How Might We use AI to innovate?

An explorative study of the opportunities when integrating AI in the innovation process

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Abstract

This study aims to investigate the opportunities with integrating AI into the innovation process. A robust qualitative methodology, using semi-structured interviews triangulated with desktop research, is used to identify possible application areas for AI in the innovation processes. Our findings contribute to innovation management research and especially the novel field concerned with how AI is used in the innovation process itself, and not as the result of the process. It is concluded that innovation practitioners can use AI to alter traditional design thinking tools or the innovation process itself. These findings are based on a mapping of contemporary cases, reflecting that there are opportunities related to the process, the principles as well as to the dynamic capabilities of a company. In conclusion, AI can alter how innovation practitioners do innovation, think about innovation as well as have implications beyond design thinking, on a strategic level.

Key words: Innovation, design thinking, double diamond, artificial intelligence, machine learning, dynamic capabilities.

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Table of content

Definitions

Key word	Description
Innovation practitioners	People working with innovation in for example an innovation team.
Design thinking	A human-centred innovation process that emphasises observation, collaboration, fast learning, visualisation of ideas, rapid concept prototyping, and concurrent business analysis (Lockwood, 2009).
Design	The action to create radical as well as incremental innovation. This is in line with the definition from Simon (1969) who state that design is "courses of action aimed at changing existing situations into preferred ones".
Innovation process	The practical implementation of novel and useful ideas for new products, processes, services, business models and structures (Amabile, 1997). In this study design thinking theory is applied for the innovation process.
Design thinking tools and methods	For the design thinking process to be effective there are tools and methods to support the process, these tools support activities such as need-finding, idea-generation, and idea-testing (Liedtka, 2015).
Design thinking principles	Design thinking builds on a few fundamental principles and these principles can be considered a mindset to innovation (Verganti, Vendraminelli and Iansiti, 2020). This study adopts five, User centricity, Iteration, Hypothesis driven, Visual communication, Multidisciplinary.
Double diamond	The double diamond model emphasises problem solving and consists of two diamonds, problem and solution. It is developed by the Design Council (Design Council, 2020)
Artificial intelligence	The field that studies the synthesis and analysis of computational agents that act intelligently (Pool and Mackworth, 2010)
Machine learning	Machine learning (ML) is a subfield of AI that uses probabilistic models to solve problems. There are three general machine learning approaches to achieve artificial intelligence capabilities: supervised, unsupervised and reinforcement learning (Agrawal, Gans and Goldfarb, 2018; Iansiti and Lakhani, 2020)

1. Introduction

People creating ideas that increase productivity are what spur long-term economic growth (Solow, 1957). These ideas are considered the core of innovation and it has become a key priority for modern companies. However, as the number of successful innovations increases, the task of coming up with other new innovations becomes harder (Pisano, 2019). More resources are put into innovation processes and R&D spending has become a tangible metric on innovation efforts. With a shrinking productivity in R&D efforts (Bloom et al., 2020), the quest for well-tuned innovation systems is rising (Ringel et al., 2020) to ensure maximum extracted value from input-resources.

At the same time, the rise of artificial intelligence (AI) is significantly changing activities within companies (Vocke, Constantinescu and Popescu, 2019) and companies try to create competitive advantage by mastering the balance between people and machines (Ringel et al., 2019; Chhabra and Williams, 2019). The rise of AI is argued to boost productivity and facilitate growth. It is further suggested that improved AI techniques can generate insights from data that could eventually contribute to idea production and innovation itself (Craglia et al., 2018). Innovation practitioners face rapidly changing environments due to globalisation, technological advancement, and political agendas. Therefore, it is crucial for companies to build capabilities that can be adjusted to this volatile environment. For companies to become better equipped to compete in today's fast changing world, internal processes need to be efficient while at the same time foster innovation (Jones, Cope and Kintz, 2016; Spieth, Schneckenberg and Ricart, 2014)

While AI is regarded as rule-based, the methods associated with the process of innovation are rather pushing for thinking outside the presumed rules. The contrast between the nature of these fields is striking. However, numerous organisations master the act of innovating solutions containing AI elements, creating value by combining the two. The most game-changing innovations of our time have AI in its core and oftentimes these are the result of fine-tuned innovation methods such as design thinking. Considering that our times most well-known companies can attribute their success to solutions where AI is a result of the innovation process - one cannot help but wonder about the potential to use AI to inform the innovation process itself.

1.1 Purpose and research question

This study is written with the purpose of contributing to innovation management research. The starting point was the identification of two strong convictions that are present among companies today. AI is the future and companies are exploring and defining ways of using AI for both product and processes development in their businesses (Agrawal, Gans and Goldfarb, 2018; Fountaine, McCarthy and Saleh, 2019; Lansiti and Lakhani, 2020). At the same time, innovation is considered a recipe for success (Beckman and Berry, 2007; Bruce, Cooper and Vazquez, 1999; Dickson et al., 1995; Elsbach and Stigliani, 2018; Furr &

Dyer, 2014) and companies are using methods like design thinking to create successful innovations (Johansson-Sköldberg, Woodilla and Çetinkaya, 2013; Liedtka, 2018; Liedtka and Ogilvie, 2011).

It is suggested by a few prominent researchers that the two concepts above could be combined (Cautela et.al., 2019; Kakatkar, Bilgram and Füller, 2020; Verganti, Vendraminelli and Iansiti, 2020). Thanks to dedicated innovation, machines are now able to accomplish activities that until recently were completed by humans. Hence, the question becomes what role AI can have for innovation. This is an interesting question, since innovation can ensure a company's long-term survival (Haefner et al., 2021). We have here taken on the challenge to further understand the combination of these convictions.

We find it interesting that AI solutions are oftentimes the result of a successful innovation project but there is still left to explore further what role AI can play in the innovation process itself. This leads to the research question:

What opportunities exist when integrating AI into the innovation process?

1.2. Contributions & limitation

The study will contribute with theoretical relevance for innovation management research by drawing connections between design thinking, AI and dynamic capabilities which have never, explicitly, been cited together. Research needs to consider the strategic perspective from dynamic capabilities. There is also an aim to contribute with practical relevance. Best practice cases are regarded as important concepts to encourage innovation within companies. Similarly, this study can be considered as inspiration for how AI can be used in various parts of an innovation process. By taking inspiration from its peers, organisations can develop their own innovation processes with support from AI. A final note about limitations of the study is that not all techniques under the AI umbrella is included in the scope. Most case examples in the sample use machine learning techniques as the application of AI.

2. Literature review and theoretical framework

This section will provide a background for the study and outline the relevant concepts, define the research gap and present the chosen theoretical framework.

2.1 Innovation process - the design thinking perspective

Innovation strategies require a culture that supports the innovative endeavours (O'Reilly and Tushman, 2008; Pisano, 2019). For a company to reach an innovation goal, a structured process can facilitate that (Liedtka, 2015). Various innovation processes have been developed to meet the requirements of organisations today (Dodgson, Gann and Phillips, 2014). In this study, the design thinking perspective is applied when talking about the innovation process. Currently, this is the most significant perspective in the studies of innovation management (Liedtka, 2015) and is effective in the fast-changing world of today (Kolko, 2015).

Another important characteristic of design thinking is that it reflects a decision-making process around innovation. It facilitates an understanding of which and how decisions are made (Liedtka, 2015; Verganti, Vendraminelli and Iansiti, 2020). We would like to take the opportunity to highlight that this decision-making characteristic supports why design thinking serves as a relevant lens to study the impact of AI on the innovation process. In many aspects, AI resembles making decisions, and as we soon will learn, automated decision-making is only one of the application areas for AI in companies today (Lansiti and Lakhani, 2020).

2.1.1 Design thinking

Design thinking was first introduced in 1987 by Peter Rowe, a professor at Harvard University and has expanded dramatically since then (Radnejad, Ziolkowski and Osiyevskyy, 2020). IDEO, a design agency in California has played a leading role in its popularising (Kelley and Littman, 2005; Brown, 2009). Design thinking is "a human-centred innovation process that emphasises observation, collaboration, fast learning, visualisation of ideas, rapid concept prototyping, and concurrent business analysis" (Lockwood, 2009). In this study, the adopted view is that design thinking builds on fundamental principles, executed in practice through a process with the help of design thinking tools.

2.1.2 Design thinking principles

Design thinking builds on a few fundamental principles that can be regarded as a mindset to innovation, but some ambiguity exists around which are the exact principles of design thinking (See Carlgren, Rauth and Elmquist, 2016; Dell'Era et al., 2020; Liedtka, 2015; Verganti, Vendraminelli and Iansiti, 2020). After summarising the most frequent principles, this study adopts the below five, which summarises the essential mindset.

(i) *User centricity:* Design thinking places users at the centre of the process. The innovation practitioners start with obtaining a deep understanding of the true user needs and throughout the process co-create with users to find a satisfying solution (See Dell'era et al., 2020; Klitsie, Price and de Lille, 2018; Liedtka, 2015; Verganti, Vendraminelli and Iansiti, 2020).

(ii) *Iteration*: Design thinking requires an iterative mindset, which means that innovation practitioners learn through experimentation. Experimentation is used throughout the process to further develop ideas and identify weaknesses. This can take the form of prototypes and experiments that are carried out early and often (See Dell'era et al., 2020; Klitsie, Price and de Lille, 2018; Liedtka, 2015; Verganti, Vendraminelli and Iansiti, 2020).

(iii) *Hypothesis driven:* Working with hypotheses requires imagining how things might be. Hypotheses are used for testing ideas. Therefore, design thinking is often associated with ideation rather than solely relying on analysis (See Liedtka, 2015; Verganti, Vendraminelli and Iansiti, 2020).

(iv) *Visual communication*: Communication in design thinking is preferably visual, such as through photos, videos, sketches, drawings, and symbols. Acquire input from listening is a crucial first step. However, innovation practitioners also need to master visual communication to convey ideas and intentions. Creative ideas are preferably translated into visualisations such as drawings to promote communication of the idea (See Carlgren, Rauth and Elmquist, 2016; Kernbach and Svetina Nabergoj, 2018; Klitsie, Price and de Lille, 2018).

(V) *Multidisciplinary*: Collaboration between members with different backgrounds are essential for design thinking, since it is what fosters new perspectives, creativity and problem-solving. Additionally, knowledge ranges become broader and more skills become available once teams consist of a multi-discipline of members (See Carlgren, Rauth and Elmquist, 2016; Fay et al., 2006; Klitsie, Price and de Lille, 2018).

2.1.3 Design thinking process

In practice design thinking is usually described in a sequential manner, more like a process. Many different visual representations of the design thinking process exist; however, they build on the same underlying idea (Brown, 2009; Liedtka and Ogilvie, 2011; Plattner, Meinel and Leifer, 2016).

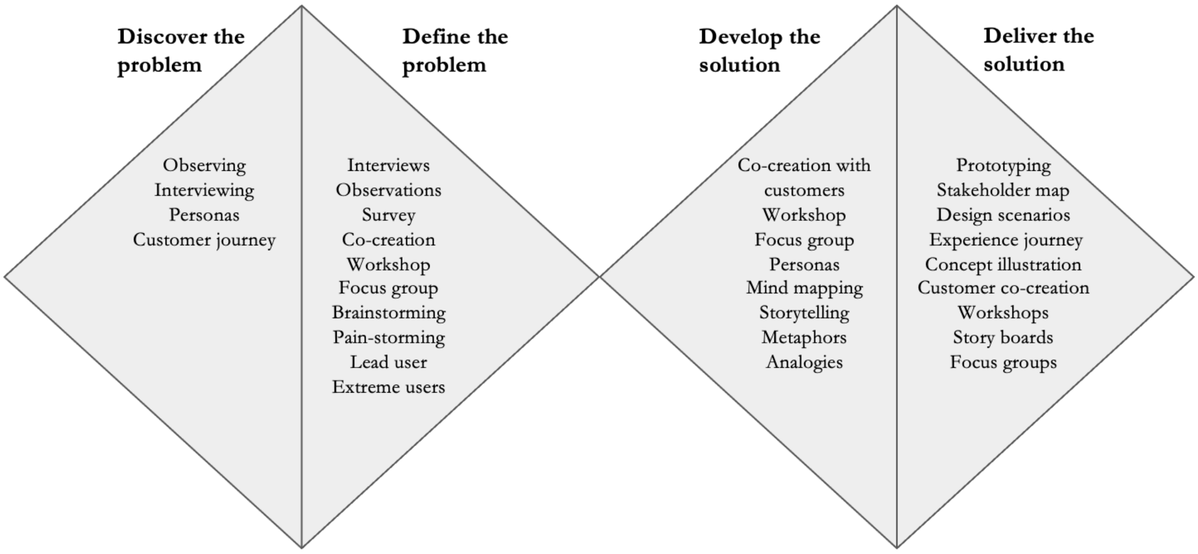
A well-established visualisation of design thinking as a process is the double diamond, developed by the U.K Design Council (Howard, Culley, and Dekoninck, 2008). Instead of being a method for opportunity discovery the double diamond has an explicit focus on problem solving (Clune and Lockrey, 2014). The double diamond consists of two basic dichotomies (Dorst and Cross, 2001). First, the double diamond distinguishes between problems and solutions. Second, it distinguishes between exploration and selection, based on the concept of divergence and convergence. This diverge and converge characteristics display the double diamond as a problem-solving approach (Dell'era et al., 2020). Together these dichotomies produce four distinct phases and two diamonds: problem and solution (Kakatkar, Bilgram and Füller, 2020) (appendix 1). The initial wicked problem, problem that is still ill formulated and broad (Buchanan, 1992) needs to be framed and reframed to find the real problem (Beckman, 2020) which highlights the importance of deep customer insights and getting close to customers (Klitsie, Price and de Lille, 2018). This is done in the problem diamond which highlights empathising with customers to find the real problem from a functional, social, and emotional dimension (Christensen et al., 2016). To find these deep customer insights it is important for the innovation practitioner to look beyond. If the innovation practitioner solely relies on data and customer profiles to find correlation it will not satisfy the need of finding the real problem. Instead, a focus on causality is needed (Christensen et al., 2016). When the problem is defined the innovation, practitioner uses imagination and creativity to ideate a solution that is prototyped, tested, and evaluated (Kakatkar, Bilgram and Füller, 2020). Prototypes can be evaluated against the level of fidelity, meaning how well the prototype represents the innovation to be (Tschimmel, 2012). Appendix 1 includes exact definitions of each phase in both diamonds.

2.1.4 Design thinking tools

For the process to be effective and to facilitate communication among the innovation practitioners involved, there are a plethora of design thinking tools (Chasanidou, Gasparini and Lee, 2015; Liedtka and Ogilvie, 2011). Design thinking tools can improve innovation by mitigating cognitive biases, such as that customers sometimes say one thing and do something else, the say-and-do gap or that current state affects thoughts about a future state (Liedtka, 2015). These tools are analogous post-it notes, whiteboards and papers but can also be digital, such as software tools (Chasanidou, Gasparini and Lee, 2015). Chasanidou Gasparini and Lee (2015) showcases software-based solutions on several of these tools. This implies how design thinking practice has the potential to adapt to the modern times and digitalisation.

The nature of design thinking, being a popular method in practice as well as a theoretical field (Dell'era et al., 2020; Johansson-Sköldberg, Woodilla and Çetinkaya, 2013), with different representations of the process makes it hard to find common ground for which are the most effective tools. Figure 1 summarise selected design thinking tools relevant for this study, based on various authors interpretations (Baldwin and von Hippel, 2011; Brown and Katz, 2011; Chasanidou, Gasparini and Lee, 2015; Furr and Dyer, 2014; Gasparini and Chasanidou, 2016; Liedtka, 2015). The tools have been placed in the associated phase of the double diamond to fit the theoretical framework of this study. Therefore, these tools can be understood as a toolbox for the innovation practitioner to pick from to facilitate the overall aim of that phase. Tools support innovation practitioners in activities such as need-finding, idea-generation, and idea-testing (Seidel and Fixson, 2013; Liedtka, 2015). A common feature of these tools is that they facilitate innovation practitioner's engagement with customers to learn about their experience (Elsbach and Stigliani, 2018).

