THESIS FOR THE DEGREE OF LICENTIATE

Navigating the Black Box:

Generativity and Incongruences in Digital Innovation

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Gothenburg, Sweden 2022

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Technical report no L2022:137

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Chalmers Reproservice
Gothenburg, Sweden 2022

Abstract

Digital technologies offer generative potential as they are malleable, dynamic and can be leveraged across a range of tasks. Prior studies have mainly focused on generativity as driver for recombinatorial innovation. However, not much attention has been paid to 1) how innovators develop cognitive frames in the face of seemingly unbound possibilities and 2) how heterogeneous actors resolve differences, or incongruences, in their cognitive frames.

Extant research provides only partial answers on how innovators navigate those challenges. Therefore, this thesis aims to generate new insight on how innovators balance generativity and incongruences in digital innovation. It is based on two empirical papers that draw upon a two-year, longitudinal single-case study of a distributed, heterogeneous innovation network engaged in leveraging digital technologies in the context of marine environment.

This thesis finds that embracing generativity increases the risk of clashes between incongruences amongst innovators. On the other hand, innovators leverage the generative potential of digital components to respond to incongruences by producing boundary objects or facilitating innovation trajectory shifts. Moreover, the appended papers illustrate how innovators may employ a non-linear innovation approach and loosely defined organizational structures to facilitate repeated shifts in their innovation trajectory. At the same time, this thesis finds that too many shifts create challenges in network coordination and maintaining a coherent strategic vision.

Keywords: digital innovation, generativity, incongruences, innovation network, AI, organizing vision, technological frames

List of appended papers

Paper I - The Challenges of Knowledge Combination in ML-Based Crowdsourcing - the ODF Killer Shrimp Challenge Using ML and Kaggle.

Published in Proceedings of the 54th Hawaii International Conference on System Sciences, 2021.

Contribution: Collected and analyzed data, conceptual development, writing of the paper.

Paper II – Organizing Vision Evolution in AI-based Innovation Networks

Bumann, A., Sandberg, J. and Teigland, R.

I presented earlier versions of this paper at a PhD workshop during the 22nd CINet Conference held virtually in September 2021 and at a research seminar at Umeå University in December 2021. I intend to further rework this paper for submission to a AJG level-4 IS journal.

Contribution: Collected and analyzed data, conceptual development, writing of the paper, developed theoretical model.

Acknowledgements

This thesis marks the halfway point of my PhD process and yes, time flies. The whole pandemic has made this journey a bit less social than it might have been otherwise. In that regard, I'm even more grateful for those individuals that have been present and provided support, knowledge and/or fika along the way.

First, I want to thank my two supervisors Robin and Johan. You have always encouraged me to believe in my abilities and the success of this thesis and I have learnt a lot from both of you. Your wit, support, and sensemaking have been invaluable.

I'd also like to thank all interviewees in my two case organizations for sharing their insights and providing the building blocks to this and future research.

Further, I want to thank the "E&S corridor". A special thanks to Martin, Tomas, Yashar, for being supportive and cheerful colleagues and making this process more enjoyable. A special, special thanks to Maria for being the best sister in arms one could wish for.

Looking back, I'm thankful to my crewmates in the deck department who, regardless of rank, have taught me more about management and leadership than any academic paper. I'm indebted to one particular officer for telling me I'd be an idiot for settling down in Hamburg at the age of 24. Ab die Pest!

Thanks to Alexandra Elbakyan for her activism and making academia a better place.

Finally, thanks to my friends and family who supported me from near and far. This thesis would not exist without you.

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1. Introduction

The pervasiveness of digital technologies has both changed how we organize and strategize to create innovation (Yoo et al., 2012) and the nature of innovation itself (Nambisan et al., 2017). A major reason for this is that digital technologies, such as artificial intelligence (AI), are characterized by generativity, i.e. they are inherently dynamic, malleable and context-agnostic. Such open-endedness creates a two-fold challenge for innovators to scrutinize envisioned innovation processes and outcomes. First, the modular architecture of digital technologies allows a near-limitless recombination of digital components (Henfridsson et al., 2018), making it difficult to recognize a useful application ex ante (Nambisan et al., 2017). Second, as digital innovation occurs increasingly at the intersection of multiple domains (Lyytinen et al., 2016), heterogeneous actors need to resolve incongruences, i.e. differing cognitive frames towards the envisioned innovation (Kaplan & Tripsas, 2008), and translate diverse and technically complex knowledge to create a shared understanding (Dougherty, 2017).

Previous research provides only partial answers on how innovators navigate those challenges. Prior studies on digital innovation have largely focused on generativity as enabler, providing seemingly unbound possibilities for serendipitous and recombinatorial innovation (Boland et al., 2007; Brynjolfsson & McAfee, 2014; Huang et al., 2017). Similarly, information systems (IS) literature has an extensive history of investigating how incongruences - misalignments between actors' cognitive frames - impact IT innovation (Kaplan & Tripsas, 2008; Young et al., 2016), but there is little research that considers the distributed and serendipitous nature of digital innovation (Spieth et al., 2021). Accordingly, there have been increasing calls to investigate challenges in socio-cognitive sensemaking (Nambisan et al., 2017) and the role of incongruences in digital innovation (Spieth et al., 2021), as well as for longitudinal studies to understand the complexity of dynamics digital innovation processes over time (Vega & Chiasson, 2019).

To address these calls, this thesis aims to generate insights on how innovators balance generativity and incongruences in digital innovation. In two empirical papers, I draw upon a qualitative longitudinal single-case study of a distributed, heterogeneous innovation network engaged in developing an AI-based innovation to predict marine invasive species. Studying such innovation networks is interesting given their non-linear innovation trajectories and growing importance for cross-disciplinary exploitation of generative digital technologies (Haghshenas & Østerlie, 2020; Lyytinen et al., 2016).

