fact of logic that it is very easy to multiply two large prime numbers p and q to get the answer n yet is nearly impossible to factorize the number n into p and q. For many technologies, the underlying programming of nature is more indirect; their base principle involves blends of other technologies. This is where propositions 1 and 2 come into play.

The first and second proposition pertain to the structure of technologies. Any technology builds on several components that are themselves technologies. Furthermore, these constituent elements are structured in a deliberate and workable way, in what we can call a working architecture. This corresponds to the concept of material configuration, explained earlier on. Generally, the working architecture comprises a backbone of some components acting on the base principle that are coupled with a supporting structure of other components. Let us take a GPS receiver as an example. Proceeding from the base principle of triangulation, this technology makes use of the fact that a position can be calculated from a given distance to and known location of at least three objects. The main assembly – i.e., what is needed for execution on that principle's basis – consists of an antenna (for receiving signals from GPS satellites) and a chipset (for all necessary calculations, power control, etc.). Alongside the main assembly, several other components contribute the supporting structure, among them a physical case, a digital display, and a battery.

I can now tie in these concepts with a technology configuration related to my project's case technology. Bitcoin, the starting point for blockchain developments, is a well documented example of a new technology getting added to the general collection of available technologies. It demonstrates nicely that Arthur's core propositions hold for purely digital technologies. The purpose of Bitcoin as articulated at its introduction was to "allow online payments to be sent directly from one party to another without going through a financial institution," according to its inventor (Nakamoto, 2008, p. 1). The principle is a bit more complicated than earlier examples'. It involves a sophisticated combination of components/technologies that in turn exploit logical relations. These phenomena, with the corresponding technologies, can be described briefly thus: 1) networks can stay decentralized through peer-to-peer network technology; 2) initiation and ownership of "wallets" for payment tokens can be decentralized by means of asymmetric cryptography (similar to the aforementioned RSA technique); 3) storage of payment history can be securely distributed to anyone who wants to participate, via an arrangement of ledger transactions grouped into blocks that are connected by hashes (another foundational cryptographic mechanism); and 4) the traditional difficulty of ascertaining who in an anyone-can-join network is allowed to decide on the appending of new transactions can be resolved via a proof-of-work incentive system (which can be characterized as voting with CPU power). All these constitutive technologies were available to others in addition to Nakamoto; the inventiveness lay rather in articulation of the foregoing principle, which represented a novel way of exploiting various logical phenomena jointly.

The technology collective

The technology-collective level aids in discussing how technology in general evolves, along with how technology classes come into existence. I have already pointed out that technologies combine earlier technologies. Furthermore, these accretions are intentional – they have been developed to meet human needs. Hence, any technology class can be viewed as possessing strong path-dependency both technically, since it builds on only technologies that are actually available, and socially, since it arises from what is considered a valuable human need to meet at the time of its development.

To illustrate the collective of technologies available to a culture, Arthur (2009, p. 177) presented a network metaphor:

> Think of the collective as a network that builds upon itself and organically grows outward. In this network each technology (I will usually call it an element) is represented by a point or node. Each node has links (directed arrows) pointing to it from its parent nodes, the technologies that made it possible. Of course, not all technologies are actively used in the economy at a given time. We can imagine the elements or nodes that are active to be lit up. I will call these the active collection of technologies: those elements that are economically viable and are currently used in the economy. The others – the waterwheels and sailing ships of past eras – are essentially dead. They have disappeared from the active collection. They may be revived for use in novel combinations, but this rarely happens.

What can be added is that if technologies are to develop, they need to be economically viable, and indeed Arthur did acknowledge this: "A candidate solution must technically 'work' to be considered for the purpose at hand; and its cost must be in line with what the market is willing to pay for fulfilling the purpose in question" (p. 178). As new technologies shift the collective network's boundaries outward, there is also a dynamic operating on the purpose or need side of those technologies, which Arthur prefers to denote in terms of "opportunity niches." It bears reiterating here that human needs are not fixed over time, and we have to remember their strong reciprocal relationship with the technologies. While new technologies depend on the state of society, they create new needs, in turn opening new opportunity niches for technology development. In summary, we can say that at any given time the cycle operates with 1) human needs that, sitting in opportunity niches, are judged worth meeting via a new technology and 2) available technologies that can serve as building blocks in creation of new technology. Interaction of forces from these two create spaces for new technological development.

Technology classes vs labels

Before we turn to the level of technology objects, some important things need to be said about how labels are employed for technology classes and the ways in which they interact with material configurations. Technology classes constitute entities in their own right (Popper, 1978). This conclusion is supported by their aforementioned path-dependency taken together with the fact that rounds of testing that contribute to their development have led to agreed-upon knowledge. At the same time, though, a parallel discourse-related process closely interwoven with this one contributes to the demarcation of technology classes. Just as we use language to communicate about concepts of whatever sort from day to day, we need structure in communicating knowledge about technology. Hence, we use *technology labels* to demarcate parts of the technology-knowledge space. Taking the example of "the aircraft," we consider the abstract concept useful "because aircraft have certain common parts and architectures we can expect and talk about" (Arthur, 2009, p. 32). We could reflect on further examples of technology labels, for the hammer, bicycle, ERP system, and internet. Samer Faraj and Bijan Azad (2012) elaborated similarly on what they have referred to as product classes. With the label "word processor" as an illustration, they showed how the material configurations behind a label can change dramatically over a span of three decades yet incrementally enough that a "neglect of change over time" can arise in the research domain (p. 244). Pointing out that "the label word processor hides the fundamental design and material changes occurring over time" (p. 246), they cast the relationship between technology labels and technology classes as not unproblematic, however stable the two might be at a single point in time.

The label attached to a specific technology supplies a fair amount of detail as to what purpose the technology can be used for (a hammer's main purpose is to strike other objects with force; an ERP system is used to collect, store, and manage data from business activities; etc.) and which material configurations constitute the technical aspects of the technology (a hammer has some kind of handle, and its head must be of a hard material; an ERP system keeps its data in some kind of database, and the internal functionality requires source code in some programming language; etc.). By speaking of "a fair amount of detail," I contrast against full detail (such as specifications for a specific company's hammer; some specific instantiation of an ERP system; etc.) but also against such sparseness of detail that the label ends up useless. This positioning of technology labels resembles that described for boundary objects at large, objects that are "both plastic enough to adapt to local needs and the constraints of the several parties employing them" and "robust enough to maintain a common identity across sites" (Star & Griesemer, 1989, p. 393). One aspect of such objects is their interpretive flexibility, which allows actors in various groups to interpret a technology in line with their locale specific perceptions and needs (Star, 2010). For technologies, the interpretive flexibility has often a time component, in that they show less such flexibility over time. Research has highlighted this phenomenon through studying processes such as conceptual closure (Orlikowski, 1992) and dominant design (Anderson & Tushman, 1990).

Technology objects

A technological object, or artifact, is an instantiation of either a technology class or several in combination that is aimed at the purpose of solving a local problem. If we think of "ERP system" as a technology class, its instantiation in many local contexts takes the form of installed technological objects. Information technology as artifacts can be considered the core of IS research (Benbasat & Zmud, 2003; Orlikowski & Iacono, 2001). Though this position has been challenged, IS research is still very much focused on the design, development, and use of technological objects that are already in place, or in the making (Yoo, 2012), rather than on the higher-level, broader-canvas discussion of not-yet-instantiated technologies that is central to this dissertation. That fact is reflected in the research apparatus readily available to the field's practitioners: the research methods etc. (Hovorka & Mueller, 2024). Despite stressing technological objects, IS research still has successfully shown throughout its recent history that the purposes for which technological objects are exploited should not be taken for granted or seen as deterministic. Scholars are now open to the fact that users interpret the objects' utility flexibly and that how an organization stands to gain from artifacts is contextual (Barley, 1986; Doherty et al., 2006).

3.2.2 DIGITAL TECHNOLOGY

Thus far, I have been discussing technology and its specificity levels generally. One domain, however, is not only central to the IS discipline but also probably the most important in contemporary technological evolution. Being a domain (a rather broad one at that), it comprises numerous technology classes. Even so, a few important high-level properties can be attributed to digital technologies as a domain, properties that have made a profound impact on technology's evolution. It is by virtue of a homogenized low-level structure (bitstrings) and separation of physical materials from the formative design providing the features that digital technologies are editable, reprogrammable, distributable, and interactive. Further, digital technologies make use of a layered modular architecture that creates loose coupling of their components by shared protocols (Yoo et al., 2010), thereby increasing the space of possibilities for recombinations (Kallinikos et al., 2013). These properties in combination render digital technologies highly generative (Yoo, 2013), conferring high "overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences" (Zittrain, 2006, p. 1980). Given that new technologies bring together already known technologies, it is fair to say that new technologies are appearing at increasing speed thanks to the digital age. Arthur summed up thus: "Technology, once a means of production, is becoming a chemistry" (2009, p. 25).

3.2.3 KEY CONCEPTS RELATED TO TECHNOLOGY

With the foregoing discussion, I laid out several issues related to technology in aims of presenting how the term "technology" is applied in this thesis and my use of it relative to other interpretations. The focal specificity level for the dissertation's purposes (that is, the default level, the meaning implied for the word "technology" if no other level is referenced in the surrounding text) is the *technology class*, since this is identifiable as the level that corresponds to the emerging technologies. The three central aspects of technology classes as defined here are important pillars of the further analysis that follows: in summary, a technology class is determined by its *base principle*, which is translated into a material configuration (a package per Section 3.1) in pursuit of a particular *purpose*. In addition, I make use of the concepts of the *technology collective* and *technology label*.

3.3 TECHNOLOGY-RELATED DISCOURSE AND PERCEPTIONS

Having focused on the nature of materiality and technology, I now turn to how we as humans come to make sense of these. This discussion proceeds from the notion of technology classes as described above – i.e., it centers on the interpretation that surrounds the general idea of certain technologies. At local levels, such as those of individuals or groups, technologies can be perceived in differing ways. On a larger scale, technologies are made sense of in community discourse (see Swanson & Ramiller, 1997).

3.3.1 PERCEPTIONS OF TECHNOLOGY

Looking at technology on its most general level, Paul Nightingale (2014) has explored what technology is and how it is understood, arriving at no fewer than seven distinct ways of thinking about technology. Each of these views reflects particular perspectives, historical time scales, and interests – ranging from those of engineers to historians and philosophers. As the lens moves closer to practice, perceptions of technology display considerable differences, depending on the perceiver's profession, knowledge, and intentions; cultural history; and other contextual factors. Although said perceptions are inherently individuals', they show clear collective patterns too.

To account for such shared cognitive structures, Wanda Orlikowski and Debra Gash (1994) introduced the concept of *technological frames*. These can be understood as interpretive schemes that emerge when groups of actors are confronted with a new technological artifact in an organization. Citing the case of a company implementing Lotus Notes for communication, they demonstrated professional IT implementers' interpretation of a new technological object as a groundbreaking group tool, a sense grounded in its technological capabilities. The intended users, in contrast, perceived the new technology quite differently, as a tool for individuals' communication, contextualized through familiar technologies such as the phone and fax. An important message from the paper, then, is that analyzing technology in organizational and societal contexts necessitates a social cognitive perspective on key players' interpretations of the technology.

Even though the technological frame differs across the many types of collective, a clear division often presents itself in organizational settings between groups that possess solid knowledge of the inner workings of the technology (typically IT professionals) and those groups concerned mainly with its functions and outputs (such as users and managers). This distinction may be conceptualized as delineating an "inside" view (showcasing a particular technology's internal material workings) *versus* an "outside" view (capturing the technology's affordances and potential benefits). While this distinction, which suits technology objects and technology classes alike, simplifies the nature of frame differences, it holds value for research analyzing interpretation of new technologies, since the views from the inside and the outside accentuate very different faces of a technology.

The motivation for working with these two views gains impetus from the distinct nature of the internally and externally oriented perspectives of technologies, as portrayed by many scholars engaged in conceptualizing technology. One of them is Nightingale, who posited that there are two parts to technologies, the intrinsic physics portion that "objectively determines how the technology behaves" and an "imposed, non-intrinsic function that determines how they should behave" (2004, p. 1271). Swanson and Ramiller distinguished instead between the core technology and the organizing-vision discourse (1997), while Arthur explicitly employed the notions of inside and outside views when discussing what the former brings to the understanding of technologies (2009). He argued that articulating the inside view 1) acknowledges that technology classes, rather than remaining fixed over time, comprise internal components that continuously change and 2) assists in regarding technology in general not as a set of limited functions but as something that "provides a vocabulary of elements that can be put together – programmed – in endlessly novel ways for endlessly novel purposes" (p. 88). A crucial part of contemplating how individual actors in organizations perceive technologies is to bear in mind that some roles involve actively engaging with both the inside and the outside view. Among these roles are those of architects and designers. They usually add great value to technology-adoption processes precisely because they bridge the two. These actors deliberately attempt to connect the interior with knowledge held outside the system's internal structure, by conceptualizing some proposed materiality that might aid in reaping the intended benefits of adopting the emerging technology. I refer to this conceptualization as seeking an answer to the *"how" question*.