Figure 1. Design thinking tools and methods

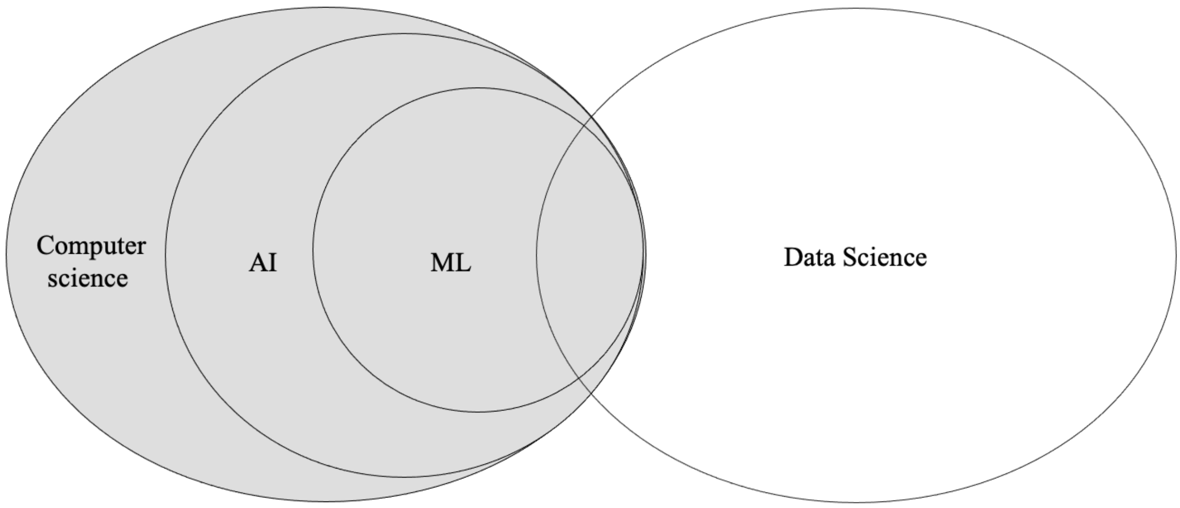


2.2 Artificial intelligence

Researchers and practitioners have not gathered behind an exact, common definition but artificial intelligence (AI) is essentially concerned with having computers executing tasks that normally require human intelligence (Craglia et al., 2018). The definition employed in this study is AI as "the field that studies the synthesis and analysis of computational agents that act intelligently" coined by Pool and Mackworth (2010). The aim with the chosen definition is to emphasise that the output is much like human intelligence but also acknowledge that the output is reached in a different manner than how humans would act to solve a problem. The quest for learning how computers can solve problems on their own have driven the development of AI as a research field since the 1950's (Duan, Edwars and Dwivedic, 2019).

There are two broad types of AI: narrow and general (Adams et al., 2012), or strong and weak as others name them (Verganti, Vendraminelli and Iansiti, 2020). The type of AI applied in settings beyond research labs is narrow, thus only able to do what it is designed for (Adams et al., 2012). This type of AI can perform advanced tasks, such as identifying cancer tumours, if it is trained in the right manner. Since narrow AI is explicitly created for a specific task, it cannot perform tasks outside what is specified to the algorithms (Adams et al., 2016). The other type, the general AI, is not restricted to a certain role but instead resembles human general reasoning. This type is still only applied in research labs, if at all (Iansiti and Lakhani, 2020; Adams et al., 2020). AI, whether broad or narrow, is the science of mimicking human abilities and has a broad span of application areas, from sale forecast predictions and image recognition to self-driving cars. The more advanced, the larger the number set of rules - algorithms, are used to perform the task (Iansiti and Lakhani, 2020).

Figure 2. Machine Learning and Artificial Intelligence



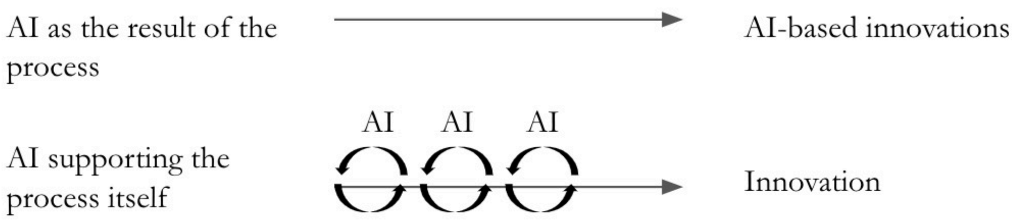
Within the broader science of AI, machine learning (ML) is a subfield (Figure 2) that uses probabilistic models to solve problems and the focal concern for evaluating the ability to solve problems is level of prediction. This prediction accuracy is improved as the machine learns, until an acceptable level of intelligence is achieved. Hence, prediction is central to intelligence and eventually these predictions are what enable ML to perform tasks that were previously attributed to humans (Agrawal, Gans and Goldfarb, 2018). There are three general machine learning approaches to achieve artificial intelligence capabilities: supervised, unsupervised and reinforcement learning (Iansiti & Lakhani, 2020) (See appendix 2). There are some additional ML sub-techniques that are important to highlight for the purpose of this study. Generative adversarial networks (GANs) are techniques with which various input data in the form of images, sound and video are replicated to close-to-real copies of the input data (Zhou, Zhou and Zelikman, 2020). A common application area for ML is to combine it with natural language processing to achieve sentiment analysis to interpret emotions from texts. Another application linked to design is computer aided design driven by ML. How these techniques are used will be reflected in section 4. Empirics.

A crucial distinction to make for the purpose of this study is the difference between AI and big data analytics. With the rise of IoT and other digital touch points, an enormous amount of data is collected and later used to “uncover and resolve business issues” (Lee and Lee, 2015), but these techniques are not necessarily based on AI. The term big data describes any data of sufficient size to alter contemporary analytical techniques (Blackburn et al., 2017) and the large quantities of data introduces challenges for companies of how to leverage the data streams to create value. More than only describing the data, AI and ML techniques can support in predicting and prescribing actions based on the large data streams (Blackburn et al., 2017). However, research focusing on big data can provide important insights to the challenge we have taken on in this study. For example, there are studies suggesting implications of big data effects on R&D management (Blackburn et.al, 2017).

2.3 AI in the innovation process

The focal point of this study is how AI can enhance the innovation process. The deliberate focus on AI in the process and not on AI solutions as the result of the process cannot be emphasised enough. The difference between the two are visualised in figure 3. During the recent years it has become evident that scholars have taken on the challenge to establish an understanding of the broad possibilities and implications of AI in the process (Cantamessa et.al 2020; Cautela et.al., 2019; Haefner et.al 2021; Kakatkar, Bilgram and Füller, 2020; Verganti, Vendraminelli and Iansiti, 2020; Vocke, Constantinescu and Popescu, 2019).

Figure 3. AI in the process and as the result

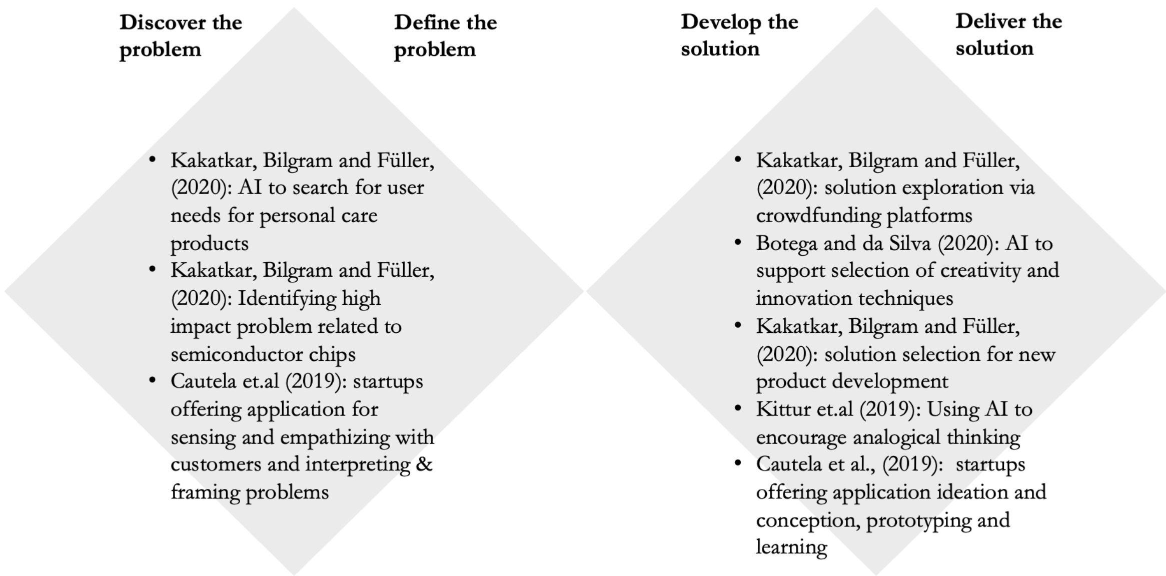


The relatively new field has developed from a more hypothetical approach (Stern, Henderson and Cockburn, 2018). More recent papers provide empirical relevance to the field (Cantamessa et.al 2020; Cautela et.al., 2019; Haefner et al., 2021; Kakatkar, Bilgram and Füller, 2020; Verganti, Vendraminelli and Iansiti, 2020). Insights from previous research can be summarised on two different levels. The first level concerns the innovation process itself and the other level is about how using AI can alter innovation practitioners' thinking, in other words the principles.

2.3.1 Process

A common denominator to understand AI in the innovation process is to refer to various steps in a design thinking process (Cautela et al., 2019; Kakatkar, Bilgram and Füller, 2020). A limited number of papers have explicitly used the double diamond to learn about the combination of AI and design thinking and its effect on innovation management theory (Kakatkar, Bilgram and Füller, 2020; Li, Dong and Liu, 2020). Aligned with the method of this study, an overview of the application areas from existing articles on the topic are positioned within the double diamond framework in figure 4.

Figure 4 – Previous research on AI and design thinking



Regarding the problem diamond, it is exemplified how AI can support in the initial steps of this diamond. In general, it can be concluded that the main effect with AI is the possibility to efficiently empathising with more users and obtain insights about needs and potential problem areas (Kakatkar, Bilgram and Füller, 2020). The main findings from the solution diamond are that AI can support brainstorming sessions and use clustering to inspire possible solutions (Botega and da Silva, 2020; Kakatkar, Bilgram and Füller, 2020; Kittur et al., 2019). It is also found that AI can support selection of the most promising solutions (Kakatkar, Bilgram and Füller, 2020).

When synthesising the above identifications, it appears possible that AI can alter activities in a phase (Haefner et al., 2021; Cautela et al., 2019; Kakatkar, Bilgram and Füller, 2020). Other authors have taken it to a more extreme and suggested that the whole design thinking process itself can change to become driven by AI. Verganti, Vendraminelli and Iansiti, (2020) refer this as problem-solving loops, a loop involving collecting real time data from customers which directly can inform the design of the product, to better satisfy needs of individuals using the product. This is also discussed by Cantamessa et al., (2020), as a data-driven paradigm where a new ecosystem is created. This study will adopt both perspectives. On the one hand, it is acknowledged that AI can alter an activity in isolation, referred to as AI changing a design thinking tool of a specific phase. On the other hand, a more advanced application of AI can alter the whole process at once.

2.3.2 Principles

Beyond affecting the process, authors investigate how AI can change the design principles, the way to *think* about design. While only one article explicitly uses the design principles (Verganti, Vendraminelli and Iansiti, 2020), researchers agree that implementation of AI in the innovation process will foster a new way to think about design (Cantamessa et.al, 2020; Kakatkar, Bilgram and Füller, 2020). Based on the limited amount of research, a few papers explore changes in how innovation practitioners think.

In terms of *user centeredness*, AI can make innovation practitioners understand needs better. This can be done by a more customised and personalised view of customers, and a more continuous interaction with customers (Cantamessa et.al, 2020; Verganti, Vendraminelli and Iansiti, 2020). *Iteration* will also change. When it is possible to collect real-time data on customers continuously, this makes it possible to also iterate the solution when it is in use making testing and validation coexist. This can result in a continuous process of experimentation and adoption, where every interaction with a customer can be an opportunity for new experimentation (Cantamessa et.al, 2020; Verganti, Vendraminelli and Iansiti, 2020). The *hypotheses driven* way to think about future scenarios is advanced when using AI and predictions can be used to support a more hypothesis driven way of thinking (Verganti, Vendraminelli and Iansiti, 2020). It has also been concluded that when AI better answers existing hypotheses it can also push the innovation practitioners to ask better questions due to the complex interaction between variables (Kakatkar, Bilgram and Füller, 2020). The research on *visual communication* is limited and to our knowledge, there are not yet any authors that explicitly discuss the effect of AI on this principle. To some extent, the importance to visualise the output from AI into color-coded clusters to increase understanding for the innovation practitioner has been discussed previously (Kakatkar, Bilgram and Füller, 2020). Finally, in terms of *multidisciplinary,* authors have concluded that the interaction between innovation practitioners and data scientists will be closer interlinked (Cantamessa et al., 2020; Kakatkar, Bilgram and Füller, 2020). This will result in a changed relationship between customers and manufacturer in terms of negotiation power (Cantamessa et al., 2020).

2.3.3 Creativity and decision-making

Recalling the fundamental cornerstones of design thinking, creativity and decision-making are key concepts. One of the most prominent researchers in the field has raised the question of whether AI can support innovation processes given that highly creative tasks cannot be fully automated (Kakatkar, Bilgram and Füller, 2020). This statement entails a subjective point that is highly discussed within the field; no one really knows what AI can and will be able to do. The effect of AI on business activities are limited by the degree of creativity needed to execute the activity and the more creativity, the harder it is for AI to add value. Others are counterarguing this by elaborating how AI can execute creative tasks such as coming up with jokes or producing music (Boden, 1998). However, in the same article, it is suggested that AI-models cannot assess their own findings. Only humans can evaluate ideas as novel, surprising and valuable, conditions that must be met for an idea to be considered as creative. Thus, a human-machine interaction is needed to unleash the full creative potential of algorithms. This ties back to the discussion whether AI can replace humans in their activities or rather that AI can enhance humans in what they do. The enhanced effect, the computational creativity, has the objective to stimulate or replicate human creativity. This involves an element of enhancing human creativity without being creative itself (Besold, Schorlemmer and Smaill, 2015; Strohmann, Siemon and Robra-Bissantz, 2017). From this perspective machine learning can play an important role (Toivonen and Gross, 2015). However, technological advancement in mainly reinforcement learning, could potentially be helpful in generating novel ideas, making the AI creative (Heafner et al., 2021).

When integrated in the innovation process AI can guide the innovation practitioner to make decisions based on data (Barro and Davenport, 2019; Kakatkar, Bilgram and Füller, 2020) AI will also be able to execute autonomous decision-making, according to the problem-solving loops described earlier. The algorithm will develop different interfaces for different users, and thus independently make decisions without ongoing human intervention (Verganti, Vendraminelli and Iansiti, 2020).

2.4 Dynamic Capabilities

An additional theoretical lens is needed to fully answer the research question what opportunities exist when integrating AI into the innovation process. Applying ML to the innovation process must be a concern for the strategic levels of a firm, since it has the potential to enhance the way organisations react to its increasingly competitive environment (Heafner et al., 2021). An additional lens will facilitate identification of opportunities on a strategic level, about the long-term implications of integrating AI into the innovation process.

