Navigating Entrepreneurial Uncertainty: The Role of AI in Causal and Effectual Decision-Making in Early-Stage Ventures

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ABSTRACT,

Entrepreneurs play a significant role in economic growth and innovation. Their ventures usually encounter challenges, such as uncertainty, a lack of experience, and a lack of resources. Adaptive decision-making is needed to operate effectively within a volatile, uncertain, complex, and ambiguous (VUCA) environment. Entrepreneurs typically use either causation, a predictive and goal-oriented approach, or effectuation, which is adaptive and means-based. Effectuation works best in early-stage ventures that experience high uncertainty, leveraging available resources, strategic partnerships, and affordable-loss experimentation to find new opportunities. Artificial intelligence (AI) is a rapidly growing, game-changing technology for entrepreneurs, but its connection to entrepreneurial decision-making is underexplored. Particularly with causation and effectuation decision-making logic. This study is based on a mixed-method approach with survey data and semi-structured interviews. Results provide practical implications for entrepreneurs and theoretical contributions through the extension of effectuation theory with AI to leverage decision-making. AI supports entrepreneurs by improving idea generation, improving efficiency, and reducing uncertainty through predictive analytics. Findings reveal that AI in early-stage ventures helps with recognising opportunities, market analysis, and scenario building. AI shifts entrepreneurs toward a more hybrid decision-making approach, where AI tools introduce causal processes into effectuation, and at the same time, AI brings more adaptive, effectual characteristics to causation. AI allows for the co-existence and usability of both logics. Unfortunately, leveraging AI comes with challenges: e.g., sustainability issues, privacy of data, poor quality results, and distrust among users. Entrepreneurs can partly overcome these challenges by increasing knowledge about AI and checking AI output, rather than blindly trusting it. This study examines ways in which entrepreneurs use AI to leverage decision-making across venture lifecycles. Additionally, AI's role in transitioning decision-making, changes in AI use across startup phases, and AI challenges are discussed.

During the preparation of this work, the author used ChatGPT and Grammarly in order to support idea generation and refine grammar. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the work.

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1. INTRODUCTION

Entrepreneurs are key players in ensuring economic growth in society. According to Sarasvathy (2001), both new job creation and real per capita income have been shown to increase based on entrepreneurial activity, especially in startups. Ventures tend to contribute to technological innovation. Startups can also contribute to solving environmental problems, for example, by developing new technologies to reduce carbon emissions (Uriarte et al., 2025). As early-stage ventures progress through different phases, from idea to post-startup, they face changing challenges (Clarysse & Moray, 2004). At the same time, startups face the liability of newness and smallness (Azeem & Khanna, 2024). Startups are struggling due to a lack of experience, established networks, and credibility in the market. According to Aldianto et al. (2021), the lack of financial stability in startups hinders their ability to innovate and scale effectively. Startups often do not have established routines, market credibility, and funding that characterise larger businesses. Despite the innovative potential startups have, they face challenges regarding uncertainty. Startup entrepreneurs operate in a volatile, uncertain, complex, and ambiguous (VUCA) environment. Because of the rapidly changing environment, businesses need to adapt quickly to changing market needs. This introduces the question of how entrepreneurs operate under such uncertainty. To gain a competitive advantage through high performance and innovation, companies demand strategic decision-making. Achieving long-term success means that entrepreneurs must be willing to adapt to changes and face setbacks. Technological innovations are one of many factors that contribute to this dynamic landscape, increasing uncertainty through rapid changes. In this case, entrepreneurs must respond quickly. Fast, informed, and adaptable decision-making is a key indicator of startup resilience. Aldianto et al. (2021) point out that strong decision-making and agile leadership help to change direction quickly and increase innovation. This adaptive nature is especially useful when considering external influences such as the COVID-19 pandemic. Agile leadership requires quick responses to feedback, which is crucial for managing startups in VUCA environments. To handle the challenges of VUCA environments, entrepreneurs should choose between different decision-making methods based on the level of uncertainty. According to Reymen et al. (2015), successful entrepreneurs continuously move between causation and effectuation based on the level of uncertainty. In a highly uncertain environment, a planning-oriented approach may not be the best fit, and therefore, it is necessary to adopt adaptive strategies to allow the entrepreneur to change the approach. It enables them to utilise existing resources, use failures as a learning opportunity, and make their businesses more adaptive to rapidly changing markets. Effectuation theory helps entrepreneurs navigate uncertainty by focusing on available resources and partnerships rather than setting predefined goals. Unlike the planning-based (causal) approach, which starts with a goal in mind and develops a step-by-step strategy to achieve it, effectuation emphasises flexibility and adaptability. Effectual entrepreneurs identify what they can accomplish with their current means, forming strategic partnerships and adjusting their goals as new opportunities emerge. This approach helps them deal with uncertainty better and have greater control over their chances of success, even in unpredictable environments. In this context, technology can provide crucial real-time information to support informed decision-making, enabling startups to respond quickly to market changes. Artificial Intelligence (AI) allows for making fast and informed decisions. This is essential in rapidly changing and uncertain environments. For example, AI plays an important role in innovation and decision-making in areas such as sustainability and clean energy (Garbuio & Lin, 2019).

1.1 The Role of AI in Decision-making

Given the complexity and uncertainty in startups, entrepreneurs must continuously seek tools that enhance decision-making. In an era of rapid technological innovation, the number of startups implementing AI is rapidly growing (Uriarte et al., 2025). AI has shown impressive capabilities in fields like healthcare, such as using supervised machine learning to detect cancer earlier than humans are capable of (Chalmers et al., 2020). However, its usage in entrepreneurial contexts remains underexplored. Specifically, its use in enhancing strategic decision-making under uncertainty. There is a notable knowledge gap, especially in understanding how AI can support decision-making in the highly uncertain environments typical of early-stage ventures. Current research focuses primarily on its technical features and advancements, with little consideration for applying it to entrepreneurial decision-making. Another knowledge gap exists in understanding how AI is used within decision-making methods such as causation and effectuation. Although research in the field of these methods is well developed, few insights exist into how AI might support them in a real-world setting (Raneri et al., 2023). Since startups often operate under high uncertainty, exploring these connections is essential to reach AI's potential to support decision-making. AI can be used by entrepreneurs for multiple purposes. Through analytics, pattern recognition, and real-time data, businesses will be able to make more informed decisions. Generative AI (genAI) can support entrepreneurs in the early stages of idea generation by providing creative insights and exploring possibilities. Decision-making can be eased with genAI by improving efficiency and reducing uncertainty. While business modelling typically follows the selection of the most promising ideas, genAI can assist in brainstorming business concepts that may later be developed into business models. Business modelling aligns closely with a causal approach, while effectual entrepreneurs shape opportunities with a more dynamic approach. AI improves venture creation through predictive analytics and can help reduce costs (Schiavone et al., 2023). According to Chalmers et al. (2021), AI can automate tasks, scale, and drive new business models in Industry 4.0. Importantly, AI cannot be used as a plug-and-play solution: entrepreneurs must actively learn how they can integrate AI tools into their decision-making. AI can provide predictive analytics, which the entrepreneur should decide on accordingly. Although most uses of AI require collaboration with the entrepreneur, Schiavone et al. (2023) explained that AI can automate processes such as customer service and supply chain management. In lean startup practices, AI transforms the Build-Measure-Learn (BML) Loop into the Build-Measure-Predict-Learn (BMPL) loop. AI algorithms support hypothesis testing by predicting market response to innovations, enabling entrepreneurs to save time and prioritise the innovation with the most potential (Raneri et al., 2023). Entrepreneurs approach decision-making differently, and AI supports both. causal entrepreneurs can use AI for forecasting, risk assessment, and optimisation of processes. Effectual entrepreneurs use AI for rapid prototyping, customer sentiment analysis, or adaptive learning. For example, causal entrepreneurs may use financial forecasting to predict financial risks, whereas effectual entrepreneurs leverage AI for A/B testing. It can be challenging for the average entrepreneur to truly identify where they can leverage AI since it is a relatively new practice in business. Organisationally, startups usually lack the means to effectively use AI (Aldianto et al., 2021). Not having clear processes and high perceived complexity are true barriers among groups, especially when AI adoption requires a shift in operations or strategy (Chalmers et al., 2020; Schiavone et al., 2023). At the individual level, entrepreneurs may not have the knowledge and understanding of the benefits of AI. Additionally, AI demands a systematic approach, as causal decision-making

needs to comply with long-term goals, whereas effectual decision-making needs continuous adaptation. To reach full potential with AI, entrepreneurs must educate themselves and be willing to adopt AI.

1.2 Research Question

Despite AI's huge potential, its impact on decision-making remains underexplored, especially the role of AI at different stages of the venture lifecycle. However, there lies an opportunity to explore how entrepreneurs can be guided in utilising AI for business development. Following the identified research gap, this study aims to answer the following research question:

"How can entrepreneurs leverage artificial intelligence to enhance decision-making in early-stage ventures?"

By addressing this gap, the research provides a more specific understanding of AI as a practical promoter of decision-making. To systematically attain the needed information to answer this research question, this research will be divided into the following sub-questions:

1. *"How does decision-making differ between early-stage and later-stage ventures?"*
2. *"What role does AI play in transitioning between effectual and causal logic over time?"*
3. *"What are the challenges entrepreneurs face when adopting AI in decision-making?"*

The first and second sub-questions will be addressed by employing a qualitative approach. Insights will be gathered from entrepreneurs, investors, and other decision-makers through semi-structured interviews. Their experiences in business will be used to explore the differences in AI adoption for decision-making. The interview will provide clear implications on AI strategies, practical implications and challenges faced by entrepreneurs in decision-making. The third sub-question will be answered by the interviews, supported by the effectuation theoretical framework, giving a structured analysis of the challenges entrepreneurs face when adopting AI.

