UNIVERSITY OF LJUBLJANA
SCHOOL OF ECONOMICS AND BUSINESS

MASTER' THESIS

THE PROSPECTS FOR AN AGRICULTURE DRONE START-UP ON THE EUROPEAN MARKET

Ljubljana, September 2023 ALEKSANDAR ILIEV

AUTHORSHIP STATEMENT

The undersigned Aleksandar Iliev, a student at the University of Ljubljana, School of Economics and Business (hereafter: SEB LU), author of this written final work of studies with the title "The prospects of an agricultural drone start-up on the European market, prepared under the supervision of Anastas Vangeli, Ph.D.

D E C L A R E

1. this written final work of studies is to be based on the results of my own research;
2. the printed form of this written final work of studies to be identical to its electronic form;
3. the text of this written final work of studies is to be language-edited and technically in adherence with the SEB LU's Technical Guidelines for Written Works, which means that I cited and/or quoted works and opinions of other authors in this written final work of studies in accordance with the SEB LU's Technical Guidelines for Written Works;
4. to be aware of the fact that plagiarism (in written or graphical form) is a criminal offense and can be prosecuted in accordance with the Criminal Code of the Republic of Slovenia;
5. to be aware of the consequences a proven plagiarism charge based on this written final work could have for my status at the SEB LU in accordance with the relevant SEB LU Rules;
6. to have obtained all the necessary permits to use the data and works of other authors which are (in written or graphical form) referred to in this written final work of studies and to have clearly marked them;
7. to have acted in accordance with ethical principles during the preparation of this written final work of studies and to have, where necessary, obtained permission from the Ethics Committee;
8. my consent to use the electronic form of this written final work of studies for the detection of content similarity with other written works, using similarity detection software that is connected with the SEB LU Study Information System;
9. to transfer to the University of Ljubljana free of charge, non-exclusively, geographically, and time-wise unlimited the right of saving this written final work of studies in the electronic form, the right of its reproduction, as well as the right of making this written final work of studies available to the public on the World Wide Web via the Repository of the University of Ljubljana;
10. my consent to the publication of my personal data included in this written final work of studies and in this declaration when this written final work of studies is published.
11. that I have verified the authenticity of the information derived from the records using artificial intelligence tools.

Ljubljana, ________________________ Author's signature: _________________________

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AESA - Agencia Estatal de Seguridad Aérea

AI – Artificial Intelligence

B2B - Business-to-Business

B2C – Business-to-Consumer

BCAA – Belgian Civil Aviation Authority

BVLOS – Beyond VLOS

CAA – Civil Aviation Authority

CAP – Common Agricultural Policy

DOI – Degree of Internationalization

EAFRD – European Agricultural Fund for Rural Development

EAGF – European Agricultural Guarantee Fund

EASA – European Union Aviation Safety Agency

EU – European Union

FSTS – Foreign Sales to Total Sales

HCI – Human-Computer Interaction

HDI – Human-Drone Interaction

IPR – Intellectual Property Rights

IT – Information Technology

MIMO – Multiple-input Multiple-output

MNEs – Multinational Enterprises

MTOM – Maximum Take-off Weight

NAA – National Aviation Authority

NASA – National Aeronautics and Space Administration

NDVI – Normalized Difference Vegetation Index

NIR – Near-infrared

PA – Precision Agriculture

RGB – Red-Green-Blue

SDG – Sustainable Development Goals

SMEs – Small and Medium Enterprises

UAS – Unmanned Aerial Systems

UAVs – Unmanned Aerial Vehicles

UN – United Nations

VLOS – Visual Line of Sight

1 INTRODUCTION

As the latest insights from the drone industry suggest, “unmanned aircrafts have become central to the functions of various businesses and governmental organizations” (Insider Intelligence, 2021). Mainly intended to serve as a non-public product used by militaries, the soundness and potential of drones for civilian and commercial purposes have been long underestimated. Commercializing unmanned aerial vehicles (UAVs) shifts their societal role. Moreover, it gives insights into how small and medium enterprises (SMEs) or multinational enterprises (MNEs) can utilize drones in various ways in a relevant industry. More specifically, 2006 was the year of turnaround of drone functionality redirection into disaster relief with the help of thermal cameras for body heat recognition (Daly, 2020).

The road to full integration of drones in society, which is bringing their effectiveness as a resource into action in our everyday lives, is paved with insecurities and frequently unanticipated vulnerabilities that arise from unsafe or improper usage. Additionally, drone legislation in some countries propels the evolution of technology and drone deployment in the opposite direction. To clarify, the ‘opposite direction’ denotes stagnation in educating farmers and the momentum of gaining knowledge. Consequently, straying away from drone implementation among farmers in practice creates an opportunity lost to boost crop production. In reality, the foremost action that ought to be conducted to motivate European start-ups to expand is the obligatory involvement of governments in encouraging legislators to analyze the use cases of drones thoroughly. Merkert & Bushell (2020) mention that the drone introduction has brought “financial implications, but also environmental impacts, as reduced inputs lead to reduced negative impacts for the same output”. Not only do agricultural drones have cost-cutting and input-reducing advantages, but they also help reach the scalability of farm operations.

During the 1940s, an American writer named Isaac Asimov[1] stated three laws that express the limits of robotic actions regarding avoiding hurting humans by any means, whether autonomously or when given an order from a human. In brief, the three laws state that when protecting their existence or when given orders by a human, they must not conflict with the elementary principle of not inflicting harm on a human or letting one come to harm. McCauley (2007) points out that Asimov has recognized the irrational public fear of technology adoption. His three laws are a product whose goal was to prove that machines should be built on and act according to his set of rules. He also argues “that fear would be the greatest barrier to success”, whose relevance is showcased across industries today. As the research will show later, the relevance of the concept of fear of technology will bring the ideas of culture and age as controlling parameters in technology acceptance.

[1] Isaac Asimov (January 2, 1920 – April 6 1992) was an American writer born in Russia, mostly known for his science-fiction writings. He coined the term ‘robotics’; later on, his ‘Three Laws of Robotics’ would theoretically demonstrate the present fears of a potentially ‘uncontrollable’ AI.

My thesis studies the potential of a Macedonian drone start-up in its nascent stages and its intended flagship product, a drone designed for farms with a peripheral that, as a business idea, is anticipated to be strategically approached and promoted on the European market. The idea came when three friends had an idea to pursue their start-up dream. Their ambition to compete in the industry of agricultural drones was born from the combination of electronics, economics, drones, and finance knowledge that each uniquely possesses.

Table 1 introduces the drone start-up and describes the services it anticipates to offer.

Table 1: AgriMak - an outline of our agricultural drone start-up

<table>
<tr><th>Name of start-up</th><th>Country</th><th>Description</th><th>Funding</th></tr>
<tr><td>AgriMak</td><td>North Macedonia</td><td>Service-oriented farm management providing company offering chemical spraying.</td><td>Grants</td></tr>
<tr><td colspan="4">AgriMak is a Macedonian start-up whose objective is redefining farming, particularly in the Balkans. This start-up offers services remarkably in crop spraying and tailored solutions based on the farm/business it operates. The company also specializes in modifying interfaces that can be brought closer to farmers considering their age. Positioning itself on the market with its unique peripheral about measuring the level of pesticides in the soil, it holds the potential for serious advancement in a country where drone regulations are weak and enforcement and control are non-existent. Hence, this situation enables AgriMak to test and deploy its drones and services without legal complications or danger.</td></tr>
</table>

Source: own work

The status quo summarized, which is slowly untangling after observations of agricultural drone markets across Europe, serves as the primary stimulus for starting this research. It encapsulates unanswered questions about how such supportive and pragmatic action can aid the environment and farmers predominantly from one side and benefit businesses, stakeholders, and politicians from another. Consequently, the nature of the research underlies an exploratory approach and intends to study business practices.

This study researches its consumers, the market for agricultural drones, and internationalization as a concept that enclosures the procedure of being involved in the farming drone business. Consequently, the nature of a start-up in this industry is primarily born-global. The definition of born-global firms complies with two conditions: 25 percent of the total sales result from exporting activities, and within three years since its start, the company must operate internationally (Kuivalainen et al., 2007). One reason for this occurrence is the geographic location of customers. In particular, unlike saturated clusters with customers of products fulfilling basic needs, the dispersion of drone users creates an environment demanding specialized services for the enterprise. It pushes competitive-based motivations to expand the company’s activities. However, the main challenge is navigating through different local drone restrictions. The local politics that place rules for drone flight define local markets with distinct properties, resulting in companies readapting their business model according to such limits in their niche segment.