3.3.2 DISCOURSE AROUND TECHNOLOGY

Shifting my gaze to how technologies are made sense of at macro level, I recognized in the literature overall consensus that technologies are socially constructed through discourse, rather than being neutral or self-evident phenomena (Gal et al., 2022). Discourse indeed shapes how technologies are understood and acted upon, but the discourse gets influenced by the material aspects of the technology, its underlying technical capabilities. Through this bidirectional action, a relationship coalesces wherein discourse and materiality influence each other, reciprocally (Gal et al., 2022; Swanson & Ramiller, 1997).

One central concept that IS scholars apply to capture these dynamics is the organizing vision (Miranda et al., 2022; Swanson & Ramiller, 1997). Defined as a discursive phenomenon formed around some central concept (here, an emerging technology), this vision is powered by vibrant dialogue regarding both the core technology and the business rationale. Organizing visions enter play at multiple levels, more macro levels (e.g., across industries' and fields' boundaries) and micro ones (within individual organizations). The higher and lower levels are interconnected, manifesting mutual influence (Øvrelid et al., 2025).

Literature on a related theme deals with the role of hype and technological fashion, both of which shape discourses around emerging technologies (Baskerville & Myers, 2009). These concepts point to somewhat malicious behavior that reflects not technology-adoption processes grounded in local needs but a result of a jumping-on-the-bandwagon mentality (Swanson & Ramiller, 2004). Through narratives generally framing the potential that an emerging technology might offer, hype- and fashion-linked dynamics contribute to inflated expectations that can exert negative effects on innovation processes. These expectation-generating narratives are often characterized by grand promises and visionary claims that may overshadow the actual material capabilities of the technology. Though speculative in nature, the narratives serve a strategic purpose in three respects: 1) they offer interpretations of emerging technologies and therefore shape public perceptions and influence policy, 2) they legitimize innovation initiatives, and 3) they assist in mobilizing resources (Swanson & Ramiller, 1997).

The trajectory of an emerging technology, then, is a product of several forces: the core technology itself (the proven material capabilities), the narratives that frame its potential utility (i.e., the associated visions), and the expectations that those narratives generate (Borup et al., 2006; Miranda et al., 2022; Swanson & Ramiller, 1997). While the material capabilities can be said to offer the foundations for the visions, or their material accountability (Bazerman, 1999), they demonstrably do not dictate the technology's path in isolation; moreover, actors often disagree about what precisely constitutes the "core" of a given technology. Narratives are performative here, actively shaping expectations, directing investments, and guiding technical development. Importantly, they stem from a whole host of sources. For example, some narratives arrive via "projective storytelling" by entrepreneurs (Garud et al., 2014) while others are developed by multiple stakeholders, during field-configuring events where they come together to construct framings (Liao, 2016).

The organizing visions of emerging technologies exhibit both diversity and coherence, which might seem paradoxical (Miranda et al., 2022). Both properties, however, are natural as well as necessary for promoting development of the visions. While heterogeneity of agendas among participating actors typically leads to ambiguous or even conflicting interpretations related to the technical materiality on one hand and the purpose of the technology on the other, diversity of frames is pivotal to developing the visions, since, through plurality, frames "induce variation in the material innovation" and "enable entrepreneurial engagement" (Miranda et al., 2022, p. 1422).

Even though diversity makes the visions richer, it also risks rendering them less coherent (Swanson & Ramiller, 1997). For instance, a study by Shaila Miranda et al. (2022) uncovered tensions between frames produced by actors who showed strong engagement with the materials of a technology and frames produced by less intensely engaged actors. Coherence can still be maintained if the various frames are seen as related (Miranda et al., 2022). The labels applied to describe emerging technologies play a crucial role in this. They facilitate communication that lets multiple actors engage with a common reference point. The label placed on an emerging technology "provides a portal into the community discourse that builds the organizing vision" (Swanson & Ramiller, 1997, p. 453).

From the multiple links explicated above between the macro level of community discourse and the micro level of individual organizations, it is evident that managing the innovation processes related to emerging technologies involves navigating both technological and discursive ambiguity. Having frames available, expressed through visions and narratives, streamlines the complex interpretation in which organizations consider the technology's usefulness, pick and choose from among the frames, and generate legitimacy for experimentation and investment (Swanson & Ramiller, 1997). This process still is complicated by the presence of hype, unrealistic expectations, and unclear material realities. One arrives at the conclusion that engagement with emerging technologies requires a certain set of management capabilities, among them the abilities to assess technical options, conduct critical evaluation of narratives, and mindfully attend to local needs (Swanson & Ramiller, 2004).

3.3.3 TECHNOLOGY'S EMERGENCE

I have placed considerable emphasis on the "technology" part of the semantic construct "emerging technology." While the second part should not be neglected, significantly briefer treatment suffices. The reason lies in my interpretation of the construct's practical use as a term pertaining to technology classes, in which the ongoing emergence indicated takes place at class, or macro, level. Though emergence of this kind is an exciting process worthy of study, my focus is squarely on early innovation processes and their relation to technologies that happen to be in a state of emergence. Hence, my treatment approaches these technology classes as not changing at macro level in the course of a local innovation process.

The notion of emergence manifests varied connotations in connection with technology. Central to all denotations, though, is that whatever is emerging is "coming into existence." Dictionary definitions thus reflect a process that is ongoing, rather than something static (see Rotolo et al., 2015). In some areas of research, such as complex-systems theory, another definition is used, one granting emphasis to the properties of emergent systems or phenomena as unable to be explained via properties of their constituent parts (*ibid.*). I employ the concept of emergence in the first, looser sense, under which an emerging technology is a technology that can be perceived as being in the state of entering existence.

3.3.4 KEY CONCEPTS RELATED TO DISCOURSE AND PERCEPTION

This section has teased out how technologies are made sense of both locally and globally. Introduction of the concept of *technological frames* is especially important, for its potential value in addressing the cognitive understanding that can be shared within and across inter-group boundaries. Since various groups internal to a technology-implementing organization are likely to produce different frames, the distinction between *inside and outside views* of technology deserves attention also. Additionally, the *"how" question* stands out as an important element in an activity that plays bridging roles – it assists in analyzing reflections on ways in which specific material configurations can help bring the intended benefits of adopting an emerging technology.

Local groups working toward common goals, such as an organization's innovation process teams or other units, cultivate rewards from developing collective frames. These frames facilitate shared understanding and afford the process's felt legitimacy. When groups of whatever sort engage with emerging technologies, community discourse offers several *available frames*, which can be adopted directly or adapted to the local settings.

It is vital that the frames present in community discourse contribute to both coherence and diversity. Multiplicity of frames can create *tensions* (e.g., between groups with high and low material engagement) while certain features of community discourse serve to hold it together. For emerging technologies, the *technology label* is a particularly crucial feature.

CHAPTER 4

THE RESEARCH STRATEGY AND METHODS

The entire research project corresponding to this thesis can be described as an intellectual journey that investigated the role of emerging technologies in innovation processes. This involved analysis of the technology studied, blockchain, along with actors' interpretations of it. The overall approach throughout the project was a qualitative one with exploratory case-study research following an interpretative tradition (Klein & Myers, 1999; Walsham, 1995, 2006). Scholars recognize that "[i]nterpretive research can help IS researchers to understand human thought and action in social and organizational contexts" (Klein & Myers, 1999, p. 67).

4.1 THE CASE STUDY

4.1.1 CASE-STUDY METHODS

A case-study approach was deemed the most suitable to address the research aim for two main reasons. Firstly, the phenomenon that I have delineated as the early stages of organizational digital-innovation processes in which the enabling technology is an emerging one was considered largely unexplored and in definite need of new theory. The case-study method, drawing together great detail, richness, completeness, and variety (Flyvbjerg, 2011), is well suited to the "exploratory phase of [work on] a research topic to discover the relevant features, factors or issues that might apply in other[,] similar situations" (Myers, 2019, p. 89). Secondly, understanding the role of emerging technologies in innovation processes requires a focus on human interpretations and meanings. As described by Geoff Walsham (1995), an in-depth case study is often considered to be the ideal "vehicle for such 'interpretive' investigations" (p. 74).

An important consequence of choosing case-study methods culminates in what one can reasonably expect in terms of generalization (Bryman, 2012). Since social structures "are not space-time invariant" (Walsham, 1995, p. 79), we cannot expect to express social laws in a manner analogous to how natural laws get articulated as a result of natural science; neither is that the purpose for the method (Bryman, 2012). Instead, we can expect to contribute to understanding and explanation of the phenomenon under study by viewing the proposed theory with regard to patterns – "as 'tendencies', which are valuable in explanations of past data but are not wholly predictive for future situations" (Walsham, 1995, p. 79). Generalization remains possible but as pointers toward new theoretical frameworks that can help guide future research, which in its turn may opt to develop the theory further (Flyvbjerg, 2006; Walsham, 1995).

In several respects, definitions of case-study research vary greatly with the research field and paradigm choice, but every case study operates with boundaries as to what constitutes an individual unit of study (Flyvbjerg, 2011). Through application of a research paradigm that is close to that of interpretive case studies (see Walsham, 1995), I have defined the boundaries – i.e., what constitutes a case and what the case is a case of – in line with the "casing" strategy of Charles Ragin (1992). His advice is to "consider cases not as empirical units or theoretical categories, but as the products of basic research operations" (p. 218). Following this strategy, I find it important to acknowledge that I set tentative case boundaries designed to develop as the research progressed. Ragin proposed such a strategy as suitable for construction of social theory (1992, p. 225):

> Casing is an essential part of the process of producing theoretically structured descriptions of social life and of using empirical evidence to articulate theories. By limiting the empirical world in different ways, it is possible to connect it to theoretical ideas that are general, imprecise, but dynamic verbal statements.

The final casing for the dissertation arose as a result of this strategy, whereby I ultimately circumscribed my case as one exhibiting the phenomenon of the early stages of organizational digital-innovation processes whose enabling technology is an emerging technology. My case involved blockchain as the case technology, and the case-context entities shared the attribute of being North European public-sector organizations in which early innovation processes with blockchain unfolded. Table 3 outlines those contexts.

Some critical voices might claim that general theories cannot be derived from single case studies (Flyvbjerg, 2006), particularly if the sample is small or otherwise risks not being representative (Siggelkow, 2007); however, I contend that the inferences from my study meet the standards for research rigor, since quality and depth of data offset lower quantities. Following what is called the interpreted case study approach, I adhere to such standards also by demonstrating my methodological choices clearly, critically reflecting on the relational settings of the study and my own role in it, and relating my findings to theory (Klein & Myers, 1999; Walsham, 2006). That said, I agree that "there does not and probably cannot exist predictive theory in social science" (Flyvbjerg, 2006, p. 223), and that it is more feasible to focus on learning instead of proofs (*ibid.*). As for the nature of my contributions to theory, as Ragin argued, "theoretical formulations are verbal and thus abstract, incomplete, and tentative [providing] an initial image, a vague starting point for looking at empirical evidence" (1992, p. 218).

4.1.2 CASE SELECTION AND DATA SOURCES

The case and its contexts were of a revelatory nature, thus displaying a character aligned well with the choice of strategy. Scholars apply this notion to refer to cases likely to yield rich theoretical insight (Bryman, 2012; Eisenhardt & Graebner, 2007). The strategy for selecting both the case and the case contexts followed a dynamic and explorative path, aligned with the casing strategy described above. The overarching principle guiding this was theoretical sampling (Eisenhardt & Graebner, 2007) – i.e., choosing contexts that should assure of generating insightful findings while suitable for capture of the phenomenon examined. I began by picking a case technology. When I commenced the research, blockchain discourse was vibrant and an opportunity presented itself for collecting data in an active project financed under the EU's Interreg program. This project, BLING, focused on early innovation with blockchain in the public sector. From that point onward, I remained on the lookout for new case contexts, because I needed to get closer to organizational settings in the public sector wherein blockchain technology was the trigger for innovation. After some high-level *ex post* investigations at Swedish state level (with initiatives in government agencies), I managed to gain access to a project that was about to start. Through this, I obtained a rich body of in-depth data meshing with my research aim.

Over the course of the doctoral project, I collected case data both connected with the case technology and for the various contexts explored. Each is described briefly below, and Table 3 presents a summary view.

I started by delving into *blockchain technology*, where the case data comprised both material details and discourse-linked elements of that technology (the section of Chapter 2 dedicated to the technology side of matters attests to the great emphasis I placed on that aspect of the phenomenon). This gathering of data started very early in the doctoral project, since I knew from the start that my research was to be centered on blockchain technology. I attended engineering classes at Chalmers University of Technology to learn about the core building blocks of that technology: cryptography and distributed systems. In addition, I attended a doctoral-level class on it and read practitioner and academic literature.

The second constellation of data collection centered on *the BLING project*, titled "Blockchain in Government." In this Interreg-supported R&D project, such entities as academic institutions, entrepreneurs, and public sector organizations collaborated to increase knowledge about public-sector blockchain applications. In conjunction with this project, my research team at the GU Blockchain Lab conducted academic research wherein the work load was distributed among the lab's researchers and student personnel. Data collection involved workshops, interviews, and internal and external documentation. Team members' attendance at the frequent steering-committee meetings constituted another source of data. I personally attended two of these meetings, which were arranged as mini conferences that rotated around the participating locations.