1.3 Practical and Academic Relevance

The strategic challenge in the VUCA business world is that entrepreneurs must constantly adapt to uncertainty. AI presents a potential yet underexplored solution for aiding decision-making at different stages of venture creation. This study addresses an existing gap in the research and provides a comprehensive overview of AI implementation into the decision-making process. By identifying AI's Role in causal and effectual decision-making, this research will extend the effectuation theory by Sarasvathy et al. (2001) by showing how AI enhances adaptive and exploratory decision-making typical of effectuation. It also enhances a planning and goal-driven approach typical of causation (Chalmers et al., 2021; Raneri et al., 2023). In addition to the academic contributions, this study will provide practical applications for entrepreneurs, startup accelerators, and investors. Insights will be shown on how AI and which AI tools can enhance decision-making, make businesses more efficient and help businesses grow. Furthermore, findings will provide insights into the ways that AI supports entrepreneurs at different startup phases, helping early-stage ventures overcome uncertainty and make informed decisions about AI adoption. Findings also highlight challenges such as a lack of technical literacy or sustainability issues. Enablers to AI adoption and strategies for overcoming challenges will be identified. Additionally, this research will support policymakers in creating AI frameworks for effective and responsible use of AI.

2. THEORETICAL FRAMEWORK

2.1 Startup Development

Almost all businesses follow a certain path from business idea to exit. Regardless of industry and experience, most companies have the same characteristics and face the same decision-making challenges based on their business lifecycle phase. Nonetheless, a shared characteristic is the high degree of uncertainty and the difficulty in making concrete plans. For this research, startup development is divided into four phases: 1. Idea phase, 2. Pre-startup, 3. Startup, and 4. Post-startup (Clarysse and Moray's, 2004). This model explains how uncertainty is changing over time and how entrepreneurs act accordingly. The startup stage model is supported by Reymen et al. (2015). Their study links the stages to strategic decision-making. Hence, it is especially useful in VUCA environments since the model explains how startups face uncertainty throughout the stages. Entrepreneurial resilience strategies are required to build adaptable and dynamic capabilities for startups to survive (Enwereiji et al., 2024).

This research focuses on effectuation and causation in strategic decision-making across the four startup stages. The implementation of a startup stage model is desired to explain the characteristics across the four stages: for example, the challenges, decision methods, and implications of the use of AI. The model fits the aim of this research because it focuses on the uncertainty at each phase, which demands a different approach (e.g., effectuation vs causation). Furthermore, it offers a time-based structure for decision-making processes. In the first two phases, uncertainty is usually high, which requires entrepreneurs to adopt the effectuation (Sarasvathy, 2021; Chandler et al., 2011). When startups proceed to the next stages, the level of uncertainty decreases because entrepreneurs gain a better market understanding and experience. Practices of both effectuation and causation will be used. This hybrid approach has better predictions and planning.

In the idea phase, startups are characterised by low structure and a high level of ambiguity. Entrepreneurs focus on opportunity recognition, initial ideation, and team formation. Uncertainty is high, particularly given the lack of funding and knowledge. Entrepreneurs experience true uncertainty: they do not know what they do not know. This requires an adaptive and creative approach to decision-making. Problems arise due to a lack of formal resources, legitimacy, and an unclear or missing solution to the main problem. At the idea phase, effectuation becomes more dominant: entrepreneurs act based on their available resources, experimenting with different strategies or choosing a stakeholder approach to create opportunities (Sarasvathy, 2001; Chandler et al., 2011). AI supports startups at the idea phase by enabling opportunity discovery through trend analysis and market gap identification. It uses datasets to detect changing customer needs and helps with idea generation (Eyo-Udo et al., 2024). Uncertainty can be reduced by AI through early insights on market trends and competition (Raneri et al., 2023). Additionally, entrepreneurs can utilise Vincent's (2021) exploratory or confirmatory decision-making approach to combine AI and intuition at the idea phase in order to avoid decision-making bias while experimenting. The former lets AI generate the decision options, where the entrepreneur applies the best option. In the latter case, the entrepreneur makes a decision first, then lets AI test or validate the decision.

During the pre-startup phase, the company starts to formalise. Business models are developed, teams are formed, and stakeholders become involved. Uncertainty remains high, but it declines as a result of stakeholders' feedback. The strategic focus shifts to developing a value proposition, testing and prototyping. Decision-making typically combines effectuation practices such

as stakeholder co-creation and elements of causation such as market segmentation (Reymen et al., 2015). Resources available include early seed funding and initial partnerships. AI can leverage businesses in the pre-startup phase with validation. E.g., Predictive modelling and simulation. Generative AI improves stakeholder engagement by co-creating new ideas or through feedback gathering (Carayannis et al., 2024). Furthermore, AI tools do not only support current strategies, but are also able to change over time to co-evolve the business (Sjödin et al., 2021).

The startup phase is characterised by implementing the business models designed in the previous phase. Typical challenges include issues regarding human resources and the acquisition of resources and customers. Uncertainty is typically lower compared to the previous phases: decisions are made based on real information and data. Both causation and effectuation play a role in this phase: entrepreneurs leverage AI to predict while remaining flexible to changing market needs (Reymen et al., 2015). Ventures in the startups phase will obtain formal funding and increase the number of team members. Uncertainty in this phase is reduced by AI leveraged decision-making through data analysis. AI is especially useful to improve customer segmentation, marketing, and supporting lean business practices (Amoako et al., 2021). Carter & Wynne (2024) emphasise a hybrid decision-making model where startups can leverage AI to combine analytics with exploratory feedback loops.

In the post-startup phase, sometimes referred to as the growth/maturity phase, the venture starts to rapidly scale up and formalise. Uncertainty levels are typically low, though complexity increases as a consequence of increasing amounts of operations and competition. Causal decision-making plays a bigger role, relying on planning and predicting. AI supports efficiency with tools related to business intelligence, supply chain optimisation, or forecasting with data (Uriarte et al., 2025). At this point, the company has more access to revenue and data, Entrepreneurs face challenges regarding stakeholder engagement and remaining competitive through innovation. At this stage, businesses can take advantage by investing time in AI readiness and making decisions dynamically (Holmström, 2022).

2.2 Balancing Causation and Effectuation

As startups progress through the different stages, effective decision-making becomes crucial in VUCA environments. The approach to decision-making becomes necessary to deal with resource constraints and unpredictable markets. Entrepreneurs should continuously analyse the situation the company is in and make decisions accordingly. To remain competitive and ensure survival, entrepreneurs typically choose a certain method to make decisions that help them respond to the level of uncertainty. In practice, this means finding a balance between planning and adapting. For this research, the focus lies on effectuation theory introduced by Sarasvathy (2001): effectuation and causation.

2.2.1 Causation

Causal reasoning can be seen as a predictive, goal-driven, and analytical approach to decision-making. It is commonly associated with traditional strategic planning and is most commonly used in stable and predictable environments with low levels of uncertainty (Sarasvathy, 2001).

2.2.2 Effectuation

Effectuation theory can be seen as the opposite of the more traditional causation model. Decision-making can be seen as dynamic where entrepreneurs usually shift toward the other logic when information changes. This adaptability has the possibility to leverage unexpected events for the benefit of the startup (Chandler et al., 2011). According to Sarasvathy (2001), effectuation embraces uncertainty and increases control through

processes starting by taking a look at existing means, allowing ideas to converge and goals to emerge. Effectual reasoning is a more adaptive and resource-driven approach. Flexibility and experimentation are key characteristics; however, this requires more coordination. It takes the company's identity, resources and network as a baseline for decision-making. Uncertainty is usually high in effectuation, though it focuses on what can be controlled rather than what can be predicted. Sarasvathy (2001) explained effectuation through five principles:

2.2.2.1 The bird-in-hand principle
Rather than starting with a predetermined goal, effectuation entrepreneurs start with their available means and create their own opportunities. Decision-making is a continuously changing loop where outcomes and goals change.

2.2.2.2 Affordable loss principle
Effectual entrepreneurs think in terms of affordable loss instead of expected returns. This approach prevents them from depending on prediction and enables low-cost experimentation.

2.2.2.3 Strategic alliances
Forming strategic partnerships reduces uncertainty and entry barriers. Effectuation highlights the value of building strategic partnerships over conducting competitive analyses.

2.2.2.4 Leverage contingencies
Effectual entrepreneurs find opportunities in surprises instead of seeing them as a threat. This flexibility allows them to adapt to changing environments.

2.2.2.5 Control vs. prediction
The future is not just uncertain, though it is steerable. Entrepreneurs can co-create their environment and create a market for their product or service.

2.2.3 Hybrid decision making
Chandler et al. (2011) supported the differences in decision-making: In contrast to causal reasoning, effectuation focuses on affordable loss instead of anticipated return. Other key characteristics of effectuation are its focus on collaboration and continuous adaptation. Causation can be seen as a unidimensional construct concerned with planning, whereas effectuation can be seen as a multidimensional construct with affordable loss, flexibility, and experimentation as key characteristics.

During the early stages of the startup, the level of uncertainty is rather high. Entrepreneurs lack initial information and must rely on intuition, which is especially unreliable for novice entrepreneurs. Uncertainty slowly perishes in later stages: decision-making becomes more predictable and structured. Initially, an effectual approach is preferred since it is most effective in highly uncertain environments. Once the startup shifts to a more mature and information-rich phase, the focus should shift to causation.

Initially, Sarasvathy (2001) argued that causation and effectuation are contrasts. However, research by Chandler et al. (2011) showed that entrepreneurs often combine both approaches in a hybrid practice. Entrepreneurs also have the ability to switch between causal and effectual logic depending on the situation (Grégoire & Cherchem, 2020). In general, decision-making shifts during the venture's lifecycle when uncertainty decreases. Furthermore, some elements in business might take a different approach than others. For example, the marketing department might be more causal when targeting the known segment whereas the development department will be more effectual by quickly changing to customers' needs.