The dynamic capabilities framework (Teece, Pisano and Shuen, 1997; Teece, 2007) has been widely used in innovation management studies (Ciampi et al., 2021; Bäckström and Bengtsson, 2019; Warner and Wäger, 2019) and can be understood as a firm's development process to adapt to its environment. Adding a strategic focus emphasises that design is not just a phase in the process of developing new products, but rather a critical capability and asset for the firm (Nobel, 2011). Scholars propose that design thinking could be a dynamic capability (Klitsie, Price and de Lille, 2018) but also urge for more research on the topic (Johansson-Sköldberg, Woodilla and Çetinkaya, 2013).

Teece (2009) divides dynamic capabilities into three dimensions; capacity (1) to sense and shape opportunities and threats, (2) to seize opportunities, making choices and moving from analysis to action and (3) to reconfigure and transform the business enterprise's intangible and tangible assets. These three dimensions can be understood as the firm's capabilities to integrate, build, and reconfigure internal and external competences in a rapidly changing environment (Teece, Pisano and Shuen, 1997) and can result in new sources of competitive advantage (Eisenhart and Martin, 2000). Sensing capabilities can be described as a firm's absorptive capacity and its ability to recognise new information (Cohen and Levinthal, 1990).

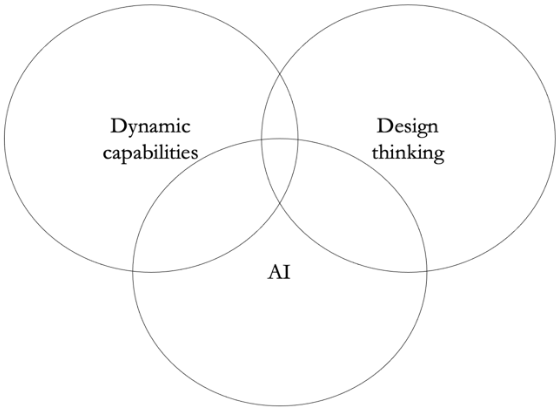
It is proposed that new digital technologies can have an impact on dynamic capabilities, favouring a rapid and more innovative approach (Ciampi et al., 2021; Hercheui and Ranjith, 2020). It is even proposed that the capability to use new emerging technologies can also in itself be considered a dynamic capability (Wamba et al., 2017; Kim et al., 2011) positively impacting innovation (Ciampi et al., 2021). With the identified linkage between first, innovation processes and dynamic capabilities and second, digital technologies and dynamic capabilities, the next step would be to learn more about the linkage between the three. Thus, dynamic capabilities are arguably important to firms but for the purpose of this study, its link to innovation management must be clarified. Scholars have made the connection between dynamic capabilities and innovation management in general (Ceptureanu and Ceptureanu, 2019; Nolsøe Grünbaum and Stenger, 2013) but only few studies have made the connection between dynamic capabilities and design thinking in particular (Cautela and Zurlo, 2012; Cousins, 2018; Klitsie, Price and de Lille, 2018; Liedtka, 2020; Noble, 2011).

2.5 Research Gap

AI and design thinking share the characteristic of supporting problem-solving. This paper is positioned as part of the emerging field that tries to understand what role AI can have during the innovation process and not as part of the solution (Cantamessa et.al 2020; Cautela et.al., 2019; Haefner et.al 2021; Kakatkar, Bilgram and Füller, 2020; Verganti, Vendraminelli and Iansiti, 2020). However, the need to further explore the opportunities for ML integrated into the innovation process is acknowledged by several authors (Botega and da Silva, 2020; Vocke, Constantinescu and Popescu, 2019). Cautela et al. (2019) is especially emphasising the existing literature gap between AI and design thinking.

Applying AI to the innovation process can support firms in responding to the increasingly competitive environment (Haefner et al., 2021). To our knowledge, there is little previous research that looks at how the use of AI can affect not only the process and principles of design, but also impact companies on a strategic level. Although we find that the link between design thinking and dynamic capabilities has been made by researchers before (Cautela and Zurlo, 2012; Cousins, 2018; Klitsie, Price and de Lille, 2018; Liedtka, 2020; Noble, 2011), there are yet no papers with explicit focus on the role of AI here. At the same time, previous research shows that introducing AI to design has led to a paradigmatic shift (Cantamessa et al., 2020; Verganti, Vendraminelli and Iansiti, 2020) and how the innovation process links to dynamic capabilities has been proved. However, to our knowledge, no one has put together the three to explore how AI-enhanced innovation can become a critical capability for the firm to compete with.

Figure 5. Overview of methodological gap



A significant methodological gap is identified among existing studies on AI and innovation processes (Figure 5). The gap concerns the limited number of case examples, where previous researchers either highlighting one application is each phase of the double diamond (Kakatkar, Bilgram and Füller, 2020), or using a limited number of examples to highlight how the practice of design change (Cantamessa et al., 2020; Verganti, Vendraminelli and Iansiti, 2020). These studies are based on preliminary anecdotal evidence, stat-up databases, officially published material, or authors own involvement in projects (Cantamessa et.al 2020; Cautela et.al., 2019; Kakatkar, Bilgram and Füller, 2020; Verganti, Vendraminelli and Iansiti, 2020). There is a quest for more enriched data collection methods by using in-depth interviews (Cautela et al., 2019). Using in-depth interviews in this study will shed light on innovation practitioners' thoughts around opportunities and strongly reflect the practice.

2.6 Presentation of theoretical framework

Cantamessa et al. (2020) identify that digitalisation can affect design within a company on various levels. It can influence how people work on an organisational level, how the process is managed and how the company operates. A similar level-approach is applied here to explain what opportunities exist when integrating AI into the innovation process.

Operational lens

Operational opportunities are identified through the double diamond to obtain insights on a process level. The focus is on how innovation practitioners do innovation work, and the case examples are mapped according to the appropriate phase in the double diamond. It is important to note that each case provides a single, or a few, concrete examples of how AI can support innovation processes.

Managerial lens

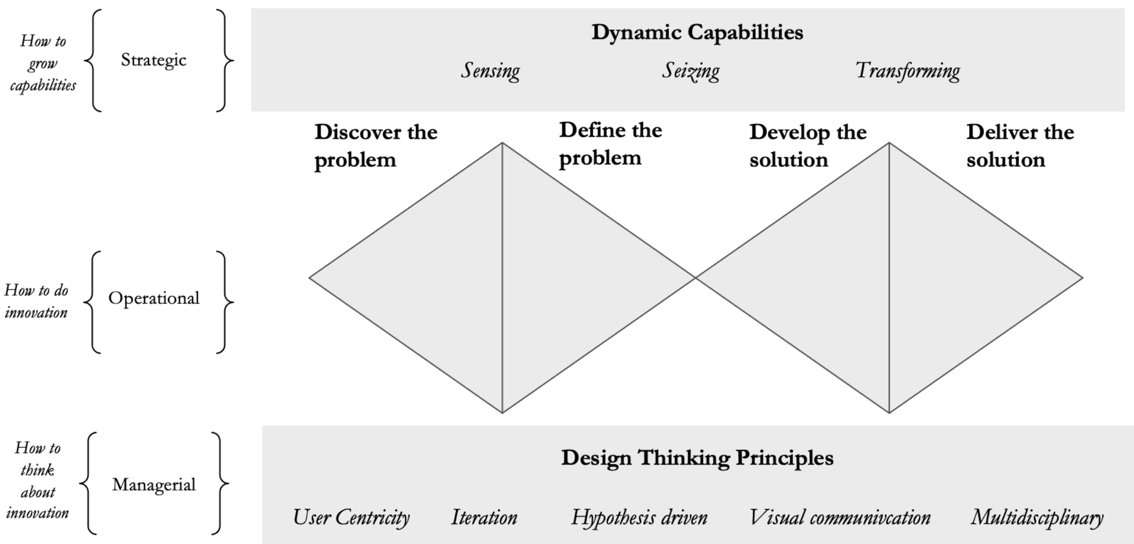
The design thinking principles facilitate an understanding of the opportunities on a managerial level and convey how AI can change how managers think about design. This is especially important since these principles are what makes design thinking a unique method, compared to the traditional linear innovation process models.

Strategic lens

A lens of dynamic capabilities clarifies how AI in the innovation process can support the company in building dynamic capabilities to strengthen their competitiveness. Aligned with previous research, it is here argued that involving AI will have effects beyond the process and principles of design thinking. Since design thinking can influence a company's dynamic capabilities (Cousins, 2018; Liedtka, 2020), such a lens must be included to fully understand the opportunities that AI can contribute with.

Hereby, the following framework (figure 6) is proposed to accommodate an investigation on what opportunities that can spur from integrating AI in the innovation process.

Figure 6. Theoretical framework



3. Methodology

In this section, the methodological considerations are disclosed, to aid an understanding of the research approach used.

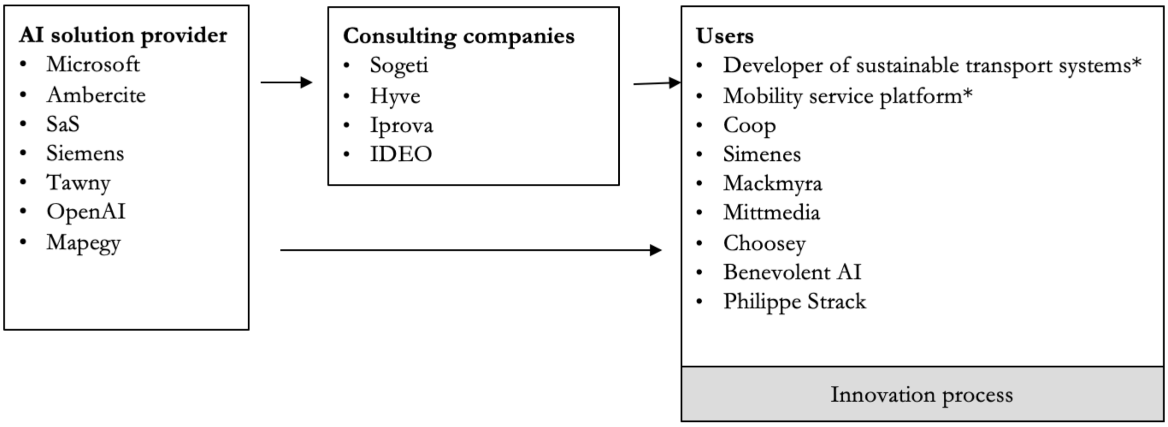
3.1 Pre-study

A pre-study was conducted to explore the chosen research area and appendix 3 and appendix 4 consist of a detailed list of interviewees, rationales, and learnings.

The four scholars gave an overview of the combination of AI and innovation processes. These initial interviews highlighted important concepts that had implications for the formulation of interview questions. For example, the need to clearly distinguish between AI as the result of the innovation process as opposed to AI used during the innovation process. Furthermore, the scholars supported access to interesting case examples by sharing what they knew about contemporary companies. Finally, the scholars shared prominent literature, which ensured awareness of what to include under section 2. Previous Research. The scholars, in combination with the literature study, facilitated a theoretical understanding. To build practical understanding, it was critical to identify suitable organisations and people to interview therefore 19 practitioners have been interviewed. The initial search process for case companies was based on the following criteria, a.) high technological maturity level b.) clearly stating that they work with AI, and not just advanced data analytics c.) designated resources to innovation work.

The outcome of the pre-study with practitioners was three-fold. First, it became clear that even though companies use AI, the use of AI specifically in the innovation process is still very rare. This realisation implied an extension of the scope, and not to limit the sample to only include for example Swedish companies. Second, for several of the interviewees, AI in the innovation processes were two very distant fields. Interviewees associated AI with automation and optimisation of manufacturing processes or sales planning, and not so much with the innovation process as such. However, several companies interviewed had AI-initiatives supporting the innovation process but not to such an explicit extent than this study first imagined. This urged a definition of clear decision rules for the selection of cases to include in this study, which will be further elaborated on in section 3.3. Finally, another key insight was the interlinks between actors in a supply chain (see figure 7), which led to the realisation that it is necessary to search for cases over the supply chain and not just among users.

Figure 7. Supply chain



*Company requested to be anonymous

An overall reflection from the pre-study was that innovation is different in different industries, which implies that the opportunities to use AI varies. This led to the decision not to limit the study to a certain industry or type of company. This facilitates an understanding of different application areas, to cover a scope of opportunities with AI in the innovation process. This, in combination with the learnings, contributed to setting up the appropriate approach for the main study.

3.2. Research design and approach

3.2.1 Scientific research approach

The chosen research question addresses a topic about which little is still known, which places this study in the frontier of a knowledge creation practice, with the ambition to explore appropriate theories and concepts. Innovation, design thinking and strategy have different origins (Johansson-Sköldberg, Woodilla and Çetinkaya, 2013) thus the underlying assumptions and epistemologies can diverge. Additionally, integrating AI in innovation processes is an ongoing practice, hence the reality studied is shaped by the actors involved in it, human as well as non-human (Callon, Méadel and Rabeharisoa, 2002). When exploring the novel field and contribute with building knowledge, an interpretivist approach is deemed useful. It is acknowledged that design thinking discourse can have different meanings in various contexts (Johansson-Sköldberg, Woodilla and Çetinkaya, 2013). Such a view is applied in this study and the ambition has been to understand how chosen concepts are expressed in the different situations studied.

3.2.2 Abductive approach

Aligned with the ambition to elaborate on existing theory from design thinking and dynamic capabilities in the context of AI, an abductive reasoning approach was used (Mantere and Ketokivi, 2013). Through an iterative process, theory and the empirical context has been simultaneously explored. The starting point was to research design thinking and the associated theoretical gap. Thereafter empirics guided in creating a theoretical framework. The iterative method facilitated discovery of theory about dynamic capabilities. This was especially critical since the realisation was that design thinking alone would not explain the research question. The abductive reasoning allowed for using theory as a guide and adapting it to the empirical findings to further extend knowledge (Ketokivi and Choi, 2014). An abductive approach resonates well with the exploratory character of this study (Mantere and Ketokivi, 2013).

3.2.3 Qualitative case study

Due to the limited number of companies explicitly using AI in their innovation processes, this study adopts an exploratory attitude, using a qualitative approach. AI and innovation processes are considered two distant fields and combining the two oftentimes requires an explanation of what type of activities that could be attributed to the combination. Several companies approached for the pre-study gave an initial confirmation that they worked with AI in their innovation processes but once interviewed, no clear AI projects were identified. The same goes the other way around, some companies hesitated with confirming, but after an hour of interviewing, some promising on-going projects were found. Thus, a qualitative approach ensures that concepts and activities can be properly understood (Yin, 2009; Miles and Huberman, 2002; Ellram, 1996). Furthermore, case studies are regarded as appropriate in the field of innovation management (Goffin et al., 2019) and there is a quest for in-depth interviews on AI and innovation processes (Cautela et al., 2019). The extensive pre-study ensured quality of the case interviews (Goffin et al., 2019), since the research questionnaires were pre-tested and revised (Paré, 2003).

3.3. Data collection

3.3.1 Interviews and desktop research

The data collection consists of two interconnected parts. The first part is the qualitative, individual interviews with representatives from companies identified through the pre-study. The initiatives described in the interviews have been complemented with information from websites, podcasts, and company reports. Using multiple sources of data have enabled us to establish triangulation (Yin, 2009; Denizin, 1970 referred to in Bryman and Bell, 2019). Collecting data in this way enables for both stronger substance in the data as well as generating different insights about opportunities (Goffin et al. ,2019). Since not all identified companies were available for interviews, but to get a breadth in different applications of AI in the innovation process, these companies are included as desktop research. This second part consists of data collected via their web pages and official documents. Information published by the company itself or public reports makes it possible to validate the source, in a more straightforward manner than for the interviews.