Paper 1 focuses on the combination of domain and technical knowledge while incorporating crowdsourcing platforms in the innovation process. The findings suggest that the specific platform design makes the innovation process less open-ended by reducing problem complexity and domain context. This results in a higher technical quality but less creativity in innovation outcomes. Additionally, the case highlights difficulties in interpreting algorithmic outputs by non-technologists. Paper 2 follows the evolution of how an intended application of AI is framed and reframed throughout an innovation process, drawing on the concept of organizing visions (Swanson & Ramiller, 1997). Findings suggest that embracing envisioned generative potential increases uncertainty and the risk of incongruences between domain and technical experts. Innovators cycle between widening and narrowing the scope of their organizing vision to explore generativity and resolve incongruences. In this cycle, they enact three action-formation mechanisms (Hedström & Swedberg, 1998), *conceptualizing compellingness, bounding digital resource space,* and *repositioning network innovation locus,* to adapt the organizing vision in order to sustain its interpretation, mobilization and legitimation.

Taken together, the two papers illustrate how innovators, in the strive to create original digital innovation outcomes, seek organizational settings that offer actor diversity, self-organizing and serendipitous interactions. The generative potential of digital technology allows actors to embrace outcome uncertainty of the envisioned innovation, making it resemble a "blank canvas" to hold multiple, potentially conflicting ideas. While this allows for creative ideation, it also increases the risk for incongruences. To respond to incongruences, innovators leverage generativity to edit digital resources into boundary objects or repurpose them to facilitate shifts in the innovation trajectory. The latter is aided by flexible organizational structures and boundaries.

This thesis contributes to the digital innovation literature by challenging the dominant narrative that generativity acts mainly as an enabler of innovation by illustrating the cognitive challenges when faced with seemingly unbound possibilities. At the same time, I show how generativity affords innovators flexibility in responding to incongruences. For practitioners, this thesis offers a detailed empirical account of the opportunities and risks in leveraging organizational forms that offer knowledge diversity and serendipity for digital innovation endeavors. Despite the flexibility afforded by the generative nature of digital components, this thesis argues that a more structured approach and the formulation of a strategic vision beforehand can be beneficial to guide the innovation process.

In the next sections, I present the literature used in this thesis in more detail, followed by discussion on the methods used in the papers, a summary of the papers and ending in a discussion of the implications and opportunities for future research.

2. Literature review

2.1 Digital innovation

Digital innovation has been defined in different ways (Fichman et al., 2014; Hund et al., 2021; Nambisan et al., 2017). I refer to it as ''the carrying out of new combinations of digital and physical components to produce novel products'' (Yoo et al., 2010). Digital components are unique in their high level of generativity, defined as "a technology's overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences" (Zittrain, 2008). Zittrain (2008) described generativity in more detail as a function of a technology's capacity for leverage across a range of tasks, adaptability, and accessibility. Generativity results from digital components' underlying characteristics of reprogrammability and editability (Tilson et al., 2010; Yoo et al., 2010, 2012; Zittrain, 2008). Reprogrammability refers to the "ability of a digitalized artifact to accept new sets of logic to modify its behaviors and functions" (Yoo, 2010), whereas editability refers to the ease with which digital components can be added, deleted or rearranged (Kallinikos et al., 2013).

Digital innovation outcomes may become organized in an architecture of loosely coupled layers of potentially generative components which renders product boundaries more fluid than in non-digital innovation (Yoo et al., 2010). As result, digital technologies, such as AI, blockchain or IoT protocols, are agnostic to specific industries or products (Henfridsson et al., 2018). For instance, OpenAI's language model GPT-3 has been utilized for various applications, such as writing SQL queries, chatbots and text-based adventure games (Shardin, 2020). All these use cases are based on the same technical core artifacts, configured to perform a specific function in that context.

IS scholars have highlighted how such characteristics impact digital innovation processes and outcomes. Nambisan et al. (2017) and Yoo et al. (2012) note because of generativity, digital innovation is inherently less bound and complex than non-digital innovation, unfolding in non-linear ways across time and space. An effective illustration of such unbounded digital innovation processes is Boland et al. (2007), where digital artifacts in innovating construction networks, the use of 3D tools as a digital process infrastructure, enabled unexpected interactions and innovation outcomes between different actors, generating multiple "wakes of innovation".

As result, digital generative technologies hold the promise of "a virtually infinite number of potentially valuable recombinations" (Brynjolfsson & McAfee, 2014) of digital components, as they can be combined across industry boundaries and modified even while the product is in use (Henfridsson et al., 2018). This is further helped by a wide availability of free online resources, such as open data or open-source tools (McAfee & Brynjolfsson, 2017). Previous digital innovation research has investigated how generativity can be nurtured (Avital & Te'eni, 2009; Eaton et al., 2015; Huang et al., 2017; Jarvenpaa et al., 2018) and potential outcomes of generativity (Autio et al., 2018; Boland et al., 2007; Eck & Uebernickel, 2016; Yoo et al., 2012). A general assumption there is that generativity is desirable and leveraging unbound generativity can spur innovation by discovering novel and unexpected combinations of digital components. This creates a conundrum for innovators as they must navigate between a seemingly unbound landscape of opportunities and constraints stemming from their organizational context to determine suitable applications of digital technology. However, there is little literature that has addressed that tension and how innovators may balance it. A notable exception is Lehmann et al. (2022) studying how digital ventures design market offerings, as they oscillate between generativity and external market conditions.

2.2 Distributed innovation

In contrast to a traditional view of a single person or R&D department within an organization driving innovation (Drucker, 2002), digital technologies shift innovation agency towards more distributed and less predefined socio-technical innovation contexts, outside of the "organizational container" (Winter et al., 2014). Such contexts include open innovation (Chesbrough, 2003) or crowdsourcing (Majchrzak & Malhotra, 2020), innovation networks (Sandberg et al., 2015), distributed innovation (Yoo et al., 2008) or digital ecosystems (Selander et al., 2013). What these contexts have in common is that the innovation process involves an often loosely organized and dynamic collective of actors with differing knowledge and motives (Nambisan et al., 2017). Such connectivity is made possible by lowered cost of communication infrastructure (Altman et al., 2015), allowing to overcome the "tyranny of space" of historically bounded settings (Lyytinen et al., 2016).