2.3 The Role of AI in Entrepreneurial Decision-making

The choice of effectuation or causation is especially important in the context of AI-leveraged decision-making. Predictive AI tools align well with causal thinking by enhancing planning and forecasting. On the other hand, experimentation capabilities of AI support effectuation. AI helps to reduce uncertainty through predictive modelling and pattern recognition, which supports a general shift towards the causal approach, especially for mature companies. AI and generative AI provide tools for scaling, forecasting and content creation. (Chalmers et al., 2021).

Furthermore, AI's connection to decision-making logics can be explained by decision-making characteristics: effectuation benefits from AI's adaptability and generative (genAI) possibilities. Causation benefits from AI's predictive capabilities based on data. AI can connect both logics with a hybrid decision-making approach, enabling entrepreneurs to switch between logics based on uncertainty and available means (Sarasvathy, 2001).

2.3.1 AI and AI characteristics

Phillips-Wren & Virvou (2025) discovered that human decision-making support systems (e.g. Decision support systems (DSS), business intelligence and analytics (BI&A)) have been used since the adoption of the computer in the 1950s. *"AI can be implemented in decision systems to enable more effective decision support by automating processes and providing a wider world view"* (Phillips-Wren & Virvou, 2025). AI not only automates tasks, but it also offers opportunities for decision-making by collecting, combining, and cleaning data together with model building. These models suggest ideas to be implemented by the decision-maker. Generative AI (GenAI) can be seen as a subset of artificial intelligence. The key distinction between traditional and generative AI is the ability to generate new things, where the former relies only on preprogrammed rules. Generative AI models, a form of machine learning, has the ability to mimic human creativity and ingenuity (Carayannis et al., 2024).

2.3.2 Benefits of AI implementation for enhancing entrepreneurial decision making

At the managerial and organisational level, data analysis supports market research and customer validation. Scenario simulations enable entrepreneurs to reduce (financial) risks and validate market needs. Early in the idea phase, AI supports the identification of market gaps through the analysis of (big) data. Assisted intelligence models support opportunity recognition by leveraging simulations and idea generation. These applications are particularly relevant as they help the entrepreneur to plan for various potential developments and respond more effectively. With the help of AI, scenario planning is sped up, becoming more efficient and comprehensive. This in turn enables data-driven decision-making that improves effectiveness for uncertain business situations (Garbuio & Lin, 2018). Generative AI possesses autonomous creative thinking which results into new innovations (Carayannis et al., 2024). Ideas will be tested, and predictions will be made with the help of AI in the pre-startup phase. This phase will benefit mostly from lean startup practices: for example, by identifying early adopters through machine learning (Raneri et al., 2023). Once the company is in the startup or post-startup phase, AI supports businesses in optimising business and facilitating growth: For example, resource allocation, product development through customer analysis, or sales forecasting. As startups grow, AI assists with reducing complexity through business intelligence and decision support systems. Garbuio & Lin (2018) discovered that autonomous

intelligence can be useful to operate independently of human instruction, which is mainly adopted in the post-startup phase. However, among the thirty startups investigated, none of them use any form of autonomous intelligence. Across multiple startup stages, entrepreneurs facing uncertainty can use AI to do affordable-loss experiments or test market responses efficiently, which can be linked to effectuation (Carter & Wynne, 2024). AI influences both causal and effectual reasoning by providing tools that improve flexibility and predictability. For effectual entrepreneurs, AI assist in experimentation with different possible futures. Furthermore, AI gives the possibility for adaptive decision-making, allowing entrepreneurs to continuously adjust their goals and discover new opportunities based on the available resources (Chandler et al., 2011).

2.3.3 Barriers to AI implementation for enhancing entrepreneurial decision-making

Various challenges arise when adopting AI in entrepreneurial decision-making. In general, AI adoption is hindered by multiple factors: Because AI is a relatively young concept in decision-making, entrepreneurs often lack the technical skills and information on how AI can be implemented. It is not only the entrepreneur who lacks information, startups lack large datasets to effectively train predictive models. Ethical concerns also arise when adopting AI, especially generative AI can be known to give misinformation and hallucinations (Phillips-Wren & Virvou, 2025). Ethical transparency and responsibilities can be a challenge: For example, ethical issues may arise when AI makes faults with biases that emerge from model training. This can lead to huge ethical concerns, such as discrimination or unfair treatment (Usman et al., 2024). Entrepreneurs adopting AI should take responsibility for making their AI solutions function transparently and make them adhere to moral and societal expectations. Public trust can be acquired by setting up ethical guidelines. Other risks arise when AI makes independent decisions, especially in fields such as healthcare or finance. Entrepreneurs need to balance such risks carefully by creating strong guidelines for AI adoption, with a focus on extensive testing and validation procedures before implementing AI solutions (Uriarte et al., 2025). Data quality has a strong impact on the accuracy and performance of AI systems for decision-making. Poor quality data leads to poor results which reduces the potential of AI leverage in entrepreneurial decision-making (Amoako *et al.*, 2021). Entrepreneurs have to make sure that the quality and suitability of the data are valid. Despite the current high state of accessibility and mass adoption of AI, the average human does not know how to use AI effectively. A lack of technical knowledge of possibilities and misinterpreting outputs are the root causes of poor AI usage (Holmström, 2022). According to Carayannis et al. (2024), especially entrepreneurs in small and medium-sized enterprises (SMEs) do not have the competencies. Therefore, hiring experts or investing in training programs becomes a necessity. Though AI can provide insightful and predictive information, AI cannot fully understand changing market conditions and customer demands, which may restrict the validity and usability of its predictions and suggestions. This limitation is particularly relevant when looking at effectuation: A key characteristic of effectuation is the ability to leverage existing resources and adapt to changing and unpredictable market conditions. Therefore, effectual entrepreneurs use AI for insights to reduce uncertainty. Additionally, resistance from within the organisation may arise with for example, with the fear of job replacement among employees. Powerful change management is required to get acceptance and adoption within the organisation (Ahmić & Šahović, 2025). Financial constraints may arise when initial investment and ongoing costs for AI adoption are high. AI requires large investments in infrastructure

and training. This challenge makes it in turn difficult to determine the ROI. Due to a short-term focus, long-term gains are uncertain (Carayannis et al., 2024). Finally, Carter & Wynne (2024) suggest that AI decision-making can only be implemented successfully with the presence of human trust and role clarity. Entrepreneurs will have to manage extensively when adopting AI into their ventures. Team resistance because of the experienced risk of AI taking over jobs needs to be reduced by combining AI recommendations with human intuition (Vincent, 2021). Both AI and human intuition are ineffective in unexpected situations (Vincent, 2021). This advocates for effectual decision-making, which emphasises flexibility.

3. RESEARCH METHODOLOGY

3.1 Research Setting

This study's focus lies on how entrepreneurs leverage AI to enhance decision-making in uncertain environments, particularly focusing on early-stage startups. Startups face challenges due to the highly uncertain and rapidly changing environment. Leveraging AI has the potential to improve entrepreneurial decision-making. Nevertheless, scientific research on this subject, particularly concerning the connection to causal and effectual decision-making logic, remains underdeveloped (Raneri et al., 2023; Chalmers et al., 2021).

Given the aim of this research and the lack of existing theory kept in mind, A mixed-method research design is adopted. The research consists of two phases. First, a quantitative survey, followed by qualitative semi-structured interviews. Qualitative research is especially valuable for gaining deep insights into complex phenomena (Gioia et al., 2013), making it useful for understanding how entrepreneurs use AI in their decision-making. Moreover, the lack of models explaining the connection between AI and causal vs. effectual reasoning supports the need to use an exploratory qualitative research method.

The initial survey is based on the validated method developed by Chandler et al. (2011). It provides a starting point to determine the participants' decision-making style, whether they are more causal or effectual. This is followed by a semi-structured interview to collect more in-depth answers. Furthermore, the survey checks if the responses of the interview align with the survey findings. Combining the two approaches allows for triangulation of findings, which allows for cross-checking the findings received from different methods (Carter, 2024). This reduces a possible bias when the participants answer in contrast with their actual decision-making practices or when the researcher steers the conversation based on assumptions or towards an expected outcome. Additionally, the two approaches enable this research to connect decision-making logics to AI-leveraged decision-making.

3.2 Sampling

The population on which this research focuses consists of startup founders and co-founders. The participants are currently active in business decision-making. This research uses a non-probability sampling approach. A total of 14 entrepreneurs are purposefully sampled. For convenience, non-probability sampling is used through multiple approaches. First, entrepreneurs from the researcher's network were selected and contacted. Secondly, Startups were found and contacted through Incubase, the incubator of startups linked to the University of Twente. Finally, online searches were executed to find other relevant startups. Contact was established via email or LinkedIn.

Only relevant entrepreneurs are selected. Participants need to be in charge of entrepreneurial decision-making in their businesses. A considerable number of entrepreneurs are either students or scientist entrepreneurs, resulting from ideas or research

developed from a university context. Some of them originate from academic projects or research spin-offs. Most participants are novice entrepreneurs, meaning that they are initially inexperienced in founding or managing a startup. The majority of the startups are high-tech ventures and are based in the Netherlands or Germany. However, the sample also includes a small number of startups operating in other industries and countries.

The sample contains entrepreneurs working for ventures who are in various stages of the startup lifecycle model developed by Clarysse & Moray (2004). Having startups across industries and in various stages enables this research to compare the development of uncertainty and decision-making over time.

Although there was no requirement for participants to use or consider AI, the results of the sampling consist of entrepreneurs who have at least some experience with AI adoption in business. This means that they can be experts who use it frequently, novices who use it on rare occasions, or someone who is considering integrating AI into their startup. The respondents range from those just using generative AI tools (e.g. ChatGPT) to those with AI models predicting their operations. Different levels of AI knowledge and adoption lead to a rich dataset containing a broad view of perspectives on AI usage in startups. It also enables analysis that suggests similarities between AI-leveraged decision-making in connection with effectuation and causation. To reduce potential bias among respondents, the sample is segmented based on AI use. Additionally, specific questions regarding AI use and knowledge were asked to ensure representative results.