The main purpose of conducting interviews has been to understand the application of AI in the innovation process in practice. This gives depth in case examples and interviews were semi-structured using an interview protocol as a guide (Yin, 2009) (See appendix 5). The protocol was iterated as new themes were discovered. Interview questions centred around how and where AI has been used in innovative work and which techniques were used. Interviews were flexible in style and probe questions were used when needed. The semi-structured approach allowed us to be adaptable depending on the specific case example that was presented initially by the respondent (Yin, 2011).

3.3.2 Sample

The pre-study was important for the research design and sample. Initial interviewees were identified based on the initial criteria outlined in section 3.1. Interviewees have further suggested other relevant companies to approach, in line with the snowball method (Bryman and Bell, 2019). This aligns with the novel character of the field and the explorative approach chosen for the study but can be criticised because the sample will not represent the population (Bryman and Bell, 2019). However, the ambition has not been to create an exhaustive list of companies using the proposed methods and techniques but rather use the case example to convey the breath of possibilities over the double diamond process. The selected companies are presented in figure 7, mapped according to their position in the supply chain of AI technology.

The limited supply of companies that explicitly work with AI in the innovation process implies a risk of selecting case companies opportunistically (Benbasat, Goldstein and Mead, 1987). Two criteria were applied for both interviews and desktop cases to avoid such behaviour. First, the company must be able to clearly state that they are using AI in particular ML and not just data analytics. Second, ML is used in a way that reinforces innovation. This means that ML is enhancing the implementation of novel and useful ideas for new products, processes, services, business models and structures, in line with this study's definition of innovation. This can be contrasted to automating or making current activities more effective, which is not an activity of innovation aligned with the meaning applied in this study.

3.3.3 Interview process

Relevant interviewees within the above-described companies were selected, based on if their position related to either innovation or AI. In most of the cases, a person higher in hierarchical position acted as a gatekeeper to allow access to collecting data from the organisation. This person was able to provide an overview of projects related to innovation and AI and refer us to the relevant people to interview.

A total of 16 interviews were conducted (appendix 6), lasting between 30 - 60 min. All except one were conducted virtually through Teams or Zoom, since Covid-19 restrictions or geographical distance forbid physical meetings. The fact that they were not conducted physically introduces the risk of a reduced understanding of the interview data (Bryman and Bell, 2019). However, all interviews were conducted with cameras, hence not as distant as it would have been with an audio call. Interviews were recorded with the consent of the respondents and soon thereafter transcribed to remember no verbal impressions and request clarification if needed (Brinkmann, 2013). Interviews were led by one of us researchers while the other took notes and probed when necessary. Language, Swedish or English, were chosen depending on the preference and native language of the interviewee. Hence, some interviews were eventually translated, an activity made with caution and including inviting interviewees to double-check and confirm the translated quotes (Hambleton, 1993). Also, the non-translated interviews were sent for confirmation from the interviewees themselves, where they could give their consent and withdraw their participation from the study. No withdrawals were noted but some small corrections were made, especially regarding the technical definitions of the AI or ML used. In conclusion, this circumvented researcher bias and misinterpretations (Goffin et al., 2019). Minor adjustments have been made to make the quotes understandable for the reader (Bryman and Bell, 2019).

3.4. Data analysis

Interview transcripts were red by both researchers to recap the understanding of the different case examples. Data was coded by both researchers independently to ensure quality (Barratt, Choi and Li, 2011). The first step of analysis included identification of tools, methods and activities mapped against the double diamond. This gave an overview of phases affected by the application of AI (see appendix 8). Second, the transcripts were coded to find themes of opportunities aligned with the design principles (see appendix 9 & 10).

From interview data, it became evident that using AI in the innovation process has effects beyond what was identified so far. Patterns among the coded interview data suggested implications on a strategic level which required revisiting theory to understand the data (Bryman and Bell, 2019). After such iterations in line with the abductive method (Mantere and Ketokivi, 2013), this data was mapped against the framework of dynamic capabilities. Appendix 8 display how these insights were obtained.

3.5 Critical Reflection on the Research Quality

Above section includes reflections on measures taken to ensure that interviewees understood the interview questions despite a complex topic, combining AI and innovation. A reflection of risks with using a virtual medium for conducting the interviews is also included. To further maintain trustworthiness, the development of the study was guided by criteria for qualitative research described below (Bryman and Bell, 2019).

Credibility

Transparency in how data was collected and analysed has been a key priority and the aim with both section 3.4 as well as the included appendix is to ensure understanding in decisions made and how conclusions were made. Triangulation of different sources, interviews and desktop research further support credibility of the result (Guba and Lincoln, 1994). A final important note on credibility here is that AI and innovation are high level concepts with different meanings for various people and companies. To validate our interpretation of the interviews correctly, interviewees were invited to read and confirm the transcripts, aligned with earlier description.

Transferability

Rather than making results generalisable, the objective of qualitative research is to describe a phenomenon at a certain point of time (Bryman and Bell, 2019). However, the ambition has been to include enough details in the description to help the reader determine if the findings could be transferable (Lincoln and Guba, 1985). An important reflection on the selection of case companies that must be highlighted is that application of AI and innovation can differ between companies and various industries which can reduce the transferability of results obtained. To help the reader to determine if the findings could be applicable in other situations than the one described in the case, a thick description of the context for each case example (Geertz, 1973 referred to in Bryman and Bell, 2019).

Parsimony

Parsimony is a critical assessment criterion in qualitative research when building theory. This study is concerned with extending current theory and it is critical to avoid presenting findings in an overly complex manner that does not add value (Cutcliffe and Harder, 2009). To achieve a high level of parsimony, work has iterated between theory, empirics, and analysis to ensure that only the most relevant insights are brought up. Furthermore, when possible, concepts have been used in a simplified manner. For example, when talking about AI and design in general.

Confirmability and reflexivity

It is recognised that our role as researchers influence the way the study is conducted and eventually the development of the findings. This is acknowledged, to convey that we act in good faith throughout the study (Bryman and Bell, 2019). We reflected upon this before creating the study and concluded that our background business school students and previous work experience might influence opinions about AI and its potential. To maintain a high level of reflexivity we have been aware about this matter and continuously evaluated us and the way we interpret theory and empirics.

Ethical considerations

The ambition has been to maintain the highest level of ethical consideration and the ethical principles outlined by Diener and Crandall (1978) have guided to ensure this. Anonymisation was made after careful consideration together with our supervisor. Names and roles are not disclosed, to ensure anonymity for interviewees and align with current GDPR rules. However, company names are displayed, except from two that requested anonymity. For this study, company names can for example allow interested readers to review company material on their own. Additionally, the role of case examples in this study is to emphasise potential and show success cases, thus, to be mentioned has a positive connotation. By asking for consent before disclosing information published here, the interest of interviewees and companies were further ensured.

Safety, both data safety and physical safety has been evaluated. Recording interviews were made upon consent from participants and manually transcribed to ensure the highest level of data safety. For example, no audio files were uploaded on external websites that automatically transcribe. All recordings were deleted after being transcribed. To comply with the regulations regarding the ongoing pandemic and limit the risk of contagion, interviews were conducted virtually. One interview occurred physically upon request from the interviewee but under cautious circumstances including safe distance.

4. Empirical Findings

This section will present the empirical findings based on both desktop research and interviews with representatives from selected organisations.

4.1 Interview empirics

The following case examples are based on in-depth interviews.

4.1.1 Problem diamond

The following cases exemplify how each phase can alter the innovation process in the discover and the define phase. Each case example is a short summary of how the example is defined as an opportunity enabled by having AI supporting the innovation process.

Case example A.
The Nordic grocery chain - Coop

Case example A is from Coop, one of the largest grocery chains in Sweden. For retail companies like Coop, a main priority is customer centricity and to understand customer needs. Traditional methods for this are interviews and observations but with the integration of AI, technology is leveraged also for innovative work. A main challenge with the traditional methods has been the say & do gap. Another challenge related to observations is the complex store environments that characterise retail operations, where various mediating factors can contribute to the observed effect. Previously, purchase and payment data has been used for understanding customers. Thus, knowledge about customer needs has mainly been created based on what they purchase, once leaving the store or leaving the online checkout.

This case example highlights an increased chance to get to know customers. Coop has developed an application called Scan&Pay that is accessible for all customers through an app. Customers scan desired groceries with their phone and can make the purchase via the app. The overall objective is to create a smoothness customer experience and allow customers to check out from the store without passing the traditional checkouts. However, the application is not only enhancing the customer touchpoints. Collected data can facilitate an increased understanding of customers behaviour in store, behaviours that Coop are not able to capture via traditional methods such as interviews and observations.

A1. "It is about insights. What people can put in words are the needs that are easy to discover. What is difficult to see are the things that are hidden to us humans. It is not until you connect streams of data and use ML to define clusters that you can find patterns, and eventually insights."

Finding hidden needs or removing the gap between what people say and do is emphasised as a benefit with this new application.

A2. "People are not that honest, not even to themselves [...] Therefore, there is a need to analyse data because our behaviour oftentimes says something else. This is something that you can do with AI [...]"

The application facilitates understanding customers on a more granular level. Coop reasons that learning about customer behaviour in this way, put them in a better position to also impact the behaviour. In the extension, Coop intends to use this data to design offers for each specific customer in real time based on actions during the customer journey. The algorithm will be able to recommend suitable groceries based on your earlier buying behaviour and goal settings for example health, sustainability, or a specific budget. At the same time, Scan&Pay itself becomes a tool for detailed understanding of the customer journey.

A3. "We can now track how the customers move and navigate in the store. With the app, the customer journey will no longer end in the physical checkouts, but instead by the vegetable shelf."

Another important element in innovation for Coop has been to create personas. These personas have traditionally been created based on demographics and purchase behaviour, but with the use of AI, an in-store behaviour element can be added to these personas.

A4. "Traditionally we have done personas. For example: 65-year olds, that are not tech savvy and eat buns and cakes. However, I know a lot of 65-year olds that are crazy tech savvy [...] then you can cluster customers based on behaviour. This clustering is something that humans cannot do; humans cannot hand pick every single individual."

Case example B.
The mobility service platform - Anonymous*

Case example B is from a mobility service platform, focusing on car sharing in cities. The internal activities revolve around understanding users' specific needs and how to solve them. Earlier, innovation practitioners have approached customers and engaged in discussions about their specific needs. In recent projects, AI has been used for several such activities. This is exemplified in especially two projects, one regarding fuelling and the other regarding damages. These are problems that the organisation previously has discovered, so-called wicked problems, and the innovation teams' task is then to identify needs and find solutions for them. AI is used in the problem phase. Through sentiment analysis, the innovation team uses Qualtrics to store data from surveys and extract sentiments from it. The innovation team searches for positive or negative associations with fuelling or damages and thereby AI has helped identify different opportunity areas around the problem. Thereafter humans have interpreted the result and created How-Might-We questions to eventually find a suitable solution.

In this way sentiment analysis based on ML is used to generate insights to understand and reframe the problem. This creates a deeper understanding of customers. With support from AI, data streams are analysed to test initial hypotheses about the problem.

B1. "Another hypothesis was that, if people have a long journey, they are more likely to refill their car, but then we analysed data and saw that no, that is not true. It was a way to invalidate our hypothesis."

Furthermore, this workstream has influenced ways of working within the innovation team and in the company. AI has changed the way decisions about what to innovate around are taken.

B2. "In the past, people with a strong voice said [let's do this], now we instead did this, based on the [ML] process."

Case example C.

Developer of sustainable transport system - Anonymous*

Case example C is a company focusing on the development of sustainable transport systems. The department of interest for this study specialises in collection of data from trucks and analyses and enriches data to generate information and insights to generate insights that can be used in new product development of trucks.

C1. "From hardware in vehicles to the fact that we make data available for product development."

The innovation process normally starts with a problem that emerges in multiple parts of the organisation. Thereafter it usually centres around customer understanding and segmentation to create customer satisfaction.

C2. "In all innovation processes we have a great customer understanding machine learning, data driven decision making or data augmented decision making, is a method choice depending on what innovation issue you want to solve."

A project of particular interest for this study is one where the company aimed to develop a novel type of sales support tool. In this project the group worked according to design thinking principles, using sprints, cross-functional groups, and a hypothesis driven approach. The outcome was a tool in which individualised, and data driven sales recommendations towards a more sustainable customer portfolio were made using machine learning capabilities.

Case example D.
The media company – Mittmedia

Case example D is Mittmedia, a large media group working in the physical as well as digital landscape. The part of the media group of interest for this study is primarily working with local newspapers. The company has worked with various types of surveys or phone calls to understand customer opinions. For example, once a customer cancels a newspaper subscription, the company has approached a leaving customer with a survey asking for feedback to understand reasons for cancellations.

Mittmedia has leveraged opportunities with industry digitalisation and has initiated two AI-based projects; churn prediction and personalisation of user content. Churn has traditionally been a metric that defines cancellation rates among subscriptions, a way to understand customer dissatisfaction in retrospect. Via a ML model, Mittmedia can now detect customers who are likely to cancel their subscriptions, in other words churning.

D1. "We would rather know about the future tendencies to churn, than how many people that churned yesterday."

This was mainly possible due to the increased data points available about customers. By tracking how customers interact with the company in various channels, Mittmedia managed to increase their understanding of factors that increases the risk of a customer churning.

D2. "It gives us insights we need; the alternative is to call subscribers that cancelled."

Eventually, team members from the churn project group describe how they, when investigating reasons for churn, saw their customers in a new light. For example, previous assumptions about the effects of push notifications were disproved and challenged. Insights generated from the AI-based churning model facilitated a discussion within the company regarding what actions to take to avoid churn. The main value of these churning insights came from being able to act on what the ML prediction model taught about the tendency to churn. This has been a huge opportunity in comparison to traditional methods. This could for example lead to solutions like targeting editorial content to customers that show high potential to churn.

D3. "It was a centralised project. I was the product owner for analysis and my colleagues were responsible for the website or editorial content. Hence, once we learned about churning behaviour, I we could immediately notify the others product owners."

Furthermore, news content presented to a customer has been decided by humans based on intuition of what they believe that people in general would like to read. Oftentimes, this was made by clustering groups based on geography. Mittmedia received funding from Google and started to experiment around personalisation of content. They hypothesised personalisation on a granular level, based on also interest in content, recency, and relevance. This led to a process where content can be personalised for each individual user and thus meet the need of each customer. Seen from a broader perspective, there is a connection between churn and personalisation.

D4. "Personalised content was actually an anti-churn project."

Case example E.

The interdisciplinary innovation agency - Hyve

Case example E comes from Hyve, an interdisciplinary innovation agency that supports companies in accelerating their innovation. Repeating what other examples have shown, traditional methods of understanding customer needs are often manual. A business analyst or researcher is trying to capture word of mouth, and oftentimes go out and ask users or non-users what they think about a product. Hyve has leveraged the potential to use AI for understanding consumer needs and lead user identification. Some special areas have been of particular interest for them in their projects. Since internet forums are full of opinions, there is a potential for AI-based models to crawl and pin-point relevant needs. Practically, this is done though training the algorithm to recognise and cluster comments on social networks. A concrete example of this was Hyve supporting a large personal care brand developing a personal care product. The aim was to derive a set of key problem areas in the body care segment. Here, AI was used to find needs and to cluster the needs in relevant areas which the innovation team could innovate around. AI has also been used to identify lead users on social forums. Hyve informed the AI which were interesting whereby lead users were identified. Focusing on lead users has traditionally been a way to focus resource allocation, arguing that lead users need represent the needs of the greater mass of customers.

E1. "Those people can have great insights and might even already have a solution in place."

In summary, working with human-machine interactions in this way supports gaining new perspectives.

E2. "After having asked three colleagues, it is probably not interesting to ask another colleague but instead look at the result a machine produces - to get a really different perspective for once. In a wider sense it can influence the creative work we do."