In 2020 to 2021, I worked alongside the other members of the research team to map all known blockchain-connected initiatives within *Swedish government agencies*. The Swedish ministry of infrastructure assisted immensely in this mapping exercise. Four interviews and compilation of several documents constituted the dataset. The data, while not analyzed for any publications, informed my overall understanding of the phenomenon studied.

Within the Nordic governmental context pseudonymized here as *Comp Agency*, I conducted work revolving around an early innovation initiative, with corresponding idea development there (the pseudonym, employed in my research output, protects the agency's particulars while revealing relevant features of this agency – e.g., that commercial organizations are among its important clients). The data collection was a longitudinal effort lasting 15 months, which coincided with an official project programmed to deliver on a government assignment. In addition to real-time data (e.g., observations from meetings), I collected data related to the historical events leading up to the project, by gathering historical accounts through interviews and archived documents (agency-internal ones and externally produced material such as media coverage).

4.1.3 DATA COLLECTION AND ANALYSIS

The overarching aim behind all my research has been to study and develop knowledge of early innovation processes involving emerging technologies. In the doctoral project, the research grew organically, with the approach behind each paper being somewhat distinct, though every one grew out of iterative analysis through thematic coding (Braun & Clarke, 2006) from empirical data and integrating prior theory. Paper 2 demonstrates the most inductive approach, letting the body of data speak for itself, whereas the analysis for papers 1 and 3 operated through theoretical lenses defined in later rounds of analysis. Paper 4 was a conceptual piece.

All data were carefully logged and categorized. This systematic approach encompassed multiple types of data, summarized in Table 3. *Observations from meetings* constituted the most important type of data in the collection efforts at Comp Agency. The project team held meetings regularly, the most common types of which were "pulse meetings" held weekly and sprint meetings (agile "ceremonies") held in a three-week cycle. Most meetings were conducted online, since project participants were geographically dispersed. Others were longer events that involved convening to create specific work outputs. The stream of meetings provided for constant sampling of the project's state, which enabled me to analyze the team's collective sensemaking and the unfolding of the project. My technique focused on taking thorough timestamped notes while tape recording all the meetings so that at any time I could revisit potentially fruitful themes for analysis.

Full-day visits and steering-group "meet-ups" supplied further data. Spending a whole day at a study site is, of course, highly valuable, because the researcher's closer involvement supports fuller "access to people, issues, and data" (Walsham, 2006, p. 321). In my data collection at Comp Agency, I took the opportunity to spend days on the site in connection with physically convened meetings or planned interviews, with the intention of capturing additional observations via field notes. The BLING project's steering-group gatherings provided similar opportunities.

As for the *semi-structured interviews* and workshops that informed the research, my work attests that interviews offer a "key way of accessing the interpretations of informants in the field" (Walsham, 2006, p. 323). My primary technique for these was semi-structured interviewing wherein a written interview protocol prepared before the interviews organized the relevant questions. All interviews were tape-recorded and transcribed (every informant was given the option of no recordings, but an opt-out situation never arose). I always strove to conduct interviews in person; however, some were conducted online on account of pandemic-based rules.

Interventions added a different kind of dimension to the study. When I was collecting data at Comp Agency, I was granted an opportunity to arrange small workshop-style interventions on two occasions. These took place as physical gatherings in conjunction with on-site work meetings. The interventions allowed me to propose interpretations I considered relevant as a researcher, so as to solicit feedback from the project group.

Finally, *documents*, of many kinds, were collected continuously. I was sensitive to each opportunity for compiling documents that could assist in analysis. At times, specific ones (e.g., strategy documents at Comp Agency) were requested proactively. Within the BLING project, a shared site for documentation supported the data-collection efforts. I have classified email correspondence as a separate data type; generally, my analysis did not directly rely on email documentation, but it nevertheless contributed to the process of growing familiar with the context.

Table 3. Collection of the data

Context	Data type	Quantity of elements	Approx. hours	Data used in paper no.
The BLING project	Workshops (materials)	1		Paper 3
	Interviews	19	17	Parts in Paper 3
	Steering-group meet-ups	2		
	Project documents	~100		
	Email messages	>100		
Swedish government agencies	Interviews	4	5,5	
	Other documents	~60		
The Nordic government entity Comp Agency	Meetings (source of observations)	93	110	Papers 2 and 4, parts in Paper 1
	Full-day visits	10	60	Papers 2 and 4, parts in Paper 1
	Interventions (tracked)	2	1,5	Papers 2 and 4
	Interviews	18	15,5	Papers 2–4, parts in Paper 1
	Email messages	>100		Papers 2 and 4, parts in Paper 1
	Project documents	~50		Papers 2–4, parts in Paper 1

4.2 PHILOSOPHICAL MATTERS

4.2.1 CORE RESEARCH PARADIGMS

There is a wide spectrum of paradigms that can underpin social research (Bryman, 2012; Moon & Blackman, 2014). One can characterize the historical development of IS studies and related disciplines as having been functionalist, substantialist, and positivist early on but then shaking off those orientations' strong dominance as counter-positions developed along the way, among them interpretivism, social constructivism, sociomateriality, relational ontology, and process metaphysics (Cecez-Kecmanovic, 2016). Some historical accounts of these shifts portray it as a maturation process (Baygi et al., 2021; Cecez-Kecmanovic, 2016), whereas others depict it as akin to the motion of a pendulum that sometimes has swung too far toward one extreme and necessarily triggered counter-movements (Leonardi & Barley, 2010). For instance, some have argued recently that various perspectives arising together in response to technological determinism (social constructivism and others) have gone too far, obscuring the internals of technology (Kallinikos, 2004; Kallinikos et al., 2012; Leonardi, 2010; Leonardi & Barley, 2010).

The multitude of perspectives and paradigms available to IS research has triggered several debates as to which path is the most appropriate (Cecez-Kecmanovic, 2016; Goles & Hirschheim, 2000), but many also cite this plurality as one of the discipline's strengths (Ågerfalk, 2013; Galliers, 2006; Goles & Hirschheim, 2000). I find it important to reiterate that, generally, any perspective captures some aspects of the relevant phenomenon well while other aspects are obscured. From this standpoint, the choice of perspective should be aligned with the aim of the research and with the questions for which answers are pursued (Bryman, 2012; Moon & Blackman, 2014). In this vein of thinking, I acknowledge the value of paradigmatic developments such as relativist ontology and process metaphysics (Cecez-Kecmanovic, 2016); I genuinely appreciate that they bring important perspectives to today's technology-intense social world. However, the direction I chose for the dissertation project does not tie in with these advancements. Rather, I built on a pragmatic combination of interpretative and substantialist/objectivist perspectives, upon which I elaborate below.

Alignment between paradigms and research aims

The aim behind my research, alongside the research questions stemming from that aim, ties in closely with my position in the research-paradigm landscape. One bump I encountered on this terrain is that my inquiries involved both the technical/material character of technologies and human interpretations of those technologies. In consequence, the philosophical pillars for the thesis do not fall neatly under any one of the classical dichotomy-expressed paradigms. Choosing from among the non-binary positions that have been proposed (Ågerfalk, 2013), I could position the dissertation as representing a pragmatic approach. However, even identification with a pragmatist perspective necessitates some caveats. Firstly, I have not conducted any design or action research, with which pragmatism is frequently associated on account of the objective of "*constructive knowledge* that is appreciated for being *useful in action*" (Goldkuhl, 2012; emphasis in original). That said, action research and constructive knowledge useful in action can be seen as a long-term goal for my research, or a beacon on the horizon that points to knowledge to which I hope the projection of my contributions leads. Also, as Pär Ågerfalk (2010) has stated, echoing the approach of Göran Goldkuhl (2008), the core of pragmatic concepts and concerns leads to an interest in not only knowledge sought *for* action or *through* action but also knowledge *about* actions. My contribution's empirical basis is related to interpretations and actions in early innovation processes.

Knowledge of the social world

With the social world as a starting point, I sought to understand how emerging technologies get interpreted and acted upon in innovation processes. To that end, I followed an interpretative approach, for its ability to facilitate apprehending "human thought and action in social and organizational context" (Klein & Myers, 1999, p. 67). Central to an interpretive approach is the view that reality in the social world is not objective but resides with members of social groups as particular realities, which are expressed through such social constructions as subjective meanings, language, and artifacts (Goldkuhl, 2012; Klein & Myers, 1999). Accordingly, one gains knowledge of the social world by accessing others' interpretations. My application of this approach acknowledges interpretation as playing out at two levels at least: it is done both by the informant in the research setting and by the researcher when offering interpretations of another's interpretations (Bryman, 2012; Walsham, 1995, 2006). From this follows the inescapable conclusion that the knowledge articulation created through social research cannot be considered objective. After all, interpretations are always based on the interpreter's prior knowledge, experiences, and preexisting values.

Knowledge of the material world

Reconciling the technical realities that surround an emerging technology – the materials and their form (Kallinikos, 2012), or the core technology (Swanson & Ramiller, 1997) – formed an important part of my research. My perspective as a researcher collecting and analyzing the body of data for grasping these diverged from the stance I took to the social world. This is not to say that I disregarded the social aspects of the technical formations of technology; indeed, these stem from human intentionality in a clearly path dependent way. Rather, I approached the technology's current state (i.e., the material components available and the knowledge of them) from a functionalist/substantialist angle (see Cecez-Kecmanovic, 2016; Goles & Hirschheim, 2000). The SHA 256 hash function offers a clarifying example. It is a well-defined mathematical function that can be implemented as a component to digital objects. In an implementation, it has deterministic material agency. One implication for the definition of this digital material and expression of the function is that it leaves no room for diverse interpretations. The hash function is what it is, and it does what it does. Analysis at a different level comes only after this, in probing what this functionality means for humans interacting with the digital object. Then, another approach is required (e.g., affordance theory; see Leonardi, 2017).

Combination of paradigms

The social and the technical world constantly interact, as we all know. What this means in the space of research paradigms is that research such as mine must manage and connect two types of paradigm. Pragmatism literature refers to this navigation as paradigm crossing (Goles & Hirschheim, 2000) and articulates several types of it. My research most closely approached what is referred to as paradigm-bridging, wherein the work spans the gap between subjective and objective perspectives on particular phenomena. Tim Goles and Rudy Hirschheim (2000) have offered the example of how Stephen R. Barley, when studying the implementation of novel CT scanner technology, recognized that "the human activities of social construction which help create organizational structure are in turn influenced by the objective characteristics of the very structure thus created" (p. 260).

The worlds of Popper

I find fertile ground in connecting the discussion above with Karl Popper's "three worlds." Expressing how reality can be understood, Popper (1978) delineated world 1 as the physical world, inclusive of its states and processes. World 2 is "the mental or psychological world, the world of our feelings of pain and of pleasure, of our thoughts, of our decisions, of our perceptions and our observations" (p. 143). Lastly, world 3 consists of the products of the human mind that can be regarded as objects in their own right, where he cited as examples "languages; tales and stories and religious myths; scientific conjectures or theories, and mathematical constructions; songs and symphonies; paintings and sculptures" but also "aeroplanes and airports and other feats of engineering" (p. 144). Many world 3 objects (technologies and their embodiments among them) belong at the same time to world 1. An airplane exists as a world 3 conceptual object, yet there are world 1 embodiments of it. Popper stated, "One can, if one wishes, say that the world 3 objects themselves are *abstract* objects, and that their physical embodiments or realizations are *concrete* objects" (p. 145; emphasis in original).

Within this framework, I consider my attention to such aspects of the material world as technical knowledge related to digital technology to be study of world 1 phenomena on one hand, comprising the logics underlying material structures (e.g., how prime numbers can be used in cryptography), and world 3 on the other, since the shared knowledge, conceptual descriptions, and language related to these structures are all shared entities that exist independently "between" humans. When studying interpretations of technology-linked discourse and the purpose of innovating with certain technologies, I studied world 2 by accessing the interpretations of informants through observations and interviews. Also my work brought in world 3 entities such as shared documents and a community discourse. Appendix A expands on how the elements of my proposed conceptualization of emerging technologies tie in with the worlds of Popper.

The reflections above have been presented in the spirit of transparency. While I did not concern myself directly with worldviews over the course of the project, I am keenly aware that the paradigms to which I adhere necessarily affect the outcome of my research immensely.

4.2.2 THE RESEARCH AS A JOURNEY

The research journey started with an opportunity to study the early engagement with blockchain technology within the BLING project. The actors involved were all organizations from Northern Europe, among them municipalities, government agencies, companies, and universities interested in some aspect of potential adoption of blockchain in the public sector. My research group at the Blockchain Lab was one of these actors.

Because I was intrigued by the challenges of making sense of a new technology with unclear use cases, the initial scope for my work was broad. Hence, I adopted an exploratory stance, letting the research scope narrow progressively. Relatively early on, I decided to grant emerging technology center stage as the technology phenomenon under study, with blockchain as the case technology. In the early stages, I took part in co-writing that led to two publications that, while not integral to the dissertation's contribution (see Section 4.8), form a part of my doctoral study's intellectual journey.