Table 1 in Appendix 1 provides an overview of the participants, including their roles, company size, startup phase, decision-making orientation (causation, effectuation, or hybrid), survey score and the reported extent of AI use in their entrepreneurial activities.

3.3 Data Collection

Primary data was collected in two stages. First, respondents fill in a survey based on Chandler et al.'s (2011) study, which measures the decision-making style of the entrepreneur. The survey contains fifteen questions with two paired statements. These are two opposing statements; the first statement connects to effectuation, and the second to causation. A five-point Likert scale, which ranges from strongly agree to effectuation to strongly agree to causation, is used to indicate the respondents' position on the decision-making spectrum.

Once the survey is completed, semi-structured interviews are conducted, which allow the respondents to respond with detailed in-depth answers. Semi-structured interviews enable the respondent to tell their experiences and standpoints on how they leverage AI in decision-making. The semi-structured nature allows the researcher to ask follow-up or probing questions based on answers given earlier by the respondents. This enables a deeper exploration of currently determined and new concepts.

The interview was divided into a total of seven sections. First, the respondents provide the context of their startup: what their role is, what the business does, and how the venture evolved over time. Following this, the startup phase is determined by ten questions. These questions seek to find characteristics for each startup phase developed by Clarysse and Moray (2004). The survey results are validated by two control questions to quickly determine whether the decision-making is more causal or effectual. The next section explores the startup's current objectives, challenges and available resources. Questions regarding AI are split into two parts: firstly, the researcher defines AI as a guide for the respondents. Insights were gathered

on what tools the respondents use and which of them are AI tools. Secondly, two sets of questions are prepared: a version for entrepreneurs currently using AI, and a version for entrepreneurs who are not using AI but have considered using AI. This section examined the enablers and obstacles to AI adoption, offering insights relevant to answering sub-question 1. At the end of the interview, respondents get the opportunity to offer advice to other entrepreneurs considering AI adoption. It also provides space for them to provide additional insights related to AI and decision-making that may not have been discussed in earlier sections.

The semi-structured nature of the interviews provided flexibility compared to structured interviews. It sets up an open discussion where follow-up and probing questions can be asked. A balance between standardisation and flexibility to explore insights from the respondents is made through the semi-structured interviews. The validity of the interviews is enhanced by asking the same questions to the participants in an identical way. However, the flexibility made it more challenging to ensure that the wording of the questions is identical. To ensure consistency across interviews, a set of pre-prepared follow-up questions was prepared in advance to allow more consistency in the interviews. Furthermore, non-predetermined follow-up questions were asked when appropriate to remain flexible and responsive to get better insights into specific experiences explained by each respondent. (Babbie, 2019).

Additionally, secondary data such as company websites, reports, and databases were used. This approach is especially beneficial when considering the complex nature of AI and its broad capabilities.

3.4 Data Coding & Analysis
The first phase of the data analysis consists of examining the quantitative survey responses to determine the decision-making style of the individual participants. For each participant, the scores on all questions are summed, and an average score is calculated. This average score, ranging from 1 to 5, gives an initial suggestion for the adopted decision-making style of the entrepreneur. A score of 1 to 2.5 suggests that the entrepreneur tends to be more effectual. A score of 2.5 to 3.5 suggests that the entrepreneur does not tend to lean towards one decision-making logic and thus adopts a hybrid decision-making approach. A score between 3.5 and 5 suggests a causal approach. This initial categorisation provides a starting point for the interpretation of the qualitative interview data. This allows the researcher to cross-validate the initially suggested decision-making styles against the qualitative data obtained from the interviews, enhancing the validity of the data and interpretation (Carter, 2014).

The second phase includes the semi-structured interviews. To ensure a correct capture of all responses, the interviews are recorded and transcribed. The transcripts were then coded to facilitate the interpretation of the data and pattern recognition. The obtained data from the interviews is coded according to the Gioia methodology, which is a systematic approach to inductive qualitative research (Gioia et al., 2013). This methodology is proven to support the development of new conceptual models, especially in underexplored research fields such as AI-leveraged entrepreneurial decision-making.

The data coding and analysis consists of a three-step process based on the Gioia methodology. The coding starts with first-order concepts: segments of raw data (e.g., interview responses) are analysed for specific words and language that describe their decision-making style, interaction with AI, enablers and barriers to adopting AI. These data segments connect to the concepts drawn from existing literature, such as effectuation theory by Sarasvathy (2001). In the second-order themes phase, the codes

are clustered by the researcher according to themes. This second step refines the codes into more abstract theoretical themes such as "affordable loss" or "AI tools". The second-order themes are subsequently further elaborated in the aggregate dimensions phase. The dimensions provide the basis for the theoretical framework of AI-leveraged decision-making under uncertainty. The Gioia methodology connects the patterns and provides insights into how AI facilitates causal and effectual decision-making logic across different stages of the startup life cycle. When analysis from the Gioia method is completed, useful insights were identified. First, the startup phase is identified based on its alignment with the characteristics of the four respective phases. The Characteristics to help identify the startup phase are the company's growth, stakeholder involvement, validation, resources, funding and uncertainty. In order to determine the startup phase, the level of uncertainty needs to be determined first, as this is a key determinant of the startup phase. This is based on how the participants perceive changes in their market and the challenges faced by them.

The concluding level of causation or effectuation was determined by the identification of indicators corresponding to causation or effectuation. Each statement suggesting a characteristic of either causation or effectuation was coded and later grouped into its respective categories. For example, a statement indicating that the decision-making is rather flexible will be assigned to effectuation, whereas indicating long-term goals suggests a causal approach. The level of decision-making logic suggested by interview data was determined by identifying a dominant decision-making logic by looking at the frequency of the codes and the perceived contributions to decision-making. In cases where neither causation nor effectuation emerged as the clearly dominant logic, the decision-making approach was categorised as a hybrid approach, suggesting the entrepreneur has elements of both logics in their decision-making. These results were subsequently compared to the survey results, and a conclusion was drawn based on both results.

To analyse how entrepreneurs use AI, the analysis was structured into three parts. First, the tools for decision-making were identified, followed by the AI tools. These tools were grouped based on their application and use, e.g. market analysis, scenario forecasting, or creative output, and assessed on their value to decision making. Thereafter, the enablers (e.g. data availability, or having knowledge) and obstacles (e.g. ethical issues, or costs) for using AI are identified. Finally, an overall attitude towards AI and advice on AI use is collected. This provides insights into the perceived value of dealing with uncertainty and leveraging decision-making in connection with AI.

4. RESULTS
This study explored how AI is used by entrepreneurs in early-stage ventures. The scope lies in AI adopting between two opposing decision-making logics: effectuation and causation. Through conducting interviews with startup entrepreneurs, this study aims to give insight into the practical and theoretical implications of leveraging AI for entrepreneurial decision-making. Combining the interviews with a survey, the results for determining the entrepreneurs' decision-making logic are validated. This research contributed to a better understanding of how AI intersects with startup phases and decision-making styles.

4.1 Entrepreneurial Process
Understanding the entrepreneurial process from the interviews is needed to provide context for analysing the use of AI. This is especially important considering the differences in startup phases, decision-making style, and level of uncertainty. The majority of entrepreneurs focus on growing their ventures. Some

of them already have a product or service on the market, while others are still testing or developing prototypes. Some ventures were already profitable, but only a few showed strong growth. How entrepreneurs found or created opportunities and how often changes are made to the business model were key themes in identifying growth.

The goals of the participants were key determinants in understanding the entrepreneurial process. The interviews reveal that most entrepreneurs prioritise growth. Particularly later-stage ventures wanted to expand their business by entering new markets or expanding into new products and services. One example aims for market domination. Increasing the team size, automating and improving efficiency were also commonly mentioned as goals.

The availability of resources and funding was identified to connect to decision-making logic and startup phase. Human resources (HR) and software tools (including AI) were often mentioned as the most important resources. Particularly for early-stage ventures, having a strong professional network and the right skillset were often mentioned as success factors. Funding models varied across the sample: most ventures were only internally funded (bootstrapping), while others were funded by external investors or were actively seeking external funding.

Finally, entrepreneurs were faced with varying levels of uncertainty. Entrepreneurs gave insights based on their preparation for unexpected events. These insights were relevant in determining decision-making style and the startup phase. For example, one participant used buffers to counter uncertainty. Some others explained fast pivots to counter uncertainty. One participant mentioned: "*We were unsure about what service to offer at first, so we tried several directions.*"

4.2 Decision-making Process

Interview results gave valuable insights into the entrepreneurs' decision-making process. The following part describes the observations of the participants' decision-making process that either align with causation or effectuation. Based on the survey results (see Table 1 in Appendix 1), these first-order codes and second-order themes, a conclusion is drawn about the participant's dominant decision-making logic.

4.2.1 Causal entrepreneurs and AI use

For causal entrepreneurs, the use of AI was closely linked to long-term planning. Entrepreneurs outlined that the leading factor for their decision-making was achieving a long-term goal. This was done by thinking backwards and with the help of timelines. Interview results revealed that causal entrepreneurs use structured validation: Entrepreneurs used data and analytics to perform analysis (e.g. market or financial analysis). Customer feedback was also collected with the help of AI. One participant explained: "*After every workshop, we send a short survey. ... Copilot helps when we need to structure feedback reports.*" Teams were usually structured with distinct roles; how AI was used was based on the person's responsibilities. Additionally, causal entrepreneurs were likely to use AI to reduce uncertainty by planning for unexpected situations and creating scenarios.

