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THE OPPORTUNITIES OF ARTIFICIAL INTELLIGENCE FOR SUPPORTING THE COMMERCIALIZATION OF ACADEMIC SPIN OFFS

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ABSTRACT

Through exploratory qualitative research, this study aim to investigate the adoption and implications of artificial intelligence (AI) within academic spin-offs (ASOs). The study focuses on Dutch ASOs, a rapidly growing segment within the Netherlands' innovation ecosystem, to analyze AI's role in addressing managerial and operational challenges unique to academic entrepreneurship.

The research consist of a first part, where the data were collected; this process involved semi-structured interviews with founders and key decision-makers across various ASOs, spanning multiple industries, organizational sizes, and levels of AI familiarity. The interviews focused on understanding the familiarity with AI, AI use cases, adoption determinants and perception of future AI implementation perspectives; furthermore, secondary data sources, including corporate reports and academic literature, were employed to validate the interview findings and ensure the robustness of the dataset.

Following, the data were analyzed using the Gioia methodology, a rigorous qualitative framework designed to enhance the systematic coding and categorization of emerging themes. The data coding process proceeded in three hierarchical stages: first-order concepts capturing direct participant perspectives, second-order themes identifying broader categories, and aggregate dimensions synthesizing key theoretical constructs. This structured approach facilitated the identification of critical factors influencing AI adoption, including organizational capabilities, external regulatory constraints, technological readiness, and individual entrepreneurial traits.

The research revealed that AI adoption in ASOs is shaped by a combination of technological, organizational, and external determinants. While AI is perceived as a valuable tool for enhancing operational efficiency—particularly in areas such as marketing, project planning, and data analytics—its implementation is constrained by factors that span from regulatory uncertainty to shortage of specialized human capital. Additionally, the entrepreneurial experience emerged as a factor that could facilitate AI integration, with seasoned founders exhibiting greater confidence in leveraging AI for strategic decision-making. These findings contribute to the broader discourse on digital transformation in academic entrepreneurship, offering insights into the conditions necessary for AI-driven innovation in university spin-offs.

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PREFACE

This research aim to expand the understanding of artificial intelligence (AI) in the commercialization of academic research through university spin-offs (ASOs). Previous studies have identified challenges in various areas of the ASOs venturing process (*Ndonzuau et al. 2002)*, that span from recognizing opportunities to maintain sustainable returns over the time (*Vohora,2004*). To mitigate or overcome completely these challenges, this research proposes AI as a key solution to these issues, offering deeper insights into how this technology can be implemented and used to reduce risks associated with the ASOs development. By addressing this gap this study try to investigate the potential of AI to accelerate ASOs growth, and enhance knowledge transfer from academia to industry, contributing to broader economic development and innovation.

1. INTRODUCTION

The academic debate on innovation and technology transfer has consistently highlighted the pivotal role of high-tech startup companies, highlighting the increasing importance of academic spin-offs (ASOs) in nurturing technological progress. These companies represent a tangible outcome of universities' technology transfer policies, often termed the "third mission," and are widely acknowledged for their significant contribution to accelerating technology innovation and fostering economic development *(Guerrero et al. 2015*). A University spin-off (ASO) can be simply defined as an establishment of an enterprise specifically formed to commercialize the research findings or the technology, derived from an academic institution; (*Guerrero et al. 2015)* The majority of these ventures, due to the specific market applicability of the academic knowledge, operate in sectors with high degree of innovation such as biomedical and IT, aiming to leverage the results of the academic effort to foster the development in the field *(Karanikić 2020)*. Distinguished by their origins within academic institutions and the innovative products or services derived from university research, ASOs hold immense potential for research and innovation, however, translating the novelty of the research into a viable venture is still a complex process which poses difficult and unique challenges to these companies.

As highlighted by the study of Hossinger,the success of this process is influenced by multiple factors from different dimensions. Internally, the success hinges predominantly upon the ability and the experience of the academic entrepreneurs to coordinate the business processes effectively. These personalities, who formerly are researchers and often do not have a strong entrepreneurial background (Hossinger *et al.*,2020 , *Fernández-Alles et al 2015),* may have more difficulties in accomplishing specific managerial tasks effectively if compared to experienced entrepreneurs with different projects in the background. This could limit ASOs growth and lead to face inefficiencies in resource allocation, as time, money, and intellectual capital, which are limited yet, may be invested in the execution of projects that may are not viable (Hossinger *et al.*,2020)
Universities,through the TTOs (technology transfer offices) try to help the development of ASOs introducing partners and supplying economic and human capital to overcome the limits, but often, given the novelty of the ASOs technology, it is difficult for these entities evaluating the potentialities of a project and supplying the right resources, leading to missed opportunities or misallocation of funds and time.(*Ndonzuau et al. 2002)*
To address these shortcomings numerous studies suggest digitalization and the adoption of new technologies as a solution to increase efficiency and efficacy in evaluating and performing business related tasks.*(Legner, C. et al, 2017*).
One of the most promising tools proposed in the field is artificial intelligence; introduced successfully in various sectors, this technology has proven adept at optimizing research activities, helping market validation , and improving business process management (Lee et al., 2019). Numerous companies have applied this technology to perform AI-driven simulations and build predictive models, improving the scenario testing to refine business plans and market strategies before implementation (Le et al., 2020); an instance of this could be observed in Origenis, an AI platform that helps pharmaceutical firms to analyze chemical structures and identify potential patent applications. Exploring the external and the internal factors, the software supported companies in detecting overlap with existing patents and refine business strategies. This novel approach based on data, helped firms to reduce costs and risks inherent in the traditional decision-making processes, as the insights provided by AI enabled the clients to be more efficient and effective in performing analytical tasks, translating into a more effective development. *(Lee et al. 2019)*.
The current literature about AI limits the findings only to specific sectors *(Ahmed et al. 2020, Le et al. 2020,Gbadegeshin, 2020),)* and does not explore deeply the implications of this technology in an academic context. Thus,in this paper we will expand the research in the field, proposing that AI can boost the ASOs development by offering potential solutions to challenges typical of academic entrepreneurship .We want to explore how artificial intelligence could be implemented by ASOs and which are the key determinants of its adoption.

Starting from the theory about academic entrepreneurs, we will analyze the characteristics of this segment and the challenges that could occur during the venturing process, proposing AI as a solution to enhance this process. After, in order to identify if AI could be useful for ASOs development, we will develop a framework to explain where AI can be applied in ASOs and the key determinants of its adoption. Our research seeks to shed light on whether the adoption of AI can effectively assist academic entrepreneurs and professionals in the growth and success of ASOs , aiming to answer the questions:

- ***What are the main key determinants for successful AI implementation in the Academic spinoff?***
- ***Which are the main applications of AI in the venturing process of academic spinoff?***

This research aim to expand the understanding of artificial intelligence (AI) in the commercialization of academic research through university spin-offs (ASOs). Previous studies have identified challenges in various areas of the ASOs venturing process (*Ndonzuau et al. 2002)*, that span from recognizing opportunities to maintain sustainable returns over the time (*Vohora,2004*). To mitigate or overcome completely these challenges, this research proposes AI as a key solution to these issues, offering deeper insights into how this technology can be implemented and used to reduce risks associated with the ASOs development. By addressing this gap this study try to investigate the potential of AI to accelerate ASOs growth, and enhance knowledge transfer from academia to industry, contributing to broader economic development and innovation. This theoretical advancement aligns with the third mission of universities, which emphasizes the role of knowledge transfer in driving socioeconomic progress *(Compagnucci et al. 2020)*.

2. LITERATURE REVIEW

2.1 ACADEMIC ENTREPRENEURSHIP EVOLUTION AND CHALLENGES

The evolution of universities since the 1990s has witnessed a significant shift from traditional roles centered on teaching and research to a broader engagement with economic growth and regional development, encapsulated in the concept of the "third mission."(*Compagnucci et al. 2020)* This mission emphasizes knowledge transfer, commercialization, and innovation as integral components of university activities, aiming to extend the research findings beyond the realms of academia to foster socioeconomic progress and the cooperation between external stakeholders such as industries and governments (*Compagnucci et al. 2020, Rubens, et al. 2017)*. Moved from this purpose, Universities and other higher educational institutions started to adopt a more entrepreneurial stance becoming knowledge hubs to boost the commercialisation of the research and the creation of new firms. *(Karanikić 2020).* These organizations strategically established incubators and technology parks near university campuses to ensure cooperative bonding with emerging industries (*Rubens, et al. 2017)* , and build strong ties with different companies to intensify business transactions between customers, vendors, and academic researchers (*Compagnucci et al. 2020*. This approach facilitates the creation of new ventures, enhancing the concept of academic entrepreneurship within academia.