After the aforementioned choice, I made a decision to narrow my search for valuable data to government agencies. I searched for all known blockchain-related initiatives among Swedish government agencies. This scanning led to a few semi-structured interviews (which did not form a part of the data corpora behind my papers but did contribute to comprehensive understanding). At this point, I developed a nagging sense that I needed to find case data from ongoing early-stage innovation activity that was actually investigating blockchain for a public-sector use case, preferably at a government agency. In late 2022, I had the good fortune to come across precisely what I was looking for, through a 15 month-long project at a Nordic government agency. I was lucky also to be accepted as a research fellow granted access to all project meetings.

My research design aligned with this opportunity was to observe all meetings held with the entire project group. I complemented my observations with other data-collection activities in accordance with the snowball principle, thus drawing on semi-structure interviews, meetings additional to project meetings, the organizations' documents, media communication, etc. I chose to arrange the body of data in a structure based on overarching themes that would shift over time as the project unfolded (with example themes being organizational history, culture, vision and strategy, the installed IT base, and activities that had led up to the project). The overall research strategy was to start inductively making sense of primary data, then employ a backdrop of theory in second round analysis. Analysis-process specifics are presented in each paper.

Paper 1 represents the culmination of analysis carried out approximately 10 months into the project, in which the data analysis applied the theoretical lens of need–solution pairing (per von Hippel & von Krogh, 2016). Paper 2 has its roots in more inductive analysis of the entire dataset, analysis with no single theoretical lens orienting the interpretation. After the data collection at Comp Agency and the analysis for papers 1 and 2 came deeper contemplation about what I had observed and reflection on the analyses' implications. That entailed developing new theoretical perspectives in response to two perspectives I wanted to explore. Firstly, interesting results emerged from contrasting the innovation process at the government agency against the corresponding process at one of the municipalities studied in the BLING project. This analysis was strongly influenced by the concept of frames, which I introduced as a way of grappling with how various actors handle complexity (Orlikowski & Gash, 1994). It resulted in Paper 3. Secondly, I found an enlightening theoretical opening in unpacking the ambiguities of an emerging technology. Contemplating this and how such ambiguity was tackled in the innovation process at the government agency culminated in Paper 4.

While the project had started out as explorations of multiple organizational processes for the purpose of advancing understanding of emerging technologies' role for innovation, I started to recognize, after the rounds of analysis corresponding to the first two or three papers, that I needed to develop a more concept-anchored understanding of the phenomenon of emerging technologies, in particular by contrasting them against established ones. This proved necessary for productive understanding of how emerging technologies influence the innovation processes in which they are incorporated.

For the synthesizing portion of the dissertation, I decided to take a step back and theorize further on what all these analyses together might tell us. My journey thereby uncovered a need to conceptualize emerging technologies as a real-world phenomenon. Only then could I discuss how such technologies influence innovation processes. I did this by exploring literature on technology further, to develop theory integrating responses to these questions.

Finally, I should note that my journey as a whole drew inspiration from the principles of "engaged scholarship" (Mathiassen, 2017; Van de Ven, 2007). I could not adhere to such scholarship strictly, mainly because of limitations inherent to the relations with the case organizations. While I received a warm welcome at Comp Agency, it did not extend to embracing a joint research aim; this was a very busy agency strongly driven by its strategy agenda. Nonetheless, the principles served as valuable guidance.

4.2.3 THE RESEARCHER'S ROLE

As I embarked on research after 15 years of working in industry with systems and software development, I was especially concerned about how to manage my experiences from the realm of practice and the worldview developed in the course of that "previous life." I often characterized arriving from a practitioner's position as feeling like both a blessing and a curse.

The positive side was that I naturally possessed hands-on experience of working with digital artifacts: gathering stakeholders' requirements, processing those requirements into system design, and implementing and testing systems.

As for the other side of carrying this prior experience into research, I felt that it has given me worldviews that make me susceptible to missing important elements when I interpret the objects of my research. In combination with my university-level engineering training, experience in systems development has only strengthened my tendency to view technology as "[a]rtefacts that solve problems" (Nightingale, 2014). That said, I find that being anxious about this risk of an engineering mindset has helped me mitigate it, since it helps me stay attentive. Furthermore, all research and all researchers in the end are bound up with some preexisting worldviews, and this necessarily affects the outcome of the research. It is for that reason that I subscribe to an interpretative approach to research (Walsham, 1995, 2006): interpretivists acknowledge the latter fact and transform it into a strength. That is, "interpretivism suggests that the facts are produced as part and parcel of the social interaction of the researchers with the participants" (Klein & Myers, 1999, p. 74).

4.2.4 ETHICS CONSIDERATIONS

In the realm of ethics-related frameworks (franzke et al., 2020), there is an important tension between realist/deontology ethics and utilitarianism. Some argue that everyone must pick a side, while others (such as proponents of "in-context" research ethics; see Hård af Segerstad et al., 2016) prefer a more nuanced view of this tension. My choice would be to proceed from a deontological standpoint yet remain aware that situations will arise that require balancing the anticipated impact against "acceptable risks of harm" (while fully aware that "require" is up to individuals' judgement and possibly contestable).

Further tension, of another kind, arises in the methods available to guarantee ethical research in planning and conducting a new study. Ideally, "a belief in and understanding of core human rights, plus basic human decency, plus common sense, [to] help us make good decisions to minimize the potential harmful impact of our actions to persons or society" should be enough (Markham et al., 2018, p. 3). However, the (partly dark) history of research has illuminated a need for generalized regulatory frameworks (Markham, 2018). Such guidelines, however, are by necessity universal so cannot handle the complex nature of the ethics problems that plague social research. In response to this problem, more context-sensitive, "case-by-case" models have emerged, with focus on continuous careful monitoring of impact (Markham, 2018) and acknowledging the need for balancing "rights of subjects" and "social benefits" (Hård af Segerstad et al., 2016).

The general approach I have developed personally for guaranteeing sound ethics in my research studies is to focus on making sure I am aware of and honor the ethics-regulation frameworks and guiding principles from the start, then, as the research progresses, constantly engage in self-reflection on ethics principles, not least in the handling of any potential goal conflicts. In addition to considering how to perform the research ethically (i.e., reflecting on the ethics decisions in which I have agency), I find it important to continue thinking critically about events and decisions in the context studied, contemplating important societal issues such as equality and sustainability. Regardless of the actor (researcher or practitioner), I support the view that Annette Markham put forward when describing ethics in terms of "moment-by-moment choices that naturally have consequence – on people [...]; on the (re)production of particular social orders [...]; and on our collective socio-political, cultural, economical, and environmental futures" (2018, p. 9).

The discussion below pinpoints ethics-related challenges and considerations that revealed themselves at various stages in my research.

Analysis of motives behind the project

My first ethics-linked reflections involved probing my own perceptions of research and advancement of knowledge. Having stable funding for conducting research imposes certain responsibilities. The most evident of these entails being genuinely involved in knowledge creation, not something else; at the opposite extreme would be such enterprises as policymaking or career-boosting. While I have chosen to engage in research for the sake of common knowledge, I have had occasion to ponder what I bring with me from my professional path. This thought process led me to two important insights. Firstly, I have chosen to see myself as an interpretative researcher (Walsham, 2006), where in so doing I acknowledge that there is no such thing as objective truth (at least in social science). Whatever knowledge I articulate has my social history embedded in it. Secondly, I have attempted to maintain a constant attitude of reflexivity and openness to discussing the outcomes of my research with my peers, for I am convinced that the dialectical processes of social-science research yield the best common knowledge.

The study design and initiation of the research

When I became aware that I was going to gain close access to a project at a government agency, I started reflecting on this setting's influence on the various stages of the research. One question I asked myself early on was how I could manage the need to stay neutral in my analysis and findings while at the same time having a social relationship to the people in the organization studied. What would happen, for example, if my analysis were to imply harsh criticism of some practice subject to study? In all honesty, I have not found a good *a priori* resolution for this. Luck was on my side, though: such a situation never arose. One solution might have been to craft a nuanced language that bundles the critique in with more general discussion.

The subjects involved and their informed consent

The primary subjects (see franzke et al., 2020) in my study were the project participants and other stakeholders closely connected to the project. In the study setting, these individuals were either part of an observed meeting or taking part in an interview I had arranged. However, in addition, there were other people who might have been indirectly affected by the research (whether in the data collection, analysis, or dissemination).

The openness of the organization examined became apparent to me very early in the work, and I detected a sincere desire to open up among the project participants, who showed a relaxed attitude to sharing their views and opinions. It is worth mentioning also that these individuals were all highly experienced individuals who had been hand-picked from various parts of the organization to contribute to a project that held strategic value for this entity. This subjective aspect is important to discuss because it has affected my overall assessment of ethic measures. One of the basic tenets of research ethics is to minimize harm (franzke et al., 2020; Zimmer, 2018). Reflecting on the ethics principle "the greater the vulnerability of our subjects, the greater our responsibility and obligation to protect them from likely harms" (franzke et al., 2020, p. 17; see also the phrasing of Hård af Segerstad et al., 2016), I concluded that the subjects in my study were not particularly vulnerable. This does not imply justification for treating their personal data callously, but it did affect where I landed in the balancing act of ethics tradeoffs.

As for informed consent, another fundament of research ethics (Zimmer, 2018), my overarching approach involved obtaining this consent at the point of data collection rather than of dissemination (franzke et al., 2020). As is noted above, the way I interacted with the subjects was either through observations (mainly at meetings) or in one-to-one interviews. In these settings, I always sought informed consent from those involved. For interviews, that was straightforward: each interview commenced with me stating the ethics standards followed – that the data were to be used only for research, that the participant could ask to end the interview at any time, etc. Meeting observations proved to be somewhat trickier. For the members of the project's core team, I initially asked the entire team for consent to tape-record the meetings, stressing that the recordings would be used exclusively for research purposes. When new people were brought onto the team or when internal guests participated, consent was sought via one-to-one communication, typically by email (usually in retrospect, since I did not know they would show up until the meeting was in progress). That said, since the project's communication always made open mention of me participating as a researcher, often the new members already knew that a researcher from Gothenburg University was involved. On the few occasions when external personnel, such as collaborating agencies' workers or other experts, took part, the meeting was not tape-recorded.

In awareness that informed consent indeed implies "full disclosure and complete understanding" (Hård af Segerstad et al., 2016), I must acknowledge that I deviated somewhat from the gold standard. In other words, there is a small risk that an individual involved as a subject in my research did not reach complete understanding, or that some part of what I should have communicated was not communicated clearly enough for reaching the threshold of full disclosure. Still, I see this as an inherent balancing act. Given that nearly all subjects in the project setting in my field study were always on the move, meetings often were no more than 30 minutes long, to support efficient scheduling for everyone. It would not have been feasible to request that five minutes of each meeting be set aside for the full disclosure implied by informed consent. This fact in combination with the discussion of low vulnerability above left me with what I think is a balanced resolution.

Publication and dissemination

When I asked participants for informed consent, I made clear that any data published would be anonymized. Experience revealed, however, that not all facets to the process of anonymizing data from a state-level government agency conducting an innovation project with an emerging technology are easily handled. This was especially true of material that could indirectly identify some mechanisms at play. For example, some members of the public might well recognize the case and organization in question from even simple contextualizing information supplied in a published article. As for referring to people by role, some informants were among only a few individuals – or even the only one – holding the relevant position at the organization (with the director-general of the agency being the most obvious example). My responsibility to safeguard participants' privacy required careful thought about arriving at a "fair," balanced level of anonymity.

My considered manner of resolving this challenge was to regard anonymization as "layered":

- I labeled the organization as a Nordic government agency without specifying the country. To be sure that important features were not lost, I retained the vital information that companies count among the agency's important target groups. Doing so does narrow the set of possible organizations, making its identification easier.
- I deliberately provided as little information as possible about the case project itself and the intended service under development. This too required finding a balance, since conveying a story well to the reader demands rich information.
- In keeping with common practice, I labeled each informant with a code; hence, identifications such as "R3" are appended to quotes from individuals. It deserves mention also that any use of a quote followed assessment of whether the quote was really needed and whether the one chosen might carry some sensitive message.

Generally, I stripped the information on the roles of individual participants from the participant codes. Instead, each publication's method section provided a listing of all roles involved, for characterization of the sample. This solution was not the initial plan; when I and my co-authors were pushed by reviewers to provide more details about the service being developed, the authors concluded that doing so could affect the anonymity balance. Therefore, we removed mentions of individual-specific roles in favor of a list.

4.3 ADDITIONAL PUBLICATIONS

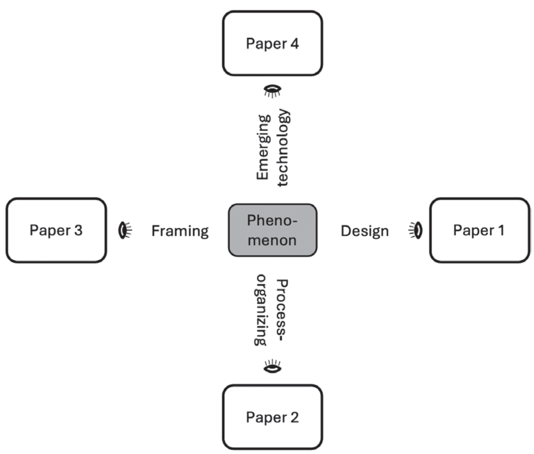
In the course of the doctoral research, I contributed to additional publications, not constituent parts of the dissertation. As mentioned above, they nevertheless have contributed to my progress. I list them here for reference.