Within this development, the trend is particularly towards an increased degree of distributed control and resource heterogeneity (Lyytinen et al., 2016). This represents an overall shift in how combinatorial innovation is organized. Modularity in the physical world, as in computer or car manufacturing, has given rise to organizational forms based on modular designs with loose horizontal couplings and strong vertical integration (Baldwin & Clark, 2000; Tuertscher et al., 2014). In contrast, digitization promises more organic innovation networks that span across industries where innovation opportunities can be exploited in real-time through dynamic reconfiguration of digitally enabled components (Yoo et al., 2012; Zammuto et al., 2007). As with the envisioned digital product or service, the boundary of the network is rarely known ex ante (Nambisan et al., 2017). Lacking clear structures or central hubs, these networks require strong informal norms, such as in open-source communities, to facilitate coordination (Germonprez et al., 2020; Lyytinen et al., 2016).

Resource heterogeneity and a certain absence of control are often linked to producing radical innovations (Carlo et al., 2012; Lyytinen et al., 2016), as illustrated by the popular quote "given enough eyeballs, all bugs are shallow" (Raymond, 1999). In contrast to incremental innovations, radical innovations aim to establish a new technological paradigm (Dosi, 1982) and are characterized as unique, in that they differ drastically from existing alternatives, and novel, in that they rely on strongly differing cognitive frames (Bijker et al., 1987) so that previous experiences are difficult to apply (Carlo et al., 2012). As result, the way innovators organize for radical innovation have been described as "intertidal zones" that remain at the "edge of chaos that exists between order and disorder" (Brown & Eisenhardt, 1997). A key challenge for innovation networks thus becomes to balance chaos and control and how to coordinate innovation processes over time (Gardet & Mothe, 2011).

2.3 Technological frames and incongruences in digital innovation

In navigating the complexity of digital innovation, IS scholars have highlighted the importance of cognitive frames to guide innovation activities (Davidson, 2002; Kaplan & Tripsas, 2008; Klos & Spieth, 2021). As innovators face an uncertain and highly complex environment, they rely on frames to form simplified versions of their information environment. As such, frames are 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" (Goffman, 1974). Orlikowski & Gash (1994) introduced the notion of technological frames that capture how actors make sense of a particular technology and its intended use. Technological frames are influenced by a variety of factors, such as personal experiences and training, dominant logics or environmental influences (Helfat & Peteraf, 2015).

Early stages of digital innovation in particular, i.e. the "era of ferment", are characterized by high uncertainty as to how digital components should be utilized and what combinations prove useful. Thus, involved actors may have differing, potentially conflicting frames, i.e. frame incongruences, resulting in high technical variety (Kaplan & Tripsas, 2008). While the development of simple technical innovations is often driven by a technological, optimizing logic (Rosenkopf & Tushman, 1994), the way in which these cognitive incongruences are resolved are a crucial factor in shaping the trajectory of complex digital innovations (Kaplan & Tripsas, 2008; Nambisan et al., 2017). Organizational actors who recognize and try to negotiate incongruences can become important change agents in that process (Young et al., 2016). Actors do not necessarily align their frames when they discover incongruences. Instead, they may negotiate a truce frame that indicates that "while consensus has not been achieved, conflict has ceased" (Azad & Faraj, 2008).

The risk of incongruences is amplified when combining multiple diverse sources of technical and domain knowledge (Pershina et al., 2019; Spieth et al., 2021; van den Broek et al., 2021). Combining heterogeneous knowledge is challenging because the tacit elements of knowledge are "rooted in action, procedures, routines, commitment, ideals, values, and emotions" (Nonaka & von Krogh, 2009). Different domains, i.e. "thought worlds" present semantic boundaries that complicate translating complex and tacit knowledge (Carlile, 2004). As result, a large body of research has highlighted the role of knowledge brokers (Sandberg et al., 2014) or boundary objects (Pershina et al., 2019) to create shared meanings (Dougherty, 1992).

Incongruences are often considered detrimental to organizational processes as they complicate cross-functional collaboration (Leonardi, 2011) or formulating a shared mental model (Young et al., 2016). For instance, Hsu (2009) describes how incongruent frames between managers and other actors hinder implementation of a security certification system. However, some scholars note that incongruences can be beneficial in leading to creative conflicts (Vaccaro et al., 2011; van Burg et al., 2013) or attract new collaborators in innovation processes (Kumaraswamy et al., 2018).

Finally, technological frames are also influenced by hype and buzzwords surrounding new technologies (Wang, 2010). Abrahamson (1999) notes that knowledge entrepreneurs, such as academics, consultants or technology vendors, have an interest in generating demand for innovative ideas. The resulting discourse may influence individual's technological frames by creating heightened expectations towards a technology's efficacy (Kriechbaum et al., 2021). Digital generative technologies like AI or blockchain, given their malleability and technical complexity, have been noted for discourse that overemphasizes their potential compared to current functionalities (Elish & boyd, 2018; Perdana et al., 2021). This may result in innovation processes resembling a solution in search of a problem (von Hippel & von Krogh, 2015) that are not necessarily guided by rational considerations to what constitutes a useful innovation outcome (R. Fichman, 2004; Swanson & Ramiller, 2004), further increasing the risk of incongruences between domain and technical experts (Ovaska et al., 2005).

3. Methodology

The purpose of this thesis is to explain how innovators balance generativity and incongruences in digital innovation. While the appended papers include a description of their respective methods to investigate this topic, this chapter expands the overall approach to the research methodology of this thesis.