However, due the nature of the Universities, the transition for researchers from academia to entrepreneurship is not without its own set of unique challenges (*Prokop, D. 2023)*. Numerous studies identify the inherent culture of academia itself as main factors affecting this process. Institutions of higher learning are traditionally organized around the pursuit of knowledge, with rewards and recognition often tied to scholarly output such as publications and conference presentations (*Prokop, D. 2023)*. At the individual level,This focus on intellectual pursuits can sometimes be at odds with the more practical, market-oriented goals of entrepreneurship, leading to what has been termed a "recognition deficit" for entrepreneurial activities within the academic community *(Hossinger, 2020).*

This cultural disconnect can result also in specific organizational challenges for academic entrepreneurs. For instance, the skills required to manage a research project within a university may not necessarily translate to the skills needed to lead a start-up company in a competitive market environment ((*Prokop, D. 2023)*. This can lead academic entrepreneurs to struggle with aspects of business management such as strategic planning, and financial management which are not typically part of the academic training (*(Hossinger, 2020*). An example of this could be observed in the structure of the license agreements that govern the commercial use of intellectual property (IP); when inadequately structured IP, can dissuade investment and restrict the entrepreneurial flexibility of spin-offs limiting the growth of these companies *(Rubens et al 2017).* Additionally, the consequent lack of resources could impede the endeavor of assembling a proficient and dedicated team for the project *(Hossinger, 2020),* as, at least during the early stages, the capacity of spin-offs to offer competitive remuneration or job security is low, limiting the possibility of acquiring the human capital necessary for operational success *(Rubens et al 2017)*. This deficit not only hampers the ability to plan and forecast with security but also severely limits the capacity for strategic decision-making, resulting in an inefficient approach towards market opportunities and technological advancements *(Gbadegeshin, S. A. (2019).*

Externally, the TTOs help to fill these gaps fostering the development of academic entrepreneurship, however, as the complexity of the operations involved in the ASOs evaluation and creation process,the actual methodologies are still imprecise and could lead to resources misallocation and missed opportunities. This lack opens possibilities to new approaches to accomplish these tasks, providing an opportunity for the implementation of AI . This technology,given its ability to produce forecasts, and insights, could help to assess the potential of a project from the early stages of development, saving internal resources but also external capital. Furthermore, it could help in planning the development of the company providing analysis on the internal and external environment. An example of this could be observed in ITONICS, a company that offers market analysis tools, which utilized specialized AI bots to perform environmental, technological, and competitor simulations that help its clients identify business opportunities and refine their strategies within their market segment.

In sum, the link between academia and business creates a formidable gauntlet through which academic entrepreneurs must navigate in order to successfully establish and scale an academic spin off. The entrepreneurs need to manage a different set of skills that are outside their knowledge background resulting in less efficient decisions and inefficiencies in the company's growth *(Hossinger, 2020).* The TTOs try to fill the lack of human and economic capital, but the evaluation and development processes could gain in efficiency utilizing AI. Thus, considering this we will focus on the venturing process of ASOs and explore where and when AI could represent an opportunity to promote the development of these companies.

2.2 ASOS DEVELOPMENT AND MANAGERIAL ACTIVITIES

According to the analysis of Fontes (2005), the venturing process of ASOs could be defined as a stage model process, where the business opportunity of a new technology or knowledge is exploited. It could be divided into four sequent macro-stages (Ndonzuau et al. 2002). The first stage, consists in generating and validating the ideas derived from the research with regard to possible commercialisation; the second stage, concerns all the activities required to translate the most promising ideas in actual entrepreneurial projects; the third stage, formalize the commercialization of the project and the venture actually launch on the market; and lastly, during the fourth stage, the company start to produce value and consolidate its business.The output of the process can result in either product-oriented or service-oriented USO and the value produced could be measured or through economic factors (economic return, job positions created), or through personal values (self recognition, societal impact)(Fontes, F. ,2005). In this process, academic entrepreneurs and TTOs have high responsibilities in the development of the project, as their function in evaluating and coordinating the firm involves a set of crucial activities. According to the Literature (Jerbrant et al, 2013) these functions could be referred as managerial activities referring to all the processes necessary to plan, develop and administer a company. These tasks can be categorized in three main categories: the planning activities, referring to the activities of sensing and scanning the environment to identify opportunities and translate them in business projects, the coordination activity, for what concern the activities of coordinating the people and the processes to achieve a defined output and lastly the control activities, relative to the process of measuring the performances and the goals achieved.

The planning activities, are the starting point of every venture (Ndonzuau et al. 2002); if the plans are not formed in an effective way, and for instance the target market is to small or the product require costs, in terms of development time and resources, too high compared to the returns, companies could face inefficiencies due to the not sustainability of the business over the time. Furthermore, the internal and external performances of a company (Nunn et al 2010), are strictly linked to the initial plan, as it firstly give the direction of the project, and secondly, could enhances the resource acquisition increasing the trust in the external investors, fondamental for new companies which have no proven records in the market (Nunn et al 2010). Given the nature of the planning activities, the other managerial activities of controlling and coordinating are strictly linked to the success of the project. A good plan has more chance of leading to a desirable output when the tasks which are brought to the execution are coordinated effectively (Jha,et al. 2006.); If the project does not respect the timeline or if there are problems in the development, the whole plan could encounter inefficiencies and lead to an output that differs from the expectations. Also tracking and evaluating the performance is a crucial aspect for a correct plan execution. Tracking the progress during the development helps to make more informed decisions and give the possibility to the company and the stakeholders to refine the trajectory of the strategy if the performance is not aligned with the expectations (Paulonis, et al. 2003). Consequently, due to this managerial inefficiency ASOs could face different challenges in various aspect of the venturing process:

Firstly, in the absence of effective planning activities, academic entrepreneurs may perform inadequate assessment of market needs and opportunities, resulting in products or services that fail to meet market demands (Nunn et al 2010). This lack of foresight can severely undermine the spinoff's ability to carve out a competitive niche and secure a sustainable market presence, causing misallocation of resources and limiting the growth and scalability of the venture. Furthermore inefficiencies in planning documentations such as business plan and business model, could decrease both the internal and the external performances, as external investors, which can not evaluate the firms, are discouraged to invest in the company, while the internal business processes could be inefficient as without clear directions for being developed.

Secondly, the lack of coordination could cause delays and ultimately the failure in the plans of these companies. Without effective coordination, these entities indeed may face fragmented operations and discord among team members, leading to inefficiencies and a dilution of organizational focus (Ndonzuau et al. 2002.) Such a scenario can result in a slower response to market changes and missed opportunities for collaboration and synergistic efforts, particularly critical in the early stages of spinoff development where adaptability and agility are key factors.

Lastly, the absence of robust controlling and evaluation mechanisms in academic spinoffs, could result in inability to monitor performance against set objectives, increasing the probability to achieve outputs that diverge from the planned goals (Di Vaio, et al. (2020). Without effective control measures, spinoffs may struggle to manage risks appropriately, or capitalize on learning opportunities from operational feedback, leading to inefficiencies in the long term development, resulting in a persistent state of operational inefficiency and a lack of improvement in processes and products, hindering the spinoff's growth and capacity

to attract investment. Furthermore the external stakeholders will find it difficult to evaluate the firm for providing human and economic capital hindering the external investments.

In conclusion, these activities can significantly influence the progress and sustainability of academic spin offs, highlighting the necessity to adopt a strategic approach to ensure the successful transition from academic ventures to thriving commercial enterprises. The table 1 gives a summary of the managerial activities and the challenges for academic entrepreneurship in ASOs development if not performed efficiently. Each stage of the management activities is critical in ensuring these ventures can transcend the initial hurdles of resource constraints and knowledge gaps; thus to foster a cohesive and synergistic operational workflow, we will explore how AI could help to solve these managerial shortcomings.

Table 1:

Managerial activities overview

Managerial activities	***Description***	***Challenges for ASOs development***
Planning	Sensing and scanning the environment to assess business ideas and solve organizational problems (*Ndonzuau et al. 2002)*	• Risk of starting a venturing project without a clear understanding of the market enhancing the risk of failure (*Ndonzuau et al. 2002)*; • difficulties in outsourcing resources (*Nunn et al 2010*) • difficulties in solving organizational issues (*Nunn et al 2010*)
Coordinating	Coordinating the people and the process to achieve a predefined output (Jha,et al. 2006.);	• Misallocation of resources (Jha,et al. 2006.); • Inefficiencies in the project execution Di Vaio, et al. (2020).
Controlling	Evaluating the organizational performances and goals to asses the progresses and create forecasts (*Paulonis, et al. 2003*)	• Difficulties in evaluating the progress/potential internally and externally (*Paulonis, et al. 2003*) Difficulties in creating forecasts and adapt the project to the changes Toorajipour, et al (2021). •

2.3 AI ADOPTION KEY FACTORS

The study of Taherdoost (2023) highlights how the integration of AI in business has become a crucial resource for organizations, but result still difficult to exploit in all its potential; consequently, to understand how this technology can be used in the management of complex business endeavors such as evaluating performances or helping in important decisions, we will focus on the ability of AI to perform particular tasks linked to the three main managerial activities of planning, coordinating and controlling.
Before diving into these applications ,It is important to define AI, and distinguish between expert systems, and 'real' artificial intelligence tools (Levine et al,1986). While expert systems, exemplified by IBM's Deep Blue, operate on predefined rules, AI models try to mirror the brain's structure through neural networks and autonomous learning from vast data sets, extracting patterns for better understanding the input provided.Currently, most of AI tools are analytical and based on cognitive intelligence (*Enholm et al, 2022*). These types of tools try to give a representation of the current world through the past experience, basing their answers on the data provided and extrapolating a context from the input of the user. These tools dominate contemporary AI applications and are applied in different industries for performing tasks such as image analysis and speech recognition. The algorithms, powered by natural language processing (NLP) could perform extensive text analysis of datasets in a shorter time and with higher accuracy than humans (*Di Vaio,et al. 2020*), producing forecasts and identifying connections between various dataset elements (*Enholm et al 2022*). By performing certain functions, AI can help firms effectively achieve innovation or societal goals (Soni, V. D. 2020).