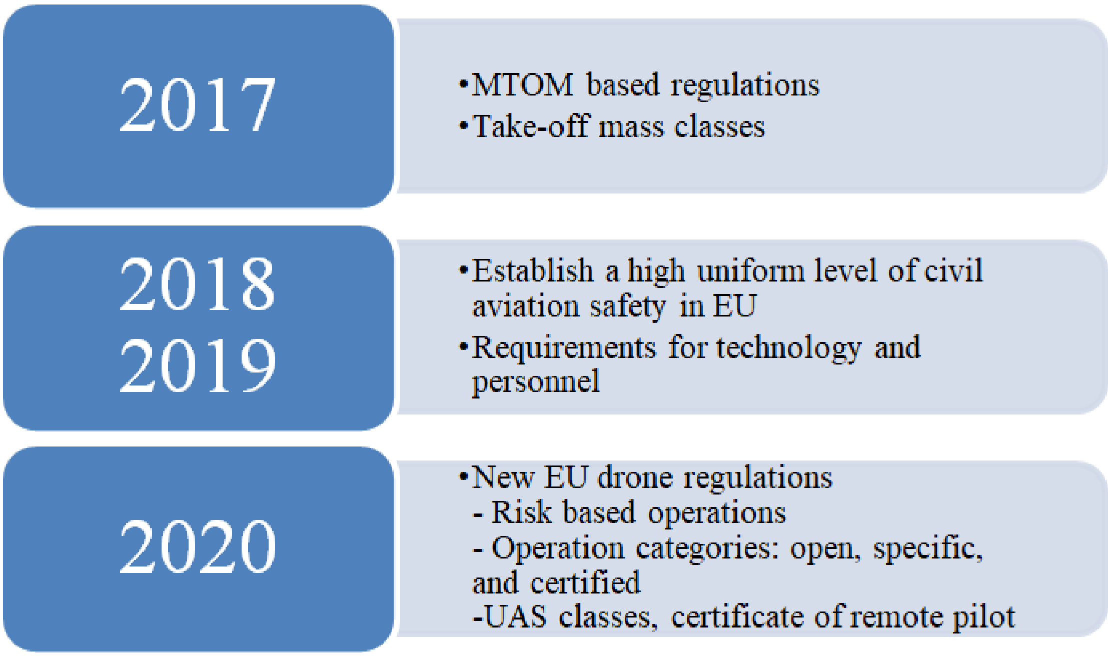
Nevertheless, apart from analyzing macro filters, one must thoroughly study the local permissions and certificates for drone flight. Finally, the emerging start-up owns a unique product with several functions that differentiate it from its competition. Due to the fast-paced technological advancement where products offer a variety of roles, customers might get lost in them or sometimes even feel threatened by them. According to Janke and Uijt de Haag (2022), regulations have become the most prominent threat to implementation due to the versatility and flexibility of attachable peripherals on drones. The most threatening peripherals are the various attachable cameras that pose privacy infringement and data security concerns.

Consequently, restrictions and the scope of drone activities are managed country-wise; however, they differ due to political backgrounds, the needs and capabilities of farmers, and market possibilities. Hence, our start-up is facing challenges that arise from the mixture of conditions that countries in Europe are separately offering to agricultural drone businesses. Such factors include farmers' lack of knowledge and awareness of drone benefits, drone maintenance costs, training costs, and the impact on biodiversity and people’s well-being.

This study revolves around two arguments that encapsulate and justify the title of my research:

a. Due to attempts at changes and harmonization of regulations in drone flight scenarios, it is a convenient moment for opportunities to expand agricultural drone businesses in Europe. Below is an illustration of the advancement of regulations that capture the ‘convenience of the moment’ and allow for more complex drone operations, drone categorization and setting general standards for each category, and enhancing the safety of drone users.

Figure 1: Updates on European Union's drone regulations



Source: Alamouri et al. (2021)

b. Data about world population growth implies the incongruence of required crop output and inputs to achieve that. Traditional machinery lacks the scalability in size and time that drones can realize. Achieving and meeting the food needs of the growing global population requires the introduction of technology capable of supporting massive global food quantities.

I must therefore approach the topic from multiple perspectives to explore the reasons and methods for a drone start-up to establish its presence on the market. I prepared research questions that will provide clarification and guide us in meeting the research goal, as follows:

a. What challenges does internationalization pose for managing a drone start-up related to the decision-making process when selecting a target country to enter?
b. How dense and saturated is the agricultural drone market? What are the barriers to entrance?
c. In which ways does the particular agricultural drone business in question have a competitive advantage over other competitors in a specific country (EU member state)?
d. Given the difficulties and restrictions in terms of technical and administrative implementation, how are European drone start-ups performing at the moment? In what ways would a practical and operational framework for emerging agricultural drone start-ups be achievable?

The versatility of drone applications may ignite interest in farmers who can tailor the software and interface to their farms' utilization. Finally, drone acceptance will surely benefit the environment, businesses that provide the service or product, and finally, the farmers' management of their farms, such as having a whole map view with the help of a drone, which also helps make their farming more sustainable (Tripicchio et al., 2015a).

Firstly, the thesis provides a theoretical background of internationalization, the value it creates, and the standard methods of internationalization. Then, the study covers an introduction to (agricultural) drones and their commonly known uses. The widespread functionalities of drones follow up with numerous peripherals attachable to an agricultural drone and the scope of combinations of drones with a peripheral. Furthermore, the most critical and 'controversial' topic that poses the greatest obstacle for drone businesses across Europe is the regulations.

Secondly, I resort to Porter's 5 Forces model, which theoretically shapes the agricultural drone industry by exploring the bargaining power of consumers and suppliers and the threat of new entrants and substitutes.

Lastly, this thesis includes a discussion with experts from the information technology (IT) and business sectors, where information will be collected through interviews. I will examine the managerial practices and market challenges of agricultural drone businesses, along with recommendations resulting from the primary data in practice obtained from experts.

2 THE START-UP INTERNATIONALIZATION PROCESS

International growth opens up new and potentially more profitable markets, boosts the firm's competitiveness, and facilitates access to fresh product ideas, manufacturing advances, and cutting-edge technology (Hollensen, 2010a). Moreover, the author states that services are becoming more sophisticated as information technology provides endless variations for sales and after-sales support for target customers. Narrowing niche markets as a consequence of competition from multinationals, the writer asserts that assets such as technological advancement, partnerships and networks, and agile response all consolidate the positioning of a particular company in a foreign market.

In recent research by Lehrer and Almor (2022a), one of the main impediments to start-ups internationalizing is their limited knowledge of the overall environment in foreign markets. The term 'overall' is defined as the totality of requirements involving the legislative, technological, and political environments. Thus, during the preparation phase, the owners should decide on and scheme a suitable business model based on their input quantities, knowledge, and information.

To that end, Hollensen (2010b) introduces the following obstacles to initiating internationalization:

a. Insufficient finances;
b. Insufficient knowledge;
c. Lack of foreign market connections;
d. Lack of export commitment;
e. Lack of capital to finance expansion into foreign markets;
f. Lack of productive capacity to dedicate to foreign markets;
g. Lack of foreign channels of distribution;
h. Management emphasis on developing domestic markets;
i. Cost escalation due to high export manufacturing, distribution, and financing expenditures.

According to Von Gelderen et al. (2000a), the initial years of a start-up company are typically filled with a lot of uncertainty and demand swift choices. Therefore, it is natural that a start-up encounters most of the obstacles mentioned above in the global environment. The support of the nation in which they operate has a big impact on start-ups, as I will discuss later. Such examples include governmental control by the host country, creating fair, competitive markets, and a regulatory framework that does not favor local companies. Further local advantages include the reliability of capital financing (Von Gelderen et al., 2000b) and intellectual property rights (IPR).

Lehrer and Almor (2022b) have also stated that “lacking a predefined business model, process niche firms engage in an exploratory process to determine the optimal markets to target”. Hence, the final target country’s choice of operation is decided following the stage of exploration, which offers the best conditions for ‘survival’. Although the paper describes ‘process niche firms’ in terms of digital non-tangible assets, the agricultural drone industry portrays companies whose focus aims at a specific cluster from the broad population of customers, i.e., a niche customer segment. Consequently, start-ups innovate to differentiate their services or products in that particular niche. Moreover, due to the nature of the services provided by our start-up, the location of its ‘home’ headquarters is determined mainly by the most rigid obstacle, the legal environment, as discussed later in my research.

Explicit variations of the label ‘international’ are described in Kuivalainen et al.’s (2012) research. The first of the three distinctions by type is the scope dimension of the degree of internationalization (DOI) composite indicator. It represents the number of different geographic places where the firm operates. In this sense, the number of countries parameter is set at 5, although this threshold remains undefined in a particular research frame.

The variable denoting the time part of DOI measures the interval between the firm's inception, its operations in a foreign environment from one side, and the firm’s international development from another. Nevertheless, it is important to mention that this indicator is tougher to work with since the lack of time series data, especially from start-ups and small and medium enterprises (SMEs), is a persistent barrier, therefore the lack of research in this field of study. Finally, the scale indicator denotes criteria where the firm has to maintain at least 25% foreign sales to total sales (FSTS) ratio.

Theoretically, the life-cycle trajectory before internationalization follows founding (inception) and establishment, then product development, followed by providing high-end service (Kuivalainen et al., 2012). Correspondingly, traditional (considered in theory) models of internationalization are practiced to a lesser extent, whereas simultaneously, internationalization methods of no particular type rise, i.e., are inherent to the product or service a company provides. For example, the Uppsala model visualizes a gradual or sporadic international expansion, physically close at first and continuously distancing culturally and spatially. The network model presents an international presence with prior personal, legal, or technical linkages or bonds (All Answers Ltd., 2022). All niche start-ups, however, do not conform to these patterns.