- Norstrom, L., Lindman, J., Lindquist, M., Karlsson, J., and Landsten, N. (2022). Turning buzzword into public service: A case study of European blockchain projects. In *AMCIS 2022 Proceedings* (Paper 7).
- Mahula, S., Lindquist, M., Norström, L., and Lindman, J. (2022). Digital transformation in local government organisations: Empirical evidence from blockchain initiatives. In *dg.o '22: The 23rd Annual International Conference on Digital Government Research* (pp. 336–345).

CHAPTER 5

CONTRIBUTIONS OF THE INDIVIDUAL PAPERS

Figure 3. The viewpoints



The dissertation extends from research presented in the four peer-reviewed, published conference papers (see Table 4). Each individual paper is found in Part 2 of this volume in the form in which it appeared in the respective publication venues. With this chapter, I present a summary for each paper. These papers are at the same time output from standalone research inquiries and reflections of the intellectual journey that eventually led to a synthesizing dissertation. From reflecting on the four papers and "connecting the dots," I conclude that together they present various viewpoints on the central phenomenon connected with the early stages of organizations' digital-innovation processes wherein the enabling technology is an emerging one.

Paper 1 approaches this phenomenon in the chosen case organization from the standpoint of design. Paper 2, in turn, offers an investigation for understanding it from the angle of process-organizing. The focus in Paper 3 is on the framing of the related innovation processes and outcomes. The final paper delves into the meanings implied when the innovation process encompasses an emerging technology. Taken together, the papers show that early engagement with emerging technologies is fraught with challenges such as maintaining legitimacy, constructing a feasible collective frame, and managing technology ambiguities.

Table 4. The constituent papers' orientation

No.	Title	Authors	Research question	Viewpoint
1	Need–Solution Pairing and the Role of Emerging Technology in a Public Sector Innovation Process	Mikael Lindquist, Livia Norström, and Juho Lindman	What are the characteristics of early innovation search processes as a public sector organization approaches emerging technologies?	Design
2	Navigating Landscapes for Digital Innovation: A Nordic Government Agency Case	Mikael Lindquist, Livia Norström, and Juho Lindman	How can a government agency carry out innovation processes involving emerging decentralized technologies?	Process-organizing
3	Innovation Frames: Governments Making Sense of New Decentralizing Technologies	Mikael Lindquist	How can government organizations frame their innovation work differently in their early engagement with new decentralizing technologies?	Framing
4	Emerging Technology and Futures: Purpose vs Material Engagement	Mikael Lindquist, Livia Norström, and Juho Lindman	How do innovation teams engage with emerging technology for future systems?	Emerging technology

5.1 PAPER 1 – "NEED–SOLUTION PAIRING AND THE ROLE OF EMERGING TECHNOLOGY IN A PUBLIC SECTOR INNOVATION PROCESS"

The first paper reports on analysis based on data that were collected in the first 10 months of the case project at Comp Agency. The body of data encompasses the unfolding of the project's activities up until the required end date in November 2022 (via observations and interviews) supplemented by earlier events, leading up to the project (by means of historical accounts). The idea behind the paper grew out of the fact that Comp Agency was developing an idea involving a future arrangement enabled by a certain technology. One way to look at this is to regard the agency as undertaking an attempt to design something new. From adopting a design perspective accordingly, it became clear that this was not a classical problem-solving activity in which the problem can be clearly identified at the outset and a solution sought for said problem. On the contrary, there was an idea about a specific (emerging) technology deemed important because its promised affordances seemed to mesh very well with the organization's formulated vision. Given this situation, I concluded that the concept of need–solution pairs, as presented by Eric von Hippel and Georg von Krogh (2016), offered a suitable lens, because it leaves open the order in which needs and solutions are identified. Rather than standard problem-solving, the emphasis is on seeking need–solution pairs that are viable – i.e., on where actualization yields rewards that are greater that the associated cost.

The aim for Paper 1, then, was to understand, through that lens, how an early innovation process unfolds as a public organization approaches an emerging technology. To answer the research question, I, alongside my co-authors, analyzed material available from our ongoing case study. One important finding was that stress shifted over time among spaces: solution, need, and need–solution pairing. We found also that the conceptualization of technology played an essential role in the search process. In light of emerging technologies' ambiguity, in their technical details but also their potential affordances, it proved imperative as an element of continuous learning during the agency's innovation with these technologies.

This paper's examination of early-innovation processes involving emerging technologies brought several contributions to the literature on public-sector innovation. We spotlighted a pivotal shift in the search focus as innovation progressed in the case context, between the needs, the solutions, and pairing of the two (revisiting this pattern, Paper 4 elaborates on the reasons for this). The paper also demonstrates the important role of conceptualization of the relevant technology as a component of the process (this too was revisited later, through Paper 3).

5.2 PAPER 2 – "NAVIGATING LANDSCAPES FOR DIGITAL INNOVATION: A NORDIC GOVERNMENT AGENCY CASE"

Even though the design perspective chosen for Paper 1 bore great fruit, suspicions gradually arose that such angles might not cover enough ground. Namely, it became obvious that a large amount of the project activities' work had to focus on things other than design. Therefore, for the second paper, we asked ourselves to consider more broadly how the government agency carried out the innovation process, given the emerging decentralized technology that was part of the project description. This brought us to a change in perspective, guiding us to more of a process organizing angle.

To obtain the desired comprehensive picture of what it meant for the agency to carry out this type of process, we embarked on a more inductive route, bringing in theory in a later round of analysis. Thus we arrived at eight second-order themes. Our theorization refined these, in turn, into three third-order themes, intended to correspond to three types of organizational activities. We chose to present these as 1) navigating need–solutions landscapes, 2) navigating the organizational landscape, and 3) navigating the competence landscape. The metaphor of navigation facilitated capturing the continuous decision-making as the innovation process proceeded to improve outcomes in all three domains (i.e., needs/solutions, the people's organization, and competence).

This paper complemented prior research by showing how a concept expressed as navigating landscapes can advance understanding and theory related to the dynamics of the phenomenon studied (articulated in the paper as that of a government agency carrying out early-stage innovation activities that involve emerging decentralized technologies). It advanced understanding in particular by identifying three important types of landscape that professionals at a state-level government agency have to navigate.

5.3 PAPER 3 – "INNOVATION FRAMES: GOVERNMENTS MAKING SENSE OF NEW DECENTRALIZING TECHNOLOGIES"

My impetus for the third paper arose from contrasts between my main case-study data (from Comp Agency) and what I discovered through involvement in the BLING project. Reflecting on these contrasts led me to the hunch that large differences existed between the organizations in how their innovation teams conceptualized the innovation processes, along with the outcomes envisioned in relation to those processes. I chose to set up an analysis mechanism for juxtaposing the Comp Agency data with illuminating data from a municipality taking part in the BLING project.

To present the variety in the actors' conceptualizations of innovation in their organizations, I introduced the notion of innovation frames, following the same logic as Orlikowski and Gash (1994), under which the ways in which groups think about and interpret technology in organizations are expressed in technological frames. To prepare for the analysis, I compiled an analysis-informing model from several streams of research that offer insight into a particular facet of the phenomenon of early innovation with new technologies. With this tool, I examined how innovation frames were utilized in the case organizations for making sense of government actors' early stages of innovation with new technology. The findings from my analysis enabled me to articulate five dimensions along which innovation was framed in varied ways within the study contexts. For a way of modeling innovation frames, I proposed the space of these as a dimension canvas.

Paper 3's contributions to theory crystallized in offering a new way to think about how early innovation with new decentralizing technologies can be framed in different ways, through the concept of innovation frames. This supported empirical illustration of vital differences among government actors, along multiple dimensions on a canvas. The contributions signal to future research efforts that progress in understanding demands greater sensitivity to settings of early-innovation work involving technologies new to the world, with the proposed scope extending beyond any single organization's processes. I argue that there is a valuable contribution to practice here, in that my work invites innovation managers and other practitioners to reflect mindfully on these dimensions.

5.4 PAPER 4 – "EMERGING TECHNOLOGY AND FUTURES: PURPOSE VS MATERIAL ENGAGEMENT"

As the journey of my doctoral research progressed (as visible in papers 1–3 but also in the development of my thinking overall), I wanted to drill down to a factor that had come to occupy my thoughts more and more: what an emerging technology really is, and what it means to engage with one under the intention of building entirely new types of system. I had a tentative sense of how one might conceptualize this, and I had case-study data suited well to related illustration. Also, along the way, the project at Comp Agency had revealed an intriguing tension between what an emerging technology actually is technically and to what relevant purposes it might be put. I found it a bit tricky at first to identify IS scholarship that might be receptive to my insight in this regard. Ultimately, though, I ascertained that the field's quite new dialogue on digital futures could be highly relevant. This stream showed openness to new ways of thinking about futures, and it also acknowledges that remaining attuned to the rapid development of new digital technologies requires us to find new ways to research them, not merely to study their use in the present or the past. That is, if we as researchers are to take responsibility for the future and be part of influencing it for the better, we need to understand it.

This article was written from a more conceptually oriented angle than the previous ones. Here, the case data serve to illustrate a model devised to capture emerging technologies and ways to engage with them. More precisely, it presents conceptualization of emerging technologies for "cross-organizational" systems (as opposed to systems intended solely for organization-internal use) and early innovation activities related to such technologies. The model's framework conceptualizes emerging technology as represented by a label, thus spotlighting ambiguity in two respects that surrounds the label. Namely, ambivalence surrounds both the material characteristics of the technology (i.e., what it is technically) and for what purposes that technology can be employed. Demonstrating the model's utility with the case data confirmed its value but also showed that early innovation related to emerging technologies for cross-organizational systems leads to three types of activities. The paper identifies these as purpose engagement, material engagement, and purpose–material integration (interfacing wherein material characteristics get linked to purposes tied to a local context).

The paper's core contribution lies in the framework capturing engagement with two ambiguities (material and purpose ambiguity) when one innovates with future cross-organizational systems enabled by emerging technologies. Furthermore, it points to consequences for innovation processes in terms of three distinct activities (material engagement, purpose engagement, and purpose–material integration) and, through reference to case-study material, also posits that 1) purpose–material integration is difficult to carry out very early, since both the purpose side and the material side present ambiguities; 2) innovation aimed at new cross-organizational systems can be hampered if one expresses innovation ambitions in relation to preexisting infrastructure and technology; this is due to tensions between those ambitions and the organizations' roles responsible for the structure already present; and 3) emerging technologies carry visions available for adoption by organizations, which might lead to actualization (whether of the entire vision or only a part of it) though not necessarily with the technology proposed at the outset. The findings hold solid practical implications for managers in that the framework highlights key ambiguities and activities that should be acknowledged in innovation processes.

CHAPTER 6
DISCUSSION

It is fitting to begin deeper discussion by returning to the dissertation's underlying objective, examining and developing fuller knowledge of early innovation processes involving emerging technologies. I gained clear direction through setting out to answer the research questions below:

- *How can emerging technologies be conceptualized?*
- *Given this conceptualization, how do emerging technologies shape the conditions for early innovation processes?*

With this chapter, I present how the doctoral research resolved these questions. Answering them produced the primary contributions of the project, which may be characterized in brief as 1) a detailing of the *elusive nature* of emerging technologies and 2) elaboration on the *framing paradox* of emerging technologies. Table 5 offers an overview of the research papers that form the empirical core of the doctoral project, along with the role each plays in the overall picture from the dissertation. The two sections below then expand on each of the contribution components, respectively.