The recent literature indicates a growing interest in the field ; the latest AI report indeed illustrates how (*Zhang et al, 2021*) the attention on AI has increased over the last years among researchers, and numerous studies recognized this emerging technology as a huge opportunity for the future, forecasting a quite optimistic scenario for the development of the research. *(Loureiro et al 2021*) While the potentialities in terms of complexity of tasks achieved is a very discussed topic,the contexts and the applications of AI still have room for exploration; we will focus on understanding where and when AI represents an opportunity for academic entrepreneurs, exploring the key determinants that could affect the implementation of this technology in ASOs. Table 2 shows the current findings in the field, illustrating the evolution of AI applications to perform different tasks and the determinants of AI adoption in academia.

Table 2:

Overview on Artificial intelligence applications in the literature

Artificial intelligence focus	**Examples**	**Sources**
General AI applications in business	Ai to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation.	Enholm, et al. (2022).
	AI to understand and classify information to analyze human feedbacks in order to perform market research and sentiment analysis	Taherdoost, H., & Madanchian, M. (2023).
	AI to help organizations in achieving their goals through the generation of forecasts and insights	Soni, V. D. (2020).
Application of AI in performing Managerial tasks (planning controlling coordinating)	Ai for creating a sustainable business model through the help of AI	Di Vaio, et al. (2020).
	Ai in supply chain management as enabler for coordinating people and processes	Toorajipour, et al (2021).
	Ai for controlling and monitoring patients cares and health performance	Luh, J. Y et al, (2019).
Digitalization and adoption of AI in business and academia	Barriers and limitations of AI adoption in organizations	Bérubé, et al, (2021)
	AI to promote academic entrepreneurship, enhancing knowledge transfer and tasks completion	Rippa, P., & Secundo, G. (2019).
	How the role of the academic entrepreneur is influenced by digital technologies	Lamine, et al.. (2023).

Firstly, for what concerns planning, AI could be able to perform well defined mechanical tasks such as analyzing extensive datasets to identify opportunities and solve organizational challenges . For instance, this capacity of AI to efficiently retrieve answers from large databases, could help ASOs founders to identify potential markets for the findings of the research (*Enholm et al 2022)* or also, help them to assess the best way to accomplish an operation (Di Vaio, et al. 2020). The ability of AI's tool to learn from diverse data sources indeed, enabled different industries to uncover novel business opportunities, as seen in the chemical sector, with the improvement of the compound analysis for protein synthesis, perfume development, and drug discovery *(Murugan et al 2022)*. In addition, Di Vaio *(2020)* highlights the role of AI-driven simulations and predictive models in enabling scenario testing, which allows organizations to refine their business models before implementation . This quantitative approach based on data and analytical analysis transcends human cognitive limitations, facilitating the discovery of innovative solutions (Di Vaio, et al. 2020). .

Secondly, AI could play a crucial role in coordinating tasks within companies, facilitating the communication and integration of various entities and streamlining collective endeavors.(*Bouschery, et al.2023*) Given the capabilities of AI to perform a variety of analytical tasks, it could be applied to redesign and automate business processes in order to execute them more effectively *(Toorajipour, et al 2021)*. In particular in the context of academic spin off, AI could facilitate the accomplishment of operational tasks such as improving the efficiency in resource allocation, as demonstrated by numerous manufacturing and retail firms like Samsung and Walmart which increasingly rely on AI for supply chain coordination *(Toorajipour, et al 2021).*; Another example of that could be observed in Ikea where AI is used as an assistant tool to anticipate changes in demand forecasting and allocate the budget consequently. *(Tambe et al. 2019)*

Thirdly, AI could be applied to business to perform controlling functions, guiding human behaviors towards desired outcomes through anomaly detection and behavior prediction (*Luh, J. Y et al, (2019)*..
This approach could help to solve broader problems evaluating the progress in the process and guiding it to a certain output. In healthcare for example, *(Blasiak 2020*) AI have been utilized in disease recognition and treatment personalization, predicting patient reactions to immunotherapy and automating documentation for patient monitoring during treatments such as radiation therapy (*Luh, J. Y et al, (2019).* A summary of the AI applications could be observed in table 2.

Table 3:

Managerial Implications of AI in ASOs

Ai Managerial application	***Ai potential Application in Academia***	***References***
Planning	• Facilitate the identification and the validation of ideas • Planning entry mode and business strategies to manage risk efficiently	• *Ndonzuau et al. 2002* • *Nunn et al 2010*
Coordinating	• Redesign and Automate operational processes to be more effective (ex. resource allocation, market strategy) • Knowledge collection, transformation, and assimilation to support the technological development	• Taherdoost, H., & Madanchian, M. (2023). • Enholm, et al. (2022).
Controlling	• Evaluating the progress to create forecasts and make more informative decisions (Risk management), and increase the trust in the shareholders	• Toorajipour, et al (2021).

Despite the potentialities of AI , as with all new technologies its implementation could be affected by different factors. The study of Berube identified the common factors that could inherit the adoption of emerging technologies through the Technology-Organization-Environment (TOE) framework, and adapted this theory to AI in order to identify the specific determinants of AI implementation.
Data governance and Data acquisition emerged as the most important specific limit in AI development. Organizations must ensure acquired data aligns with both quality and quantity thresholds essential for efficacy; the models base their answers and forecasts on the data provided ,and a lack of reliability in the dataset could compromise the integrity of the algorithm as the retrieved answers will be based on wrong information (*Berubè et al. 2021, Cubric et al. 2020*). The accuracy of the model is also influenced by the dimensions of the database, if the amount of data is not sufficient and updated the algorithm could face inconsistency in retrieving the correct information over the time, causing inefficient outputs. Notably, data quality surpasses

quantity in significance for building an effective model, as a minor quantity of data but more reliable, guarantee a more precise output as the answer will not be influenced by inaccurate data.(*Campbell et al.2020*)
Another important barrier identified by literature is the lack of experience in industrialization of AI (*Cubric, 2020*). Given the novelty of the technology, organizations struggle to understand the true benefits of the technology; usually companies are reluctant to restructure the business processes and include new roles that could satisfy the technical needs, as the costs could overcome the benefits. The shortage of individuals with technical competencies,furthermore could hinder considerably the AI implementation, as the lack of professionals in data engineering and data science can causes organizations to face obstacles that they do not know exactly how to overcome,limiting the performance of the model and enhancing the risk of data leaking linked to the shortage of data protection practices. *(Bérubé 2021)*

The accountability given to the model's output emerged also as an important barrier; as highlighted by Feuerriegel (2022), when AI systems make erroneous decisions, the accountability for these decisions ultimately falls on human managers, posing governance challenges. In situations where decisions made by AI have far-reaching legal, ethical or strategic consequences, organizations have to establish clear boundaries for AI decision delegation. Large organizations with diverse roles and stakeholders can find managing accountability risks challenging, compounded by the ethical aspects of AI decisions (*Kaplan et al. 2019*).
For companies it is still essential to do appropriate evaluation before considering the output of the tool, as it will be limited to the information provided in the algorithm and it may not keep in consideration important external factors that a human instead may consider (*Cubric et al.2020*).
Finally, the maturity of the legal environment proves crucial, influencing the ease of implementation *(Bérubé 2021)*. This, merged with the other general implementation barriers, such as a lack of top management support and strategic vision, persistently hinder AI integration, emphasizing the necessity for appropriate regulations that could align organizations with the AI's transformative potential.*(Bérubé 2021).*

2.4 AI ADOPTION DETERMINANTS IN ACADEMIA

To understand if there is an opportunity in implementing AI in ASOs, we will expand the findings of the TOE framework (*Lamine, et al.. (2023)* and apply it to academia; this framework has been utilized in various contexts and is proven useful for evaluating the key determinants that could enhance or hinder the adoption of a new technology. (*Lamine, et al.. (2023)*. It explores which factors could influence the adoption of a new technology linking external organizational and individual dimensions.