4.2.2 Effectual entrepreneurs and AI use

Effectual entrepreneurs started with available means, especially when leveraging AI. Entrepreneurs began with what tools were within their reach (e.g. free version of ChatGPT) and applied AI with their current knowledge. They steer the company in the right direction by looking for opportunities based on personal interest, experimenting or close collaboration with partners. Causal entrepreneurs worked closely together with partners with more resources (e.g. laboratories or production facilities) or collected customer feedback extensively. One participant stated: "*It's*

better that they do it because they have expertise and the experience for these kinds of things, which we don't have. ... So, they are also helping with the product development.*" Flexibility was also a common theme: entrepreneurs explained using an adaptive strategy with frequent changes and flexible decision making. The financial strategy was according to the affordable loss principle, and budgets were not made based on goals but rather on current means. AI allowed for experimentation in effectual startups: AI's generative capabilities allowed for offering new views and ideas. Common effectual observations include a high level of improvisation and exploring new markets.

4.2.3 Hybrid entrepreneurs and AI use

Hybrid entrepreneurs possessed traits of both effectuation and causation. For example, AI was being used for both market analysis and setting long-term goals. One participant used AI for validation, but combined it with improvisation of the implementation. A typical example of a hybrid approach is given by a participant: "*I always explore new tools and see what they can do, but I also know what I'm working towards.*" The first statement clearly describes a key characteristic of effectuation, namely exploration. The second statement implies having a long-term goal, which is part of causation.

4.3 Utilisation and Interaction with AI Tools

The entrepreneurs in the sample mentioned that they use AI for a wide range of purposes. Many participants described that they used AI tools to perform market research, support business growth or automate tasks. An analysis of the sample revealed that ChatGPT was the most frequently mentioned tool out of the eleven AI tools discussed. Tools such as Microsoft Copilot, Zapier, or specific automation tools were also commonly used. Other tools being used include: Make.com, HubSpot, Dall-E, Sizespace, Canva, NotionAI, GitHub Copilot, and Mixpanel.

4.3.1 Creative tasks

These AI tools were generally used to improve efficiency, reduce workload or make tasks easier. AI was also used for creative tasks and marketing purposes: entrepreneurs reported having enhanced their website's performance through SEO analysis done by AI. One participant mentioned the following: "*We use ChatGPT to help generate marketing emails, blog posts, and product descriptions. It saves time and gives us a good starting point.*" Tools such as Canva, Dall-E or ChatGPT were used to generate pictures.

4.3.2 Process automation

Process automation was often mentioned by participants, particularly by causal entrepreneurs. AI was used to automate a wide variety of tasks. Entrepreneurs leveraged AI to automate the process of getting feedback. AI automated feedback after the service: It sends emails to the customers, and when the feedback is received, it automatically extracts the main subjects.

4.3.3 Strategic analysis

For strategic analysis, AI was extensively utilised to conduct market research and competitive analysis. Participants described using AI tools to analyse content, discover trends, and conduct data analysis. The search engine capabilities of ChatGPT were employed to search for current patents and help set up patent requests. Mixpanel, an analytical tool, was used to discover patterns of user behaviour.

4.3.4 Idea generation

AI played a significant role in idea generation, especially for effectual entrepreneurs at the start of their ventures. In the idea phase, entrepreneurs used AI to generate ideas or to evaluate various ideas. AI's opportunity recognition capabilities explored new markets to enter. Entrepreneurs viewed AI as an alternative

to their own thinking and helped them with brainstorming and getting new views on a certain topic.

4.3.5 Scenario analysis
Additionally, scenario analysis was conducted often in early-stage ventures. Entrepreneurs used AI to generate different business scenarios and let AI tools evaluate these scenarios. For a startup in marketing, A/B testing or trying out marketing messages was regularly performed by AI. This saved time and added an extra layer of validation to the entrepreneur, particularly valuable when dealing with uncertainty.

4.3.6 AI human-like support
A few respondents mentioned the more general uses of AI, which were also helpful during the entrepreneurial process. These general uses involved AI's human-like support. AI was seen as a personal assistant that improves and automatically schedules your calendar, takes minutes during a meeting, or summarises documents and emails. As participant 4 put it: "*I use AI to summarise emails, draft replies, and even take notes during calls. It's like having an extra team member.*" But it is also used to get some quick information on a subject or to correct human-made mistakes

4.3.7 Administration
In some companies, particularly in post-startup years, AI was being implemented to support accounting. Entrepreneurs used AI to recognise invoices, auto-booking, and to map bank statements. As one entrepreneur explained, "*AI helps us recognise invoices and match them with bank statements. It saves our accountant hours each month.*" AI improved operational efficiency by streamlining operations with tools such as ChatGPT or NotionAI. In general, administration was considered less time-consuming and more reliable when AI was used.

4.3.8 Using AI for decision-making
AI was particularly valuable when making decisions. Entrepreneurs indicated that they leverage AI to make decisions more quickly and with more confidence. Mixpanel and ChatGPT were used to get insights from raw data. AI tools helped them to analyse risks and to rationalise decisions.

4.3.9 Knowledge
Entrepreneurs stated that knowing about AI and knowing how to use AI was one of the reasons why they leveraged AI. Knowing how to write a prompt and having technical literacy enabled them to effectively use AI. Other factors mentioned were external support and general knowledge.

4.4 Barriers to Adopting AI

4.4.1 Environmental, ethical and social issues
Interview data showed obstacles regarding sustainability when considering leveraging AI. Participant 5 expressed concerns about AI's environmental impact, stating, "*AI consumes a lot of energy and also causes drinking water shortages because a lot of water is needed for cooling.*" Besides the high energy and water use when using AI, the high raw material usage was also a common theme among entrepreneurs. Some entrepreneurs expressed their concerns about the ethical and social issues of AI. The most prominent was the fear of replacing humans or jobs. Entrepreneurs explained that they do not know who owns their data or how their data is used. As one entrepreneur explained, "*We avoid putting confidential data into AI tools. You never know where your input ends up or who might use it.*" Additionally, interview results showed that a lack of transparency in AI algorithms can cause ethical biases: e.g. discrimination based on gender or race. During an interview, a participant specifically linked the Dutch benefits scandal to the presence of AI bias.

4.4.2 Trust and quality
The most mentioned obstacle was the general distrust of AI outputs. Some of this study's participants explained they feel a lack of control and underdelivering results. Almost all participants expressed their concerns about AI hallucinations and explained that they will always check the results for mistakes. Participants felt a lack of control when using AI: they did not know how the output was generated.

When quality is not assured, entrepreneurs would rather trust their intuition/gut feeling. They perceive AI as still immature and explain that they can easily recognise when text is generated by AI. The text is seen as generic, often lacking emotional depth and a personal touch. For simple tasks, such as writing an email or blog post, the poor perceived performance and required manual correction, which made it too time-consuming for them.

4.4.3 AI useability
Particularly early-stage ventures highlighted the lack of available data as an obstacle. They did not have company data available yet, and it was considered challenging to train their own models based on the amount of time and costs it takes.

Overreliance is also seen as an issue: people may over-rely on AI results, making them unable to produce the output themselves. Multiple participants fear this occurrence among their team members. For example, during programming, they did not know themselves how the AI-generated code worked. A participant explained: "*Always ensure you understand the output yourself.*" Participants were also afraid that team members would lose or not grow their skillset when using AI too often.

Finally, financial limitations were identified as an obstacle, particularly for early-stage startups that are operating with small budgets. Buying of subscription to premium software (e.g. ChatGPT Pro), hiring AI experts at a cost, and training expenditure were all mentioned as obstacles to AI adoption.

4.5 Enablers to Adopting AI
In addition to barriers, the interview data also revealed some insights on enablers that facilitated entrepreneurs to leverage AI.

4.5.1 Personality traits and organisational culture
The personality of the entrepreneurs seems to be a strong enabler of AI adoption. A curious mindset was one of them. As one participant explained, "I try to stay up to date with new tools. When ChatGPT came out, I just had to try it to see what it could do." This willingness to follow trends and being open to innovation was a common theme discovered during the interviews. Entrepreneurs emphasised that their organisational culture was a key determinant of successful AI adoption. Many participants described their teams as diverse and innovative. They adopted a flat company structure with a focus on continuous learning to get familiar with AI tools. As one entrepreneur explained: "We have quite a flat organisation. If someone finds a new tool, we'll just try it out together."

4.5.2 AI tool accessibility and business experience
Interview results show that AI was successfully adopted by the entrepreneurs because they were beginner-friendly. The majority of entrepreneurs mention the ease of using ChatGPT without having technical knowledge. Especially for early-stage ventures with small budgets, a free version of AI tools enabled them to use AI. One entrepreneur explained: "*It's great that so many of these tools have a free version. We started with those, and it already gave us a lot of value.*" For first-time entrepreneurs, lacking business and field experience, AI was useful to compensate for the lack of knowledge. For example, one participant explained the following: "*I don't know much about SEO, but ChatGPT helped me figure out what I needed on the website.*"

5. DISCUSSION

This study explores how entrepreneurs in early-stage ventures can leverage AI for entrepreneurial decision-making. The findings support that AI enables startups to make faster, more adaptive and confident decisions. AI plays a wide variety of roles in early-stage ventures. As explained by Sarasvathy's (2001) effectuation theory, entrepreneurs are likely to operate in a VUCA (volatile, uncertain, complex, and ambiguous) environment. This uncertain nature requires adaptive decision-making. AI enables adaptiveness by offering possibilities for idea generation, quick feedback, and affordable testing. AI tools such as ChatGPT helped founders to check scenarios, study consumer behaviour, and generate content, enabling them to spend less time and money. However, AI adoption is not straightforward. The findings show the complex interplay of factors such as technological literacy, data availability, and the entrepreneur's ability to critically evaluate AI outcomes. This requires careful AI adoption and purposive integration rather than blind adoption of AI

5.1 Theoretical Implications

The findings also align with Raneri et al.'s (2023) Build-Measure-Predict-Learn (BMPL) loop. Entrepreneurs in this study utilised AI to simulate market reactions before market entry, which reduces uncertainty. This aligns with the AI's predictive capabilities discussed by Chalmers et al. (2021), increasing causal decision-making with planning and forecasting. One example of valuable AI adoption involved training a custom GPT model to perform competitor analysis, which made the decision-making more effective and saved considerable time. This aligns with Garbuio and Lin (2019), who point out that AI not only assists in execution but can enable entrepreneurs to gain competitive advantages. An interesting finding was that AI can compensate for a lack of knowledge, especially common among novice entrepreneurs. This finding supports previous research by Chalmers et al. (2020), explaining that AI can fill knowledge gaps for inexperienced entrepreneurs. Entrepreneurs leveraged AI to respond to a lack of knowledge in areas such as marketing, accounting, or customer segmentation. This also aligns with the theory that AI can reduce the "liability of newness and smallness" (Clarysse & Moray, 2004), which would typically affect startups due to their lack of experience and market credibility. This aligns with effectuation to the principle of starting from available means: entrepreneurs used AI as a substitute for lacking expertise.