Table 5. The papers' contribution to the doctoral research

#	Title	Research question	Theory lens	Contribution to scholarship	Role in the dissertation
1	Need–Solution Pairing and the Role of Emerging Technology in a Public Sector Innovation Process	What are the characteristics of early innovation search processes as a public sector organization approaches emerging technologies?	Need–solution pairs	Showing that the search for needs and solutions shifted, over time, between the need space and the solution space; examining the pairing of the two; and demonstrating how the technology's conceptualization played a vital role	Highlighting one important aspect of innovation processes in the design-oriented search for an envisioned solution to meet an envisioned need; revealing other important factors in the unfolding of the process; and, further, supplying the insight that the framing of the technology is important
2	Navigating Landscapes for Digital Innovation: A Nordic Government Agency Case	How can a government agency carry out innovation processes involving emerging decentralized technologies?	N/A (inductive study)	Showing how the notion of navigating landscapes can aid in understanding / theorizing on the dynamics of the phenomenon studied and identifying three important landscape types: need–solution landscapes, organizational landscapes, and competence landscapes	Analyzing empirical data inductively, after which pairing with theory revealed what activity types were important for the innovation process, thereby revealing that innovation with emerging technology requires multiple navigations (legitimization, competence sourcing, etc.), not merely design-oriented activities
3	Innovation Frames: Governments Making Sense of New Decentralizing Technologies	How can government organizations frame their innovation work differently in their early engagement with new decentralizing technologies?	Several (frames etc.) synthesized into an analytical model	Proposing a new concept, innovation frames, to illustrate how early innovation with new decentralizing technologies can be framed differently by government actors, along several dimensions (e.g., that of material engagement, capturing whether technical details and their alignment with goals have been analyzed)	Contrasting a local government context with a state-level agency context, whereby the study revealed that the framing of innovation (outcome and process) with emerging technology can vary greatly, with framing involving several dimensions, such as materiality engagement
4	Emerging Technology and Futures: Purpose vs Material Engagement	How do innovation teams engage with emerging technology for future systems?	Emerging Technologies	Presenting a framework of dual ambiguities for emerging technologies, where the consequences for innovation processes crystallize via three distinct activities (material engagement, purpose engagement, and purpose–material integration) and, further, proposing that 1) said integration is hard to carry out very early on, 2) innovation of this sort can be hampered if tensions spark diversion from existing infrastructure and technology, and 3) emerging technologies come with visions that can be adopted even if the technology ultimately is not adopted	With the material space and dual-ambiguity framework, providing solid guidance to inform understanding of how emerging technologies can be interpreted, while also explicating the catch-22 for an innovation initiative that proceeds on the assumption that an emerging technology can bring something to the localized context; spotlighting a research avenue suggested by the case study: delaying integration of the two spaces; revealing tensions between those engaged with digital materials and those probing potential utility of the emerging technology; and helping show that technology labels are helpful but deceiving

6.1 EXAMINATION OF EMERGING TECHNOLOGIES

This section, conceptualizing technology in its general sense as a material space; both clarifies how labels function in understanding and communicating around this space and discusses how emerging technologies exhibit what I denote as dual ambiguity (two pronged ambivalence extending to both material and purpose). My contribution to addressing the elusive nature of emerging technologies is rooted in these advances.

6.1.1 THE MATERIAL SPACE OF TECHNOLOGY

While Paper 4 introduced the material space of technology, I found that it deserves more thorough grounding. Hence, this section explains and extends it further, to afford deeper understanding of how emerging technologies fit into the picture of the vast collection of technical knowledge available to a culture (a whole framed in Chapter 3 as the technology collective). The material space of technology provided fertile ground for subsequent theorizing.

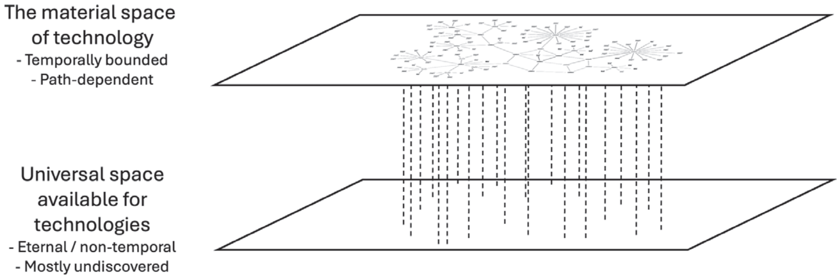
The starting point for this conceptualization, which is illustrated in Figure 4, may be encapsulated by Arthur's notion that technology is a programming of nature. Proceeding from this meaning, in which technologies are clever ways that humankind has managed to leverage natural laws, we can create the mental construction that I choose to call the *universal space* for technologies. It contains all potential ways in which nature could be exploited for any type of human purpose, by arranging materials into particular forms and thereby invoking a base principle as discussed in Chapter 3. In other words, the universal space corresponds to all possible purposeful material configurations. Several properties follow from this conceptualization. Firstly, there is nothing temporal about the universal space. It equates to nature; since the laws of nature are eternal, so is this space. Secondly, nearly the entire universal space is undiscovered to us as humans.

What we humans have discovered, on the other hand, is the *material space* of technology, depicted in the upper portion of Figure 4. It corresponds to what I have discussed as the technology collective, a collective consisting of all technologies known to us, discovered over history. As new technologies constantly get shaped, gather cumulative, form, and continue to grow, the collective is constantly growing as it develops through time. Figure 4 illustrates this as a network of technologies, thus capturing all technologies' essence as recombinations of previously known technologies. As the dashed lines indicate, the technologies in the collective are linked to the universal space, where the link refers to the collective's correspondence to what has been discovered of the universal space and also been deemed purposeful for humans.

Just as the universal space does, the material space has certain traits. Firstly, it bears a temporal aspect, in that it is always developing (therefore, the illustration of it in Figure 4 should be viewed as a snapshot at any given point in time). In addition to being temporally conditioned, it is path-dependent. Accordingly, the collection of technology that is available to a culture at a given instant is a result of preceding incremental development in that culture's history. If in a thought experiment we were to rewind this world and let it play forward to evolve again, the collection of technologies would likely be equally advanced but would not be exactly the same. For example, "if bronze appears before iron in the real world, many artifacts are made of bronze; if iron appears before bronze, the same artifacts would be made of iron" (Arthur, 2009, p. 185).

It is abundantly obvious that path-dependency holds consequences for what technologies we acknowledge and are available to us for further development. In an example from relational-database technology, the "normal forms" are one component of the constituent rules. The third normal form (3NF) states concisely that "no non-prime attribute of R is transitively dependent on the primary key." It was not preordained, let alone a law of nature, that the third normal form was to be exactly this. One could imagine a parallel universe in which a similar technology developed and reached dominant design with slightly different normal forms (in another order, defined slightly differently, etc.). In our universe, though, the relational database and its normal forms have long since reached closure. That is not to say that rules and technologies cannot be tweaked and challenged; rather, it is simply infeasible to make the entire world adjust part of the meaning behind a label, such as the 3NF schema standards for relational databases.

Figure 4. The universal and material space of technology



6.1.2 INDIVIDUAL TECHNOLOGIES – BASIC PRINCIPLES VS. LABELS

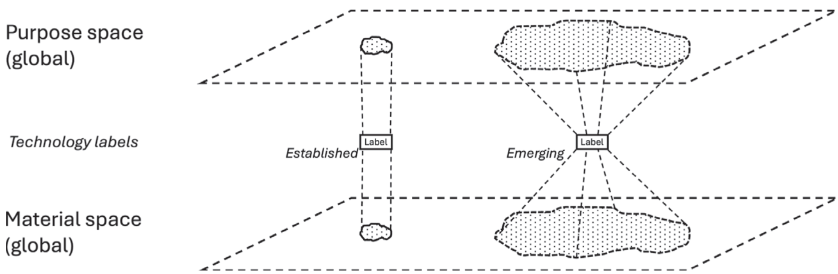
Peering within the technology collective, we can talk about individual technologies (or, per Chapter 3, technology classes). One way to define an individual technology is to identify its base principle, the aforementioned idea of how natural phenomena may be leveraged for a specific purpose. In technologies, the base principles get translated into material configurations, and they correspond to the nodes in the network shown in Figure 4. Under this definition, an individual technology consists of a shared entity that is socially constructed but with intersubjective coherence; in Popper's taxonomy, the latter would be considered a world 3 object.

A relationship between technology labels and base principles is evident. As Chapter 3's example of word processing illustrates, technologies can develop over time such that their base principles mutate. Notwithstanding this updating, a given technology in spans of stability reflects a state-of-the-art base principle. A thought experiment demonstrates this fact too. Were we to interview all the people in the world who claim to be experts in word-processor technology, the majority would probably be knowledgeable about and agree as to what the current state-of-the-art material configurations are for that technology. However, the foregoing conclusion about technologies having agreed-upon base principles pertains to conditions of relative stability, with technologies that are known to us and have long been around us, what I refer to as established technologies. But what about emerging technologies? I argue that these do not follow the same logic as established ones. Some would even dispute whether we should treat these nascent formations as technologies at all.

6.1.3 AMBIGUITY CONNECTED WITH TECHNOLOGY LABELS

Prior research attests that low levels of ambiguity are expected from established technologies, whereas emerging technologies are characterized by greater ambiguity (Rotolo et al., 2015). The study reported upon in Paper 4 helped provide deeper insight into the ambiguity of emerging technologies by investigating an innovation process engaged with emerging blockchain technology. While yielding evidence of the ambiguity of emerging technologies, it valuably demonstrated the importance of the associated technology label along the way. The most important property of an emerging technology's label is that it holds a discourse together, serving as a "portal" to the community discourse.

Figure 5. Ambiguous global interpretations projected to the purpose space and material space at a given time (diagram adapted from Paper 4)



Moreover, the ambiguity of an emerging technology plays out from two angles. Paper 4 elaborates on this, complete with empirical demonstration, while Figure 5 concisely diagrams the relations between the label and these two perspectives. The first dimension of ambiguity involves the material configurations proposed as constituents of the technology. Conceptually, these reside in the material space introduced above (the figure captures this aspect too). Most often, actors in the broader community do possess knowledge of and/or ideas about the material components, but these remain ambiguous (responses differ from actor to actor; coherent answers are lacking). How best to work with the materials to fulfill certain purposes may be even less clear. Some observations from the blockchain case exemplifies this (Section 2.3 supplies more details):

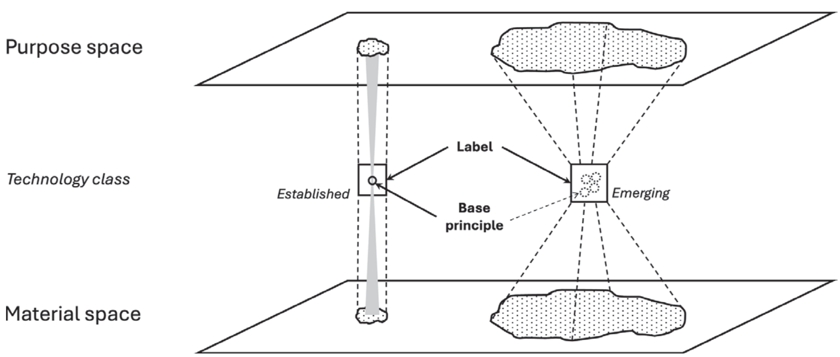
- Members of the Bitcoin community have refused to accept applying “blockchain” as a generic label agnostically to any type of permissioned blockchains.
- The Corda platform was promoted as blockchain although said implementation lacked many of the properties that are commonly attributed to blockchains.
- When the European Blockchain Partnership introduced tools for four initial use cases to spark blockchain development among member states in 2018, two of those were primarily enabled by a technology (verifiable credentials) that was not itself blockchain, though it encompassed the latter as a non-necessary support structure.

In other words, the label points to the material space here too, but the area circumscribed is broader than in the case of established technologies and is subject to less agreement.

The work behind Paper 4 uncovered that the ambiguity of emerging technologies exerts force beyond the material space too. Building on the notion that technology possesses a material side but also a purpose side (Kallinikos, 2012), we conceptualized a purpose space accompanying every technology, which indicates all purposes envisioned as to be potentially fulfilled by that technology. We then showed that emerging technologies, defined through the label applied, are ambiguous in relation to both the material and the purpose space. This pattern, illustrated well by Figure 5, is what I dubbed the dual ambiguity of emerging technologies.

Later contemplation led me to a dimension supplementing the model depicted in Paper 4. This captures further differentiation between emerging and established technologies. Important for interpreting the distinction, this dimension might be significantly less obvious. I walk through it in two steps here. The first returns to what a technology class is. It can be defined by its base principle, and a technology label generally functions to refer to the class. For an emerging technology, though, the dual ambiguity implies that no such clear relations exist. Rather, the discourses around labels offer several ideas of what the emerging technology could be used for (its purpose space) and several ideas as to what material configurations will constitute it (the material space). The resulting overall body of ideas encompasses several proposed base principles, some of a more speculative nature than others. This situation, illustrated in Figure 6, creates confusion in practice at multiple layers when some emerging technology gets discussed *as* a technology. I posit that the web of complicating factors goes some way toward explaining why emerging technologies are associated with inflated expectations. The second step follows from having multiple base principles: when a label connects the material space to the purpose space via multiple base principles, risks of "false couplings" follow. In this phenomenon, there is a single proposed purpose linked to a single proposed material configuration but with the involvement of multiple connectors: several, irreconcilable base principles. From the development of blockchain, we could again cite the introduction of permissioned blockchains. The central change wrought by this step is that decisions on who would be allowed to vote on new blocks were moved to administrative nodes. This solution, in which they are no longer decentralized, offered an attractive solution to actors who had an interest in such positive attributes of blockchain as the claimed increase in trust brought by decentralization but who were unable/unwilling to accept a loss of control. A particular proposed purpose (decentralization) had been identified as achievable via one particular proposed material configuration (permissioned blockchain), yet the two can be said to rely on mutually contradictory base principles. The base principle of permissionless blockchain allows for decentralization through the manner of construction, but the latter purpose is at least partly lost if control moves from voters to administrative nodes.