Starting from the external environment, the main key factor identified lay in the nature of academia itself. Given the cultural resistance to change and traditional academic structures within universities, these institutions may present barriers to embracing digital technologies for entrepreneurial endeavors *(Karanikić et al. 2021)*. Some institutions, for instance, may lack technological infrastructure and resources necessary to implement and provide digital solutions, hindering the integration of new technologies into academic entrepreneurship initiatives (*Lamine, et al.. (2023)*.This lack in flexibility could translate into a deterrent for successfully introducing AI as a common use tool in this context. On the other hand AI could be useful to evaluate the research produced within these entities accelerating the development. The TTOs for instance could utilize this technology to assess the potentialities of a spin off through forecasts and scenario simulations, increasing the efficiency in the investment; the other external stakeholders also, could take advantage of these information to evaluate potential partnership and develop connection with the spinoff, deleting the asymmetric informative between the parts. Thus, in this sense AI could be an opportunity for increasing investments and the growth of these companies.
The sector in which the company will operate could also affect the implementation of AI; firms operating in highly technical sectors may be better equipped to embrace digitalization and integrate disruptive technologies compared to those in less technical fields, enhancing the probability of success in the adoption of new technologies (*Cubric, M. 2020)*. Moreover, organizational factors such as resources and dimensions contribute significantly to AI usage *(Berubè et al. 2020)*, highlighting the multiple nature of the factors which can influence the technology adoption within spinoffs.
(Legner 2017). The majority of academic spin offs operate in high tech sectors and consequently should be more flexible and driven to change in their operations, opening the opportunities for implementing this technology.

Focusing on the more practical side of AI, the skills gap among faculty and staff in terms of digital and business proficiency could drastically influence the use of this technology for entrepreneurship (*Rippa et al.2019)*. As mentioned before,technology development requires resources in terms of human and economic capital to be maintained,which could lead to difficulties in finding and hiring the right people to support the project. Academia should enhance the implementation of this technology providing incentives and courses to mitigate this competencies gap; this investment could be translated into a more efficient development in the future and in staff members and students that are more capable to leverage new technologies.

Lastly, shifting to the more individual dimension, the personal characteristic of academic entrepreneurs could affect the AI implementation more than in a normal startup context. *(Lamine, et al.. (2023)* Entrepreneurs with deeper entrepreneurial experiences may perceive AI tools as more beneficial, understanding precisely how and when to leverage them effectively. This, because Individuals with more entrepreneurial experience could find it easier to integrate digital software within business projects as they know exactly where it could be useful, while more inexperienced entrepreneurs could struggle to find the convenience in using these tools, resulting in an inefficient adoption and lack of support from the management(*Rippa et al.2019)*. Consequently, companies led by such individuals may be better positioned to utilize AI tools to their fullest potential (*Cubric, M. 2020)*. Some individuals also, are more inclined to maximizing the knowledge in technologies that they are familiar with instead of learning new tools. The skills necessary to gain a good proficiency in a new tool requires time to be mastered, consequently it could be discouraging and easier maintaining the work linear keeping the same mechanism. A solution to overcome this lack could be identified in more user friendly softwares that allow the users to train and personalize the AI model with smaller entrance barriers. The softwares currently used to administer and evaluate ASOs, could be upgraded inheriting AI functions in order to reduce the skills gap necessary to operate with AI and at the same time utilizing its benefits.

These factors collectively contribute to the interest for academic entrepreneurs to adopt the Ai as a tool to enhance the venturing process.The above sections illustrate the current state of artificial intelligence providing an overview on the factors that could affect AI adoption and how to overcome them.

3. METHODOLOGY

3.1 RESEARCH SETTING

This study adopts an explorative approach employing qualitative research design, which is recommended to explore phenomena that remain poorly understood. Also, according to the findings of Rothaermel (2007), a qualitative approach is the most suitable for the case as ASOs may lack quality data due their youthness and a quantitative study may be inconsistent and difficult to conduct. For the research we will focus on the context of the Dutch ASOs; these enterprises have increasingly become a significant driver of growth within the economy of the Netherlands, fostering technological advancement and the strategic adoption of new tools such as AI. These organizations' impact can be observed by many growth indicators, such as the capability of creating job positions and their impact on the innovation diffusion while also fostering a culture of innovation and entrepreneurship that permeates the broader economy outside their origin country.
Their role in regional development helps to mitigate the centralization of economic activities by promoting technological innovation and skilled employment opportunities in peripheral regions, aligning with the regional policy goals and of the Dutch economy to embrace and leverage new technologies such as AI. Due to their origin in academia these organizations and in particular the academic entrepreneurs who decide to take part in these projects, face unique challenges and Artificial Intelligence represents an opportunity to overcome these limits(*Cubric, M. 2020)*; by leveraging this technology, academic entrepreneurs indeed can potentially streamline the managerial processes and enhance different business processes, overcoming the barriers associated with the development of academic spinoffs. While this technology offers transformative potential, its integration into the practical operations of an ASO could encounter unique challenges different from other contexts that are not linked to academia.The development of university spinoff companies indeed, unfolds across five key phases as described in the study of *(Vohora 2004)*: the Research Phase, where foundational scientific knowledge is created; Opportunity Framing, where this knowledge is evaluated for commercial potential; Pre-Organization, where resources and basic structures are assembled; Re-Orientation, where business strategies are refined based on market feedback; and finally, the Sustainable Returns Phase, where the venture becomes financially self-sustaining.Each of these stages is connected to the following one by transitions called "junctures," that occur between these phases, and represent challenges the venture must overcome to progress.
There are four such junctures *(Vohora 2004)*: the first one is identified as opportunity Recognition, and occurs when transitioning from the research to the opportunity framing. In this juncture ASOs try to identify a viable commercial application for a scientific discovery, and combining technical knowledge with a deep understanding of market needs is necessary to recognize a practical opportunity. Academic researchers however often lack this commercial insight, which can hinder their ability to perceive how their innovation can meet the market demand and cause inefficiencies in seizing the opportunity (*Bérubé, et al, 2021)*;the second junction is identified as Entrepreneurial Commitment and it is positioned between the opportunity framing and the pre-organization phase; it involves the decision to actively pursue the commercialization of the opportunity and organize the spinoff or not continuing with the development, transition that requires a sustained commitment from the academic entrepreneurs, who must be prepared to engage fully in the business side of the venture. Many academic entrepreneurs experience reluctance at this stage, as it necessitates a departure from their familiar academic roles and often involves significant personal and professional risks, compounded by potential social and institutional pressures within academia against commercial pursuits *(Bérubé, et al, 2021)*. Following, the third juncture identified, is the threshold of Credibility; it occurs between the pre-organization and re-orientation phases, and ventures have to establish themselves as credible in the eyes of investors, customers, and other stakeholders in order to have access to external capital and also a good position on the market. Achieving this level of credibility involves demonstrating proof of concept, market readiness, and the presence of a capable entrepreneurial team, all of which are essential for attracting early-stage investment and customer interest. At this stage, however, the academic origins of USOs can present a gap in this, as academic entrepreneurs, given the academic origin may be perceived as lacking the commercial experience needed to scale a business, making it difficult to secure both financial and human resources critical for initial operations *(Bérubé, et al, 2021)*.. The fourth and last juncture is identified as threshold of sustainability and marks the transition between the reorientation phase and the sustainable returns. In this juncture the ASO have to generate consistent revenue streams to maintain and expand its operations, but to achieve this sustainability often is necessary restructuring business activities or refining market strategies to ensure that the venture can meet long-term growth and profitability objectives.Without overcoming this juncture, the ASO risks stagnation or decline, as the ability to sustain financial viability and operational stability is crucial for transitioning from an experimental venture to an established market player *(Vohora 2004)*.
Thus, to try to overcome in part or totally these junctures, we propose Ai as a solution amd we aim to analyze its potential applications in the asos context. The focus of the study will be on identifying the key determinants that could affect AI adoption and the use cases of this technology in order to create a framework to explain how to introduce AI during the development process of Academic spin offs. This framework will provide a guideline of the AI use cases in academic spinoff development

and, also an analysis of which factors could affect the adoption of Ai aiming to understand if AI represent an opportunity for the ASOs development.

3.2 DATA COLLECTION

We employed semi-structured interviews as main data collection techniques to collect insights from different academic entrepreneurs and relevant personalities involved in the development of academic spin offs. The participants were identified through different databases affiliated with the University of Twente and contacted by email and phone to schedule the interviews. We interviewed 9 managers and founders who are actively participating in the ASOs ecosystem, the sample includes participants from different backgrounds and experience to provide a better overview on the current perception of AI . Also, to ensure a broad representation within the sample, the sampling approach prioritized diversity in the selection of the organizations provenience, including spinoffs and ex spinoffs, which operates in Biomedical, IT and semiconductor sectors as illustrated in the following table.