5.2 Practical Implications

Surprisingly, all participants used AI to some degree. even a participant who was strongly against AI adoption. This explains a lot about its accessibility and necessity when time, skills and resources are scarce. In many cases, AI enabled the lack of resources without external funding. A considerable number of entrepreneurs are willing to pay for premium AI tools. Furthermore, AI tools can be used for decision-making as well as learning. AI reduces the complexity of decision-making, helping entrepreneurs to validate their ideas and build confidence. AI can be seen as a smart sparring partner with often more creativity and knowledge, making the entrepreneur able to make faster and more analytically rich decisions. Importantly, the advice given by the entrepreneurs reveals a shared understanding among entrepreneurs that AI is best used as a supportive tool rather than a replacement for human judgment. While AI significantly enhances efficiency, entrepreneurs consistently emphasise the importance of validating AI outputs and maintaining core human competencies. The advice to "*start small*" and "*never use AI blindly*" reflects a cautious adoption strategy. Finally,

entrepreneurs suggest that a curious and open mindset is crucial for successful AI adoption.

Concluding, AI supports early-stage ventures by enhancing idea creation, validation, flexibility and reducing uncertainty. Entrepreneurs work more efficiently, enabling them to make decisions faster. By helping entrepreneurs reduce uncertainty, AI emerges not only as a technical tool but as a strategic enabler of startup growth.

5.3 AI Across the Startup Lifecycle

How entrepreneurs leverage AI differs across the stages of the lifecycle. The findings demonstrate that AI plays multiple roles during the early stages of a venture (idea phase, pre-startup, and startup) where uncertainty is high and resources are scarce. AI was for multiple entrepreneurs a valuable tool for idea generation. It has helped them in exploring opportunities, generating ideas, and eventually evaluating them. Progressing to the pre-startup phase, the role of AI shifts from exploration to testing. Entrepreneurs operating in the pre-startup and startup phase mainly used AI for experimentation and validation. Entrepreneurs use AI to manage small operational tasks such as content creation or customer feedback collection. This allows them to learn quicker and reduces uncertainty. Entrepreneurs value AI at this stage for its quick feedback and feel that they don't have to rely on instincts alone. As supported by Carter and Wynne (2024), AI supports decision-making in early-stage ventures by helping with judgement and experiential learning. Its main value lies not in automation, but in managing the uncertainty through quicker insights. AI use during the post-startup phase is characterised by optimisation and integration into the business. Theory suggests that post-startups typically focus on scaling operations and optimisation. For example, one participant extensively implements AI for the optimisation of logistics to reduce delivery time. In general, a shift can be seen that AI is used to increase efficiency and reduce human-like tasks, such as reducing time during accounting practices through invoice recognition or bank statement mapping.

The findings support the proposition that early-stage ventures use AI to explore and adapt, while later-stage ventures use it to optimise and scale. Entrepreneurs change their AI usage along with their decision-making needs, making AI's role constantly shifting.

5.4 AI's Influence on Shifting Between Effectuation and Causation

Effectuation is best described by flexibility, experimentation and leveraging available means. Interview participants with an effectual decision-making style explained that they make decisions without a clear long-term goal in mind. Effectual entrepreneurs leverage AI mainly to explore. For example, exploring new opportunities or markets to enter. They use AI to generate new ideas or scenarios. With AI, these scenarios can later be evaluated. AI for effectual entrepreneurs is especially used to assist decision-making. AI acts as a virtual colleague offering creativity and expertise to support decision-making, especially in early-stage ventures. The use of AI for tasks such as content or scenario generation shows resource-based thinking, a key characteristic of effectuation. AI enables entrepreneurs to leverage available resources, enhancing flexibility through optimisation and predictive capacities. These AI appliances help to reduce uncertainty when making entrepreneurial decisions. For example, one participant described a lack of long-term vision and explained that they rely on resource-based improvisation. AI use reflects and reinforces the entrepreneurs' decision-making style. Patterns can be seen in how AI is used across the two decision-making logics. This difference can be explained by the

purpose of using AI. For example, causal entrepreneurs use AI with a predetermined goal kept in mind. Causal entrepreneurs use AI mainly for planning and to validate strategic decision-making. AI practices among the entrepreneurs reflect a goal-driven approach, where technology enhances efficiency and reduces uncertainty, which is a key element of causation. They leverage AI mainly for automation and analytics. This aligns strongly with causation, where goals are predefined, and means are selected to achieve them. Causal entrepreneurs trust AI as a strategic support tool to enhance planning and reduce uncertainty with stronger decision-making. Hybrid entrepreneurs implemented AI tools to track market trends and adapted the business accordingly. This is in line with the study of Reymen et al. (2025), which suggests that entrepreneurs tend to switch and combine both logics over time. Connecting existing theory with practices discovered during the interview, patterns can be seen between the fit of AI and decision-making. The predictive nature and analytical capabilities of AI appear to gradually shift effectual entrepreneurs towards causation.

Interestingly, many participants adopted a hybrid decision-making style. Entrepreneurs actively switched between the logics and even used practices of both for a single decision. AI appears to enable hybrid decision-making by offering tools for exploration, as much as for validation. This closely connects to the findings of Sjödin et al. (2023), how AI enhances business model innovation with flexible decision-making and strategic partnership. When entrepreneurs use a hybrid approach to decision-making, they can use AI for a wide range of use cases. They can use AI to explore (effectual) and to validate or predict (causal). Therefore, the findings support the proposition that AI shifts entrepreneurs toward a more hybrid decision-making approach, where AI tools introduce causal processes into effectuation, and at the same time, AI brings more adaptive, effectual characteristics to causation. AI allows for the co-existence and usability of both logics. This flexibility supports the idea that AI is not just a tool, but also an enabler of adaptive decision-making. These findings agree with Sarasvathy's (2001) study, which showed that decision-making under uncertainty is a step-by-step process. Moreover, it aligns with Chandler et al. (2011), who emphasise that effectuation allows entrepreneurs to change based on the situation. AI strengthens this dynamic nature.

5.5 Challenges to Adopting AI
This study also found challenges to adopting AI. It supports prior research stating resource and energy use as a significant barrier. One participant highlighted environmental costs, such as data centre energy and water use, as key obstacles. Ahmić & Šahović (2025) suggest that generative AI models are particularly energy-intensive and contribute significantly to CO2 emissions and water consumption. This contradicts the sustainable mindset of many startups (Sjödin et al., 2023). A respondent critical of AI use explained that they would be willing to adopt AI when minimal AI use aligns with ecological goals. Sustainable entrepreneurs are more likely to reject AI tools that harm the planet, aligning with effectuation theory in VUCA environments. Effectual entrepreneurs act according to the bird-in-hand principle and thus only incorporate means that align with their values and vision. Closely linked to environmental issues are the ethical issues linked to AI. Many participants had ethical concerns about AI. Another issue relates to the transparency of the environmental impact of AI use. This lack of transparency causes data privacy issues and hinders innovative or privacy-sensitive entrepreneurs from using AI. This causes entrepreneurs to fear that their information will be made publicly available. AI software companies usually hide data regarding environmental impact, such as energy consumption or resource use (Adeyemi &

Muhammed-Jamiu, 2025). The lack of internal company rules and the absence of laws are potential contributors to this. As highlighted in the literature, emerging technologies often outpace legal and policy developments, leaving entrepreneurs vulnerable to unforeseen negative consequences (Uriarte et al., 2025). Interview results have shown that AI can have biases that can lead to, for example, discrimination. This aligns with the study of Sideri & Gritzalis (2025), where they observed instances of gender-based discrimination against women by AI.

AI biases and AI hallucinations also introduce a sense of distrust in the output. All participants have stated that they do not fully trust AI in most cases. Most of the participants manually check the result of AI, and a considerable portion of these outputs require human correction. This introduces issues when outputs are not checked or misunderstood. Using AI for complex tasks can lead to overreliance, making users unable to produce the output themselves. This overreliance on AI reduces users' critical thinking skills and contributes to compulsive usage patterns (Yankouskaya et al., 2025)

Because AI is still developing, both publicly available and company-specific data are not always readily available. This is especially a problem for early-stage ventures, since they often lack the knowledge, means and data to train AI models on. Additionally, a lack of financial means limits access to premium AI subscriptions (e.g. ChatGPT Plus). This issue, and not being able to pay for hiring AI experts or personal AI education, leads the entrepreneurs to not reach AI's full potential for their startup. In general, patterns can be observed among interview participants between the frequency of AI use and their level of knowledge about AI, especially IT startups that use AI more extensively. For example, one participant explained that AI hallucinations will rarely occur when you have the right skills and give the right prompt. It is proposed that entrepreneurs in later-stage ventures, with typically more causal decision-making, are more likely to overcome the barriers of poor-quality AI outputs and AI hallucinations. This is because they have more data, knowledge, and financial means for premium software.