3.1 Research Process

I started my doctoral studies and joined the case organization dubbed Alpha that served as my study context in the fall of 2019 with the aim to research the impact of digitalization in the maritime industry. While this was one of multiple potential goals outlined during Alpha's conception, the appended papers illustrate that Alpha's trajectory was highly serendipitous and ended up going in a different direction. I therefore turned my focus towards the digital innovation literature to help explain that serendipity. Particularly helpful in that sensemaking process were industry events on digital transformation, observations from similar publicly funded innovation networks and conversations with friends working as data scientists. Those helped me realize that Alpha's challenges in combining diverse knowledge while embracing the generative potential of digital technology were distinct but not necessarily unique to Alpha. Subsequently, I iterated between the empirical context and various theoretical concepts, eventually landing on the concepts described in this thesis. Figure 1 graphically illustrates the research process.

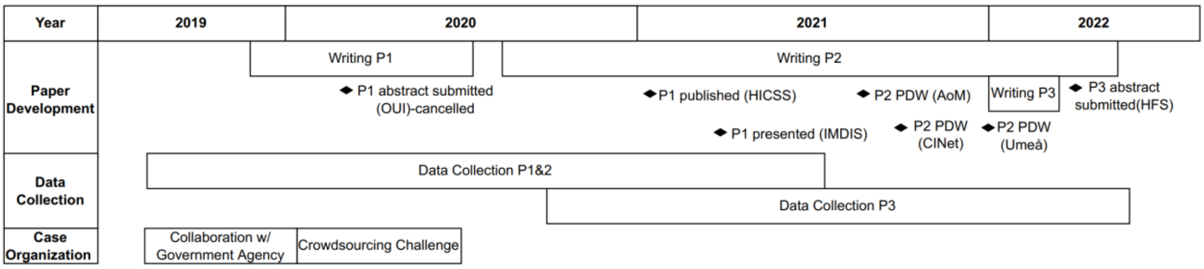

Figure 1 - Data collection and development process of papers

3.2 Research design

Although the IS literature has a long history on studying the development and adoption of IT-based applications, the specific subfield of digital innovation is still fairly young (Fichman et al., 2014; Holmström, 2018; Yoo et al., 2012). We still know little about how innovators in distributed, heterogeneous settings approach generativity and how that might impact potential incongruences (Nambisan et al., 2017). Accordingly, I have chosen a qualitative approach for this thesis, using exploratory research questions and data collection through interviews, observations and archival documents, to build theoretical perspectives (Flick, 2009). For both appended papers, I draw upon a 2-year single-case study based on one anarchic innovation network that explored potential usage of AI, ocean data and other digital resources in the context of marine invasive species. A single-case study is considered appropriate to for exploratory research where little theory exists and current perspectives seem inadequate due to lack of empirical evidence (Eisenhardt, 1989). Typically, case study research involves combining different methods of data collection, such as observations, desktop research, interviews and archival data (Maxwell, 2013). Focusing on a single case in contrast to multiple cases has allowed me to gain rich and in-depth insights relevant for the aim of the thesis, and uncover the complexity related to the phenomenon. The longitudinal character of the study has allowed me to track changes and compare intentions with outcomes in the process (van de Ven & Poole, 1995).

As my research subject revolves around how innovators understand their environment through social construction, using language, digital artifacts or interaction with other actors, I was guided by recommendations for interpretative case study research (H. K. Klein & Myers, 1999). In particular, I have emphasized the importance of context, both because I aim to provide the reader with an understanding of the background that explains the research setting and because an interpretative approach acknowledges that interactions between actors and their inner and outer contexts help to explain why processes unfold in specific ways (Pettigrew, 1990). In addition to convenience sampling, the selected case is suitable for investigating the role of generativity in innovation from a theoretical perspective as Alpha's open-ended goals and structure fit the description of an "extreme" case (ibid).

3.3 Data Collection

Paper I and paper II were written as part of the same research project with the same research design. Thus, data collection will be described jointly, before describing the data analysis for each of the papers.

Data was collected between the fall of 2019 and summer of 2021 and included semi-structured interviews, participant observations and archival data to allow triangulation (Pettigrew, 1990). Both papers focus on the period between fall 2019 and summer 2020, with later data collection done to allow for retrospective insights. Data collection was done mostly by me, with 2 interviews done together with a co-author, and 10 interviews done together with another person who declined to co-author the papers but will be named in acknowledgments for paper II. Interviewees were selected consistent with purposeful sampling (Flick, 2009) to include participants within Alpha with different backgrounds and roles to gain a holistic insight in the innovation process, as well as crowdsourcing solvers whose responses were important to understand dynamics in the crowdsourcing challenge. Interviews lasted between 30-60 minutes and were conducted consistent with the "dramaturgical model" for semi-structured interviews (Myers & Newman, 2007). First, I established the context by introducing the research project and myself in the role not as an Alpha participant but as researcher. Second, to reduce social dissonance, I emphasized how interviews would be anonymized and not shared with other participants. The interview guide focused on actors' activities and perspectives in the innovation process. As I interviewed several persons repeatedly, I made use of the longitudinal nature of the case study by inquiring about planned future activities and following up on those in the next interview. This allowed me understand deviations from planned activities over time. Being a participant of Alpha has allowed me to gain trust from and understand tacit interdependencies between actors. In participant observation, my main data source stemmed from meeting minutes that I took during work meetings as part of my role within the project and complemented the minutes with own research notes. Finally, I had access to a large amount of internal communication and documents, such as technical documentation and presentations. Those were helpful in providing temporal snapshots of how innovation goals were presented to outsiders and discussed internally. Communication via the messenger app Slack was a particularly useful data source, as actors used thematically named channels like #shippingdata to share small updates on those topics.