As will be seen later, one particular agricultural drone start-up company practices a combination of the network model of internationalization and joint ventures. Networking relations are a bridge between companies exchanging information or a resource that ties the firms together (Hollensen, 2010c). Relevant to our agricultural start-up case is knowing the local administrative procedures in a host country that may aid in obtaining a certificate or permission faster. On the other hand, crucial operations in this industry are customer relationships, which allows for the assumption that joint ventures are the most relevant method of internationalization in the agricultural drone case. Manufacturing, selling, and communicating with local customers reflect the situation where firms share the risks and costs of internationalization in joint ventures (Kirby & Kaiser, 2003).

3 THE DRONE INDUSTRY AND AGRICULTURAL DRONES

3.1 History of Unmanned Aerial Vehicles (UAVs)

The thought of a person staying above the ground dates back centuries, as this concept demanded incalculable intellectual and experimental endeavors by scientists. It was rewinding forward to the period of World War I when, as an outcome of reducing the number of deaths while in the air, UAVs were born. Unfortunately, military applications have dictated the development of these aircraft. Palik & Nagy (2019) describe the UAV object's creation, where Elmer Sperry designed their foremost impromptu model in 1917. Tracing the evolution of the first three unmanned aerial vehicles, Custers (2016) mentions the mechanically controlled object that failed to drop bombs precisely, the Kettering Bug, launched in 1918 but never deployed in combat, and the Queen Bee, the first drone device.

In light of Nonami, half a century later, drones' are safely marked as reliable devices capable of more functionalities. To begin with, intensified research and development of winged and rotor drones of lesser size took place in the 20 years between 1990 and 2010. Universities, companies, and research centers have been interested in advancing the field of developing and improving drones. “Many of the world's leading venture companies of drones today were born from the 30 main drone research teams of the world”, mentioned in the research. Thus, drone evolution gave birth to different utilizations, such as entertainment and commercial purposes (2018a). Modest efforts in legislation are being made to acclaim their further inclusion. By using drones in agriculture, safety, and surveillance of residential and non-residential structures, start-ups open possibilities for improvement and optimization within numerous solutions.

The impact of drones is three decades old. “The dramatic growth period of drones from the 1990s to the 2000s” (Nonami, 2018b) brought communication tools and micro-computer technology into a drone. Table 2 lists essential milestones in the history of drone development.

Table 2: History of Drones/ Unmanned Aerial Vehicles

Year	Event
1849	Air Balloons – Dropped bombs during the attack on Venice by the Austrians.
1918	Kettering Bug – A vehicle designed to drop bombs during WWI but never used.
1964-1969	The Lightening Bug – Surveillance during the Cold War by the US
1982	Battlefield UAVs – Many Syrian aircraft were destroyed by the Israelis.
2001	Predator – military surveillance drone.
2003	Commercial drones - Drones are becoming more common in construction, search, and rescue.
2010	Parrot announces the first augmented reality (AR) drone that can be controlled via Wi-Fi using a smartphone.
2013	Delivery of products - Amazon announces drone delivery.
2015	Lily Camera – The first autonomous drone that can follow and film its user. The company filed for bankruptcy due to massive delays.
2016	DJI’s Phantom 4 drone rather than being limited to following a GPS signal, was able to avoid barriers and intelligently track people, animals, or objects.
2019	Commercial drone delivery in Australia delivers fresh food and health products to customers’ homes.
2020	Ingenuity – the first helicopter landing on Mars was designed and launched by NASA.

Sources: Chakrasthitha (2020); Dormehl (2018); American Institute of Aeronautics and Astronautics (n.d.)

3.2 Getting familiar with drones

During the 2010s, drone settings received much attention; thus, these objects have become far more effective. Research teams in this domain progress exponentially since different and distinct drone utilizations find a real purpose across businesses and industries. That being said, exempting military applications and referring to the views of Floreano & Wood (2015), some of the current drone implementations are as follows:

a. Real-time information extraction.

Drones wielding specific and modern cameras paired with cloud data technology can create aerial images that provide farmers with persistent monitoring of the fields, crops, fauna, and soil parameters. As a result, quick decision-making measures can be taken in a short period of time.

b. The infrastructure and energy industries are accompanied by drones while surveying.

For example, monitoring bridges, gathering or distribution systems such as pipelines, and freeways gives a much smaller time gap where responsible teams interfere accordingly. Thus, cracks or leaks that damage roads or channels can be appropriately assessed and managed.

c. It is transforming logistics.

Due to their size and maneuverability, drones can provide necessary and urgent aid by transporting medical supplies across areas without decent infrastructure.

d. Surveillance and safety

Surveillance cameras attached to buildings have a limited range of capture and, therefore, limited vision. Introducing drones enlarges the sight range significantly and obtains information about the non-reachable perimeter by standard cameras compared to fixed surveillance cameras. A similar concept applies to illumination with flashlights.

The diverse tasks drone usage brings, especially in agriculture, will be discussed later.

Nevertheless, to address the majority of these issues with drones, their basic technical schematics are as follows: According to Kardasz and Doskocz (2016), drones are a two-part unit composed of movement and control systems. The former is characterized by a frame that consists of a certain number of so-called arms, which further specify the number of engines the drone wields. Given notice, the number of rotor-engine drones can vary from 2 to 16. Engines, in conjunction with propellers, form the driving force of drones. Objected to carrying loads or gaining maneuverability and agility, the propeller system, based on the vector of movement, can be classified in the form of X: an even number of propellers where two are the lead ones; Y: three propellers where either one or two are lead; and H: capital-shaped two lead propeller drones. Since propellers are attached to the arms, in cases where durability is required, the number of propellers can be doubled by adding a propeller on the bottom of the arm rotating in the opposite direction. Hence, it can carry more without duplicating costs or adding significant weight. Figure 2 shows a rotor drone employed in research on awareness models.

Figure 2: Drone model MD4-200 used in research for monitoring its surroundings

Source: Nonami (2018d)

Drones' power supply is predominantly batteries, although easily replaceable; their duration while in flight is significantly short, i.e., 15-40 minutes on average. Therefore, a tradeoff occurs between a more straightforward approach to more complex tasks and repeatability within a preset time interval.

The control system is responsible for steering and stability. Controls are selected before flying a drone so that relevant parameters correspond to the "maximum current consumption of the motor" (Floreano & Wood, 2015).

Today, drones are tools whose importance brings the utmost value to the user regarding feasibility and approach in certain areas. On the other hand, they require full customization conditioned on the purpose for which they operate as one-size-fits-all does not satisfy niche procedures (Nonami, 2018d).

3.3 Current UAV Functions and Drawbacks in Agriculture

Drones are units comprised of more components; however, when discussing industry applications, drone creators concentrate on delivering the intrinsic value within the software advancement rather than the 'mechanical' part of the drone. To this end, data science handles the software for managing data, and human-computer interaction (HCI) handles the relationship between the user and the data the drone collects. As a result, it gives birth to numerous and diverse applications for specific solutions (Molina & Campos, 2020a).

Recent research has occurred in the field of agricultural drone usage. Antunes (2021) and Hassler & Baysal-Gurel (2019) elaborate further on this topic, for example:

a. They are managing natural hazards such as moles or orchids. Namely, a French project has implemented a method of observing the mole population. Drones are allowing information to be collected about these so-called invasive species through constant monitoring. As a result, the area can be expanded by handling them accordingly and getting to know their movements, resulting in higher crop cultivation.
b. Assisted by appropriate software, drones can map field areas through aerial imaging. The extent of size capture capability spans from small farms to vast lands. Mapping can obtain information about assessing the normalized difference vegetation index (NDVI), i.e., if there is an occurrence of live vegetation used in seed planting, evaluation of tree sizes and their spots, or measuring the variance of flora over a land. Maps are created such that images taken with a UAV are later merged and undergo data correction procedures called orthorectification and vignetting.
c. Drones are thriving in aiding farmers by dispensing beneficial insects and chemicals on fields. Insects, in particular, as ‘preventative treatments’ provide agriculturists with better crop management, so less water and fertilizer are spent. Certain economic and technical advantages arise from drone implementation while applying (spray) chemicals. As an illustration, since geography substantially differs in terrain, drones can overcome such limitations as rigid territory. Similarly, fields vary and save up to 43%, corresponding to 90% of herbicide in maize and sugar fields.
d. Weeds dispersion: one of the most essential and widely spread usages of drones in agriculture is situating weeds among the crops on the land. Namely, it maps the presence of harmful and interfering plants as weeds using machine vision. The indicated method is part of the emerging precision agriculture (PA) technology, which is proficient in generating weeds maps.

Further solutions drones offer in this domain are planting seed pods, wildlife monitoring, dry land improvements, i.e., irrigation, micro-drones eating insects combined with additional research in the area of concepts such as PA and smart farming (Ahirwar et al., 2019; Antunes, 2021).