Table 4:

Interviews sample

Founder reference	Industry	Dimension (nr. of employees)	Experience with AI
Company 1	Biomedical	1-50	New user
Company 2	IT	1-50	High
Company 3	Biomedical	50-100	Low
Company 4	Biomedical	100+	High
Company 5	Biomedical	50-100	New user
Company 6	Semiconductor	50-100	High
Company 7	Semiconductor	1-50	Low
Company 8	Semiconductor	50-100	New user
Company 9	Semiconductor	100+	Low

The table illustrates respectively the sectors in which the interviewed operates, the dimension of the spinoff and lastly the personal experience with the artificial intelligence, categorized as ‘new user’ for the ones who never used AI tools, ‘Low’ for the ones which have limited knowledge of AI or have used it only for minor tasks and ‘High’ for the ones which have high knowledge of AI or use it regularly.
The diversity within the sample facilitated the generation of more generalized findings and insights for understanding where AI could be useful and when there is an opportunity for implementation across different domains . Throughout the interviews, we maintained a structured yet conversational approach, ensuring the comprehensive exploration of relevant themes while facilitating open and insightful responses from the interviewee. Furthermore, to ensure the structure and the efficacy of the questions, all the interviews were subdivided into three parts: firstly, the interviews started with the introduction, where we established a rapport with the interviewee,where we ensure the confidentiality, and clarified the purpose of the interview, emphasizing the utilization of the gathered data for research purposes. Also, in this first part, we asked some background information to acquire relevant data; the inquiries regarded the interviewee's role and experience within the ASO, their familiarity with AI technologies, and an assessment of the spinoff current managerial practices. Subsequently, in the second part, we aimed to gather insights into potential AI use cases in academic entrepreneurship, with questions addressing the perceptions of AI's and applications area. In this part, we also focused on identifying the current specific determinants affecting AI implementation in ASOs, encompassing questions regarding the external, the organizational and the internal factors that potentially could affect AI adoption. Finally, the interview concluded with closing questions, aiming to gather insights on the future outlook for AI utilization in ASOs and recommendations for an effective AI implementation. The data gathered from the interviews were anonymized to ensure the privacy of the participants and the objectivity during the analysis, while secondary data collection techniques, such as websites and reports were used to validate the findings of the answers. This approach ensured reliability in the construction of the dataset and tried to delete completely the subjectivity from the data utilized for the research.

3.3 DATA CODING AND ANALYSIS

To expand the findings of the literature and understand better the implications of AI in academic entrepreneurship, the research needed a solid methodology to gather information and analyze the acquired data. In order to accomplish these tasks, the analysis of the interviews followed the GIOIA methodology. This methodology was chosen after an accurate review of the actual literature and this qualitative approach emerged as the most suitable.
Compared to other research designs such as a multiple case study with no methodical data-coding and data-analysis techniques,this methodology provides greater rigor,given the more systematic research approach, helping us to analyze the interviews and develop the final framework for the adoption of AI. Furthermore, the GIOIA methodology emphasizes the development of a grounded theory model, which aims to depict the relationships among emergent concepts that explain the phenomena of interest (*Gioia et al. 2013*) helping us to extend the knowledge by expanding existing understanding, and ideally generate new concepts or ways of understanding the phenomenon (*Gioia et al. 2013*).

During the elaboration of the model and to ensure the correct analysis of the data: we developed the coding following the principal rules suggested by the literature. For the first order concept the first step followed was reading through the data various time in order to identify the main concepts and getting familiar with the data; after this first analysis, we tried to capture every important concept mentioned by the participants, avoiding every prejudice or previous notion, in order to ensure objectivity and relevance in the data. Subsequently, after the identification of the first order concepts, we proceeded to identify correlations and relationships between them; we grouped the concepts in categories, following a constant comparison from the data and the literature, ensuring that the data was not only grounded in the participants perspective but also informed by relevant theoretical foundation. This grouping brought us to identify broader and more abstract dimensions that included a set of different concepts. Lastly, these identified categories were distilled into aggregate dimensions that represented our third grade concepts. These dimensions represent the highest level of abstraction of the coding structure and illustrate the concepts that are theoretically significant and could help to develop the final grounded theory. In details, the 1st order concepts highlighted the thoughts of the interviewed capturing the main idea of each participant. This set of ideas included personal opinion and points of view about AI in the ASOs context being as close as possible to the reality; an example of relevant citation that helped to develop the first order concepts are:

Interview 3:'...I think that artificial intelligence could be definitely useful for doing this tasks (planning activities) but at the same time I think the human touch should always be included to have the best results'.

Interview 1:'AI is useful for certain aspects for sure, it can increase the speed of certain things. Marketing, for example, or design for sure are areas where AI can make the difference and people are looking at it with interest'

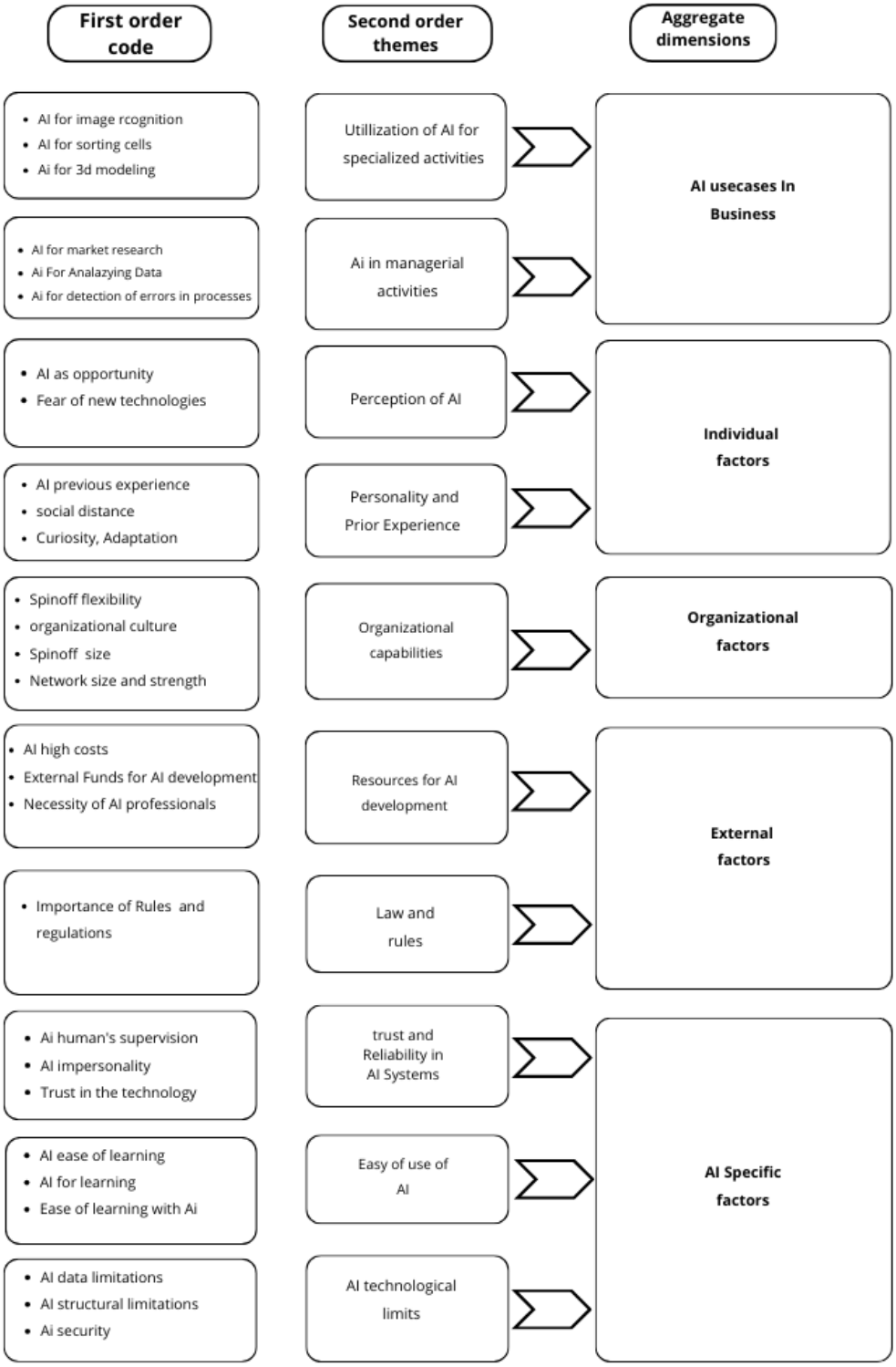
From them, the set of 1st order concepts were formulated identifying the common concepts behind the answers of the interview and categorizing them in different clusters such as: '*Human support'* and ' *Ai for marketing purpose'*. After this passage, the set of concepts has been elevated to a less personal dimension, categorizing even more the ideas, under broader and more abstract concepts, explained by the 2nd order concepts. An extract of the concepts emerged are: '*Organizational Capabilities'* and 'N*ecessity of human resources',* dimensions that explain most of the information extrapolated from the interview.
Lastly, all the identified concepts have been categorized under even more abstract dimensions trying to represent the shared perception around the topic of AI in the context of academic spinoffs. These dimensions are respectively:'*AI use cases'*, '*External factors*','*Technological factors*', '*Organizational factors' and* lastly '*Individual Factors*'. Furthermore, given the possibility of having biases during the coding of the data, all the data have been verified by a triangulation process with different data sources and theories to contribute to the robustness of the study, analyzing corporate websites,Linkedin profiles and paper to verify the information provided by the participants. Also, every decision in the coding was annotated and keeped in consideration in order to have coherence during the study and maintain reflexivity. This systematic approach ensured a lack of biases during the actual coding of the data.