3.4 Data analysis

For paper I, I used thematic analysis (Patton, 2015) to guide the analysis process to explore different ways in which domain and technical knowledge were combined in multiple stages of a crowdsourcing event. First, data was openly coded, helped by the software Nvivo, to create first order codes on knowledge use and translation. This was an iterative process, as each subsequent reading of the data revealed new insights, which in turn resulted in another round of reading to ensure as many codes as possible were generated across the entire data set (Patton, 2015). Guided by inductive reasoning, codes were then sorted and grouped based on similarity, and similar codes were combined to form overarching "themes".

For paper II, the coding procedure was guided by the method described by Gioia et al. (2013). The resulting coding scheme is presented in paper II. I deviated from the canonical Gioia method by additionally incorporating the concepts of organizing vision and divergence and convergence at a later stage. As this paper was based on a large volume of varied longitudinal data and a case characterized by much serendipity, the analysis has been a highly iterative process. While I don't refer to paper II explicitly as a process study, it fits the description and thus I have included some recommended approaches in my analysis process. As Langley (1999) notes, "process data are messy. Making sense of them is a constant challenge". To assist me in this sensemaking process, I have used narrative-type narrative inquiry (Polkinghorne, 1995) and timelines using the software Aeon Timeline to get a holistic, temporally sorted view of actions, decisions and incidents that have influenced the innovation process. Using timelines in particular has been useful in providing both a visual mapping tool (Langley, 1999) and an event sequence database of 166 identified key events (Poole et al., 2000). This allowed me to iterate between raw data and the timeline to "reveal temporal interconnectedness" (Pettigrew, 1990). To do so, I decomposed the process along its horizontal dimensions, i.e. "the sequential interconnectedness among phenomena in historical, present, and future time", and vertical dimensions, i.e. "the interdependences between higher or lower levels of analysis upon phenomena to be explained at some further level (Pettigrew, 1990). In my case, horizontal decomposition concerned analyzing temporal patterns that influenced the innovation process, such as introduction and discarding of new ideas or intended and realized use of digital resources. This, in conjunction with insights from informants, led to the temporal bracketing structure found in the paper. Vertical decomposition concerned providing analytical levels to processes and events that influenced the focal process, the evolution of Alpha's organizing vision. These analytical levels were guided by different theoretical concepts related to the digital innovation literature, with the final version drawing on Swanson & Ramiller (1997) elements of discourse, practitioner subculture, problematic, community structure, core technology and adoption that produce an organizing vision.

Despite a lengthy and iterative process that, in retrospective, could have benefited from a more focused research design, I believe this approach yielded relevant and robust insights and allowed me to sharpen my academic skills by exploring a variety of analytical approaches.

4. Summary of papers

4.1 Paper I: The Challenges of Knowledge Combination in ML-Based Crowdsourcing – the ODF Killer Shrimp Challenge Using ML and Kaggle

In this paper, we study the challenges of actors that organize and participate in a crowdsourcing challenge that is integrated in the development of a machine learning-based application. We observe how the process was characterized by changing degrees of how domain and technical knowledge were used and perceived, and subsequently aim to understand why this has been the case. To achieve that, we investigate the interactions amongst domain and technical specialists in the seeker organization during preparatory problem formulation, how solvers with technical expertise approach the challenge, and the resulting interactions amongst seekers and solvers.

In relation to digital innovation, this paper provides several interesting insights. First, it represents a case where the challenges and opportunities of combining complex interdisciplinary knowledge, generally considered a key requirement for digital innovation, are highlighted. As illustrated in the paper, a strive for novelty and experimentation drive actors towards exploring new opportunities presented by digital technology, such as integrating the use of crowdsourcing platforms in development of ML-based applications. This results in a non-linear and iterative problem-formulation process that requires translating a complex and unbounded real-life problem into technical specifications while balancing ambition and technical feasibility. Second, it illustrates how the design of a crowdsourcing platform allows solvers to disregard the domain context in lieu of technical optimization. This in turn reveals incongruences between seeker expectations towards crowdsourcing platforms enabling interdisciplinary, creative innovation outcomes, and solver actions motivated by training their technical skills. Finally, the interactions between seekers and solvers highlighted challenges in contextualizing digital resources and AI-produced outputs, highlighting the importance of boundary objects and knowledge brokers with both sufficient domain and technical expertise to translate knowledge.

The main contributions are in the form of recommendations derived from the case to integrate crowdsourcing into domain-specific digital innovation processes. This paper has been accepted and published in the *Proceedings of the 54th Hawaii International Conference on System Sciences* (*HICSS*) in 2021.

4.2 Paper II: Organizing Vision Evolution in AI-based Anarchic innovation networks

In this paper, we draw on a 2-year longitudinal study of a project within an anarchic innovation network Alpha as a case of AI innovation by tracing the evolution of its envisioned application of AI from its initial conceptualization over an unplanned continuation to the project closing. The focus of our analysis is on how Alpha, by changing its rhetoric, usage of digital resources and network orientation, adapted its vision of how to utilize AI while contextual conditions changed over time.

The paper comes to illustrate the serendipitous and longitudinal nature of digital innovation, specifically the serendipity that emerges when collective cognitive frames formed from heterogeneous knowledge are challenged. To that end, it shows how the innovation trajectory cycles through phases of divergence, characterized by an exploratory strategy and formation of new AI-related expectations, and phases of convergence, characterized by exploitation and harmonizing incongruent expectations.

We develop a theoretical model that explains this process as the evolution of an organizing vision, i.e. a community's focal idea for the application of AI in their organizational context. Based on our findings, we note that changing contextual conditions trigger a shift in the organizing vision trajectory, namely goal uncertainty and a collective interest in exploring the generative potential afforded by AI initiating divergent behavior, and revelation of incongruences through external actions initiating convergent behavior. Further, we develop three action-formation mechanisms, *conceptualizing compellingness, bounding digital resource space,* and *repositioning network innovation locus*, embedded in a theoretical model that explains how innovators adapt their organizing vision. The new organizing vision represents a redefined collective understanding of how the envisioned application of AI creates value, what resources are required to realize it and why external actors should adopt it.