6. LIMITATIONS AND FUTURE RESEARCH
This research provides insights into entrepreneurial decision-making and AI use in early-stage ventures. However, some limitations must be acknowledged. First, this study only focused on early-phase startups with small team sizes. Future research can focus on post-startup companies and large-sized companies. Further research with larger and more mature companies could provide valuable new perspectives. AI use might differ in larger post-startup companies due to lower uncertainty and greater resources. Second, not all startup phases were covered by the sample. No ventures were currently in the idea phase, although valuable insights into the idea phase were still gathered from participants reflecting on their past experiences, and conclusions were drawn based on these insights. Research can be extended by focusing on a micro level and evaluating the performance of AI. For example, no insights were given on what settings were used and what exact prompts were given to tools such as ChatGPT. Exact measurements of performance, usability and effectiveness of AI were not included in this research. Future research could extend this work by focusing on how AI is used on a micro-level. Finally, AI is still in an early-stage op development and is rapidly changing. New tools, capabilities and uses are likely to develop. Also, the level of accuracy and performance is expected to improve at a fast pace. The fast evolution of AI might soon make some of this research's findings irrelevant, including the problem of identifying which tools are best suited for what task and predicting future AI capabilities.

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9. APPENDIX

9.1 Characteristics of Interview Respondents

Table 1. Characteristics of Interview Respondents

Participant	Role	Size	Startup Phase	Survey Score	Score-based Decision-making Style	Conclusion Decision-making Style	AI Use
1	Co-founder & CEO	1	Pre-startup	3.1	Hybrid	Hybrid	Extensive
2	Co-founder and CEO	5	Pre-startup	2.1	Effectuation	Effectuation	Medium
3	Co-founder & CTO	4	Pre-startup	2.9	Hybrid	Hybrid	Extensive
4	Co-founder & CEO	100+	Startup	3.1	Hybrid	<u>Causation</u>	Extensive
5	Co-founder & CEO	2	Pre-startup	2.5	Effectuation	Effectuation	Minimal
6	Co-founder & CEO	6	Startup	2.0	Effectuation	<u>Hybrid</u>	Extensive
7	Founder & CEO	12	Post-startup	2.6	Hybrid	<u>Causation</u>	Small
8	Co-founder	2	Startup	3.3	Hybrid	Hybrid	Medium
9	Co-founder & CEO	5	Startup	2.4	Effectuation	Effectuation	Medium
10	Co-founder & CEO	5	Startup	2.3	Effectuation	Effectuation	Small
11	Co-Founder	4	Startup	3.3	Hybrid	Hybrid	Medium
12	Founder & CEO	7	Post-startup	3.1	Hybrid	<u>Effectuation</u>	Small
13	Founder & CEO	7	Pre-startup	1.9	Effectuation	Effectuation	Medium
14	Co-founder & CEO	22	Post-startup	3.6	Causation	Causation	Medium

9.1.1 Explanation Conclusion Decision-making Style.

The decision-making style of the participants is based on both survey results and interview results. As explained in the methodology section, the survey provided an initial indication of the dominant decision-making logic:

"For each participant, the scores on all questions are summed, and an average score is calculated. This average score, ranging from 1 to 5, gives an initial suggestion for the adopted decision-making style of the entrepreneur. A score of 1 to 2.5 suggests that the entrepreneur tends to be more effectual. A score of 2.5 to 3.5 suggests that the entrepreneur does not tend to lean towards one decision-making logic and thus adopts a hybrid decision-making approach. A score between 3.5 and 5 suggests a causal approach. This initial categorisation provides a starting point for the interpretation of the qualitative interview data. This allows the researcher to cross-validate the initially suggested decision-making styles against the qualitative data obtained from the interviews, enhancing the validity of the data and interpretation (Carter, 2014)."

When interview results (interview transcripts and Gioia method analysis) suggested an opposing decision-making style to the survey results, a conclusion is drawn based on both information. The conclusion can be found in the column *Conclusion Decision-making Style*. When the outcome is not equal to the survey results, the conclusion is underlined.

Out of the 14 participants, 4 had a different outcome compared to the survey results:

For participant 4, the conclusion was drawn based on the fact that it had a clear end goal and focus, combined with a long-term vision. This is highly correlated to causation. There were not many indicators for effectuation, except for the fact that they have some short-term flexibility.

For participant 6, a long-term goal was present, and the business model was defined. An additional quote revealed patterns of causation: *"We create a long-term plan, and we follow it."* A characteristic of effectuation, mentioned during the interviews, was the quick reaction to data insights. Combining this with a survey score corresponding to effectuation leads to a conclusion of a hybrid approach.

For participant 7, causation was indicated, since they built a "business roadmap", had a clear brand vision, goals had been set, and a product vision was defined.

For participant 12, the participant explained that they adopted short-term planning, which was highly flexible and made decisions based on the current situation in terms of resources (and finances), which correlates highly with effectuation.

9.2 Gioia Method Interview Analysis

First order concepts	Second order codes	Aggregate dimensions

- o Product has launched into market
- o Ongoing prototyping
- o The Age/duration that the company exists
- o The company is profitable
- o Creating opportunity
- o Finding opportunity
- o Change of business model

Growth

- o To grow/scale the business
- o Develop products/services
- o Automate processes
- o Improve efficiency
- o To hire more employees
- o To enter the Market
- o To dominate the market

Goals

- o HR/employees
- o Software tools
- o Office
- o Network, professional contacts, advisors
- o Skills & knowledge that the entrepreneurs has

Resources

- o Internal funding (bootstrapping)
- o External funding (investors)
- o Seeking external funding

Funding

- o The company operates under low uncertainty
- o The company operates under moderate uncertainty
- o The company operates under high uncertainty
- o Fast pivots to counter uncertainty
- o Buffer to counter uncertainty

Uncertainty

Entrepreneurial process

- o Orientation towards innovation
- o Flat organisation culture
- o Having a diverse company culture
- o Have AI tool familiarity among team members
- o Culture of continuous learning

Organisational culture

- o Curious mindset
- o Open to innovation
- o Following the hype

Personality traits

- o Tools are beginner-friendly
- o Tools are available for free (free version)

AI tool accessibility

- o Not knowing the industry compensated by AI
- o First time leading or founding a startup compensated

Lacking relevant business experience

Enablers to adopting AI

Figure 1 Gioia results entrepreneurial process and enablers to adopting AI

o Raw material usage when using AI
o Water usage when using AI
o Energy usage when using AI

Sustainability Issues

o Fear of job replacement resulting from AI adoption
o Fear of replacing humans resulting from AI adoption
o (Data) privacy concerns resulting from AI adoption
o Lack of transparency on how AI works
o Not having ownership of data when using AI
o Lack of laws and regulations concerning AI
o Lack of internal company rules concerning AI (governance)
o Ethical Bias of AI (e.g. discrimination)

Ethics and social issues

o Not all tools are reliable (technical)
o Inconsistent results/analytics when using AI (technical)
o Experiencing AI hallucinations (technical)
o Preferring intuition and gut feeling instead of using AI (personal)
o Feeling a lack of control when using AI (personal)

Distrust in AI output

o Identifying AI-generated content
o Required manual correction and validation after AI use
o Under-delivering AI results
o Feeling no need to use AI
o Immaturity: tools are not mature enough
o Missing the emotional tone in AI output
o AI is too time-consuming (for simple tasks)

Quality and capabilities

Barriers to adopting AI

o AI does not know the company data
o Not having enough data to train AI/lack of available data
o Costs time and money to set up

Data and resource constraints

o Not all tasks can be done by AI
o Traditional methods are often more efficient compared to AI

Task specific issues

o Misunderstanding the generated output
o Not being able to produce the output

Over-reliance and skill dilution

o The costs of a premium subscription or buying the software
o Costs of hiring experts
o Costs for training

Financial Issues

Figure 2 Gioia results barriers to adopting AI

First order concepts	Second order codes	Aggregate dimensions

o Customer-based development
o Selecting a market based on means
o Selecting tools based on means
o Learning through experimenting
o Personal interest drives strategy

→ Start with available means (the bird-in-the-hand)

o Co-creation: stakeholders are involved in shaping the product/service
o Ideas are tested through informal validation
o Collective learning with partners
o Collecting informal feedback

→ Forming partnerships (strategic alliances)

o Budgets are made based on what the entrepreneurs can afford to lose, not expected return

→ Affordable loss

o Flexible decision making, plans are often changed
o Frequent changes
o Adaptive strategy, adjusting to new insights
o Changing business plan

→ Flexibility (leverage contingencies)

o Explore new markets as opportunities emerge
o Improvisation, problems are solved in real-time

→ Create opportunities (control vs. prediction)

Decision-making: effectuation

o Decisions are made based on achieving a long-term goal
o Thinking backwards from end goal
o Data-supported decision-making to reduce uncertainty
o Uses timelines to track progress

→ Long-term planning

o Long-term goals are set
o Long-term goals are key for decision-making

→ Goal-oriented

o Structured feedback is used to make decisions
o Structured market analysis to make decisions
o Structured financial analysis to make decisions
o Using data to validate and confirm assumptions

→ Financial Issues

o Team members have distinct roles
o Tasks are pre-determined

→ Structured team design

o Long-term goals are set
o Long-term goals are key for decision-making

→ Financial Issues

o Planning for unexpected situations
o Scenario planning
o Focusing on its own market
o Check before making decisions

→ Avoiding uncertainty

Decision-making: causation

Figure 3 Gioia results Decision-making

First order concepts	Second order codes	Aggregate dimensions

- ChatGPT, Zapier, Make.com, HubSpot, Dall-E, Sizespace, Canva,NotionAI, Microsoft Copilot, GitHub Copilot, Mixpanel

AI Tools

- Automate tasks
- Send emails automatically
- Automated feedback

Process automation

- Make faster decisions
- Get more insights
- Rationalise and contextualise decisions
- Risk analysis

Using AI for decision-making

- Streamline operations
- Administration tasks

Improve operational efficiency

- Competitor analysis
- Content analysis
- Make data analytics more accessible and centralised
- Patent research
- Market research
- Feedback analysis
- Spotting patterns

Strategic analysis

- Narrow down ideas / evaluating ideas
- Generate ideas
- Explore new markets
- Brainstorming
- Alternative thinking, getting a new view