Case example F.
The Industrial conglomerate - Siemens

Case example F is Siemens, a German industrial conglomerate with special focus on their offering around digital industries. Design thinking starts with identifying paint points, which is reflected in how Siemens describes their work.

F1. "[...] you start from the pain because friction can always transfer and translate into an opportunity. The more friction the more opportunities."

According to traditional design thinking methods this has been done by innovation practitioners identifying pain points through interviews. When introducing AI into these processes, opportunities to scan the web to search for pain points emerge.

While the above-described application, area is focusing on customers, Siemens is also using ML based methods to explore the external business environment. Algorithms identifies patterns in a huge amount of data, mostly news articles and investment or tech branches, which later can be sliced on various parameters. Competitors, verticals, and topics are parameters explored to see how trends shift and move. This creates insights for Siemens innovation team.

F2. "This is rather in the exploratory phase, not in the exploitation phase. This gives some kind of indication, that here is some uprising topic or touch point, [...]you can ask yourself - what is this about?"

Based on these, sometimes surprising, insights the innovation team decides on areas that are relevant for Siemens to explore further.

Case example G.

SAS System

SAS is a leading software company that offers analytics platforms to help clients turn data into valuable decision-making foundations. Their offering consists of advanced analytics software that support customers throughout the analytical life cycle, from exploring data, building models, and making decisions on the output. The intention is to involve users on various knowledge levels. Hence, various user interfaces are built in so people with less data science experiences can use drag-and drop functionalities whereas skilled data scientists can use the same platform and code own models. Interviewees highlights that the main value of this is that it facilitates teamwork among the client's employee base. Also, ML-based functionalities save time for the users.

A concrete example of a client use case is a manufacturing company producing consumer goods. They use customer feedback in social media for their product development, using the SAS platform and its algorithms to track the text data. Through integrating several of the client's customer channels to the platform, and stream the real-time data, the client can access close-to-direct feedback on products developed and learn for future product development endeavours. This can help clients understand customer problems better.

G1. "This can confirm what you already knew, or make you see new patterns."

The interviewee emphasises the importance of visualisation on the platform and the algorithms behind it.

G2. "We have built a plot to explain how a model is built, natural language processing can generate a description of what the diagram means."

The approach to consider application areas for AI in internal processes are summarised by the interviewee:

G3. "To put it short - AI shall be seen as a team member when integrated into processes"

4.1.2 Solution diamond

The solution diamond consists of an exploration and defining phase related to generating ideas of solutions and eventually selecting one to prototype around.

Case example H.

The patent company, enabling inventions - Iprova

Case example H comes from Iprova, a consulting company that generate insights from inventive information from all around the world. The company acknowledges that the traditional way of coming up with new inventions is to manually search the internet, databases, registers, and other platforms where inventive information is processed and stored. Or it is all about being lucky.

H1. "Invention is really based on people accessing the right information at the right time, it has struck me that the way that it is today which is based on serendipity, accessing information through chance, attendance to a conference or reading though a journal. It makes no sense when we live in a digital, data-driven world."

Iprova leverages AI based on this presumption, to invent in a faster and more disruptive manner. Clients approach Iprova with target invention areas and with Iprovas AI-based tool they can sense day-to-day social, market and technological changes that occur around the world. These insights are especially valuable since information about industries other than the clients own are included. Eventually this will trigger inventions within the client's operation.

H2. "If you believe that invention [...] means having the right information at the right time and not that invention requires unique and individual genius, then maybe you can use algorithms, data and machines to invent in a much better way by bringing the exact right information at the right time to the inventor."

The ML support with increased speed in innovation for their customers in two ways. First, there is usually an uncertain time delay between a technological advance occurring and the invention being created based on the advance, Iprovas technology is minimising this delay. Second, in terms of patent applications, companies need to be the first to maximise the chances of a successful patent protection. With broad claims, Iprova gives the patent a better chance of having intrinsic commercial value.

Iprova has clients around the world, with companies like Philips, Deutsche Telekom and Panasonic and BIC. One concrete example of a client case is a mobile phone company that explored an advance in forensics with the help of Iprova, this triggered an invention around the interface of the mobile phone. Exemplifying that an advance in one area can trigger innovation in another completely different one, for example that an advance in human biology that can relate to lighting.

Case example I.

Consulting company - Sogeti

Case example I come from Sogeti, a part of a consultancy conglomerate with focus supporting clients on their technology-driven growth journeys. A project with high relevance for this study is the Artificial Data Amplifier (ADA). ADA addresses the challenge of getting hold of actual data to test solutions and applications before launch. When data is expensive, time consuming or even impossible to get hold of due to for example GDPR rules, ADA can support. Based on an initial, small training set of data, generative adversarial networks (GANS) use the variation in the distribution of data points to generate more data with the same variation. In conclusion, ADA uses real data sets in small volumes to generate synthetic data in large volumes. The synthetic data are bespoke to the input data and can be used for prototyping. Sogeti highlights that this supports the innovation process for companies working with sensitive data. It reduces the dependency on real, personal data and thereby facilitates for pharma companies to conduct tests during product development and for governmental agencies to try their services before launch.

I1. "It is not that one cannot test ideas without ADA. There are always ways to get create data sets good enough for ones needs, if one has the patience to compile various information sources. However, to conduct reliable test results, a large amount of data is needed. That is where ADA come in."

Hence, one of the main benefits with ADA is that it facilitates for companies to test solutions and applications before putting them into production. With the help of ADA, clients can circumvent the time and access challenges of getting hold of data needed to develop and test products during their innovation process.

I2. "[...] data and data quality are often the showstoppers and to be more innovative is to also execute on the projects."

I3. "In the end, AI need to have enough data to come up with a functionality that works."

Case example J.

A patent search company - Ambercite

Another company that works with AI in a way that fits into the solution diamond is the Australian company Ambercite, specialised in patent search. There are more than 100 million patents existing, thus it is impossible to identify and review all patents relevant for a company. With an algorithm that can find patterns in patent citations, their tool is stated to overtake the conventional patent search system.

The main benefit with their algorithm is that it circumvents assumptions, as opposed to conventional search systems. Thus, the innovation process is stated to be less biased by the experience and knowledge of the patent searcher. This gives their clients new perspectives on inventions and overcome limitations such as siloed industry thinking.

J1. "Since we take away assumptions, we also take away limitations."

There are two benefits with this. First one, is the previously described quality improvement in the outcome, the found patents. Second, there is an increased speed of the process.

J2. "More than 10 years ago, patent search was a manual process which demanded patent searchers to investigate big libraries of printed books to find insights."

Companies can thereby quickly learn if their developed inventions are truly novel, if someone has already patented their solution or if there are existing features patented that would make their invention even better. An AI-supported patent search process enables speed through the possibility of answering these questions faster and thereby innovate faster.

Case example K.
The Industrial conglomerate - Siemens

In example K, Siemens is brought in again. The following examples will convey how Siemens Digital Industries is using ML to leverage their product design offering, thus supporting the innovation process.

In 2018, Siemens acquired Mendix, a software platform that became part of Siemens Digital Industries software. This software platform enables both professional and hobby developers to create apps and has been used to develop more than 200,000 applications. Mendix is based on low code a visual approach to software development and removed the requirement of coding skills and instead built that into the software. It is stated that to develop applications, the tool has various functions and features that facilitate both advanced data scientists to develop applications but also for the less experienced people to participate in the development process. For example, the tool is trained to give suggestions of ways to build the applications using as few resources as possible and based on previous learnings from the app developed by data scientists in the tool. One interviewee describes that:

K1. "In that way, the tool can facilitate collaboration among various stakeholders - the visual programming parts enable people without coding skills to participate [...]. Traditionally, in development projects there is a customer ordering the project and a set delivery date upon which the final product is presented. Upon delivery, the customer's need and context has changed and thus the product will not be used. Our tool invites the traditional customers into the process themselves."

The interviewee states that the tool encourages collaboration and involvement which facilitate iteration in the design process. It is a clear example of how the AI-based platform facilitates inclusion of various voices in the development process, thus extending the human power of the process to also include people without a data science background.

K2. "We try to make it possible to involve all people in the development process [...] you do not have to be a data scientist. We have coined the term citizen developer."

Company representatives believe that software solutions like this have great development potential.

K3. "In the future, we might say: "Siri or Alexa, I have this problem, can you develop this application for me?"

Another part of Siemens offering is their NX software for computer-aided design (CAD). As with the Mendix platform, NX has system default modes that accommodate for different types of users to use the platform with maximum convenience. In the software, customers can design models during the product development process. In 2019, ML and AI was integrated in the software update to support the creation of digital twins of a product, the production environment, and its performance. These recent versions are monitoring actions from designers creating models, both successful and unsuccessful ones. Analysis of previous user's actions result in prediction of users' next steps. The NX platform can eventually suggest commands and actions in a dynamic manner and adjust the user interface accordingly. This increases the speed of which designers can work and supports intelligence, leading to better design outcomes and a reduced time to market.

With support from their IoT service solution, Mindsphere, performance data from the real world can be fed into the production loop and the digital twin is simulating the manufacturing process. Insights from this can be used to improve and develop the product. This has altered the way design teams work with simulations. Siemens witnessed that this creates a continuous design process, even after the product is deployed.

K4. "Information about the product the whole way back to the design phase, you will then feed your model with real data about how 100 000 cars or wind turbines really works resulting in [...] improving the products."

Another initiative Siemens have piloted is using AI when predicting how likely an innovation project will fail. Quickstarter is an initiative to encourage entrepreneurial spirit, where employees can send in propositions of inventions and business opportunities. Based on this database with innovative ideas, AI is used to determine which ideas have the highest likelihood to succeed.

Case example L.
The mobility service platform - *Anonymised

In example L, the mobility company focusing on car sharing in cities is brought in again. This time with a suggestion of how AI can support experimentation. ML is here used to evaluate various solutions.

L1. "We can use AI to simulate a potential solution, in an imaginary environment with historical data."

The innovation team applies ML to de-risk implementation of new solutions with the help of historical data. During one of the innovation teams' projects, a simulation was used to evaluate the potential of the proposed solution. In concrete terms, the team created a machine learning model to predict if a customer, based on the length of their car reservation, would need to refuel their vehicle or not. By analysing historical data on an advanced level, the team could test the proposed solution and thereby better evaluate the cost of implementation compared to potential impact.

Case example M.
The emotion analytics platform - Tawney

Case example G uses emotion technology based on AI to analyse user's perception. Tawny can identify human feelings throughout the customer journey with a tool that track customer feelings when navigating on apps, websites, and other social media platforms. This is an important contribution to designers' work since human emotions now can be measured to better identify what works and what are potential pain points. This facilitates understanding of the nonverbal user experience.

This is used in the innovation process to develop better and more human-centric solutions. Emotions are a crucial element in the innovation process, and by using AI that can read and code emotions a lot of insights can be extracted. This advantage can result in opportunities in the innovation process.

M1. "If we understand emotions better, we can also design and create innovations that are more desirable from a consumer perspective, and that fit better into their life."

This can be leveraged in the phase of user testing, when the innovation practitioner prototype and wants to collect feedback based on people's true reaction and not only of what they are saying. Tawney comments on the future potential of this type of design on their website and outlines that they believe that customer research in this field will be driven by AI.

Case example N.
Microsoft and Mackmyra

The next example comes from a collaboration project between the whiskey producer Mackmyra, Microsoft and the technology consultants Fourkind. This exemplifies how AI can support a creative process and support in idea generation during a product development process. Mackmyra is a Swedish whiskey producer that has set sight on creating whiskey with a clear Swedish touch. In a traditional process, a human with a master blender title develops the recipe and can spend a lifetime to create the best taste combinations. Mackmyra has explored a project where AI supports the whiskey development process.

N1. "The innovation process of Mackmyra centres around coming up with new recipes and here they decide to use ML for this"

The distilleries machine learning model uses Microsoft's cloud platform Azure and AI cognitive services, to input existing recipes, sales data, and customer preferences. The master blender stated that the AI was given information such as which bottlings previously made, which barrel they used, and which awards they had received. To fine-tune the results, additional parameters such as specific smokiness were included. Based on this data AI presented over 70 million recipes expected to be popular. The first recipes that the AI generated were according to the master blender impossible to produce. Based on feedback from the master blender on parameters, when a barrel would be ready to use for example the AI was further developed. Eventually after an iterative work back and forth between the master blender, Fourkind and the AI the AI generated 5 recipes that the master blender saw potential in. Which of these flavours to launch was eventually a decision made after having mixed and tasted the proposed recipes. That this was a collaboration between the human and the AI is emphasised by the master blender:

N2. "AI is a great tool, but it will never replace human knowledge, the knowledgeable nose and palate. All the knowledge I have acquired about lager, about the specific aromas and flavours - this is something you cannot transfer to algorithms. But it can be used as a tool to enhance humans."

This exemplifies how AI can support a creative process and support in idea generation. However, the interviewee from Microsoft emphasises the importance of human interpretation:

N3. "You need to understand that it is not the whole innovation process. Machines can not invent, to come up with their own inventions. Humans need to interpret the results from the AI to innovate."

4.2 Desktop empirics

The following desktop examples are based on secondary sources. Sources are summarised in appendix 7.

4.2.1 Problem diamond

The problem diamond consists of a discovery phase and a defining phase related to identifying and reframing the actual problem around which to innovate. The following examples highlight how AI can be part of the design thinking process.

Desktop O.
Online fashion company - Choosey

Generating insights about customer needs is important to satisfy customers' demand. Choosey is an online fashion company that has placed AI at the core of its innovation process and leverages language processing based on ML techniques. In comparison to traditional methods for designing clothes, Choosey start their design process from what customers want to wear. They take the made-to-order business model one step further by having a system powered by AI that supports the company's "style scouts". It is described on their website as a three-step process where their algorithm researches trends across social media platforms to find the most popular styles under the hashtag "outfit of the day". Meanwhile, customers are invited to vote via social polls and comments, among suggested outfits to explicitly convey their opinions. The company's human style scouts will then combine input from the two to decide which outfits to produce and similar looks become available within less than two weeks.

This exemplifies how AI can be used to generate customer insights in the first part of the double diamond, to create products that customers will love.

Desktop P.

Drug Discovery - Benevolent AI

The next case example comes from Benevolent AI, a company that set out to use AI and machine learning to reinvent the drug discovery process. Benevolent AI states that they want to augment human intelligence during drug discovery for diseases that are still untreated. Drug development is time consuming and many drug programs fail but their method increases the number of hypotheses and results in high quality target choices. More specifically, they use relation inference AI models to find types of diseases that are overlooked by human scientists alone. By instead focusing on the reason why patients are more responsive to treatment the process can be enhanced by increasing the success rate and decreasing costs. AI is used to understand patients' unique underlying mechanisms that cause diseases, and these insights are used to develop new drugs. This process enforces the potential to identify diseases that otherwise have been overlooked. This case exemplifies how AI can support product development in this solution phase.

4.2.2 Solution diamond

Developing and delivering are the phases associated with the solution diamond. Following examples highlight how AI can be implemented in this part of the design thinking process.

Desktop Q.

Technology intelligence platform - Mapegy

Mapegy is a technology intelligence platform that has challenged the traditional way of doing time consuming desktop research. They are set out to support innovation practitioners to handle the enormous amount of data created every day from various sources such as patents, publications, press and market data. Their solution summarises the beforementioned sources in the Innovation Graph. Mapegy is then analysing and interpreting the data in the Innovation Graph using ML algorithms. Eventually, users can access the information via tables, forecast timelines and trend charts. They state on their website that their solution can reduce desktop research time from weeks to minutes. With their user application SCOUT, users can create search queries composed of keywords themselves. Algorithms can then extract the relevant insights from the Innovation

Graph to be presented in a structured and visual manner. Targeting clients like Wolsvagen, Henkel and Sony, Mapegy states that they can empower companies' internal innovation practitioners and thereby streamline their innovation processes. This example illustrates how AI can be used to collect insights from various sources that can be used to better understand a problem.