4. RESULTS

In this section, we will analyze the results obtained after the coding of the interviews with the GIOIA methodology; the findings helped us to understand which factors could affect the AI implementation in academic spin off and having a better representation of the shared perceptions around it. After the analysis four macro categories of factors emerged as the most relevant, these dimensions are respectively : External, Technological, Organizational and Individual. The external dimension, includes all the factors that are not directly linked to artificial intelligence but still play a role in its adoption, such as regulations and availability of professionals and resources; the technological dimension, include all the factors that are specific for artificial intelligence meant as a new technology, such as computational capability or technical complexities. The Organizational dimension includes all the factors that are specific for the academic spin offs themselves, such as the capabilities and the internal culture of these organizations. Lastly the individual dimension includes all the factors at the personal level that can affect AI implementation such as background and personal traits. Besides these four categories, another important cluster, called 'AI use cases' illustrates the possible applications of AI and the current uses within the academic spinoffs. These dimensions and the final results of the coding are summarized in table 4.

Table 4:

Coding tree of the interviews following the GIOIA methodology



4.1 AI USE CASES

The first emerging theme during the interviews regarded the possible applications of AI tools. Not surprisingly, the tasks such as data analysis and text generation, are the principal activities where AI is utilized.The participants feel comfortable in using AI tools in these activities given the ease of use and velocity in retrieving information of AI tools as mentioned during multiple interviews:

' *Interview 4: I think that for the tasks that require analyzing data there could always be a bit of margin for use Ai models… we obtain a lot of data from it and it has to be checked manually every data have to be considered but you can use AI to let it read them and that will make things way more efficient'*;

' Interview 5: So we are mainly focused on innovation now looking at AI well, AI is useful for certain aspects for sure, it can increase the speed of certain things. Marketing, for example, or design for sure are areas where AI can make the difference and people are looking at it with interest'.

Furthermore, according to the interviews artificial intelligence can be implemented to support a different range of tasks including the main managerial task of planning, coordinating and controlling, activities where ASOs lack in knowledge. For these tasks, AI can be particularly useful when we talk about creating forecasts or creating reports, while in tasks where more in depth knowledge of the organization is needed, such as plan the work for people, AI still lacks applicability and needs human supervision as mentioned during the interviews:

'*Interview 7: I think that yes absolutely there is an opportunity for artificial intelligence here (financial planning) because at the end it is analyzing data and so is what the artificial intelligence is created for'*;

' Interview 8: When you get a bigger team and you have some projects that have a pretty clear development or timeline , you know, tasks that need to be done in any certain order and some in parallel and some not, you can use AI . But when you have a smaller team with a different skill set I can imagine that would be difficult considering all the variables…';

'Interview 4: I think that artificial intelligence could be definitely useful for doing this task (planning activities) but at the same time I think a human review is always necessary to achieve the best results'.

Besides these activities, which are more general, the participants proposed different applications of AI in more specific areas such as medical examination, circuit design and 3d modeling. In these areas there is still room for improvement given the novelty of the technology and the progress achieved in the last years, but actually, given the high level of flexibility in the ASOs some spinoffs have adopted AI to their specific processes:
'Interview 7: I also use it for circuits design but design a complex system and when you ask gpt for example for an idea it gives quite a good guideline from you can use this step by step to reach your final goal';

' Interview 2 :We used AI in cell sorting and analysis as we used to be involved in the sorting and analysis of extremely rare cells and the results were very accurate.'

In conclusion for ASOs Ai can be relatively helpful in more generalized tasks such as the creation of report and the data analysis, but for tasks where the human knowledge is needed, such as organizing the work of people around their skills, AI is still not ready to fully cope with this complexity and still require a sort of supervisions behind. Also, for specialized tasks, AI can be adapted to the internal processes of ASOs given their flexibility and adaptability to new technologies.

4.2 INDIVIDUAL FACTORS

During the analysis of the interviews, different individual factors emerged as dominant; the participants expressed interest in artificial intelligence perceiving it as an opportunity for growing their business and expressing their intention to approach it in the future and try to have a competitive advantage on the market.

'Interview 8: I see it as a problem solver for every market there is now when we want to grow we have to be more efficient but there are then things that are limiting the growth there are no more people on the market to help us so the next step is AI';

Interview 1: you implement it, because you're afraid that others will implement it, and then will have a competitive advantage…. I don't want to miss the boat I want to stay ahead on the rest and I think it's necessary to know how to use it and execute the necessary steps to implement it';

This perception of AI as a catalyst for the growth of the business were drastically influenced by the background and the previous experience of the interviewed; the participants with a background in IT subjects such as engineering and data science, were more enthusiastic about the technology while the people with a background not related to these field expressed still some resilience in adopting it given its novelty and the necessity to change their way to work.

Lastly, different personality traits such as curiosity and perseverance emerged as important traits to influence AI adoption, as different participants expressed their determination and curiosity to new technologies to grow their business while others seemed more reluctant to this change.

4.3 ORGANIZATIONAL FACTORS

At the organizational level, a common theme emerged during the interviews is related to how the different characteristics of a spinoff could affect AI adoption; the shared idea is that a disruptive technology such as AI requires changes in the organization and flexibility is the key to achieve this. The participants indeed expressed their concern in reorganizing the whole organization around a technology that is still not perfect and imprecise, preferring their ordinal workflows to a new ones.

Interview 2: 'a lot of people they think that they want to work like they worked all for years and when things are new they have to create new routines etc they all find it too difficult most of them are scared, scared about the new development and they don't understand it, that's what most people is problem to use AI';

Furthermore , the interactions between the managers of other organizations and with universities were mentioned as useful to provide insights and cases on where to use AI, improving the understanding and the chances to adopt the technology .
Academic spin offs, due to their academic origin, are very well positioned in the network and in particular, the proximity of all these companies to universities and between each other increase the chances to transmit knowledge and foster innovation.

4. External Factors

Another theme emerged, related to the external environment and the variables that could affect AI adoption in ASOs. The participants expressed preoccupation with the security and privacy of their data highlighting the need for rules and laws that can protect themselves.

Interview 1: 'my answer is that I ehm will not trust giving sensitive data but is in parallel the only solution for using the potentialities of AI, so I hope we will be more protected on that side from the governments…';

Interview 4:'If it's, uh you sharing something to someone else, you always want to have the acknowledge that there are one whatever type of rules that are regulating that at the European level and the the global level about the personal data.'

Also, the participants expressed concerns about the limit in resources to implement AI. During the interviews indeed emerged the need from academic spinoff to have the right amount of resources from the universities and the extern, both in terms of human capital and funds, as implementing AI effectively still requires hiring specialized people and reorganizing the internal business processes . The lack of professionals, indeed, was mentioned multiple times, highlighting the need for professionals in the sector, and the need to train the employees to use the technology.
Interviews 8:' the costs of finding a professional that know about artificial intelligence or to teach some employee on that and also to build the server and everything to run it internally are high; So if we want to use it we have to ask for resources from the outside';

Interview 2:'A very important point is about how much you are spending from maintaining and implementing this artificial intelligence both in terms of time but also economic value… We are not Equipped to to implement this and as a small company we're always low on resources. so even though we would like to develop it fully ourselves, it's just not a commercially viable thing to do'

4.4 TECHNOLOGICAL FACTORS

The last emerged theme is about the factors linked to the technological development of AI itself. The participants mentioned the simplicity in using the technology for little tasks such as brainstorming or learning new things, given the very user-friendly interface and velocity of tools such as chatgpt and Coopilot; while instead to perform tasks that have an high degree of responsibility such as managing automatically capital or perform analysis on patients they find AI still not advanced enough as the variable to keep in consideration are too many for the tool.