Figure 6. Labels vs. base principles in relation to material and purpose spaces



The most striking practical implication of the ambiguities discussed above is that the space of potential application areas is large and it is by no means obvious what material configurations might suit which such area. In the realm of established technologies, in contrast, shared knowledge normally is available that sheds light on how material configurations might be employed to meet certain purposes. For emerging technologies, such knowledge – both explicitly presented in niche literature and held tacitly by professionals with experience of the technology in question – is harder to access and less coherent.

6.1.4 EMERGING TECHNOLOGY AS LABEL AND VISION

The foregoing discussion lets us conclude that the strongest element (the "glue") holding an emerging technology together is its label (Swanson & Ramiller, 1997), and that for it to stay relevant it needs to be upheld by a discourse that shows sufficient coherence (Miranda et al., 2022; Rotolo et al., 2015; Swanson & Ramiller, 1997). We also know that discourses here constantly shift, in evolution with many drivers, such as desires and expectations, industry analysts' output (Pollock et al., 2022), and actions in certain so-called mediated fields (exemplified by news media and social-media influencers; see Miranda et al., 2022). It is in consequence of this that tensions arise between those actors that show high material engagement and those that do not (Miranda et al., 2022). These conditions create murkiness in how the potential material configurations (points in the material space) will enable and constrain the visions discussed (corresponding to the area in the purpose space).

That means that if we analyze a given emerging technology, blockchain or any other, from the perspective on technology that has been employed here, we can conclude that it lacks several properties of a technology class, however often it may get referred to as if it were one ("a technology" etc.). This points to the elusive nature of an emerging technology, a notion that had already begun crystallizing for me in the course of the analysis behind Paper 1.

6.1.5 THE ELUSIVE NATURE OF EMERGING TECHNOLOGIES

Unpacking emerging technologies in the manner presented thus far in Section 6.1 led me to deeper awareness of their elusive nature. I intend this term as a placeholder referring to a set of properties of emerging technologies that together create the effect of relative formlessness outlined above:

- The *dual ambiguity* of emerging technologies exerts an effect, with both the purposes of the technology and the material means by which said purposes can be fulfilled exhibiting ambiguity.
- As a result of the dual ambiguity, absence of a clear base principle exerts its own influence. That is, emerging technologies lack a property that is important for established technologies: the presence of a fundamental idea that allows the technology to "work." A serious consequence of lacking a clear base principle is the risk that interpretations of the possibilities of the emerging technology mix available propositions in ways that are not reconcilable.
- Discussion, in academic but also practice-oriented communities, often refers to an emerging technology as "a technology," with the effect that it may be perceived as more stable than it really is. Blockchain offers a vivid example.
- Comparing general properties of emerging technologies with those of established technologies reveals a striking difference in that an established technology reflects clear, unambiguous shared knowledge surrounding the base principles and material configurations and is not subject to active visionary community discourse, whereas cases of an emerging technology display an ambiguous conception of the material space alongside vivid and heterogeneous community visions (Swanson & Ramiller, 1997). In simpler words, an emerging technology when viewed *as a label* is more a technology vision than a technology.

In conclusion, the elusive nature of emerging technologies implies that the discursive entities frequently cast as emerging technologies (which, partly by virtue of the very term, actors might perceive as true technologies, with all the properties possessed by established technologies, such as an agreed-upon base principle) are in fact something else. They should be viewed rather more as labels referring to visions of future technology that are tentative in nature. Those visions often provide some sense of how material configurations could be leveraged for certain purposes, but the conditions pose a risk of the propositions in the visions getting blended in irreconcilable ways.

This is where my novel conceptualization of emerging technologies demonstrates immense value: it teases apart emerging technologies as labels that project ambiguous information onto two spaces (the material and the purpose space), thus helping uncover how and why, therefore, the vital issue of the technology's base principle has not yet been settled. Additionally, this conceptualization proves valuable in grappling with the second research question considered in my doctoral research. I turn to that question, which revolves around early innovation processes connected with emerging technologies, next.

6.2 CONDITIONS FOR EARLY DIGITAL-INNOVATION PROCESSES

Solid conceptual foundations for grappling with emerging technologies let us examine the circumstances wherein organizations intend to undertake the early stages of innovation wherein an emerging technology is viewed as an enabler. Considering this situation shifted our focus to how the enabling technology's nature as an emerging technology shapes the conditions for the early digital-innovation process.

Innovation that clearly entails work with an emerging technology ushers in several obvious challenges, bound up with such factors as the technology being unfinished, "in the making," and how tricky it is to acquire knowledge about materials. From this standpoint, I can discuss how actors reduce the complexity of the emerging technology through framing and how the dual ambiguity of emerging technologies creates a catch 22 situation as ambiguities need to be reduced. After laying out several tensions that are likely to arise in consequence of this situation, I arrive at an expression of my second contribution, the *framing paradox* bundled with emerging technologies.

6.2.1 COMPLEXITY AND FRAMING

Paper 1 presents the conclusion that "[i]nnovation processes in the public sector are uncertain and complex [and that their] uncertainty increases with the level of immaturity of the technology involved." We know from prior research that actors construct frames to handle such complexities (Kaplan & Tripsas, 2008; Spieth et al., 2021). A frame can be thought of as a "lens through which actors reduce the complexity of the environment in order to be able to focus on particular features, make context-specific interpretations, decide, and act" (Kaplan & Tripsas, 2008, p. 791). This powerful concept can be applied at various levels, in multiple scopes. One pertinent contribution in this respect came from Orlikowski and Gash (1994), who focused on technological frames to analyze how groups think about and interpret technology in organizations. In their engagement with emerging technologies, actors can further draw from the frames available in community discourses.

A setting wherein organizations' actors approach an emerging technology for innovation purposes exhibits high complexity, rooted in the ambiguity of emerging technologies as explained above. Hence, they need to produce collective frames to make sense of their options. To capture this phenomenon, Paper 3 introduced the notion of innovation frames. Contrasting early innovation activities between organizations enabled me to articulate several dimensions along which frame details can differ.

6.2.2 THE CATCH-22 OF MATERIAL–PURPOSE INTEGRATION

An inescapable requirement arises from the fact that emerging technologies present dual ambiguity. Namely, because the label driving the discourse is ambiguous with regard to both what material configurations are available and the purposes to which this supposed technology could be put, organizational actors who step toward some emerging technology, circumscribed by its label, must find a strategy for reducing ambiguity on both fronts – in what Paper 4 refers to as purpose and material engagement, respectively – if they are to arrive at a proposed technology-enabled use case. Had the purpose already been identified, the "search" in the material space would have been more straightforward. Similarly, if the material configuration had been at least to some degree decided, elaboration as to the purposes to which it could be put would have become more tractable. However, the starting point of dual ambiguity with no a priori anchor points leaves something that could be labeled a catch-22 situation.

The activity that eventually must occur if the emerging technology is embraced rather than abandoned is cognitively linking the two spaces together in a way that tentatively answers the "how" question: how (i.e., via what functions related to a material setup) can the emerging technology fulfill a purpose related to the organization's goals? To exemplify how innovation initiatives may be initiated without this link (a connection denoted in Paper 4 as purpose–material integration but also discussed in Paper 1 and Paper 2), we could consider an early statement of the following type: "We think that emerging technology X can be used to improve our business." Such a statement speculatively associates an emerging technology with the high-level purpose of being business-relevant but does not indicate in any way what material configuration might speak to what type of purpose. Ambiguity in both the material and the purpose space exists here. What type of materiality does emerging technology X entail? What specific purposes is use of that supposed technology aimed at fulfilling? From this position, an initiative to ascertain whether the assertion stated is valid can of course be approved in the absence of an up-front answer to "how," but pressure on the initiative mounts as the amount of time taken to provide an answer rises. There will be increasing pressure to demonstrate material accountability (see Bazerman, 1999).

Hence, the catch-22 situation requires delaying the linking of material configurations to purpose until ambiguity has been reduced for at least one space. Paper 4 presents the strategy applied by one organization, the entity in the study reported upon, for tackling this need for delay. In conjunction with conceptualizing the central pressing issue as material–purpose integration, comprising "activities that cognitively investigate what combination of digital materials [...] could possibly be used to reach whatever purpose that has been envisioned to be met," the paper describes that strategy as consisting of intentional decoupling of engagements in the two spaces, delaying their integration. This still may not be enough to mitigate some of the tensions that can arise from the catch-22 conditions. Indeed, that is the outcome that came to pass for the case organization.

6.2.3 FRAMING-BASED TENSIONS

When organizational actors responsible for emerging-technology-based innovation construct innovation frames to initiate innovation work, at least two types of tension may present themselves (these are identified and, further, demonstrated in Paper 2 and Paper 4). The first is related to how an innovation initiative becomes legitimate in an organization. Normally, for an initiative to be accepted by the organization, there has to be a "business case" or other, similar rationale. In other words, stakeholders "require a convincing story that the potential value of its initiation/continuation exceeds the effort it takes" (as Paper 2 states on p. 1981). The catch-22 situation renders this story more difficult to tell, since it is not clear from the start what problem to tackle, by means of what material configuration, and why there is reason to believe that the initiative is going to bear fruit. Hence, innovation initiatives face the challenge of creating and maintaining the legitimacy that is needed, given that there is no business case in place.

Moreover, strategies employed to handle the catch-22 situation can, in their turn, impose tension between the innovation ambition expressed and actors responsible for, or invested in, current IT infrastructure (internal and external alike). This effect creates a need for subsequent strategies, designed to handle the tension. The case organization discussed in Paper 4 chose to employ a future-oriented approach that 1) justified delaying the purpose–material integration and 2) consequently expressed the envisioned future outcome without reference to preexisting technologies and infrastructure. Since actors responsible for IT infrastructure typically evaluate propositions with an inside view of technology, their interpretations tend to proceed from material knowledge of current architecture etc. The case dataset provides an example: the outcome envisioned was expressed in future-oriented ways that contradicted one prevailing pattern for handling inter-organization communication, what can be referred to as the "API paradigm."

6.2.4 THE FRAMING PARADOX OF EMERGING TECHNOLOGIES

On my journey to understand how emerging technologies shape the conditions for early stage digital-innovation processes, I identified several paradoxical elements and multiple tensions. These form the heart of the dissertation's second main contribution (connected with the second research question). I have chosen to label the model for them the framing paradox of emerging technologies, since they all tie in with difficulties in creating and communicating frames for the innovation work at hand. Awareness of the following constituent elements enhances efforts at understanding:

- Innovation frames, addressing how an emerging technology is approached for innovation work, which can be framed in several ways
- The catch-22 factor due to the dual ambiguity of emerging technologies, which must be handled by the actors engaging early on with an emerging technology for innovation work such that ambiguity reduction informs the material and also the purpose space
- The legitimacy tension arising from the catch-22 situation – namely, the challenge in proposing a clear business motivation at the early stages, through which the legitimization of an innovation initiative faces pressure
- Tension connected with current IT infrastructure that stems from lack of explanation of the material space (this tension can arise most prominently among stakeholders invested in the preexisting IT infrastructure)

In conclusion, the framing paradox presents several vital issues related to dealing with the dual ambiguity of emerging technologies. Strategies to address these issues were visible in my empirical material (the summaries here enhance illustration, while Paper 4 supplies details). However, not all organizations develop strategies of this sort, and also it is likely that in other settings alternative strategies develop. Hence, I have sought to abstract away from the particular to the abstract situation in my treatment here.

CHAPTER 7
CONCLUSION

The aim behind this dissertation was to study and develop knowledge of early digital-innovation processes that involve emerging technologies, where emerging technologies are understood as the discourse-based entities that societal actors and individual practitioners recognize when giving regard to novel promising technological innovations. To reach that aim, I engaged in theorization centered on emerging technologies. This creates a backdrop for sound interpretation of the results presented in the connected research articles and for arriving at further conclusions on how emerging technologies influence early digital-innovation processes.

Taking blockchain as the case technology for empirically grounded examination of those early innovation processes in a set of public-sector organizations in Northern Europe, I developed a comprehensive picture especially through my in-depth case study of a government agency that developed a service idea prompted by notions surrounding the potential benefits envisioned for blockchain technology. Analysis performed from four distinct perspectives – aligned with the results offered in the four articles produced – converged in the two main findings identified in the synthesizing discussion.

Namely, I was able to uncover how emerging technologies interweave with ambiguities in both the material aspect of the technology (i.e., how it is structured) and its purpose aspect (i.e., the particular uses to which it can be put). This two-pronged ambiguity renders it especially challenging to gain a clear view of what solutions one could and, furthermore, should pursue via the technology in light of the given organization's local goals. Accordingly, consensus is lacking, and community discussions tend to circle back around to both of these aspects. The discourse remains fraught with conflicting responses while ambiguity surrounds what material components constitute the technology and what types of problems that technology may help solve. The constellation of issues here informed my second vital finding: that early-stage efforts in digital innovation that involves an emerging technology resist easy framing. My study, further, highlighted that reducing the ambiguity demands some strategy, which might well lead to tensions with stakeholders not directly involved in the process.