Desktop R.
Design company - IDEO and Open.AI

IDEO is a global design agency and has played a central role in popularising the design thinking method. In this example IDEO consultants try out a solution from the AI research company OpenAI. IDEO use a GPT-3, autoregressive language model, for brainstorming. Traditional brainstorming has leveraged techniques to trigger the human mind, for example analogies on physical cards or how-we-questions. In this case, an IDEO consultant asked the model how to support young people engage in the habit of saving money and fed it with some suggestive answers. Eventually, the model started to generate new ideas based on the input. All were not great ideas but many good enough to be forwarded to the rest of the team. To show the creative use of the GPT-3 algorithm, the input prompt, the suggestive ideas, were replaced with wilder ideas. The algorithm gave new suggestions accordingly, which shared analogous similarities with the wilder prompt input.

This example illustrates the possibilities to use AI for the diverging parts to generate ideas. The ideas that AI propose can potentially trigger creativity among designers. However, in the convergent phase humans still need to make choices and synthesise information.

Desktop S.
Technology company - Sketch2code by Microsoft

Translating ideas into tangible prototypes in a quick and easy has implications for the innovation process. Sketch2code is a web-based solution from Microsoft with the purpose of using AI to transform sketches and drawings into HTML code. Visual elements that are important during the design thinking process oftentimes takes the form of sketches and drawings. With Microsoft's software, design elements are recognised in pictures uploaded by the user via a Custom Vision Model. Thereafter, a text recognition service is extracting any handwritten content. This then becomes input to an algorithm that generates an underlying structure and eventually creates HTLM. This solution can replace the manual process of translating a photograph of a drawn design into a HTLM wireframe. Furthermore, Sketch2code accommodate for an iterative process, where any changes made, for example during a design workshop can be captured instantly.

Desktop T.
Furniture company - Phillippe Strack

Strack provides a great example how AI is leveraged for the innovation process. The chair was designed by Philippe Starck, in collaboration with Autodesk and Kartell. Traditional methods of designing prototypes can differ but for creative sectors the methods have mostly been sketching and building physical prototypes. In this case, the team used prototype generative design software. Since artificial intelligence was involved in creating the designer chair, the trio would have to get the algorithm to process their instructions and concepts. The team accomplished this by using a conversation type of input including questions in line with “do you know how we can rest our bodies using the least material?". Philippe Strack states that using AI resulted in the most creative outcome achieved through generative design. This is stated to amplify expertise among designers and engineers. To conclude, this exemplifies how AI can be used for prototyping but also to trigger creativity in creative industries.

4.2.3 Problem and Solution diamond

Desktop U.
Streaming service provider - Netflix

Netflix is a first example of how part of the job of designers and engineers are delegated to AI. Their digital streaming service platform produces its own content and offers sourced material for customers on a subscription-based business model. Netflix claims that data and technology is at the core of everything they do. Not only because their business model is purely digital, they also master working with ML to enhance and personalise the user experience (Verganti, Vendraminelli and Iansiti, 2020).

More specifically, they highlight that they are using ML to promote content, model prices, deliver content effectively and for adaptive streaming (Netflix, 2019). Here, detailed design choices are taken by algorithms to decide interfaces for each specific user, in real time. With reinforcement learning techniques called multi-armed bandits, Netflix can address challenges regarding recommendation and personalisation towards each individual user. The prediction model present visuals to an individual user and based on user response (policy), the model eventually improves while learning more about users' preferences (Verganti, Vendraminelli and Iansiti, 2020).

Netflix seems to have reached a level where AI is utilised in various parts of the process, a loop of knowledge enhancing that facilitates design decisions. What is even more particular is that the AI is working this loop independently, without intrusion from humans.

Desktop V.
Music streaming service - Spotify

Spotify provides another example of where AI is not only part of the solution itself but as important in the innovation process. The Swedish music streaming service is built on a purely digital business model and possesses a wide community of developers and data scientists. Their platform is built to provide each user with a personalised experience and there are several examples of how AI has taken over the process of designing those experiences. One example that is of particular interest for this study is the Bandits for Recommendations as Treatments (BaRT) algorithm that is used behind the Spotify Homepage. By using ML and defining success as "when the user streams the playlist for at least 30 seconds" the Spotify interface adapts to the specific user by suggesting content based on what listeners enjoy listening to. Much of Spotify's innovation process revolves around designing the customer touchpoints. With support from AI, Spotify has created a real-time design process for this part of the business. Like the case of Netflix, Spotify leverages AI in a learning loop.

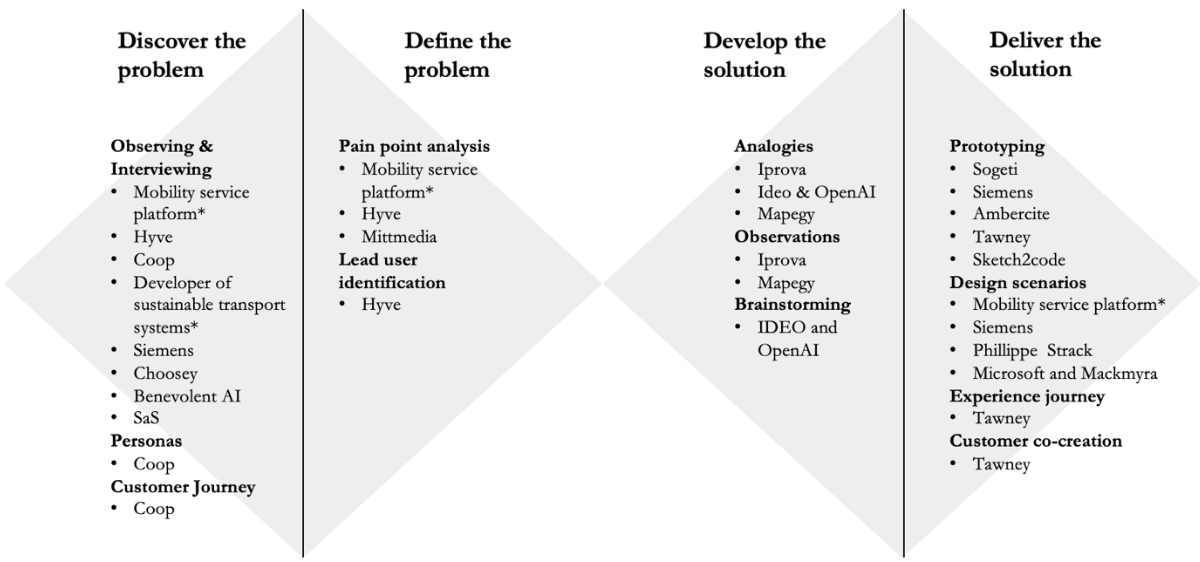
5. Discussion

This section discusses the empirics through the theoretical framework presented in section 2.7 to understand opportunities from the three proposed perspectives.

5.1. Operational opportunities - The process

The initial aim is to understand how innovation practitioners can do innovation with AI. The research field is unexplored (Verganti, Vendraminelli and Iansiti, 2020; Vocke, Constantinescu and Popescu, 2019) and there is a quest for understanding what is going on in practice. Hence, this initial mapping has a great stand-alone value in providing an understanding of the contemporary ways AI is used in the innovation process.

Figure 8. Design thinking tools identified



*Company requested to be anonymous

In figure 8, empirics are mapped towards the design thinking tools explained under section 2.1.4. It shows that, in practice, most of the studied companies use AI in the first phase, discover, as well as in the last phase, deliver.

5.1.1 The Double Diamond

Discover

The traditional approach encourages observing or interviewing to generate insights about users, and the more high-quality data, the better (Klitsie, Price and de Lille, 2018). It is concluded that this part of the process can be enhanced with AI. The most common method from the empirics is sentiment analysis based on ML, as shown in case example B, Hyve as well as from the desktop case Choosey. This implies that AI can support empathising with a larger number of users as well as potential customers, thus making the discovery phase more effective. Another example is from Coop, who is using AI to support its understanding of customer journeys in store. The Scan&Pay solution helps them identify behaviours that are not visible with traditional observation methods or surveys. This aligns with the findings by Kakatkar, Bilgram and Füller (2020), who concluded that AI provides the user with the opportunity to go broader in the search process. Interviewees reason that the main advantage of using AI in this phase is that looking at a larger sample will lead to better knowledge about customers. This study supports the research field with a concrete example of how AI assists in finding insights beyond what human capabilities have been able to achieve. Design thinking researchers occasionally use empathising and engaging with customers synonymously (Klitsie, Price and de Lille, 2018) but case examples in this study suggest that companies can get to know their customers without physically engaging with them. In conclusion, there are opportunities to enhance existing tools such as interviews, observations, creating personas, and understanding customer journeys with AI.

Define

The discovered insights must be converged, in a phase of reframing the problem to a true problem (Beckman, 2020). This is often done by exploring lead users' opinions and identifying pain points (Baldwin and von Hippel, 2011; Furr and Dyer, 2014). By finding anomalies and patterns in large amounts of data, AI assists in recognising opportunities for innovation (Heafner et al., 2021). Empirics from case example B and case example C suggest that ML can be used to identify pain points more precisely. While many companies today work with big data to find correlations, Christensen et al., (2016) highlights that this can be misleading when searching for the real problem. However, AI can truly open for companies to detect causal relationships, which is proposed to be a better method to find the real problem in customer data. Not only will decisions be better informed since companies can increase the scope of information available for them. It can also provide support in the choice of the most promising or impactful avenues to focus innovation effort towards. As in the case example from Hyve, AI was used to cluster high impact problem areas in the body care segment which could later be refined by the innovation team to innovate around.

Second, it was discovered in the case of Mittmedia that AI is used to prioritise work based on identified pain points. When predicting churn, the company could better understand which areas that had most impact on customer satisfaction. This aligned with Heafner et al. (2021), arguing that AI methods cannot develop innovation independently but instead can point innovation practitioners towards most impactful paths for innovation. This is supported by the fact that AI can only do what they are programmed by humans to do. Recalling the earlier definition, while AI can differ between cats and dogs, AI does not know the meaning of a dog or a cat.

An important conclusion in this phase is the human-machine balance. In all our cases, it is still humans that defines the real problems with support from AI. In conclusion, there are opportunities for human-machine collaboration when AI is used to identify lead users and customer pain points. Adding this to the finding of Kakatkar, Bilgram and Füller (2020) will result in that innovation practitioners not only gain depth and speed in reaching insights but also that these insights can be prioritised with support from AI.

Develop

This has traditionally been the phase where people gather in groups, building on each other's creative ideas and develop solutions (more often than seldom on post-it notes). Iprova supports their clients in finding solutions to concluded innovation problems with their AI-based solution supporting analogical thinking. They can support their customers with solutions from industries far away from where the clients themselves would turn to for finding solutions.

There are few examples where AI replaces the most creative activities executed by human innovation practitioners. Desktop research case Ideo describes how they use AI to generate metaphors and analogies to trigger creativity, which is aligned with theory suggesting that AI can act as stimuli for brainstorming (Toivonen and Gross, 2015). In summary, this is rather an example of computational creativity, where AI enhances human creativity (Besold, Schorlemmer and Smaill, 2015; Strohmann, Siemon and Robra-Bissantz, 2017).

Deliver

In the final part of the double diamond, the main activity is testing the proposed solutions though prototyping. There are a plethora of traditional tools and methods here, focusing on sequential development of prototypes, and experimentation around different features (Furr and Dyer, 2014). Empirics convey several use cases for AI in this phase. Using ML when building prototypes can remove levels of the prototype creation process. Microsoft's Sketch2Code solution can support speed in the prototyping phase so that a high-fidelity prototype is reached faster (Tschimmel, 2012). This is also seen on a more advanced level, in the NX platform from Siemens to support the creation and usage of digital twins. This enables testing prototypes on real data, in a close-to-real environment, thus ensuring better design outcomes. A final example is Tawney, which uses emotion AI technology for prototyping to capture people's true reaction when interacting with a product. To summarise, there are opportunities to support prototyping, scenarios testing, experience journey and co-creating with customers with AI.

5.1.2 AI to enhance tools or be embedded in the process

A significant conclusion from the initial mapping is that contemporary AI initiatives can enhance or replace some of the design thinking tools and methods from figure 8. Empirics exemplifies AI-based versions of several of these tools and methods, used in various phases (figure 8). However, Spotify and Netflix cannot be mapped in a straight-forward manner since they seem to support activities in various parts of the double diamond.

Based on this it can be concluded that AI can be integrated into the innovation process in different ways. It can be placed on a scale between either integrated on a granular level involving task automation of the associated tools and methods or integrated into the process as a problem-solving loop. Figure 8 displays the difference in this distinction. All the interviewed examples can be mapped against a tool or method, the case example closest to the loop is Siemens. The loop is most applicable for inherent digital solutions, where the ML algorithms can find problems and generate solutions in a loop (Verganti, Vendraminelli and Iansiti, 2020). This is reflected in the cases of Netflix and Spotify.

The application of AI in the innovation process can therefore be a new way of using the tools and methods. Or it can, aligned with Verganti, Vendraminelli and Iansiti (2020), be included as a broader problem-solving loop. Tools or methods altered occur in an associated phase and will therefore change that specific phase, while the structure of the design thinking process will stay the same. The problem-solving loops will instead alter the whole process of design thinking.

This study has empirically clarified this distinction by pointing to different applications of AI in the innovation process. Therefore, it can finally be concluded that the opportunities for AI in the process are to either change the tools and methods or be integrated to facilitate problem solving loops.

5.2 Managerial opportunities - The principles

This section focuses on how innovation practitioners think about innovation. After each case study, identified opportunities were listed. These opportunities are here sorted under the design thinking principle they are argued to effect. For a full overview of how these categories were constructed see appendix 8 & 9.

5.2.1 User centricity

Understanding user centricity in relation to ML is about understanding how to think about customers and users. The previous analysis, using the double diamond, explained how innovation practitioners work with ML to empathise with customers.

Physical interaction between humans, oftentimes between the customers and the innovation practitioners, can become redundant when customer data can be analysed using ML. Thus, when users become numbers on a screen, there is a potential risk of losing user centricity. Talking to and observing users in their natural environment, seeing social and emotional elements, will facilitate understanding of the real problem (Christensen et al., 2016). However, empirics indicate that AI can make innovation practitioners user centric and help them identify the real problems in new ways. This is because the more people, the higher the quality of the algorithm enabling more individualised insights (Verganti, Vendraminelli and Iansiti, 2020). This has been illustrated in case example B, Hyve and Mittmedia where interviewees argued that AI can replace time and resource consuming ethnographic studies. This results in more data about individuals. The large volume of data enables the innovation practitioner to reach deeper insights on a more granular individual level. Additionally, understanding emotions and feelings has been a quality previously attributed to humans. However, as seen in case B, sentiment analysis can contribute to a deeper understanding of feelings. Moreover, Tawny even uses emotion AI technology to interpret emotions during prototyping. This example shows that AI would be able to understand emotions which according to Christensen et al. (2016) is argued to better satisfy the need of the customer.

In conclusion, there are opportunities for innovation practitioners to reach a higher level of individualised user centricity, one that includes not only direct observable behaviour but also indirectly reflected emotions.

5.2.2 Iteration

The principle of iteration implies that innovation practitioners should approach innovation challenges with a mindset of testing (Dell'era et al., 2020; Klitsie, Price and de Lille, 2018; Liedtka, 2015; Verganti, Vendraminelli and Iansiti, 2020). This promotes work according to fast cycles and uses prototypes to test ideas and get feedback to learn and improve.