On the other side, many concerns stem from fast-paced research and the massive (but slow) implementation of drones. Thus, there will be issues with drone usage soon due to privacy concerns, safety risks, regulatory challenges, and ethical dilemmas. As Pathak et al. (2020a) discuss, we face several challenges when drone technology meets agriculture:

a. Weather

Since drones are weather-conditioned, they lose the battle against the heavy machinery traditionally practiced today when maneuvering and maintaining control under windy or foggy circumstances. Hence, ‘fair’ weather conditions are required for drone work advancement.

b. Battery duration

One of the main limitations of drones in agriculture during their airborne support is their battery life. Since drones’ flight time ranges between 20 and 30 minutes, it limits the area they can cover and the tasks they can perform. Moreover, recharging or replacing batteries can be costly based on the kind of task the drone is achieving and time-consuming, especially in remote or rural areas. Therefore, battery limitations are a significant challenge for the widespread adoption and application of drones in agriculture. Facing such constraints, I contacted an expert in the field, discussing a partial solution in the later sections.

c. Expertise

For a farmer to maximize production, he or she has to acquire specific competencies and an understanding of data. Hence, the costly tradeoff between hiring an expert to perform the analysis and learning to perform the analysis of field data themselves becomes obvious.

d. Misapplication of functionalities (narrowed to monitoring drones)

By exploiting cameras, drones are commonly misused, especially in entertainment. As fast and remote as drones are, they are in a position to infringe on privacy and abuse that data later on.

3.4 Certifications and regulations of the (commercial) drone market

The increased popularity of drones in public and commercial domains is undoubtedly due to excellent production and higher demand. For example, in the US, by 2032, the market scope is estimated to reach USD 82.9 billion (Fact.MR, 2023). A specific component of the motivation of new entrants positioning themselves in a particular market, aside from the fact that the global drone market size increases linearly (Precedence Research, 2022), lies behind the homogenous laws and regulations about flying UAVs in the European Union (EU) members. According to Jones (2017), countries are having difficulty harmonizing niche regulations due to the dynamics of the drone industry’s development. However, in the converging direction of a “more permissive approach to regulation”, laws have been continually reevaluated, rewritten, and reconsidered within the last two years. Furthermore, in his research, the author provides a depiction of drone regulations globally among countries and further pigeonholes the spectrum of permission from ‘outright ban’ to ‘permissive under circumstances, further experimentation, and openness about change in legislation. His description includes a visual line of sight (VLOS), pilot training, insurance, flight over permitted areas, and other obstacles describing legislation.

Although ‘to an extent’ outdated, the research by the author provides a simple and clear picture of the laws considering flying drones half a decade ago and presents the background of the current approaches by the European Union Aviation Safety Agency (EASA).

The EASA propels the modeling of drone regulations conditioned on one principal variable: the mitigating risk approach. Since applications and solutions where drones are present substantially vary, separate considerations and risks are discussed. Three categories are presented in the current general legal EU framework. Hence:

a. Low-risk or ‘open’ category: specific weight requirements, VLOS requirement, operating at a maximum altitude requirement, built at home or by you, neither dropping nor carrying a hazardous load, belongs to a classification labeled 0-4 with three more subcategories A1, A2, and A3 shown in Table 3 below.
b. Medium-risk or ‘specific’ category: drones incompatible with the open category. Despite EASA’s lack of explicit description of grouping such drones, it clarifies that the National Aviation Authority’s (NAA) authorization is compulsory or a qualified regulatory body in the country it operates in.
c. High-risk or ‘certified’ category: drones whose regulations are similar to those of manned aerial vehicles. Licenses, technical maintenance, and appropriate training are under the umbrella of the NAA.

Additionally, in light of the legal framework, since December 31, 2020, drone operators have been obliged to register themselves (EASA, n.d.). To do so, the NAA provides all the notable information for registration, pilot tests, and certifications and allows online flight zones. Secondly, taking insurance into account, above the threshold of 20 kg, possessing drone insurance is compulsory. In our start-up case, commercial activities are covered by bond withholding insurance, i.e., drone actions that yield income (Molina & Campos, 2020b).

To resolve the ambiguity of whether EU member states have complete autonomy over national legislation in correspondence with EASA or instead are ‘compelled’ to follow centralized/uniform legislation, the authors also state that, with disregard for the rigidity of particular national legislation, the parameters at the intersection of every legal model are VLOS and maximum range between the pilot and the UAV, and give detailed examples of Spain, the UK, and Belgium. Namely, the responsible parties modeling regulations are named AESA, CAA, and BCAA in Spain, the UK, and Belgium, respectively. With this in mind, these legal bodies correlated with the above categorization of drone operations modeled by risk, EASA does not hamper individual EU member states from deciding upon certain features such as prohibition or permission above certain zones, the earliest age of piloting a drone, insurance, and penalties in case of breaching the regulation.

To clarify, individual regulatory bodies in EU member states must not establish or apply their national regulations. However, they are legislated to conduct actions based on the previously mentioned remaining concepts in correspondence with the general risk-based scheme by EASA Drones (EASA, n.d.) (Last updated 10.09.2021).

Table 3: EASA requirements applicable to different classes of drones (open category)

UAS		**Operation**		**Drone Operator/pilot**		
Class	MTOM	Subcategory	Operational restrictions	Drone Operator Registration	Remote pilot competence	Pilot min. age
Private	< 250 g	A1 (can also fly in subcategory A3)	- may fly over uninvolved people (should be avoided when possible - no flyover assemblies of people	No, unless camera / sensor on board and a drone is not a toy	- no training needed	No min. age
0					- read the user's manual	16*, no min. age if a drone is a toy
Legacy drones (art. 20)						16*
1	< 900g		- No expected fly over uninvolved people (if this happens, should be reduced) - no fly over assemblies of people	Yes	- read the user's manual - complete online training - pass the online theoretical exam	16*

(table continues)

Table 3: EASA requirements applicable to different classes of drones (open category)
(continued)

UAS		Operation		Drone Operator/pilot		
2	< 4 kg	A2 (can also fly in subcategory A3)	- no fly over uninvolved people - keep a horizontal distance of 30m from uninvolved people - (it can be reduced to 5m if a low-speed function is activated)	Yes	- read the user's manual - complete online training - pass the online theoretical exam - conduct and declare a self-practical training - pass a written exam at the CAA (or at a recognized entity	16*
3	< 25 kg	A3	- fly away from people - fly outside of the urban area (150m distance)	Yes	- read the user's manual - complete online training - pass the online theoretical exam	16*
4						
Private						
Legacy drones (art. 20)						

Source: (EASA, n.d.)

Our start-up with our not-yet-patented peripheral for a drone belongs to the specific category that allows such categorization to perform commercial activities. Suitable drone certifications and additional documentation are anticipated following the contradiction between the pilot's nationality and the country of operations to draw closer to an actual problem through real applications.

3.5 Scope overview of products present in the agricultural UAV industry

The newest reports display a population estimation of 9.7 billion inhabitants by the year 2050, an increase of currently 1.7 billion (MacroTrends, n.d.). In addition, if we take into account the research outcome conducted by van Dijk et al. (2021), that is, between 2010 and 2050, total food needs will rise between +30% and 62%. In brief, I can elicit a few conclusions. Substantially higher food consumption evokes a greater need for growing crops on arable soil and, therefore, considerably larger land areas to be managed. Secondly, with land expansion, the capital required as an input, such as tools and farmers or workers, is positively correlated with this increase. Luckily, drones' latest technical and legal evolution brought about their inclusion in agriculture.

Before proceeding with actual drone models, a significant mention should be made of the so-called peripheral part of the drone or additional tools attached to a platform. Hassler & Baysal-Gurel (2019) and Tsouros et al. (2019) give examples of such peripheral equipment that dwells in the area of precision agriculture (PA), which is the practice of applying a set of methods for real-time data acquisition. Peripherals described above are, therefore:

a. Thermal sensors acquire information about the temperature of a particular plant or animal and thus create images based on this property.
b. Red-green-blue (RGB) cameras are the most basic and widely used due to their cost and usage, creating images of an object based on the intensity of any of the three colors at any pixel of the picture.
c. Near-infrared range (NIR) and multispectral cameras generate images as RGBs. However, NIR cameras capture NIR intervals of bands of light[2], and multispectral cameras generate 5-12 bands of light values instead of 3 from RGB for every pixel on the picture.
d. Hyperspectral sensors' exceptional functionality lies in acquiring values for several thousand narrow-spectrum light bands.

According to the task drones operate in, they can be divided into a group flying across a field in a shorter time if imaging resolution is required, trading off speed for a heavier peripheral, or a mission requiring spraying by carrying a heavier load or a specific grappling peripheral. Krishna (2017a) notably elaborates on models of drones used in agriculture. Namely, higher-speed and aerodynamically shaped drones are fixed-wing drones. In this category, some notable models are those represented as 'easier' to be controlled and most frequently have a camera/sensor peripheral attached to them. Therefore, the most frequently utilized imaging processes and those that fly greater distances are listed in Table 4 below.