This case makes apparent the uncertainty innovators face when balancing between their organizational context and the seemingly unbound potential offered by generative digital technologies. In addition to the theoretical model, this paper contributes to the literature on digital innovation by challenging the dominant view that unbound generativity is desirable as enabler of radical, recombinatorial innovation. Instead, we find that, while generativity facilitates creative ideation by allowing consideration of multiple, potentially conflicting ideas in divergent phases, it increases uncertainty. At the same time, we find that innovators leverage the generativity of digital resources in convergent phases to overcome organizational and technical challenges.

This paper is a manuscript at the time of writing. The aim is to submit it to a paper development workshop of a AJG level-4 IS journal in summer 2022 and submit it to the same journal end of 2022.

5. Discussion

With the purpose of this thesis to *generate new insights on how innovators balance generativity and incongruences in digital innovation,* my research has provided new understanding of the challenges and opportunities that emerge when innovators try to leverage new digital technologies in different ways. In this section, I discuss and build upon the findings from the appended papers to address these issues.

5.1 Generativity & incongruences

The appended papers illustrate that the ambiguity and complexity of technical information challenges actors to develop cognitive frames that transform a complex information environment into a manageable one (Walsh, 1995). Particularly in early phases, differing cognitive frames are the source of variation and shape the innovation trajectory, confirming what previous literature has suggested (Garud & Rappa, 1994; Kaplan & Tripsas, 2008). However, paper II challenges the notion that harmonizing incongruences will eventually lead to convergence towards a dominant design (Kaplan & Tripsas, 2008), instead highlighting the cyclical nature of digital innovation processes (Nambisan et al., 2017; Van de Ven, 2017). Rather than converging in a singular design, the generativity of digital resources allows for serendipitous continuation and recombination. As such, generativity and cognitive differences interplay in two ways.

On one hand, this thesis finds that embracing *generativity increases the chance for incongruences*, contrasting the dominant assumption in literature that generativity is necessarily desirable. As innovators seek knowledge diversity to detect novel and unexpected recombinations, they invite multiple actors with highly different backgrounds and interests to participate (Van de Ven, 2005). Thus, there is a high variety of cognitive frames towards the nature and envisioned application of the technologies at hand. While this heterogeneity allows innovators to explore multiple variations, it also increases the risk of incongruences between different frames (Kaplan & Tripsas, 2008). Given the dynamic and loosely defined organizational context, it is particularly difficult for innovators to approach a technology mindfully, i.e. with reasoning grounded in their "own organizational facts and specifics" (Swanson & Ramiller, 2004). Presented with seemingly infinite possibilities, or "an ocean of opportunities" (paper II), innovators thus need to create a buffer between the generative potential and their organizational context (Lehmann et al., 2022). They do so by constructing an organizing vision (Swanson & Ramiller, 1997) that helps to inform both boundaries on technology application and organizational boundaries. Early visions, as described in paper II in phases of divergence, resemble a "blank canvas" that can hold multiple, potentially conflicting ideas. Given the outcome uncertainty, these visions tend to emphasize the potential functionality rather than how to realize it. While this helps to attract new collaborators, this may also give birth to potentially unrealistic expectations.

On the other hand, *generativity impacts how innovators respond to incongruences*. First, the inherent uncertainty complicates resolving incongruences. In early creative chaos, many ideas seem equally viable (Austin et al., 2012). Given the lack of previous comparisons, it is particularly difficult for those with expert knowledge to be assertive and provide "checks and balances" (Swanson & Ramiller, 1997). Concerns may be voiced but addressing them may be delayed until there is more clarity, resulting in a truce frame (Azad & Faraj, 2008). For instance, paper II describes how different frames towards the envisioned complexity of a prediction tool – with technologists noting the small number of datasets could be analyzed with simple statistics – were acknowledged, but resolving the conflict was delayed due to lack of clarity about the envisioned outcome.

Second, the recombinatorial nature of digital resources (Henfridsson et al., 2018) facilitates overcoming incongruences by leveraging different functionalities to produce a new dominant frame. For minor incongruences that arise from challenges in translating knowledge across interpretative barriers (Dougherty, 1992), actors may edit digital artifacts in ways that help transmit meaning to others (Nambisan, 2017). Both paper I and II describe instances where technologists produce prototypes or visualizations to portend the functionality and limitations of AI models.

Major incongruences reflect fundamental misconceptions about the purpose of the envisioned innovation and may present an "insurmountable performance gap" between goals and feasibility (Majchrzak et al., 2004). There, the generative potential of digital resources allows actors to facilitate shifts in the innovation trajectory to overcome these incongruences. For instance, paper II illustrates how actors reframe their use of open data to allow replicability of their outcomes, helping shift towards an educational focus. This may produce serendipitous opportunities later on. For instance, the decision to omit proprietary data later helped spur the new idea to explore the use of crowdsourcing.

One may conceptualize this interplay as a village community building a house with a range of tools. A small tool shed may attract only the local carpenter who will build the same house he built many times before. A well-equipped shed will attract more craftsmen that introduce new ideas, resulting in an innovative design. However, given the knowledge diversity, misunderstandings may arise whether a new room is necessary or how it'll affect structural statics. In such cases, a fitter may craft a small model of his envisioned design to explain it to others, or weld new pillars out of old metal scrap to support a new design.