AI can increase the speed in learning cycles, resulting in a higher degree of learning (Verganti, Vendraminelli and Iansiti, 2020). As mentioned before, speed is a critical element in innovation and the logic promotes failing fast to succeed fast (Dell'era et al., 2020). Increased speed in iteration is confirmed by Sketch2code and Medix, two simple, yet valuable examples of how the barriers to quickly prototype and test are erased. Reduced time in testing a hypothesis will also affect the speed. This was seen in case example B were an initial idea about the cause of a problem quickly was tested and invalidated.

While the innovation process previously ended when products and services were launched, it is now possible to collect feedback while products are in use and make improvements after launch. This leads to a never-ending iteration, resulting in a prolonged learning (Verganti, Vendraminelli and Iansiti, 2020). This alters the mindset of the innovation practitioner. With previously mentioned approaches to simulation and digital twins, the case of Siemens describes how the loop of learning can continue even after the product or service is in the hand of customers. This new way to work for the innovation practitioner enforces a constant drive towards testing. The distinction between the problem-solving loops (Verganti, Vendraminelli and Iansiti, 2020) and enhanced tools is important to make here. While the loops iterate themselves, the enhanced tool enforces innovation practitioners to change towards a stronger emphasis on trial and error.

In conclusion, there are opportunities to increase speed in iteration and prolonging iteration cycles.

5.2.3 Hypothesis driven

The principle of hypotheses pushes the innovation practitioner to think in terms of what could be as opposed to what is. This mental mode is promoting testing, to validate or invalidate ideas (Liedtka, 2015; Verganti, Vendraminelli and Iansiti, 2020).

It is up to innovation practitioners to imagine the new, rather than solely focusing on the present. Imagining new possibilities can be blocked by cognitive constraints, since humans have limitations in absorbing and processing information and are constrained by previous experience (Heafner et al., 2021). Searching for answers to innovation problems across industries can help spur ideas, as shown in the case example Iprova and Mapegy. Their ML-based search tool identifies analogies from industries other than in which their clients operate. Finding inspiration of application in one area inspires innovators to build hypotheses around what is possible in another. If innovators find inspiration from outside their own knowledge sphere the result could be more radical and disruptive innovations (Heafner et al., 2021).

Working with hypothesis testing can result in insights from ML that push reformulation of current hypotheses. This is for example since innovation practitioners can see causes of a problem that they were not aware of before. For case example B, the team initially had an idea of what caused the problem around fuelling. Having data scientists in the innovation team, using ML based tools to analyse real-time data helped the team to invalidate the hypothesis and start working according to a new hypothesis to understand what caused the problem. This is in line with findings from Kakatkar, Bilgram and Füller (2020) suggestion that the complex interaction between variables that AI can interpret can be used to drive new hypotheses.

In conclusion, there are opportunities to reduce constraints that traditionally have limited the process of formulating new hypotheses

5.2.4 Visual communication

Design thinking is a team-based process, thus the importance of communication throughout the process becomes obvious. Visual communication is a core component in communication to convey ideas and intentions (Carlgren, Rauth and Elmquist, 2016)

As seen from previous examples, AI alters the information innovation practitioners use for input to the innovation process. The change of input requires a new way of thinking of the output meaning the way you visually communicate insights. One could argue that ML would make the innovation process more focused on data and numbers, as opposed to graphics and drawing. Empirics shows that ML has an indirect effect on the ability to visualise activities and ideas throughout the process. Not only does several of our interviewees stress the importance of visual translations using ML, these aspects are also reflected in the studies examples. Siemens NX platform and Sketch2Code are two concrete examples of such cases. Another key point on this topic is that AI is rather complex from a technical point of view. Oftentimes, numbers and metrics need to be visualised, for example in the form of color-coded clusters, for an everyday innovation practitioner to understand them. Kakatkar, Bilgram and Füller (2020) that suggests visualisation of output is important for transparency and to understand the raw textual content. Hence, Insights obtained from using AI needs to be translated to visual representations to include more people to leverage the use of it.

In conclusion, there are opportunities to visualise insights from data to enable innovation practitioners to truly make use of the output.

5.2.5 Multidisciplinary

To widen innovation practitioners' thinking during the innovation work, multidisciplinary teams are an important source of new perspectives. It is proven that a diverse mindset and perspective can improve innovation (Carlgren, Rauth and Elmquist, 2016; Fay et al., 2006).

Empirics shows that AI enhanced innovation processes require designers and data scientists to work together. These two groups that historically have been located far away from each other. The new team setting was emphasised by case example B, case example C and Mittmedia. Though there can exist an over belief in what AI can do, case example B conveys that the data scientist can act as a filter for what is actually possible and thus validate creative insights. Hence, the data scientist had a central role in the innovation process. This fosters immediate iteration and steers designers to focus on coming up with ideas to facilitate technical requirements, referred to as the creative blind spots (Kakatkar, Bilgram and Füller, 2020). Another interesting indirect effect is identified, where the competence barriers between the two groups of designers and technicians, are lowered. Especially in the case of SaS and Mendix, this becomes clear. Via their ML-based platforms, not only the skilled data scientist can take part in prototyping applications, but also the everyday designers.

AI can make designers understand problems from new perspectives, enforcing a more multidimensional mindset (Fay et al., 2006). The interview with Mittmedia conveyed how the ML-based churn project generated conclusions that none of the human innovation team members had considered. One interviewee pushed it as far as stating that regardless of the AI's perspective being right or not, the mere contribution creates a contrast as to how the rest of the design team thinks. This shows that AI contributes with another perspective of problems distinct from the way the human mind works.

In conclusion, there are opportunities to create new team constellations and inform new perspectives.

5.2.6 Conclusion of principles

It is evident that the human mindset still is critical to make sense of insights and execute the process according to the principles. To previous research that elaborates on the design thinking principles, this study contributes with a distinct emphasis the role of visualisation and multidisciplinary. Researchers before having briefly discussed these elements but through this study, its stressed importance has placed them on a principle level to convey its central role in the age of AI. While some articles focus on, or frame, the principles differently (Verganti, Vendraminelli and Iansiti, 2020), this study proposes that the principles of design thinking in general are enhanced suggesting that AI intelligently augments humans instead of replacing (Jarrahi, 2018).

5.3. Strategic opportunities by building dynamic capabilities

Up until this point, opportunities related to the process and principles of design thinking have been identified. However, integrating AI into the innovation process will also result in strategic opportunities, beyond the process and the principles. Development of dynamic capabilities; sensing, seizing, and transforming, is triggered.

Sensing

The capability to sense involves organisations identifying threats and opportunities within its environment (Teece, 2009). With AI, companies become better at sensing in two ways. First, several of the companies in the empirics are using ML to analyse emotions and behaviours of the customers which enables identification of use-cases and trends. These new methods to analyse customer behaviour can unleash new opportunities to understand customer reactions to products that they have not yet experienced (Liedtka, 2015). Customers nowadays require companies to understand their reactions to products and services of the future. Second, AI support in generating insights from other actors across industries. In an increasingly complex environment, AI increases the scope of information sources sensed (Heafner et al., 2020). Especially in the interview with Iprova, it seems clear that contemporary innovation advantages stem from access to right information. The ability to define the value in information, absorptive capacity (Cohen and Levinthal, 1990) is thereby challenged in the age of AI. It can be argued that sensing requires managerial gut feeling and intuition, or an analytical process that can proxy for it. Our interviews suggest that AI can support in obtaining this analytical proxy by supporting a structured method to, in the increasingly wider scope, identifying what is truly important.

Seizing

Companies need to organise properly to ensure that what was sensed, becomes actual value to the company. This involves making choices and moving from analysis to action (Teece, 2009). Seizing capabilities are influenced by opportunities for changed power structures and a quest for visualisation.

Traditional power structures within a company are affected from integration of AI to the innovation process. According to case example B, previously people that scream loudest had the final say in what initiative and idea the team decided on. This can result in a changed power structure, putting AI-literate team members in a prominent position. With a higher number and more well-defined opportunities and threats, we argue that companies are in a better position to make decisions about what to seize. However, skills are required to properly interpret these opportunities and to understand implications of the algorithmic processes to fully utilise its value. Humans with AI-literacy on a level good enough to make the complex relations seem simple will be regarded as powerful in the new organisations.

In an innovation process with AI, the ability to convey ideas and insights will be even more important. What one can visualise will be what matters, to obtain buy-in to ideas. Instead of having a person good at sketching and drawing on post-its steering the design thinking sessions, data scientists will take on this core role at certain points during the process. A role that previously have been performed by user experience innovators or product managers (Beckman, 2020).

Transforming

To obtain sustainable competitive advantage companies need to have the ability to reconfigure its resources. This involves transforming business processes in an organisation (Teece, 2009).

In simple automation of tasks AI is replacing humans when implemented as a tool (Jarrahi, 2018). The effect on dynamic capabilities suggests that AI is more than just another tool. It is a team member. When team members are defined as actors supporting several steps during the innovation process, contributing with new perspectives, sharing workload and trigger creativity, they surely deserve a position in the innovation team. These are characteristics that our case studies have highlighted, hence it is evident that companies that assent to this are able to reconfigure their resources and thereby transform their ways of working. Working with AI as a team member would require a new set of capabilities for the organisation to adapt to this new way of human machine interaction. Companies that reconfigure their dynamic capabilities need to place adoption of technology and human skills development at the centre of innovation strategies (Barro and Davenport, 2019). Developing this dynamic capability is therefore critical to impact the organisation competitive advantage in the long run.

Concluding reflections

The case for AI in the innovation process is seemingly strong, however the inevitable question is: why have not more companies implemented AI into their innovation processes to a greater extent than identified via this study? The empirics propose three plausible reasons. First, even though AI as a technique is not novel, it appears to be driven by some competence. Mittmedia reported that their churn project based on AI was driven by a skilled data scientist team, thus the inverted situation seems plausible. Without access to such resource's companies might lag in embracing AI for their innovation process. This ties in to the second suggestion for possible reasons. The rationale, as mentioned in section 5.2, behind successful AI work is access and understanding of quality data (Iansiti and Lakhani, 2020). This is reflected in the case of Sogeti, where the mere value of ADA becomes obvious. Even if there is an increased access to data, there are challenges related to how to integrate various data sources for a complete picture of the situation as well as to unbiased data that convey an accurate picture of the situation. Finally, most of the interviewees found the two fields, AI and innovation processes, to be distant. To develop work processes around something that many practitioners cannot even envisage is rather unlikely, which is a good explanation for why AI is not applied to a larger extent. Recalling that the purpose of this study was to identify opportunities with the combination of AI and innovation work, it will serve as inspiration to set the thoughts in motion and for some even act as a hypothetical proof of concept for companies.

6. Conclusions

The purpose of this study was to investigate the use of AI in the innovation process - not as the result of the process. The aim with the research question was to tap into the current paradigmatic shift in innovation management, where AI is introduced.

What opportunities exist when integrating AI into the innovation process?

Based on data collection, there are opportunities identified on three levels. First, there are opportunities related to how innovation practitioners *do* innovation - the design thinking process. The design thinking tools will be enhanced through new ways of using them, illustrated in figure 8. Alternatively, AI can be embedded in the process altering the whole process.

Second, there are opportunities related to how innovation practitioners think about innovation - the design thinking principles. We have identified opportunities regarding the principles that emerged from using AI in the innovation process and thereby influences how managers think: (1) Opportunities for innovation practitioners to reach a higher level of individualised user centricity, that include not only direct observable behaviour but also indirectly reflecting feelings. (2) Opportunities to increase speed in iteration and prolonged iteration cycles. (3) Opportunities to reduce constraints that traditionally have limited the process of coming up with hypotheses (4) Opportunities to visualise insights from data to enable innovation practitioners to truly make use of the output. (5) Opportunities to create new team constellations and inform new perspectives.

Finally, the AI-based tools have effects beyond the process and principles. Integrating AI into the innovation process can trigger development of dynamic capabilities. Companies can increase their sensing capabilities among customers and across industries. Seizing capabilities are influenced by opportunities for changed power structures and a quest for visualisation. Transformational capabilities are built when companies leverage human-machine interaction thus encouraging viewing AI a core team member.

Theoretical contribution achieved

While earlier papers on AI and innovation processes mainly have focused on the process or principles of design (Cautela et.al 2019; Kakatkar, Bilgram and Füller, 2020; Verganti, Vendraminelli and Iansiti, 2020), this study adds another dimension to research adding dynamic capabilities. This implies novel insights into the possibilities that AI in the innovation process can have organisational effects beyond the process.

The study has provided new insights related to the principles of design thinking. This has been brought up earlier, but it is found that Verganti, Vendraminelli and Iansiti (2020), is the only author that explicitly has used the design thinking principles within a theoretical framework. This study extends Verganti, Vendraminelli and Iansiti (2020), with the addition of two principles: visual communication and multidisciplinary. These principles are, in this study, highlighted to fully understand opportunities for AI in the innovation process.

Methodological contribution achieved

This paper contributes with empirical relevance though the chosen research method. Previous research is based on preliminary anecdotal evidence (Cantamessa et.al 2020), databases on start-ups (Cautela et.al 2019), authors involvement in a few projects (Kakatkar, Bilgram and Füller, 2020), or secondary research (Verganti, Vendraminelli and Iansiti, 2020). While previous researchers use one or few case studies to reflect their thoughts (Kakatkar, Bilgram and Füller, 2020; Verganti, Vendraminelli and Iansiti, 2020), the analysis in this study builds on a greater number of cases. This captures the current state of using AI in the innovation process from a more holistic perspective. Furthermore, a methodological contribution is obtained via conducting in-depth interviews. Since previous methods are rather shallow anecdotal evidence or secondary sources, this study provides an understanding of current state in the contemporary business environment. From interviews, insights are generated around innovation practitioners' thoughts about human-machine interaction. In terms of different case examples, this study has a breath by adapting an exploratory research style searching over the supply chain. In summary, both depth and breadth are achieved. Lastly, this study has made the distinction between altering a tool and AI embedded in the process, this discussion has never been clearly stated before.

Managerial implications

This study will act as a proof of concept for AI in the innovation process and give concrete examples on the use cases that can act as inspiration for other companies, curious to employ it. The effect AI in the innovation process can have on dynamic capabilities can be used to support innovation practitioners in trying to convince higher-level management that this is a valuable venue.

Limitations of the study

The chosen research question has shaped this study; hence it is appropriate to use the same question when reflecting upon its limitations. Three main limitations must be acknowledged. The first one reflects to the first word in the research question. The identified opportunities outlined are not a full list, rather they represent the opportunities that stem from the type of studied companies that have adopted AI in the innovation process early. The second limitation emphasised is the opportunities as such. Due to the diverse and complex natures of contemporary companies, that the exact same opportunities would exist for also other companies, is a rather bold claim. Third, limitations relate to the part “to integrate AI in the innovation process”, and whether the effects described by interviewees are limited to the mere integration of AI. Companies are complex, suggesting that there can be other underlying factors that can influence the effect identified in this study. basically, does the opportunities stem from the technology itself or can it partially be a result of a certain company culture, a certain competence or even a specific person.

Suggestions for future research

The combination of dynamic capabilities, design thinking and AI has not been explored before, thus we encourage researchers to build on ideas suggested in this study. More specifically, future research could investigate the technologies within the AI umbrella. Also, comparative studies investigating the topic from the perspective of certain products, industries and innovation types are deemed appropriate. This study has consciously not made a distinction between incremental and radical innovation. However, most of the case examples might have contributed to more incremental innovation. Future research could take degree of novelty into consideration to see where AI benefits most. It was concluded that creative activities would remain in the hands of humans, however the indirect effect on creativity is severe. Further studies could deep dive in the creativity parameter. This would also be interesting when AI technology is proven to become increasingly creative, making music, whiskey recipes and art pieces. Verganti, Vendraminelli and Iansiti (2020) stated that this is one of the most fascinating and interesting fields for innovation management in years to come and we could not agree more.