7.1 IMPLICATIONS FOR RESEARCH AND PRACTICE

My results contribute to advances in several ways, reflected upon here from the standpoints of scholarship and practitioners' development work both. First, the findings highlight the importance of drawing attention to early-stage digital innovation with emerging technologies as an area of focused inquiry, distinct from other early-innovation settings. My empirical material supplies a starting point for considering this setting. Secondly, relating emerging technologies (generally and in specific manifestations) to material and purpose spaces, in turn, enriches research into emerging technologies by unpacking the "emerging technology" concept to reveal not only measurable externally evident properties of such technologies, normally discussed for classification purposes (examples being coherence, impact, and fast growth), but also tease out the idiosyncrasies in particular emerging technologies that exert effects in both spaces.

The findings of my doctoral project hold several practical implications. For organizations, the theory-anchored insight presented here illuminates guidance for multiple important roles in the innovation processes. Firstly, personnel who participate in planning and execution of digital innovation can benefit greatly from acknowledging emerging technologies as a nexus of ambiguity, alongside the framing paradox that follows on the heels of the two-pronged ambiguity. The project's findings should prove instructive during the interpretation of new labels for any of the many emerging technologies that present themselves as potential ideas for adoption but also in the local development of application ideas then triggered via such prospective technologies. Secondly, organizations' top managers could better steel themselves against the hasty reactions that can readily follow hyperbole permeated discourse. With their sensitivity thus strengthened, they can increase the amount of mindfulness in innovation decisions. After all, glamorous stories of emerging technologies can hold strong appeal indeed. Audiences encouraged to take those narratives as wholesale truth could find themselves pushed toward shiny but illusory innovation outcomes. Finally, those responsible for elements of developing and governing digital infrastructure touching the organization could benefit from a solid understanding of the dynamics I identified in emerging technologies. The theory angles presented shed light especially on linking a proposed technology's material structure (the "inside" view) with the purposes articulated for that technology's use (the "outside" view). Reflecting on the "how" question, as addressed in the dissertation, represents an important example of this.

7.1.1 ASSISTANCE TO ORGANIZATIONS

Even though the dissertation project did not focus on practical guidelines as such, the findings presented in it hint toward several guiding principles that I wish to elucidate here. My first recommendation for organizations' actors considering early engagement with an emerging technology presented as promising in community discourses pertains to curiosity as the starting point. It is best summed up thus: 1) *be curious* about what the various new emerging technologies might have to offer. There are definitely gems to be found in the vast amount of information surrounding them.

However, simultaneously they are of a special nature, in that these constellations of labels, notions, and mechanisms must not be equated to established technologies – they are not really technologies but, rather, technological visions that suggest new possibilities within a certain technical arena. The second recommendation follows from this; it is therefore important to 2) *be mindful of emerging technologies' special dynamics*. Most crucially, they are surrounded by promises and inflated expectations, they are ambiguous in what they mean technically, and which possibilities any particular technical solutions offer are anything but certain. A natural outgrowth of this fact is that one should not expect to be able to explore any emerging technology in its entirety. Its specifics require specificity; that is, 3) *form a strategy that narrows the scope to a subset of avenues*, such as one possible useful application area.

Emerging technologies' nature implies also that they, and the vision represented, are best approached as inspiration for the innovation process while at the same time humility is imperative. That is, 4) *be inspired but humble on the exploration journey*. In particular, it is unwise to risk building promises into initiatives by applying the technology label, which might bring both a certain prestige and certain expectations with it. The heightened uncertainty already inherent to innovation efforts is generally amplified when emerging technologies are part of the picture. Therefore, 5) *be wary so that sponsors do not adopt unreasonable expectations* surrounding the efforts' outcome. This necessitates the humble attitude stressed above.

Additional stakeholder-related risks arise in connection with this uncertainty – there is a strong possibility of tensions with stakeholders who follow the innovation effort from the sidelines. To maintain legitimacy, the initiative's leaders must 6) *be sure to have a communication strategy suited to tackling background players' questions*. For example, organizations should be able to speak to the concerns of those currently responsible for structures that might get affected by an ambitious innovation effort.

Among the questions to which answers usually are expected is "how is this new technology X intended to act to the benefit of the organization?" – i.e., those behind the initiative should furnish a description that addresses which technical solutions are to be used, what functions they enable, and how those functions are going to yield benefits. In other words, they must concretize a cognitive link from technology to a beneficial purpose. It is absolutely not the case that offering an answer to this question should be rushed; on the contrary, it may be valuable to delay said exercise. What is important, in contrast, is to 7) *have a conscious strategy for handling the question over time*. This should cover how and when the process should near an answer.

7.1.2 BROADER IMPLICATIONS

The findings from my research have implications beyond organization and even industry level. For government entities, two fields of particularly strong impact revealed themselves. The first is linked to innovation funding, which frequently gets allocated to scientific and practice-based research with relationships to developments identified as emerging technologies. The Europe-wide initiative titled “Future & Emerging Technologies,” which began receiving European Commission funding in 2013, is a case in point. Pointing out the necessity of "coherent and systematic operationalization of emerging technologies […] for more informed policy-making and governance of emerging technologies," Rotolo et al. (2015, p. 1841) defined a set of externally measurable properties for them. My research carries such conceptualization further by adding qualitative facets. I argue that policy-making processes ought to assess these too, via factors such as material structure and suggested purposes. Secondly, activities related to innovation-portfolio management in government bodies typically demand especially profound mindfulness, considerably beyond that discussed above as underpinnings for organization level. Particularly because public spending requires transparency and deals in taxpayers’ money, the perspective of the amount of resources available gains additional importance. Especially since tolerance of risk in such settings often is low, governments face limits to what they may spend on explorative innovation (Magnusson et al., 2020). In consequence, care in choosing “which horse to bet on” is crucial.

Finally, society at large stands to benefit from awareness of the agency and power dynamics bound up with technology development, on one hand, and from understanding the power of labeling exercises, on the other. Critical voices have arisen within research spheres to draw attention to the vast power of technology development growing concentrated in the hands of strong market forces. Lack of transparency has received focus as one telling pattern. Among the critical voices here is Bernd Carsten Stahl (2011), who advocates “better ways of democratically controlling the development of technology” (p. 83). My research findings further impel endeavors to speak out in this regard, by casting greater light on the power dynamics around the less obvious matter of labeling of emerging technologies (a domain wherein Gartner and other heavyweights exercise great power; see Pollock et al., 2022).

7.2 LIMITATIONS AND FUTURE RESEARCH

The contributions presented in the dissertation represent nothing less than a new theory of emerging technologies and their influence on digital-innovation processes. Since this nascent theory was built on case-study data from examining blockchain technology and a set of contexts found in the public sector in Northern Europe, several limitations bound up with the qualitative case-study method naturally hold relevance (Bryman, 2012). Firstly, a small, albeit deep, set of data such as that collected from my source material brings limitations related to generalizability, at least in the formal sense of extrapolating findings to some general population of cases (Flyvbjerg, 2006). Critique in this regard might particularly be voiced if the data sample is small or in other ways risks not being representative (Siggelkow, 2007). However, the case-study method has offered high quality and depth of data which I argue has offset low quantities given the research task at hand. Also, the aim of the project was not formal generalization but what could be called analytical or theoretical generalization, which is intended to produce novel theory (Eisenhardt, 1989). A related consideration is that features of both the technology studied and the geographical boundaries chosen may have had an influence on some findings. Other emerging technologies might display an ambiguity pattern different from what I found for blockchain, and the influences rooted in the ambiguities might play out differently for innovation processes unfolding in other geographical regions, on account of such factors as cultural or regulatory variations. Hence, further research is needed to expand the theory in this regard.

I can identify a second set of limitations also, stemming from the research's scope. Firstly, by focusing on factors that affect the early stages of digital innovation, the dissertation-level synthesis excluded the unfolding of the process from its scope. Broader scope, though too impractical for my project, could have unveiled further threads with potential to inform the theorization process. Secondly, by positioning organizations' innovation processes as the center of inquiry, I chose not to consider the process at the level of the emerging technology. That is, for ease of analysis, I took what one might call the technology-emergence process as if it were in a "frozen" state. Since the processes on micro and macro level are intertwined (Øvrelid et al., 2025), this could have had effects on my theorization activity. Restricting the scope to organizations' innovation processes, or the demand side (see Fichman et al., 2014) necessitated also ruling out consideration of supply-side advances – i.e., the angle of actors engaged in development of technology. One could expect some parts of important dynamics to escape notice if not attending to how the core technology gets pushed forward by technology providers and developing communities in feedback cycles.

The discussion I have presented offers numerous avenues for future research, in and beyond the IS field. All of the practical implications presented in Section 7.1 merit scholarly attention. Perhaps most prominently, the seven recommendations offered merit scrutiny within the setting of an action-research-type project. Also, the findings overall hint toward the hypothesis that the posited dynamics surrounding the elusive nature of emerging technologies may possess power for explaining processes related to the hyperbole phenomenon and management fashion (Baskerville & Myers, 2009; Swanson & Ramiller, 1997, 2004). Studies and modeling could proceed accordingly. Moreover, dedicating a research stream to emerging technologies as a portal to digital futures would be particularly suitable for the IS discipline. Developing and refining this demands new ways of thinking about the methodological apparatus, as Dirk Hovorka and Benjamin Mueller have noted (2024).

The new perspectives I have probed for capturing how emerging technologies can be conceptualized, in a manner proceeding in part from Arthur's (2009) theory of technology, could prove integral to such apparatus. This conclusion holds potential beyond the IS field. Organizational research particularly could gain inspiration from the angles and findings presented in the dissertation. One avenue for adjacent disciplines would cultivate empirical and conceptual study of strategies for reducing the "dual ambiguity" that arises in approaching emerging technologies when pursuing early-innovation processes. While my research project has equipped scholarship with one empirical account (in Paper 4), one may presume that several strategies can bear fruit.

APPENDIX

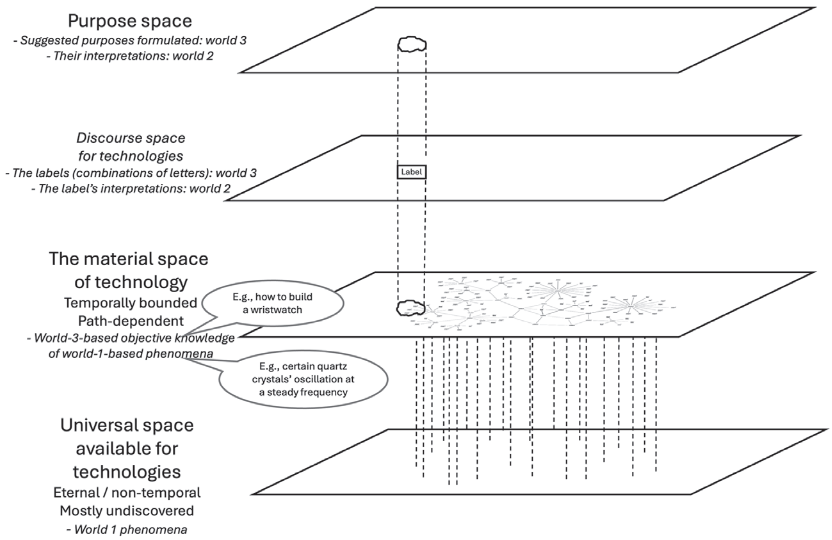
It is worth elaborating on how my proposed theoretical constructs tie in with the worlds of Popper (1978) – namely, 1) the physical world, inclusive of its states and processes; 2) "the mental or psychological world, the world of our feelings of pain and of pleasure, of our thoughts, of our decisions, of our perceptions and our observations" (p. 143); and 3) the world consisting of those products of the human mind that can be regarded as objects in their own right. Among these world 3 objects are "languages; tales and stories and religious myths; scientific conjectures or theories, and mathematical constructions; songs and symphonies; paintings and sculptures. But also aeroplanes and airports and other feats of engineering" (p. 144). Many world 3 objects – technologies and their embodiments being the most relevant for our purposes – belong at the same time to world 1. For instance, an airplane exists as a world 3 conceptual object while there are world 1 embodiments of the same.

Therefore, studying facets of the material world such as technical knowledge related to digital technology entails study of world 1 phenomena on one hand, comprising the logics underlying material structures (e.g., how prime numbers can function in cryptography), and also world 3 ones on the other, since the shared knowledge, conceptual descriptions, and language bound up with these structures are all shared entities that exist on their own, "between" humans. In contrast, as one examines interpretations of technology discourse and the purpose of innovating with certain technologies in this connection, one studies world 2 when accessing interpretations by informants through observations and interviews. World 3 entities still come into play here, though, in such forms as shared documents and community discourse.

Along with this reasoning, Figure A1 illustrates how each layer of my proposed model relates to the three worlds. The universal space exists fully separated from humans and, accordingly, wholly in world 1. The material space of technologies can be viewed as the entire body of objective knowledge of technology acquired as of a given point in time (a complete set). Composed of products of the human mind, this knowledge resides in world 3 yet points to natural phenomena, which belong to world 1.

At the uppermost two layers, the purposes formulated or articulated for the technology and, accompanying these, the labels and language used to communicate about the technology are world 3 in the sense that they are all entities produced by human minds. However, simultaneously, the continuous mental work of interpretation performed in the minds of engaged actors with these world 3 materials resides in world 2 instead.

Figure A1. A Popper's three worlds perspective on the theoretical framework



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