Idea generation

- AI is like a personal assistant
- AI improves personal calendar
- AI for (simple) daily tasks
- Check for human-made mistakes
- Notes/minute making
- Making summaries (e.g. documents, emails)

AI (human-like) support

- Accounting
- Invoice recognition
- Auto-booking
- Bank-statement mapping

Administration

- SEO improvement
- Blog writing
- Writing product description
- Writing Emails/messages
- General text generation
- Picture generation

Creative AI tasks

- Scenario generating
- Scenario testing
- A/B testing

Scenario analysis

- Knowing how to write prompts
- External support
- Intelligence (e.g. IQ)
- Technical literacy

Knowledge

Utilisation and interaction with AI tools
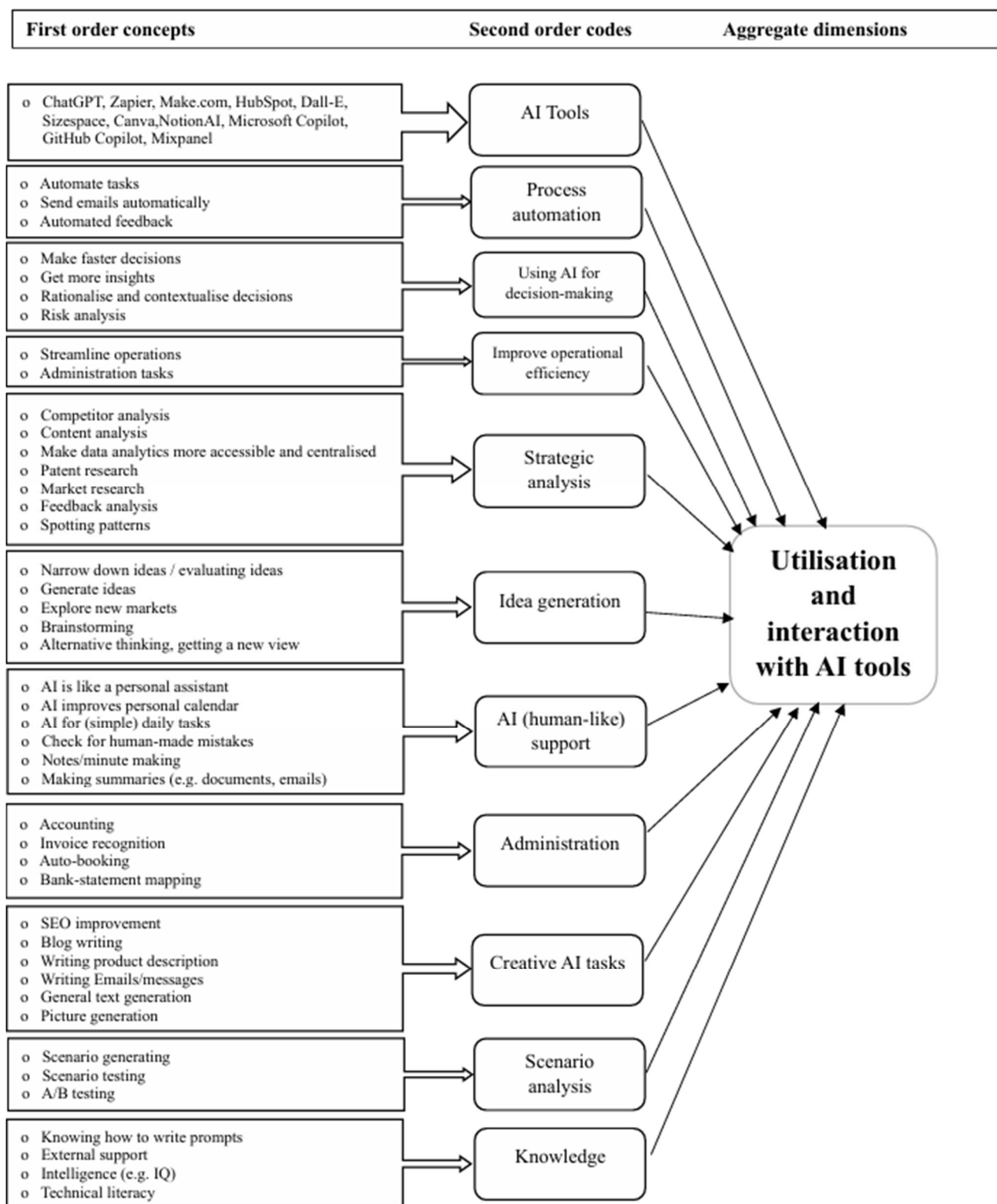
Figure 4 Gioia results utilisation and interaction with AI tools

9.3 Interview Guidelines

Section A: Introduction and context

1. Can you introduce your startup and your role in it?
2. What inspired you to create your venture, and how has the venture evolved so far?

Section B: Startup phase identification

C1 Initial development

1. How did the initial idea for your business come about, and what were the first steps you took to explore it?
2. When you started, did you validate your business idea with tools, analytics, or with the help of others

C2 Business model

1. What key elements of your business model have already been defined or implemented?
2. How have you gone about testing or validating your value proposition so far?

C3 Team structure

1. What does your team look like today: how many people work for the company, and do they have distinct roles?
2. To what extent and how do external stakeholders influence your company?

Optional sub-questions:
- Can you give me some examples?
- To what extend to your product/service?
- To what extend to your strategy?
- To what extend to your structure/team?

C4 Decision-making under uncertainty

1. Can you describe how you make strategic decisions and how does the process look like?

    - How does it change under certain and uncertain times?

2. Has your approach to planning and decision-making changed over time? If so, how?

C5 Activities

1. Are you currently offering your product/service to customers?
2. How do you use feedback from customers or market data in refining your offering?

Section C: Causation vs. Effectuation (Validation of survey results)

1. When making key business decisions, do you usually start with a clear long-term goal and then figure out the steps to achieve it, or do you prefer starting with what you already have and seeing what opportunities emerge?
2. How do you usually respond when something unexpected happens: do you try to get back on track with your plan, or explore how to turn the surprise into a new opportunity

Section D: Strategy and resources

1. What are currently the main objectives/goals of the company?
2. What challenges may arise that can prevent you from reaching these goals?
3. How do you see your company evolving over the next year?
4. What types of resources (financial, human, technological) are currently available to your company?
5. Have you raised any external funding, and what was it primarily used for?
6. What kinds of tools or methods for decision making are you using now (for example, testing ideas, doing simulations, forecasting, etc), and what do you primarily use them for?

Section E: AI

Explain what is AI: AI in business decision-making refers to tools used to analyse information, identify patterns, predict outcomes, and support or automate choices, helping businesses make faster, more informed, and often more objective decisions.

1. Do you use any AI tools for activities such as testing ideas, do simulations, forecasting, or optimise operations?
2. How do you see AI contributing to better strategic or operational decisions in your startup?
3. Can you give an example where AI helped reduce uncertainty or improved the speed or quality of a decision?
4. In your opinion, how could AI further support your decision-making processes in the future?

Section F: Enablers and obstacles to using AI

If the startup uses AI:

a) Where and how are you currently using AI in your business? (e.g., customer analytics, product development, operations, marketing)

a.   Optional sub-question: Can you describe previous experiences where AI played a critical role in your startup's journey?

b)   Do you think using AI in decision-making is valuable and to what extent do you trust its results? If so, how do you assess the value or return of using AI tools in your venture?

c)   What aspects have enabled you to successfully use AI in your business? (e.g., technical knowledge, funding, tools, partnerships)

d)   What challenges or obstacles have you encountered while integrating AI into your operations?

e)   How have you addressed issues such as data privacy, explainability, or ethical concerns in AI use?

f)   To what extent do you trust the outputs of these AI tools when it comes to making strategic or creative output (e.g. visuals, creative text)?

If the startup does not use AI:

a)   What do you think will enable you to start using AI? (e.g., technical knowledge, funding, tools, partnerships)?

b)   What challenges, obstacles could you encounter when considering using AI for decision making?

Section G: Closing

1.   What advice would you give to other entrepreneurs considering the use of AI in their startup?

2.   Is there anything else you'd like to add that we didn't cover but you think is relevant to AI and decision-making in entrepreneurship?

9.4 Survey Questions

Table 2 Survey questions with opposing statements

	Effectuation statements	Causation statements
1	We allowed the startup to evolve as opportunities emerged.	We analysed long run opportunities and selected what we thought would provide the best returns.
2	We adapted what we were doing to the resources we had.	We developed a strategy to best take advantage of resources and capabilities.
3	We were flexible and took advantage of opportunities as they arose.	We designed and planned business strategies and we stuck to it.
4	We avoided control processes that restricted our flexibility and adaptability.	We organized and implemented control processes to make sure we met objectives.
5	We formed partnerships and adapted as new information emerged.	We researched and selected target markets and conducted meaningful competitive analysis.
6	We allowed our goals to emerge rather than pursuing a fixed end vision.	We had a clear and consistent vision for where we wanted to end up.
7	We adjusted our marketing and production based on feedback and experimentation.	We designed and planned production and marketing efforts
8	We experimented with different products and/or business models.	The product/service that we now provide is essentially the same as originally conceptualized.
9	The product/service that we now provide is substantially different than we first imagined.	The product/service that we now provide is essentially the same as originally conceptualized.
10	We tried a number of different approaches until we found a business model that worked.	We followed a planned approach to reach a known business model.
11	We were careful not to commit more resources than we could afford to lose.	We invested a certain amount of money into the startup with the expectation of getting more in return.
12	We were careful not to risk more money than we were willing to lose with our initial idea.	We calculated potential returns and invested based on projected turnover.
13	We used our current means and let our strategy emerge through action.	We designed our strategy in detail before executing.
14	We focused on forming partnerships and available resources to shape the direction of the start-up.	We limited early involvement with partnerships to maintain control and reduce uncertainty.