Interview 3'I wouldn't Trust a machine to plan what I have to do as I think that there is too much uncertainty in the market and the environment in general to predict it'

Interview 5'I think that is always better someone that is overlooking on these softwares and that is not my work out on but honestly I think that for having this kind of autonomy from this tool we are still very far away'

Another discussed point between the interviewed regarded the security of the models. The general idea is that it is always better to have in-house solutions such as personal servers and employees who develop the algorithm internally, as relying on third parties can cause data leaking. The participants do not feel confident in sharing their own data with a model that they do not understand completely or third parties given the potential risk of losing money, consequently the data remain a problem;

Interview 1: 'There's an ethical side to sharing data that you have developed that is precious within the company, and AI can't guarantee a total privacy on them'

Interview 8:'I 'm afraid that the information about clients get into places we don't want where in word we have a lot of liabilities when something it comes out into the market so we have to be very sure that our information stay with us and at this moment there's no trust that that will be the case it's very sensitive information'.

Also, the difficulty in adapting the current softwares and processes to acquire and process the data in order to be used by AI remains a problem. The managers express concerns regarding changing their workflows and invest money to be adapted to a tool that still has limitations.

Interview 1:'What is AI? It's mainly based on probability. It's a probability that something will happen. It's a probability there is never 100% accuracy, but because of the fact that the model is built in such a way that has the certain limitation'

5. DISCUSSION

5.1 THEORETICAL IMPLICATIONS

Finally, after the analysis and the results gained from the interviews, we can translate these factors into an adoption framework to explain where and when Artificial intelligence can represent an opportunity for the venturing process of academic spinoffs. We tried to expand the framework of Vohora *(2004*),including artificial intelligence. We kept into consideration the findings and the use cases derived from the literature and the conducted interviews regarding AI. The framework can help entrepreneurs and researchers to evaluate the opportunity in implementing artificial intelligence in academic spin off, providing them an overview on the current factors that could affect this process.

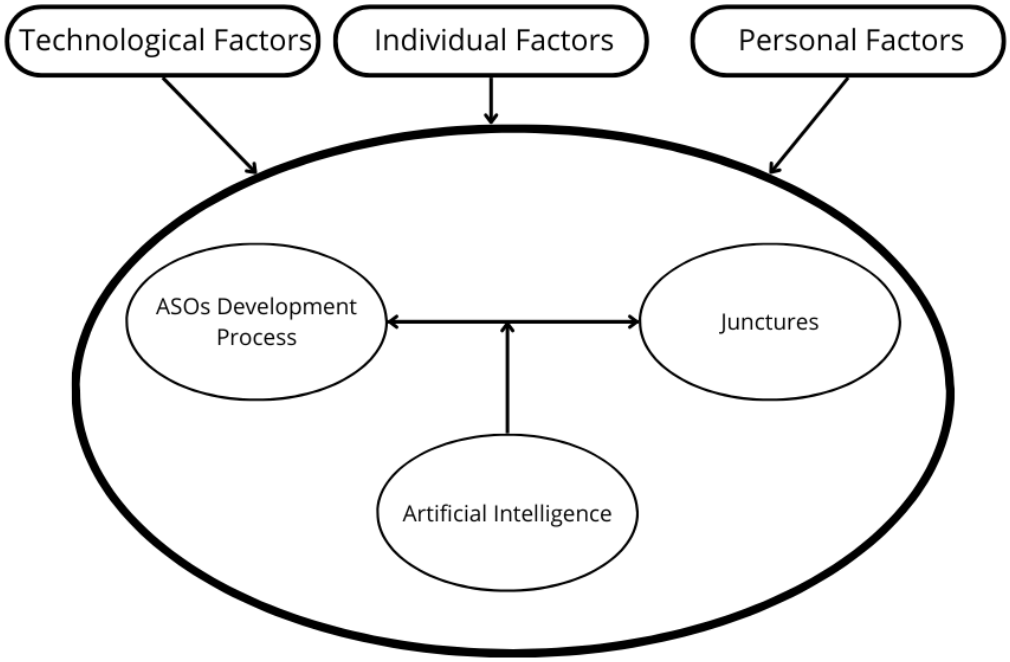


Figure 1: *AI adoption framework in academic spinoffs*

The findings suggest that while AI offers transformative opportunities to improve process efficiency, the successful adoption of AI is contingent on overcoming several challenges that span from technological and external factors to more specific limitations peculiar to the ASOs and the individuals. ASOs are well positioned to adopt AI given their network of industries and academic researchers, but sometimes the limited availability of motivation from the individuals who are used to consolidated work practices and organizational constrains can hinder this transition.Altough the development of AI is still progressing and new laws and features get available, ensuring the privacy and the security of the users data remains the biggest obstacle to make the transition easier.

Furthermore ASOs can utilize AI in different applications in order to increase the efficiency and the efficacy of their processes. In particular repetitive tasks and tasks that require the collection of data or the creation of forecasts are the main areas of utilization of AI, while for more specific tasks which require organizational knowledge or personal evaluation, AI can still be used only marginally. Some spinoffs furthermore demonstrated that some operational and specific tasks can benefit from AI, such as the cells sorting or the circuit design, but at the same time there is still margin of improvement in these processes..

5.2 AI FOR OPPORTUNITY RECOGNITION

As highlighted in the interviews, AI tools can analyze large datasets, identify emerging trends, and generate insights from data that would otherwise be processed manually requiring a lot of time. This capability could allow academic spinoffs (ASOs) to frame their technology within viable market opportunities, a task that traditionally presents challenges due to limited commercial insight from the academic entrepreneurs. By streamlining the data retrieval and analysis processes, AI can reduce the knowledge gap and speed up the identification of high-potential applications, making it easier to recognize a market need aligned with the ASO's technology .

5.3 TRESHOLD OF CREDIBILITY

AI can support ASOs in developing a credible business proposition by assisting with report generation, forecasting, and project planning, which are essential to building investor confidence. For instance, as indicated in the interviews, AI can aid in financial planning and forecasting, helping spinoffs provide data-backed projections for revenue potential and market demand. AI-driven reports and analyses can enhance the credibility of the ASO's business case by providing professional-level insights and well-structured documentation, which are crucial for initial fundraising and establishing trust with investors. Additionally, AI can potentially help simulate market scenarios, providing validation for the business model, which investors typically scrutinize at this juncture.

5.4 ENTREPRENURIAL COMMITMENT

For what concerns this juncture, although AI can not replace the commitment of an entrepreneur, it can support planning and coordination tasks, helping academic founders better understand project requirements and timelines, which may alleviate some uncertainty that can arise. For instance, AI can assist in generating structured project plans for complex tasks and provide preliminary guidelines, as seen in tasks like financial planning and circuit design, as noted in the interviews. However, the human element remains essential in making strategic decisions and taking on full commitment, as AI tools are not yet capable of handling the nuanced, experience-driven aspects of entrepreneurship

5.5 TRESHOLD OF SUSTAINABILITY

In this Juncture, acording too the interviews, AI can be useful to automate routine activities such as marketing and data analysis, allowing ASOs to be more efficient and allocate resources more strategically. While AI can be highly effective in these general tasks, it still requires human oversight for complex tasks where organizational knowledge and human judgment are indispensable. Consequently,for activities such as team management and project customization, AI is not the best solution as its capabilities are still limited and could be difficult delegate completely these tasks, given the quantity of information needed from the model to perform accurately.

5.6 EXTERNAL FACTORS

Analyzing the results of the interviews, three primary external factors emerged as the most relevant. The first key factor identified is the importance of having robust laws and regulations to safeguard privacy and ensure the data security of the user.

This theme was recurrent during multiple interviews, and illustrates how, given the novelty of the technology, it is difficult for the government to provide robust frameworks and rules to ensure the safety of the users that want to utilize AI. The privacy and the data provided by the users are still perceived as low protected from the current regulations, consequently this can decrease the willingness to adopt the technology for particular tasks given the fear of losing sensitive information.

Secondly, the second factor emerged is the need for financial support in the form of incentives and funding. Many spin offs face financial constraints that hinder their ability to invest in AI technologies, making external financial aid a critical factor that could favor the adoption of new technologies and consequently AI. This is correlated to the fact that for implementing and maintaining powerful AI solutions it is necessary to have specialized human capital to support the development, but the availability of experienced professionals is very low and consequently more expensive to hire. This factor highlights the necessity of structures that could help to create skilled professionals and help the successful implementation and integration

of AI solutions, pointing to the necessity of a knowledgeable workforce. These findings highlight how the external resources are critical for implementing AI in academic spinoffs .