5.2 Embracing uncertainty in search of outcome originality

As generativity allows for a "virtually infinite number of potentially valuable recombinations" (Brynjolfsson & McAfee, 2014), innovators are faced with an unbound solution space that complicates knowing a suitable outcome ex ante (Dattée et al., 2018; Henfridsson et al., 2018). Previous empirical studies on digital innovation have described it in settings with clear structural boundaries (Zorina & Dutton, 2020) or where digital innovation was guided by an overall organizational goal (Nylén & Holmström, 2019)´or commercial interests (Lehmann et al., 2022). This thesis however illustrates how innovators, in strive for outcome originality, embrace the uncertainty afforded by generative technologies. To operate in such high uncertainty, they do not aim to follow a linear innovation process, as outlined in frameworks like the stage-gate model (Cooper & Kleinschmidt, 1986) or what Bonabeau (2008) describe as "rational approach". Rather, they employ what Schroeder et al. (1989) describe as "fireworks" approach to innovation, emphasizing discontinuity, unexpected value, dead ends, bottom-up engagement and adapting organizational structure during the innovation process.

This allows innovators to explore many different recombinations of digital components in seemingly random patterns, jumping between hills in a "rugged landscape" in search for an optimal outcome (Kauffman & Levin, 1987). As they encounter incongruences, they are open to adapting their organizational processes and network boundaries dynamically. For instance, at launch, Alpha outlined a detailed 6-month plan outlining the envisioned innovation process, that was quickly abandoned when initial assumptions were challenged. Such flexibility is helped by emphasizing outcome originality as something inherently valuable (Austin et al., 2012; Avital & Te'eni, 2009). In other words, an innovation outcome that falls behind its original vision is not considered a failure, as the uniqueness and learning gathered from the process are considered positive outcomes themselves (Schroeder et al., 1989).

On the other hand, a continuously shifting innovation environment can lead to challenges in motivating and coordinating involved actors (Gardet & Mothe, 2011). Distributed innovation systems that rely on bottom-up engagement, such as anarchic innovation networks or crowdsourcing challenges, need to ensure that the interests of individual actors align with the overall organizing vision (Aarikka-Stenroos et al., 2017). This is not an issue if changes in the innovation process do not affect actors' goals or the perceived cost of engagement is low. For instance, paper I describes how solvers remained engaged after a major change in crowdsourcing rules, since they were still able to achieve their personal goals of training their technical skills. However, when actors perceive new goals to strongly misalign with their own, they may choose to disengage, as illustrated in paper II with multiple commercially orientated actors leaving when Alpha shifted towards an educational focus that excluded the use of proprietary applications.

Additionally, continuous adaptation of innovation goals as result of exploring different usage of digital technology may eventually make it difficult for actors to recognize an overall strategic vision, i.e. a meaningful view of the organization's future (Collins & Porras, 1991). This can impede innovation processes as a strategic vision helps inform the long-term purpose of a collective of actors and thus helps sensemaking of their environment (Möller, 2010). For instance, during the end of my observation of Alpha, I observed multiple instances of actors struggling to understand "what Alpha is all about", and as a result, to prioritize their efforts and attract new collaborators. While this aspect has not been addressed in the appended papers, it illustrates the cognitive challenges when embracing uncertainty in the absence of a long-term goal.

In the house-building metaphor, an architect may choose to omit a clearly defined blueprint in lieu of a vague description like "an innovative structure for recreation". On one hand this will allow for a wide exploration of designs and adapting the dominant design when running into problems. However, when the design changes too often, builders may become confused or abandon the project.

5.3 Distributed digital innovation as complex adaptive system

So far, I have drawn upon the concept of anarchic innovation networks (Lyytinen et al., 2016) to describe the case organization because it accounts for the distribution of control and resource heterogeneity. However, I also find that this concept is limited in explaining the coevolution of the innovation environment along the innovation process. While the examples of anarchic innovation networks described by Lyytinen et al. (2016), such as in the construction of the Guggenheim museum in Bilbao (Boland et al., 2007) or a particle accelerator in CERN (Tuertscher et al., 2014) show non-linear innovation trajectories, they remain relatively static in their overall objective and network composition. In contrast, paper II illustrates how open network boundaries and continuous reframing of an organizing vision attract and repel actors, resulting in a highly volatile and dynamic innovation environment.

An alternative lens for such evolvable and agile systems can be found in the notion of complex adaptive systems (CAS), stemming from complexity theory (Benbya et al., 2020). CAS describes systems that evolve and adapt while they self-organize. They are composed of autonomous agents with the ability to adapt according to a set of rules in response to changes in the environment and other agent's behaviors, which in turn alters the structures of a CAS. As result, CAS are nonlinear and unpredictable in that small input changes can lead to large and unpredictable differences in the output. CAS oscillate between phases of stability, chaos and an in-between state of "emergent complexity" (Benbya & McKelvey, 2006). The latter provides organizations with "sufficient stimulation and freedom to experiment and adapt but also with sufficient frameworks and structure to ensure they avoid complete disintegration" (McMillan, 2008).

Based on the discussion so far, I argue that CAS can be a useful lens to capture the coevolutionary change within distributed digital innovation environments as interplay with the innovation process. For instance, paper II illustrates how dysfunctional interactions between domain experts and technologists made the latter take initiative to create boundary objects, thus raising their social status within the network. Similarly, the continuous exploration of new opportunities provided from digital technology can be understood as actors placing themselves at the edge of chaos in search of novelty. While I have identified the alignment of heterogenous frames into an organizing vision as key factor to navigate that chaos, a CAS perspective would suggest that this framing process is inherently coevolving with the overall system's structures and boundaries. This is congruent with previous research that highlighted the complexity and resulting coevolution in digital innovation processes (Benbya et al., 2020; Vega & Chiasson, 2019; Vidgen & Wang, 2009). However, this thesis does not go beyond identifying this perspective and its use as a potential framework for explaining the phenomena described above.