7. References

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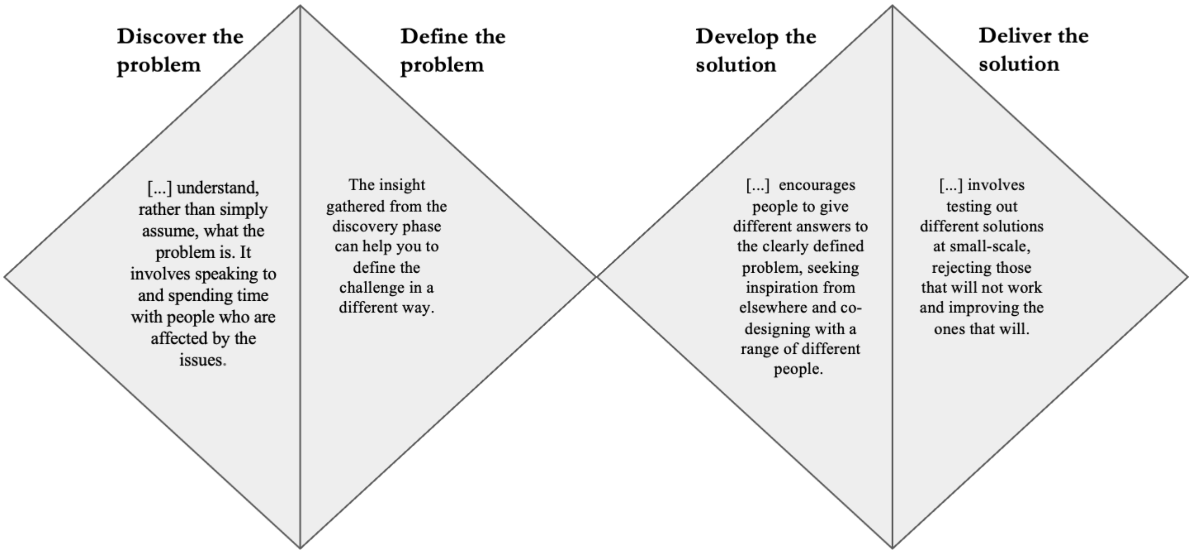
8. Appendices

Appendix 1. Double diamond definitions



Appendix 2. Machine learning

Machine learning definitions Iansiti and Lakhani, 2020	
Supervised Learning	Supervised learning is concerned with training a system to predict a known outcome with the same success as a human expert would achieve. This is based on a labelled data set split in two categories, training and validation. The model is trained to perform a certain task, such as identifying from pictures if an animal is a cat or a dog. The outcome is compared to the validation set and the model can be adjusted for a more satisfying result.
Unsupervised Learning	Unsupervised learning is instead trained to discover insights in data with limited assumptions and find groupings in data that are not obvious. Despite few preconceptions, the algorithm can find patterns that humans later can label. There are additional subgroups of unsupervised learning: clustering, association rule mining and anomaly detection that will be referred to in this study.
Reinforcement Learning	Reinforcement learning is set out to find the best possible action in a specific situation, based only on a starting point and a performance function. A common subgroup within reinforcement learning is multiarmed bandit which are used for optimization problem.

Appendix 3 Expert interviews (pre-study)

	Experts	
Name and title	Rationale for conducting a pre-study interview	Outcome/learnings
1 interviewee (SSE)	Theoretical and practical knowledge and help to find suitable case studies.	Knowledge about the field and mediation of contacts for case study
1 interviewee (Halmstad University)	Provided theoretical and practical knowledge and overview of the field.	Knowledge about the field and propositions of companies to investigate further
1 interviewee (RWTH Aachen University)	Eminent research in the field of this study. Provided both theoretical and practical knowledge and overview of the field.	Knowledge about the field multiple company examples of AI in the innovation process
1 interviewee (Maastricht University)	Researcher in the intersection of AI and innovation. Helped in navigating the research field.	Knowledge about the field and propositions of companies to investigate further

Appendix 4. List of practitioners (pre-study)

Practitioners		
Who?	Rationale for conducting a pre-study interview	Outcome/learnings
1 Interviewee (Peltarion)	Overview of the field. The close-to-industry nature of the firm led to contact details to some interesting case companies. Confirm the viability of our research question.	Case study examples provided.
1 Interviewee (AI sustainability center)	Confirm the viability of our research question.	Case study examples provided.
1 Interviewee (BCG gamma)	Find potential case companies and confirm that AI in the innovation process "is a thing".	Confirmed that companies are working on projects like this but gave no explicit firms/details/contact details.
1 Interviewee (Sogeti)	The only consulting firm we have found who explicitly market their product in the field of AI and innovation processes. Supplier perspective on AI solutions.	A project for this study.
1 interviewee (Ericsson One)	Potential use case since One has explicit focus on design thinking and the recent strategic initiatives by Ericsson suggest that internal projects with AI in its core are well-developed.	Provided contact information.
1 interviewee (AI Innovation of Sweden)	Extensive knowledge about the AI landscape in Sweden therefore possibility to suggest cases and mediate contact.	Provided contact information.
1 interviewee (The Service Design studio)	Overview of the practical landscape and possibility to give examples of case studies.	Company examples to investigate further.
2 interviewee (Elekta)	Potential use case, especially since it is a prominent company within healthcare which is considered a forefront industry within the field of AI and innovation.	Does not work with AI in the innovation process at all.
3 interviewees (Developer of sustainable transport system)*	Potential use case, especially since it is a prominent company within mobility which is considered a forefront industry within the field of AI and innovation.	Work with AI in the innovation process to some extent but not a clear-cut.
1 interviewee (Schibsted)	N/A	Have potential project for us to study.
1 interviewee (Coop)	Overview of Coops AI initiatives and innovation process.	One case examples suitable for this study.
2 interviewee (Pfizer)	Innovative company possibility that they used AI in innovation process.	Work with AI in the innovation process to some extent but not a clear-cut. Work with customer data a lot.
1 interviewee (Lexplore)	AI driven company.	Start-up, supplying organisation with their eye tracker technology with enables people to understand/see things humans can not.
1 interviewee (Snafu Records)	Market their solution as being based on AI and especially interesting since the company is active in the entertainment industry which has provided with forefront examples of AI in the innovation process (E.g. Netflix & Spotify).	Working with data to predict trends, which enables innovation in the music industry. AI is a solution, not part of the process.
1 Interviwee (IBM)	AI driven company.	Knowledge around AI and suggestion of examples.

Appendix 5. Interview guide

Interview Guide base

(Specific question for each of the cases has been added)

Initial questions
Can you tell us about yourself?
What kind of project are you involved in?

Innovation
Can you describe how you work with innovation?
How does your innovation process look like?

AI
How are you working with AI?

AI and innovation
How are you working with AI to support innovation?
How do you work with AI to find needs?
How do you work with AI to find solutions?
What are the main benefits?
What are the challenges?

Innovation strategy
What role does (the project) have in your long-term strategic work?
(The project) is used for x how has it affected your work internally?

Creativity
How has AI made you see new things?

Decision making
How has AI informed decision making?

Other projects
Can you think of more projects like this?

Future outlook
What is your future outlook for AI in the innovation process?

Appendix 6. List of interviewees (main study)

Organization	Interviewee	Date	Sector	Person interviewed Located in	Format
Ambercite	Interviewee 1	Oct, 15,2020	Patent Search	Australia	Virtually
Coop	Interviewee 1 Interviewee 2	Oct, 6, 2020 Oct, 13, 2020	Retail	Sweden	Virtually
Hyve & Tawny	Interviewee 1	Oct, 8, 2020	Innovation management	Germany	Virtually
Iprova	Interviewee 1	Oct, 7, 2020	Patent and trend discovery	Switzerland	Virtually
Mobility Service Platform	Interviewee 1	Oct, 13, 2020	Mobility	Sweden	Physical
Mittmedia	Interviewee 1 Interviewee 2	Oct, 26, 2020	Media	Sweden	Virtually
Mackmyra	Interviewee 1	Dec, 4, 2020	Whiskey	Sweden	Virturally
Microsoft	Interviewee 1	Oct,16, 2020	IT	Sweden	Virtually
SAS System	Interviewee 1	Oct, 21, 2020	IT	Sweden	Virtually
Developer of sustainabler transport systems	Interviewee 1 Interviewee 2	Oct, 14, 2020 Oct, 16, 2020	Mobility	Sweden	Virtually
Siemens	Interviewee 1 Interviewee 2	Oct, 9, 2020 Oct, 16, 2020	Industrial electronics	Sweden and Germany	Virtually
Sogeti	Interviewee 1	Oct, 5, 2020	AI consulting	Sweden	Virtually

Appendix 7. Desktop sources

Desktop O	Online fashion company - Choosey
	Komar (2018). This New Brand Only Sells Clothes Inspired By The Most Popular Looks On Instagram. Date Retrieved Nov 15, 2020 from https://www.bustle.com/p/what-is-choosy-the-new-clothing-brand-is-about-to-make-copying-instagram-ootd-so-much-easier-9867021 Getchoosy (2002). Homepage. Date Retrieved Nov 15, 2020 from https://www.getchoosy.com/
Desktop P.	Drug Discovery - Benevolent AI
	Benevolent (2020). Homepage. Date Retrieved Nov 15, 2020 from https://refworks.proquest.com/library/recent/
Desktop Q.	Technology intelligence platform - Mapegy
	Mapegy (2020). Homepage. Date Retrieved Nov 15, 2020 from https://www.mapegy.com/
Desktop R.	Design company - Open.AI by Ideo
	Syverson (2019). The Rules of Brainstorming Change When Artificial Intelligence Gets Involved. Here's How. Date Retrieved Nov 15, 2020 from https://www.ideo.com/blog/the-rules-of-brainstorming-change-when-ai-gets-involved-heres-how
Desktop S.	Technology company - Sketch2code by Microsoft
	Jana (2018). Turn your whiteboard sketches to working code in seconds with Sketch2Code Retrieved Nov 15, 2020 from https://azure.microsoft.com/en-us/blog/turn-your-whiteboard-sketches-to-working-code-in-seconds-with-sketch2code/
Desktop T	Furniture company - Phillippe Strack
	Starck (2020). Homepage. Date Retrieved Nov 15, 2020 from https://www.starck.com/ Jordahn (2019). Philippe Starck, Kartell and Autodesk unveil "world's first production chair designed with artificial intelligence. Date Retrieved Nov 15, 2020 from https://www.dezeen.com/2019/04/11/ai-chair-philippe-starck-kartell-autodesk-artificial-intelligence-video/
Desktop U.	Streaming service provider - Netflix
	(Verganti, Vendraminelli and Iansiti, 2020) Christopher (2020). How Netflix Uses AI For Better Content Recommendation Retrieved Nov 15, 2020 from https://albertchristopherr.medium.com/how-netflix-uses-ai-for-better-content-recommendation-e1423784ef4 Chandrashekar et al. 2017. Artwork Personalization at Netflix. Date Retrieved Nov 15, 2020 from https://netflixtechblog.com/artwork-personalization-c589f074ad76
Desktop V.	Music streaming service - Spotify
	Lalmas (2019). Recommending and Searching. Retrieved Nov 15, 2020 from https://www.chalmers.se/en/areas-of-advance/ict/events/initiative-seminar-AI2019/Documents/MouniaLalmas.pdf McInerney (2018). Explore, Exploit, and Explain: Personalizing Explainable Recommendations with Bandits. Date Retrieved Nov 15, 2020 from https://static1.squarespace.com/static/5ae0d0b48ab7227d232c2bea/t/5ba849e3c83025fa56814f45/1537755637453/BartRecSys.pdf

Appendix 8. Mapping of process

		Companies	Tools and Methods
Problem diamond	Case A	Coop	Observing and Interviewing Personas Customer journey
	Case B	Mobility service platform*	Observing and Interviewing Pain point analysis
	Case C	Developer of sustainable transport system*	Observing and Interviewing
	Case D	Mittmedia	Pain point analysis
	Case E	Hyve	Pain point analysis Lead user identification
	Case F	Siemens	Observing and Interviewing
	Case G	SAS System	Observing and Interviewing
	Case H	Iprova	Analogies Observation
	Case I	Sogeti	Prototyping
	Case J	Ambercite	Prototyping
	Case K	Siemens	Prototyping Design Scenarios
	Case L	Mobility service platform*	Design scenarios
	Case M	Tawney	Prototyping Experience journey Customer co-creation
Solution diamond	Case N	Microsoft and Mackmyra	Design scenarios
	Case O	Choosey	Observing and interviewing
	Case P	Benevolent AI	Observing and interviewing
	Case Q	Mapegy	Analogies Observations
	Case R	Open.AI by Ideo	Analogies Brainstorming
	Case S	Sketch2code by Microsoft	Prototyping
	Case T	Phillippe Strack	Design Scenarios

Appendix 9. Principles affected (User centricity, iteration, hypothesis driven, visual communication & multidisciplinary)

Principle affected: User centricity

Company	Short description that reflects key points in the case
Coop	Understand behaviour in store
Coop	Find hidden needs
Coop	Understanding individual customer needs.
Mobility service platform*	Deeply understand the real customer problems
Mobility service platform*	Extract patterns around the pain points for customers.
Developer of sustainable transport system*	Understand customers driving patterns and thereby making a indivudalised recomendation
Mittmedia	Identify pain points to understand the real problem
Mittmedia	Understand users needs on an individualised basis
Hyve	Identify lead user
Hyve	Review large amounts of customer eWom for product development.
Tawney	Understand customers emotional reactions.
Siemens	Scan the web to search for pain points.
SaS	Learn from customer feedback
Chosey	Understand the needs of customer
Benevolent AI	Understand needs
Spotify	Understand user needs on individualised basis

*Company requested to be anonymous

Principle affected: Iteration

Company	Short description that reflects key points in the case
Philippe Strack	Suggest potential solutions
Mobility service platform*	Quickly test potential ideas
Siemens	Predict likelihood of success for a project
Sogeti	Enable testing that has been challenging/impossible before
Ambercite	Speed up investigation of proposed solutions and identify their plausibility
Siemens	Support more realistic prototypes and virtual copies that later be used for visualization
Siemens	Make protptypes quickly
Siemens	Feedback about product after launch
Mobility service platform*	Simulate effects of proposed solutions
Microsoft and Mackmyra	Suggest potential solutions
Sketch2code	Make protptypes quickly

*Company requested to be anonymous

Principle affected: Hypotesis driven

Company	Short description that reflects key points in the case
Iprova	Use analogies from other industries to broaden the search process
Iprova	Identify points of disruption with regards to market, technological or social convergence
Siemens	Identify innovative strategic moves
Mobility service platform*	Test hypotesis in a close-to-real environment
Mapegy	Use analogies from other industries to broaden the search process.
Siemens	Test different aternatives for a solution
Ideo and Open.AI	Open up mindset for possible new ideas

*Company requested to be anonymous

Principle affected: Visual communication

Company	Short description that reflects key points in the case
Sketch2code	Visualisation input
Siemens	NX and Mendix visualisation of the solution

Principle affected: Multidiciplinarity

Company	Short description that reflects key points in the case
SaS	Involve other domains in the innovative work
Mobility service platform*	Work in teams over disiplines
Developer of sustainable transport system*	Work in teams over disiplines
Mittmedia	Centeralised project, data scientist and project owner worked closely together

*Company requested to be anonymous

Appendix 10. Identified sub-themes

Principles	**Identified sub-theme**
User centricity	Individualised user centricity
Iteration	Speed in iteration
	Prolonging iteration cycles
Hypotesis driven	Reduce constraints
Visual communication	Visualise insights from data
Multidiciplinarity	New team constellations
	Inform new perspectives