The second group of agricultural drones is -copter or propeller-based rotor drones. Among these, drones are enumerated in the following way: they are frequently (but there are exceptions) heavier (80kg/unit), hover at a relatively slower pace, are usually enhanced with greater endurance, and support carrying larger loads. Such UAVs' are used by farmers in tasks such as dusting and spraying, which economically impacts the use of pesticides (50% less spraying chemicals are used during drone usage, which is a significant optimum compared to human manual performance), spreading and planting seeds of trees

[2] The set of colors named spectrum is obtained by splitting white light through a glass prism.

carrying liquid fertilizers, and similarly performing close monitoring about adverse pest attacks or diseases on growing crops.

Table 4: Categorization and list of drones based on the task they are performing

Type of drone	Names of representative drones	Basic properties
Most commonly fixed-wing drone	▪ Wave Sight ▪ eBee ▪ Precision Hawk's Lancaster ▪ Agribotix Hornet ▪ Trimble's UX5	Image-processing drones; sacrifice carrying of load weight for speed; simpler to be controlled; typically combined with different cameras as a peripheral
Propeller drones	▪ EnsoMOSAIC Quadcopter ▪ Venture Surveyor and Venture Outrider ▪ Yintong ▪ RMAX	Slower UAVs can carry heavy loads and have longer flight duration and durability; many different peripherals are attachable – spraying peripherals, chemical tanks, etc.

Source: Krishna (2017b)

With the rise of Industry 4.0, smart farming is currently in its nascent stages. Together with an exponentially rising industry and intensive R&D, this area still awaits to be utilized.

3.6 New CAP, SDGs, and relation to drones

The Common Agricultural Policy (CAP) is a series of policies in the EU aimed at increasing farm incomes, leading to a system in which subsidies are not tied to food consumption but to socially desirable goals such as rural development and animal welfare (Baldwin and Wyplosz, 2020a). The website for the CAP of the European Union for 2023-2027 focuses on social, environmental, and economic goals and is built around ten key objectives (European Commission, 2023a). These objectives served as the foundation for developing the CAP strategic plans in each EU member state. The most relevant to this study are environmental care, encouraging and nurturing innovation, gaining knowledge to improve competition, promoting and assisting in generational renewal, and preserving the safety and quality of food produced. The relationship with drones comes from integrating UAVs to a greater extent on EU farms to achieve the objectives.

On the other hand, agriculture requires funds for the targets to be met. Baldwin and Wyplosz (2020b) mention that CAP accounts for 40% of the EU budget and consists of two pillars referred to as the "two pillars". The European agricultural guarantee fund (EAGF) (first pillar) primarily funds market interventions and income support for farmers. In contrast, the European agricultural fund for rural development (EAFRD) aids in enhancing the competitiveness of agriculture and fosters sustainable management of climate change and environmental resources (European Commission, 2023).

By locating similarities between CAP and the Sustainability Development Goals (SDGs) of the United Nations (UN) by the end of 2030, we may further enhance the utilization of drones in agriculture. The UN Department of Economic and Social Affairs (n.d.) explains the SDGs. For example:

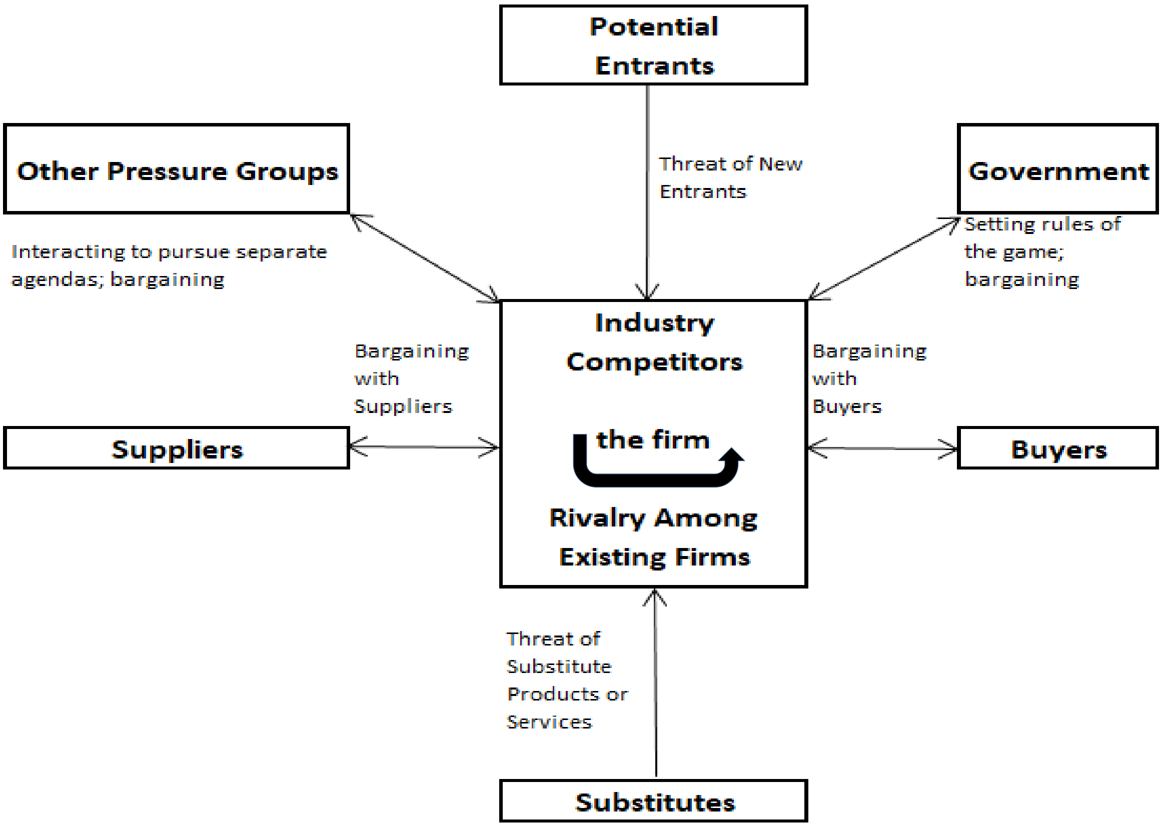
a. Eradicating poverty (SDG) and increasing competitiveness (CAP) support sustainable agriculture and food systems and ensure food security and nutrition for everyone. As I will acknowledge with an expert later, drones can significantly reduce the repetitive tasks farmers perform on the field and boost productivity by focusing on other tasks.
b. Climate action (SDG) and climate change action (CAP) aim to increase climate change adaptation and resilience while reducing greenhouse gas emissions from agriculture and land use. Drones can partially replace traditional vehicles that use fuel to propel themselves with batteries, or they can also use a lesser portion of the fuel than a tractor.
c. Life on land (SDG) and environmental care (CAP) care for the sustainable management of natural resources and work to protect and restore ecosystems and biodiversity. Farmers can optimize inputs such as workforce, pesticides, water, and time spent using drones.
d. Partnerships for the Goals (SDG) and Fostering Innovation and Knowledge (CAP) aim to encourage research, development, and innovation toward sustainability and promote cooperation and coordination among sectors. Precision farming tools such as drones are revolutionizing aspects of agriculture. Furthermore, the theme of encouraging innovation in agriculture motivates software developers to improve the existing systems on drones.

Drones' presence as a bond between CAP and SDGs will replace traditional machinery; hence, lower inputs and substantial gas emissions reduction will directly aid climate change action. Next, drone fundamentals underlie heavy research in technology as start-ups must compete in niche segments and specific solutions, thus supporting the generation of knowledge and creativity. Finally, drones will enhance significant production and preserve plants' health, maximizing sustainable food quantities' capacities.

4 ANALYSIS OF THE AGRICULTURAL UAV INDUSTRY

In his research paper, Goyal defines Michael Porter's 5 Forces as a model of competitive advantage and proposes a persuasive view on how a corporation can attain a competitive advantage in a specific market by utilizing the industry's five inherent factors. Referring to Goyal, the five forces are various factors that may impact how a company is positioned in a given industry (2020a). The following section will refer to Porter's 5 Forces model to describe how competitive forces shape this sector. By implementing this theoretical model in practice, our start-up can choose the best course of action to gain a competitive advantage and add value even before entering a foreign market.

Figure 3: Porter's 5 Forces model complemented by Boddewyn's non-market forces



Source: Grosse (2010a)

Figure 3 augments the default Porter's 5 Forces model by adding two additional non-market factors. A crucial link to drone business integration is the added government involvement.

This chapter, based on the relevant literature review, will use the deepening of the model to analyze the threat of substitutes, the threat of new entrants, the bargaining power of suppliers, the bargaining power of consumers, internal industry rivalry, and the role of government. The section will serve as a foundation that will influence the investment decisions of agricultural drone start-ups.

4.1 Threat of substitutes

To understand and analyze the conditions for the internationalization of a drone start-up and discuss substitutes, I briefly resort to the historical trace of equipment and capabilities local farmers possessed in the past. As Mazoyer & Roudart (2006) stated, drudgery with manual labor marked the earliest known existence of Homo sapiens', more than 10.000 years ago. As a most anthropologically advanced species, humans have transformed their work by inventing various tools such as chisels, axes, knives, and drills made of bones, stones, or wood.