5.7 TECHNOLOGICAL FACTORS

The second category of factors emerged during the interviews is linked to the technological aspects of AI; given the novelty of the technology, the intrinsic limitations of AI itself, such as the imprecision of the algorithms and the need for advanced computational resources, were frequently mentioned as obstacles during the interviews. The answers provided numerous use cases in which artificial intelligence is implemented or is going to be implemented in the near future, highlighting that for some of them the actual technological capabilities, in terms of cognitive intelligence and complexity of tasks achieved, of Ai are still insufficient. The data factor in particular, considered as the quality, quantity, and accessibility of them, is an aspect that emerged as significantly important for the usage of AI tools. As Ai systems that are not trained enough or do not have access to the right data can result in inefficient answer formulation,the necessity of having adequate infrastructure to host the data, emerged as a problem; The participants expressed preoccupation in how and where storing the data without potential security and availability problems. The participants prefer to opt for in-house solutions to store their data, such as a personal server, compared to sharing their data with third parties, this to preserve the security and the integrity of the data that could be sensible and the risk of losing them could cause reputational and economic loss. These limits combined with the difficulties to adapt the current processes and the existing workflows to acquiring the data and utilizing AI, limits drastically the possibility to fully adopt the technology from academic spinoffs. The participants during the interviews mentioned multiple times their feelings toward the trust that they put in AI and the shared idea is that AI is still not reliable and powerful enough to deserve high investments and drastic changes to be implemented inside their organizations. This was emphasized by the fact that the human interactions with these systems were still perceived as a crucial aspect from the participants, as the tasks that AI can perform autonomously with a high accuracy in the answer are still not enough. Indeed while for simple tasks such as writing text or brainstorming ideas AI can work independently, for more complex tasks AI almost always requires someone behind who ensures the reliability of the final result, indicating the necessity for AI systems to work in conjunction with humans to ensure a reliable and ethical result. Lastly,The ease of use of the technology emerged as another critical factor; user-friendly AI solutions are more likely to be adopted by spinoffs given their simplicity is the uses; on the other hand when is necessary having more complex outputs particular skills are necessaries and that could hinder this intention of adopt the technology from the employees

5.8 ORGANIZATIONAL FACTORS

Based on interviews,at the organizational level two main categories of factors emerged as the most relevant; the first factor identified lay in the spinoff Organizational capabilities such as the ability to be flexible and ready to reorganize its processes. Smaller spinoffs often exhibit a high degree of organizational flexibility, which can be a critical enabler in the adoption of AI technologies, while larger corporations may be more structured and with more complex and rigid processes, smaller spinoffs can reorganize and adapt more rapidly to new technological advancements enhancing the possibilities to implement AI. This flexibility is often a product of a less hierarchical structure and a culture that promotes innovation and agility, characteristics that usually are more common in smaller organizations. In the smaller spinoffs interviewed indeed, the founders and managers were closely involved in day-to-day operations, allowing them to directly influence and support AI initiatives, characteristics that instead emerged as more difficult to achieve in bigger organizations. The role of the managers consequently results as very important in AI adoptions, as the leadership in these organizations drives the strategic direction and has the power to foster a culture that embraces technological advancements, through investments in AI tools and training for the employees.
The second key factor identified is the networks that founders and the managers within the academic spin offs engage with other companies and personalities. These networks, comprising academic peers, industry contacts, and professional organizations, serve as rich sources of knowledge and practical insights for managers who often learn about AI applications and their potential benefits through these interactions, gaining exposure to real-world use cases that demonstrate the value of AI. Also, these interactions could provide trusted references and success stories from other organizations that have already implemented AI, reducing the perceived risks associated with adoption. This reliance on proven use cases from trusted sources makes the adoption process smoother and more convincing for the decision-makers within the spinoff.

5.9 INDIVIDUAL FACTORS

Based on interviews conducted with various spinoffs, several key personal characteristics have emerged as influential in the Ai adoption process.

The first factor that affects the adoption of AI in spinoff is the individuals' prior experience and, more in general their acceptance of technology; those with a technical background are more inclined to embrace AI tools and in general to use and experiment new technologies. This is enhanced by their familiarity with technological concepts that enables them to identify potential applications of AI more clearly and understand if effectively there is room for innovation in their current business processes. For instance, individuals with experience in technical fields such as computer science or engineering are typically more adept at recognizing where AI can be integrated into their workflows and are less hesitant to leverage these technologies, while, in contrast, individuals with less technical expertise may struggle to see the practical applications of AI, feeling uncertain about its benefits and how to utilize it effectively. These differences in the background lead to a consequent different perception of AI between technical and non-technical individuals. Technical individuals generally exhibit less fear towards new technologies, viewing AI as a valuable asset rather than a threat. This confidence stems from their understanding of how AI functions and its potential to improve efficiency and innovation. Conversely, non-technical individuals often perceive AI as more risky, primarily due to a lack of understanding. This perceived risk can act as a barrier to adoption, as these individuals may fear the implications of using unfamiliar technology.

Additionally to the background particular individual characteristics emerged as crucial for AI adoption. Individuals with personal traits such as curiosity, confidence, and motivation are particularly inclined towards AI adoption. Their intrinsic curiosity drives them to explore new technologies, while their confidence enables them to be proactive to a trial and error process that can enhance AI implementation. Moreover, individuals that are motivated to grow their business and experiment are more likely to perceive AI as an opportunity; given their willingness to do better they are more inclined to integrate these tools into their business strategies. These characteristics can be very important in overcoming the initial barriers of AI adoption. In addition, another relevant point emerged from the interviews, is the societal shifts prompted by the COVID-19 pandemic and how it has influenced individual preferences towards AI. This period of social distancing transformed the perception and the way people interact with each other, shifting the idea of human contact to a more individual side , prompting AI as a viable solution for maintaining operational efficiency without the need for direct human interaction. This aspect has become particularly interesting , as it aligns with the evolving societal norms and the growing preference for remote and automated solutions.

6. LIMITATIONS AND FUTURE RESEARCH

This resarch try to explore the implementation of AI in the context of academic spinoffs, providing an objective and documented resume of the process, but given the specific focus, there is still the way open for improvement in the future. Firstly, the research was conducted with a targeted sample in the Netherlands, primarily focusing on those within the University of Twente, consequently this small and geographically concentrated sample may not fully capture the diversity of experiences and challenges faced by academic spin-offs globally. Future studies could expand the sample size and include spin-offs from different regions and industries to provide a more generalised understanding and compare the evolution of the technology across specific sectors;. Furthermore, as AI technology is still evolving, its capabilities and applications may expand, opening opportunities to expand the research with new findings. Lastly, given the difficulty in capture the whole lifecycle of a spinoff, the study focuses on the adoption and implementation phase of AI but does not address the long-term outcomes or impact of AI on spin-offs. For instance, areas that would be important to expand could be how the AI adoption influence the financial performance after its implementation, or also, focusing on a more ethical perspective, which are the unintended consequences of AI implementation, such as job displacement or over-reliance on automated systems. Future research could evaluate these long-term effects of AI adoption and assess its broader implications for the ethical-sustainability and competitiveness of academic spin-offs.

Overall the research give a picture on which processes of ASOs could benefit from AI, providing a comprehensive guide that could help managers or academic entrepreneurs to evaluate the strategic decision of adopting artificial intelligience in the context of academic ventures. Additionally, policymakers and universities could use the insights gathered from this research to foster the development of AI technology through the implementation of new regulations and the creation of ad hoc programs that could help the growth of high trained professional in the field of AI.

7. CONCLUSION

In conclusion this research tries to provide an overview on the benefits and the disadvantages of introducing artificial intelligence in the academic spin offs venturing process, giving as a result an adoption framework to explain where Ai implementation can be useful in the academic context and the different factors that could affect its adoption. By identifying key factors that influence AI adoption—ranging from technological readiness and organizational flexibility to individual traits and external environmental conditions—this study has provided a comprehensive framework that can guide academic entrepreneurs and researchers in effectively integrating AI into their business processes. The framework in synthesis can help entrepreneurs and researchers to evaluate the opportunity in implementing artificial intelligence in academic spin off, providing them an overview on the current factors that could affect this process. Answering to the first research question :

What are the main key determinants for successful AI implementation in the Academic spinoff?

The findings suggest that while AI offers transformative opportunities to improve process efficiency, the successful adoption is contingent on overcoming several challenges that span from technological and external factors to more specific limitations peculiar to the ASOs and the individuals. ASOs are well positioned to adopt AI given their network of industries and academic researchers, but sometimes the limited availability of motivation from the individuals who are used to consolidated work practices and organizational constrains can hinder this transition.Altough the development of AI is still progressing and new laws and features get available, ensuring the privacy and the security of the users data remains the biggest obstacle to make the transition easier.

For what concerns the second research question:
Which are the main applications of AI in the venturing process of academic spinoff?

ASOs can utilize AI in different cases in order to increase the efficiency and the efficacy of their processes. In particular repetitive tasks and tasks that require the collection of data or the creation of forecasts are the main areas of utilization of AI, while for more specific tasks which require organizational knowledge or personal evaluation, AI can still be used only marginally. Some spinoffs furthermore demonstrated that some operational and specific tasks can benefit from AI, such as the cells sorting or the circuit design, but at the same time there is still margin of improvement.

In conclusion, as AI continues to evolve, future research should focus on expanding the sample size and exploring AI's impact across different regions and industries, to validate and refine the proposed framework and ensure its broader applicability. This study tries to fulfil in part the weaknesses of the Asos development process proposing AI as a solution and analyzing its applications and the influencing factors in the adoption:ultimately aiming to aligning with the broader goals of academic entrepreneurship to foster innovation and economic growth.

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