5.4 Practical recommendations

A key question arising from this research topic is how to what degree innovators should embrace the generative potential from digital generative technologies to produce innovative outcomes (Eck & Uebernickel, 2016). Based on my findings, I find that it depends on how innovators determine the value of the intended innovation outcome. Open-ended innovation endeavors that consider outcome originality and new knowledge as inherently valuable (R. Fichman, 2004), such as Alpha, may benefit from embracing uncertainty and employing a highly unstructured innovation process to explore many different variations. However, in order to capture the value of new knowledge, organizations would be advised to set up appropriate structures for knowledge retention and dissemination (Brix, 2017) to allow organizational learning. Further, given the multitude of interests in collectives of heterogeneous actors, it would be important to set the expectations right from the beginning to ensure continuous engagement. This can be facilitated by formulating a strategic vision (Collins & Porras, 1991) that is broad enough to encourage experimentation and serendipitous adaptations, but still provides a long-term goal that provides purpose to actors' actions in a dynamic environment and allows them to scrutinize whether new organizing visions are aligned with that goal. In other words, if actors don't understand what the purpose of their organizational context is, they cannot scrutinize whether an envisioned technical innovation is suitable for that context or not. This issue highlights the role of leadership in taking a "fireworks" approach to digital innovation, and the thin line between empowerment and laissez-faire leadership (Wong & Giessner, 2018). While providing actors with a high degree of autonomy allows them to explore multiple pathways and can lead to serendipitous emergence of new ideas, leaders may consider choosing to take a more proactive role in situations of high uncertainty to help sensemaking and to ensure strategic alignment.

Finally, this thesis illustrates how exaggerating the generative potential through the use of buzzwords can be beneficial in the innovation process by attracting external collaborators and creating legitimacy (Swanson & Ramiller, 1997). However, this also bears the risk of setting unrealistic expectations and creating frustrations when those are not met. This may be mitigated by creating incentives for actors to speak up when in doubt to detect potential incongruences early on. It may also be helpful to set realistic expectations internally about technical complexity and resulting barriers for domain experts to engage. This reflects a general conundrum in digital innovation in how to translate complex domain and technical knowledge (van den Broek et al., 2021). Organizations may choose to either facilitate cross-disciplinary learning or establish clear boundaries and responsibilities between the different groups (Kudaravalli et al., 2017). No matter what approach, it may be useful to establish that strategy early on and provide appropriate structures.

6. Limitations & future research

6.1 Limitations

This thesis has a number of limitations. While one of the strengths of the thesis is that the challenges of embracing the generative potential of digital technology are evident in the case of Alpha, an organization that emphasized organized anarchy and was created with public funding tied to few specific deliverables, this may be also a key weakness of my findings. While I would expect that less chaotic or commercially orientated organizations face similar dynamics (c.f. Haghshenas & Østerlie, 2020), it is an empirical question whether my outlined theorized relationships hold up across contexts.

Another limitation lies in the cultural context, as many of Alpha's members had a Swedish cultural background. This may have contributed to a particular embrace of flat hierarchical structures and being comfortable with uncertainty (Hofstede & Hofstede, 2001), and as such impacted how potential incongruences may be perceived and addressed. Innovators from other cultural contexts may be less comfortable with open-endedness and aim to formulate a clearer meaning of available digital components in earlier stages of the innovation process.

Finally, while purposeful sampling did guide data collection, it was not theoretically driven in a sense that theoretical concepts discussed in paper II or this thesis were not utilized during data collection. Instead, those concepts were applied during data analysis after data collection had stopped. Thus, I did not stop data collection upon saturation with respect to the theorized relationships, but rather on saturation of new insights on a general level.

6.2. Future research

I aim to accomplish two objectives with this licentiate thesis. First, I tried to summarize and synthesize the research within the papers that I have produced up to this point. Second, I tried to build a bridge for future research. Reflecting on the conclusions outlined above, I believe there are multiple interesting paths to explore.

For one, innovation networks have proven an interesting context to research how diverse actors combine knowledge and resources to develop digital innovations. The frameworks advanced in this thesis are well suited for early ideation stages in digital innovation and an environment characterized by high uncertainty and knowledge diversity. However, it is not clear how they would work for innovation projects that go beyond ideation and move into activities for testing and implementation. One would expect that during such phases, tensions between intent and outcome would be resolved differently, for instance when trying to balance envisioned complexity and feasibility, and that the "amplitude" of phases of divergence and convergence would be smaller. Similarly, one would expect that a more structured environment would impact how actors react to unexpected changes. Thus, a potential research question would be: *how do differing degrees of knowledge heterogeneity and distributed control impact the digital innovation trajectory in innovation networks?*

In addition, paper II touched upon interesting tensions from designing an AI application to predict an accurate future state situated in the real world while having imperfect data. This reflects the challenge of agreeing on and evaluating a "ground truth" which has been noted by previous researchers (Berente et al., 2021; Lebovitz et al., 2021; van den Broek et al., 2021). While the actors in paper II overcame this challenge by downscaling their scope and intended accuracy, it would be interesting to see how actors balance this tension when developing an AI application that is primarily evaluated by its accuracy against a real-world baseline e.g. in naturalistic decision-making (G. Klein, 2008) while working with imperfect data. Thus, a potential research question would be: *how do innovators balance output accuracy and feasibility in AI innovation intended for naturalistic decision-making?*

Looking forward, I plan to continue this research drawing on the case of Alpha and a second case of a federated innovation network (Lyytinen et al., 2016). Data collection for the latter has been ongoing since late 2020 and its objective in developing an AI-based end-user innovation in a marine context is similar to Alpha. Preliminary observations from that case indicate that a stronger defined strategic vision results in less serendipity, because major trajectory shifts like in Alpha are more difficult to justify. To overcome obstacles, innovators thus have turned to creative ways to leverage generativity, for instance by prototyping the AI tool in different simulated and physical environments. Thus, I see that case as a well-suited study context to push this research further in above outlined avenues, both by comparing and contrasting two polar cases (Pettigrew, 1990) and investigating the second case more in-depth. Perhaps just as important, data collection in that case has been fun because it had led me in unique and interesting situations. The role of fun in academia is rarely acknowledged, but from my perspective, it is an integral part in succeeding as a researcher.

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