Fast forwarding to the twentieth century, the aftermath of events such as the World Wars and the Industrial Revolution reshaped the consumer needs and habits of everyone at the time. The shift from individual production to mass factory manufacturing, i.e., industry dominance, closely accompanied by the accumulation of livestock and agricultural output, called for intellectual ignition, inventing huge machinery and motorized devices.

The concepts of change and adaptation have been omnipresent across historical periods. Hence authors (additionally noting the importance of internationalization where all end-products are a result of it) emphasize that we have come to a point in time where present-day farms “are equipped with heavy tractors and large machines; they require huge amounts of synthetic fertilizers, treatment products, livestock feed, and specially selected plant varieties and animal breeds” (Mazoyer & Roudart, 2006b). The variability and diversity of the tools above call for introducing the term ‘Industry 4.0’. According to Lasi et al. (2014), in its simplest form, it translates as a further enhanced mash-up of technology, and manufacturing, i.e., a closer integration of anticipated technological inventions paired with internet technologies within machines, dictating an alteration of future production ways and methods. The concept of Industry 4.0 looks forward to unveiling the upcoming era of smart farming. Hence the striving acts of farm management transformation involving drones and the Internet of Things. Consequently, smart farming is going to modify the vertical chain of production such that a specific peripheral fits a drone intended for a unique task on the field (executed presumably within an optimal time interval), thus outputting different (than prior-to-drones-era) quantities, changing the strategies among the bottom-chain stock, and selling services.

Thus, from the depicted chronological timeline, it can be inferred that farmers bear a crucial and essential global role in massive food production, where they also should specialize technically and enhance their technological expertise. The magnitude of their responsibility implies that farmers must not face the unpredictability and inaccessibility of technology. As a result, not only would it be physically impossible to meet the world population's food consumption by 2050 if drones and precision agriculture were not used, but using drones and precision agriculture is a natural evolutionary step. The most controversial substitute for drones is replacing humans on farms. This situation raises farmers' concerns about directly substituting them on the field, hence losing jobs. As it will be analyzed later during my research, drones will not ‘compete’ with humans about gaining or losing jobs but instead aid them. Such examples are substituting repetitive manual labor like crop spraying with propeller drones, flying rotor drones with seed dissemination peripherals instead of driving heavy machinery and vehicles performing the same task, and load-carrying propeller drones instead of lifting or carrying fertilizer bags or tools that may affect the spine and can cause muscle injuries.

As a result, our infant start-up, with its unique product, comes into play. We currently dwell at a time when drones are the following evolutionary step. Thus, the agricultural drone industry does not encounter the overall hazard of substituting, but conversely, instead – smart farming is the predicate of drones before taking agriculture over.

The threat of drones replacing traditional machinery and tools is somewhat complex because it depends on various factors such as the size of farms, type of crops, soil quality, climate, management, and long-run expectations and planning by the owner. Altogether, these components contribute to tailored solutions on farms differing in application method, duration, availability of such service in the farm's country, potential value creation, etc. Based on the theoretical and practical advantages of drones on farm solutions in rather disparate scenarios, the threat can be estimated as medium to high. Moreover, it will be seen later in the study that implementation of drones is welcomed positively among farmers.

Therefore, farmers' vision, knowledge, and preparedness are 'contextually' rooted, intensifying the threat of anticipated substitution of heavy farming vehicles with drones.

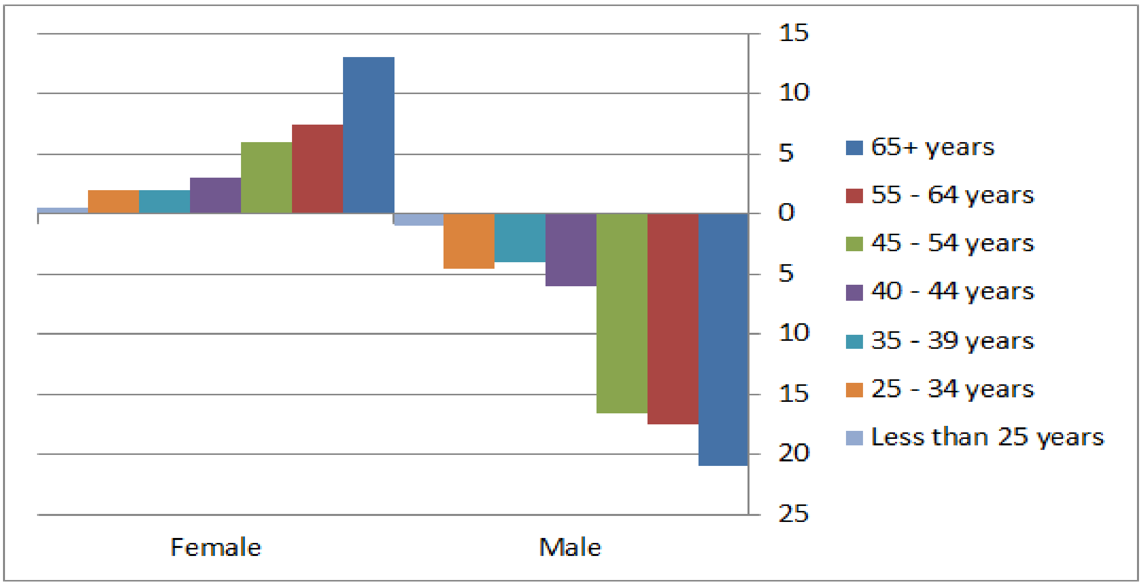
4.2 Bargaining power of consumers

Due to the nature of the study, one of my research objectives is to encapsulate a market defined by sellers with a portfolio of smart farming technology services or products, i.e., management. In reality, there is not a well-established and well-defined market that functions with such parties. The concept of prospects in my thesis leads us to a yet-to-appear market anticipated in Europe, whose properties are not currently familiar. The implementation, acceptance, and integration followed by frequent drone practice among farmers imply a totality of minor structural changes in the economy, which would later translate into a shift in social welfare among European countries and a re-adaptation of consuming habits. However, although Europe is presently in the implementation phase, the mentioned notions are separated by an 'expertise' metric. Although the European Commission's CAP stands for standardized availability of funds (Pe'er et al., 2019), information distribution, and related sectors (infrastructure, knowledge pursuit, and regulations), current farmers' bargaining power considering agricultural drones is not favorable due to the following:

a. Since the agricultural drone industry does not compete in prices (not yet) but rather in quality (modifications and reliability of parameters here are the backbones of the purchase process decision-making), consumers' spending limits, goals, and varying priorities are what buying decisions depend on. Therefore, this implies that the industry is highly differentiated and defined by products and services tailored to agricultural issues. Additionally, farmers' decision to buy a high-quality drone adds a value superior to hesitating over whether one should save and buy a cheaper drone or a peripheral of lesser quality. Furthermore, cutting costs before purchasing a drone would not be worth it since, as I will discuss later, drone utilization's return on investment (ROI) pays off in a few seasons if the performance is according to market estimations.

b. Farmers’ lack of information and education about drone potential sets a significant roadblock in assessing bargaining power in B2C terms. Namely, Eurostat (n.d.) points out that two-thirds of EU farmers are “at the older end of the age spectrum” and more than 65 years old, as seen in Figure 4. This particular result suggests that reluctance to high technology is plausible among this generational cohort; therefore, numerous difficulties are inherent to specializing in, say, hyperspectral imaging interpretation of results. I will discuss this in more detail about the human drone interaction later.
c. The data indicates that in 2016, the number of farmers totaled around 10.5 million, a substantially greater number than commercial drone sellers, indicating weak bargaining power.

Figure 4: Gender and age distribution in 2020 of EU farm managers (in %)



Source: Eurostat (n.d.)

4.3 Bargaining power of suppliers

The subsequent chapter considers B2C relationships rather than B2B processes.

Considering suppliers’ bargaining power, two main arguments prevail on this particular topic. Firstly, the diversity of services offered to farmers’ links with the previous analysis concerning the scope of services and expertise required. Secondly, suppliers’ power is tightly connected to their numbers. Here scarcity is used as a competitive advantage (‘number‘ of differentiated products relative to other competitors). However, I will address this matter further in the upcoming chapter, along with how business models’ interactions on a competitive level shape the market, aided by non-adjacent drone industries.

Delivery of customized solutions where a certain peripheral is made for a particular purpose on farmland attached to a specific drone model binds sellers and buyers in a unique relationship. Here, ‘made’ entails a process of research and development, many steps of decision-making, creating initial versions of the product, testing, optimizing, customizing, producing quantities of it, selling it, establishing contracts with logistics companies about distribution, and lastly, the drone entity receiving it.

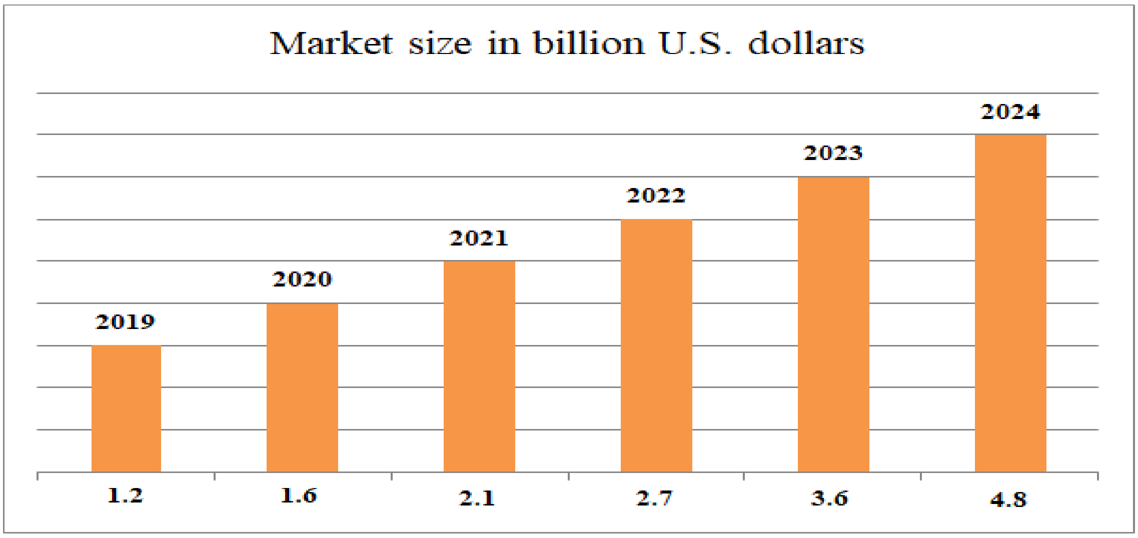
Such a previously defined vertical chain generates a value of individuality (or scarcity) in the market, where diversification dictates the business model.

One-to-one and new relationships are established between sellers and buyers, accompanied by the historical shift in timing when agriculture enters the digital era with full steam. It forces farmers to adopt modern technology and smart solutions gradually. Accordingly, during the gap between first implementing drones and farmers’ familiarity with these items, sellers are given enough space to push negotiations in their best interests. The supplier’s bargaining power brings the research to the next Porter's component: the industry's internal competition.

4.4 Competition between existing firms

In the opinion of Grundy (2006), the author asserts that the intensity and the grounds on which businesses compete determine how the competition reduces the industry's potential for profit. Competition is greater and profits are lower when growth is slow or rivalry is intense. The author also describes internal rivalry as the central notion in Porter’s 5 Forces model, the heart component that encircles and gives rise to four other elements linked, affecting the industry and creating new opportunities for the competitors.

Figure 5: Size of the smart agriculture drone market worldwide 2019-2024



Source: Statista (2023)

Figure 5 above shows the industry's steady exponential growth in the last four and the upcoming two years which further enhances attractiveness. This pattern also justifies EUR 10 billion annually by 2035 and more than EUR 15 billion annually by 2050, as the SESAR Joint Undertaking (2020a) envisions, and UAVs' presence as an ordinary occurrence being part of a farmer's toolkit.

However, such future expansion in market shares implies either:

i. A few dominant and prominent companies with a portfolio history would further attract companies to enter the industry and pose competition. If such, the position of dominant incumbents involuntarily pushes them to devise strategies to deter entrance, i.e., to systematize barriers to entry for new firms.

Provided that customers of this particular industry (unlike hobby/leisure drone buyers) belong to a non-distinctive group, i.e., there are no customer segmentations involved (the size of a farm is a parameter that does not influence shocks on the competitive side of the supply), every player does compete against the takeover portion of the same segment. Consequently, incumbents enjoy more comfort in their position, as no dilemma is present when considering which customer segment should be contested. This dilemma arises in industries whose sequence of development and innovation advances rapidly. It allows everyone to own or use a product that was initially inaccessible to most consumers.

An example of this dilemma would be the automotive industry, where Ford in the past had to decide whether to compete either with Toyota (the more accessible products) or continue with R&D to satisfy its current customers (Harvard Business Review, 2012).

Alternatively, the distribution of market shares is, to some 'extent' uniformly distributed among firms competing; hence, the market structure is unlike the above.

4.5 The threat of new entrants

Revolving around the concept of barriers to entry, the threat of new entrants involves the possibility of new companies entering a particular market and competing with the existing players. Goyal (2020b) describes this component as when new entrants pressure incumbents, challenging their profitability.

Nevertheless, several factors contribute to the loose entry conditions. Therefore, the market structure in i. above cannot hold, indicating that the threat of new entrants significantly threatens companies' profits. For example, such factors are:

a. The weakness of uniformity in local regulations among all EU members, i.e., the loss of homogenization, is the most substantial. Thus, applications in practice either take time or change quickly.

b. The IT industry helps access, share, and spread information, which can further promote knowledge generation since it is closely connected to many sectors. This conjecture can greatly reward those whose network connections within the IT universe exist.

The takeover of the family of technologies named under the umbrella term ‘artificial intelligence’ (AI) makes data collection across industries more practical, making the lives of responsible decision-makers easier. Under ‘more practical’, substantially large volumes of data are understood, which, by further cleaning, filtering, normalizing, etc., contain the potential to examine new patterns in the business upon which exploratory approaches can be made.

Ken Research Private Limited (2022, July) grants a novel list of several crucial firms that operate in Europe within this industry in Table 5 below:

Table 5: Europe's Agricultural Drone Companies

Current and Emerging Agricultural Drone Firms	**List of Companies**
Europe's Major Agricultural Drone Industry Players	▪ AeroVironment Inc. ▪ DJI ▪ Parrot Drone SAS ▪ PrecisionHawk ▪ Atmos UAV ▪ Delair-Tech
Europe's Emerging Agricultural Drone Companies	▪ UAVIA ▪ Hemav ▪ Drone AG ▪ Hummingbird Technologies ▪ birdpilot GmbH ▪ Azur Drones

Source: Ken Research Private Limited (2022)

Additionally, the uprising and anticipated agricultural drone firms that are yet to compete in this market are listed in Table 5.

To conclude, information about high-end utilization and optimizations of a drone to be used in tailored solutions is endless and disseminated quickly across the industry (Molina & Campos, 2020c). Hence, from this perspective, it is painless to enter the industry if a firm possesses an uncommon idea. The solutions and applications seem to stack rather exhaustingly as the industry converges toward the smart farming concept.

Initially resorting to the two main arguments about eliminating manual labor without the fear of erasing jobs as new positions arise, SESAR Joint Undertaking (2020b) states that such related and threatened professions are: insurers, maintenance contractors, localized operations controllers, and legislators. As mentioned earlier, meeting global food needs requires more significant production, which inescapably involves more manual labor. Drones' role as catalysts in the world of data is analyzed in more detail in the interviews about human-drone interaction (a subset of human-computer interaction), micro- and macroeconomic phenomena that enable further performance, and the existence of drones.

4.6 Beyond Porter: Non-market factors

One of the essential entrepreneurial aspects of maximizing net profit as the outcome of any decision-making process is recognizing that the government's engagement is critical when it affects expected profit. By now, I have described Porter's 5 Forces' relations to a start-up in the framework of the agricultural drone industry. Jean Boddewyn has been one of the first to acknowledge the importance of the role of the government when a business expands internationally. In the views of Grosse (2010b), he argued that the value of the relationship between multinational companies and a government in a foreign country is overlooked. The potential it holds, the author states, is concealed within so-called 'uncontrollables' or constraints – factors that are commonly associated with risks rather than opportunities as a means of gaining a competitive advantage in the marketplace.

Boddewyn's insights play a massive role in the context of agricultural drone start-ups. Market research reveals that governments are in a position to create a market mostly on their own. As it will be clarified later, European governments can shift regulations with their authority. Thus, a particular EU country creates conditions for the existence of a market. Boddewyn puts most emphasis on viewing relations as value emerges from "managing the multinational to optimum results rather than focusing on the relationship with governments itself", where the mutualistic link "is thus frequently one of a 'positive-sum game' where both parties benefit from their relationship" (Grosse, 2010c).

During one of the interviews, I addressed a question about the main driver for pushing local restrictions where agricultural drone businesses mutually co-benefit with farmers.

4.7 Summary of Porter's 5 Forces model findings

In Table 6 below, I have shown the main macro factors currently shaping the agricultural drone industry. The model reflects market properties where local legislators set the competitors' playground. However, companies should be the main driving force in the future as farmers' customization and specialization of requirements will require much more complex legislation, and uniformization will be nearly impossible. As the complexity of solutions due to numerous factors rises, farmers and agricultural drone firms will transform the relationship between governments and stakeholders, benefiting the environment, companies, governments, and farmers.

Note: The above-discussed theoretical scenario will work if and only if governments, controlling for social welfare ceteris paribus, nourish and aid the country's agricultural sector over pursuing personal gains.

Table 6: Key takeaway points of Porter's 5 Forces model analysis

Factors	**Key takeaway points**
Threat of substitutes	The risk of drones replacing heavy machinery and slow vehicles is high, as there are more advantages than disadvantages. Also, experiments in practice show consistent improvement and acceptance by the farmers.
Bargaining power of suppliers	Scarcity and specialization of solutions are the ultimate competitive advantages of companies in the agricultural drone industry. Also, the European market is not saturated with competitors in the spraying segment.
Bargaining power of consumers	Tailored solutions do not offer consumers much space for bargaining but instead mutual contribution and improvement (feedback by farmers and implementation by companies). The lack of digital knowledge among farmers does not currently offer bargaining power. The generational renewal may shift bargaining power in the future.
Internal rivalry	Start-ups today specialize in niche solutions on farms where competition is sparse. Companies pushing R&D toward precision agriculture, AI interfaces, and data analysis will uncover a new territory of smart farming.
The threat of new entrants	Major obstacles to accessing the agricultural drone market are regulations set by the EU and shaped locally by local legislators afterward. However, considering the literature review and the secondary data, the number of European agricultural drone start-ups is not high.
Non-market factors	The most significant barrier to entry is the regulation. Local governments are key players in shaping the future of the industry.

Source: own work

5 METHODOLOGY AND RESEARCH APPROACH

5.1 Research design

Saunders et al. (2009a) define research design as the overall strategy for solving the research questions that will include specific objectives drawn from them. Moreover, the authors emphasize that the research design defines the sources from which the researcher aims to collect data, evaluates the restrictions that will unavoidably arise (e.g., data access, time, location, and money), and examines ethical considerations. The thesis will predominantly rely on qualitative data since it is most relevant to my topic, which is an exploratory study. The underlying research questions dictate an outline where the research analysis is based on primary and secondary data. Hence, a literature review was initially conducted to provide the fundamentals of the theory behind the subject.

Meanwhile, the first two questions are confined to macro matters, for which data is hardly accessible online. Therefore, they have been discussed with interviewees from selected start-ups. Thus, an increasingly critical approach has been developed throughout the interviews and afterward during the analysis of the results obtained. In particular, the third research question narrows to the microdomain and has been addressed by a computer science expert. The last question is deducted from the outcomes of the interviews and is discussed in more detail in the conclusion.

5.2 Research methods

5.2.1 Samples

The qualitative data has been obtained through four expert interviews for this research. The expert interview appears to be "quick, easy, and safe" to utilize and can potentially be very valuable in practice. It is a qualitative empirical research technique used to examine expert knowledge (Meuser & Nagel, 2009). Such a decision stems from exploring an area requiring precise knowledge and solidified experience in a business setting with an intersection of agricultural drone technology. As a consequence, semi-structured interviews served as a tool for gaining insights. All the discussions have been performed online, with prior consent for recording through email communication. Two interviewees have been found through networking with my existing contacts, asking for referrals and recommendations, and reaching out to relevant people. The third interview entailed extensive online research and sending requests via email or LinkedIn to visible and available contacts on websites. Finally, the last interview was conducted with the founder of an agricultural drone start-up in N. Macedonia. Van Audenhove (2007) describes the advantages of expert interviews:

a. Quick entry into a new or unknown field
b. Obtaining particular information quickly
c. Have a strong understanding of aggregated and particular knowledge that is difficult to examine using different methods.
d. Much less time intensive than many other methods.
e. Regularly networked person, naturally leading to other interviews.
f. Frequently willing to collaborate and exchange knowledge.

The thesis captures an inherent difficulty, since there are not too many people in Europe whose expertise involves an intersection with business practices, understanding the hardware of agriculture drones, and awareness of management obstacles when integrating UAVs into everyday life.

I have chosen an interview sample based on distinct criteria rather than the number of interviewees who meet the same standards. From a start-up's perspective, I attempted to conduct interviews and close gaps with information whose relevance would be analytically considered in a realistic scenario.

Table 7: *Sample outline*

Interviewee	**Industry**	**Experience with drones**	**Relation to drones**	**Interviews' main focus**
Interviewee 1	Computer science/Human-computer interaction	Close to 4 years	Ph.D. research student of computer science; software for synchronizing micro-drone swarms	Human-drone interaction
Interviewee 2	Electronics	More than 8	Innovator of a drone brand about payload peripherals and search and rescue accessories	The future course of drone development and the case of Slovenia
Interviewee 3	Agricultural drones	More than 5	Head of international sales for a company that develops and offers specialist drone-based agricultural solutions.	Strategic and macro challenges of an agricultural company in the EU
Interviewee 4	Drones & electronics	Close to 10	Hobby about drones that transformed into a start-up idea with the potential to revolutionize the industry	The case of a Macedonian start-up

Source: own work

As the thesis deals with entering a market that faces competitors, I narrowed my focus to obtaining information from a computer science expert or researcher who deals with drones. Accordingly, the first interviewee assisted us in discovering new ways of utilizing the software in the future, highlighting the importance of culture and age when accepting drones and introducing human-drone interaction as a concept.

Secondly, other interviews explained the challenges from the perspective of decision-makers in an agricultural drone business. It is essential to add that even though the interview questions have been non-exhaustive, they have covered a 'satisfactory' territory of what I attempted to synopsize and critically assess.

The structure of all interviews was the first step in introducing the topic to the interviewees and having a brief dialogue concerning its importance today.

5.2.2 The layout of the semi-structured interviews

Following the research questions, I have used semi-structured interviews, as they appeared most consistent and natural with the objectives of this research and the research strategy adopted. Gathering such reliable data using a ‘non-standardized’ interview structure defines a framework with a clearly specified direction (Saunders et al., 2009b).

The goals of my interviews are:

a. Due to limited secondary data about competitiveness and market behavior, I aimed to collect data on what defines the competitive advantage in the European market.
b. To identify managers' opinions on the current technological, administrative, and political impediments that hinder the efficiency of their business.
c. To ascertain the validity of present regulations about drones in agriculture and how they benefit or pose a drawback to farmers.
d. To explore and connect the links of the newly obtained information to describe realistic settings to be practiced in a start-up scenario on the EU market.

With an average duration of one hour, the interview questions have been modified and a few removed to fit the duration limit. In addition, new questions have been added because the conversation led to related topics that had not been initially thought of. The first stage included briefly introducing the subject and clarifying why it is relevant to be debated today. Interviewees’ discretion and confidentiality were guaranteed from the beginning. Being divided into two parts, the first set of questions captured their educational and professional backgrounds. The preliminary questions posed to the computer science expert included an explanation of the terminology that preceded the second part of the interview. By asking open-ended questions about AI in drone technology, I tried to discover how users perceive this advanced technology and how it relates to human-drone interaction research. Next, I explored the significance of implementing artificial intelligence in a drone setting. In this manner, a competitor’s point of view was examined and discussed, along with what advantages drone usage would bring to farmers and in what ways it is possible to stand out in this market. After exploring competitive advantages, and limitations in Industry 4.0, the last two questions addressed the importance of culture and age when considering agricultural drones.

To familiarize ourselves beyond theory with the latest data about the business climate in Europe, I contacted three drone experts: one established in Slovenia, the second in Hungary, and the third from N. Macedonia. New questions arose during this part of the research, further clarifying the explored topic. The focus was on internal management activities, market behavior, and the challenges of integrating drones and drone services between EU goals and farmers controlling for age.

The two interviews started with discussing the background and motivation behind working in this industry with the respondents. This section of the discussion was where the content discussed parted ways. In one interview, an emphasis was put on sales (overseas in this case) and the significance of relations.

In the meantime, questions in the second interview revealed the dynamics of expansion, challenges related to competitiveness with well-established brands, and post-sales dedication to customers and its significance.

And in the fourth interview, we uncover the story of the Macedonian start-up that anticipates entering the agricultural drone industry.

5.3 Data analysis

I have examined the interviews and directed my attention to deriving explicit expert knowledge. Following the two main arguments, I focused on a few data points. My study depends on expert interviews because they provide us with mostly 'insider' knowledge since, apart from the military application, drone integration is not widespread yet but emergent. With this in mind, the goal of the methodology of purpose-oriented interviewing is to analyze the information obtained and compare and contrast answers systematically. Afterward, synthesize the findings, prepare and formulate a strategy, and unveil the conditions to be examined before internationalization. Below in Table 8 are the critical aspects inferred from the data.

Table 8: *Interview topics*

Respondents	**Topics examined during the interviews**
Respondent 1	▪ Defining HDI (human-drone interaction). ▪ What is the present situation with AI in drones? How should it help within the interaction process with humans, communicating context? ▪ Moral dimension during the integration of AI within the software in drones. Reliability in the context of pre-programming drones. ▪ Examining competitive advantage in a drone business setup. Drone swarms, benefits, and compatibility with farmers. ▪ The importance of age when introducing drone technology to farmers. Aiding and supportive solutions instead of eliminating jobs as a future course. ▪ The significance of culture and privacy in drone adoption.
Respondent 2	▪ Overseas sales. ▪ Slovenia's example of drone restrictions. ▪ General discussion regarding post-COVID market structure.

(table continues)

Table 8: *Interview topics* (continued)

Respondents	**Topics examined during the interviews**
Respondent 3	▪ Post-sales activities and the importance of customer satisfaction. ▪ Provisional disadvantages of Chinese drone saturation in a particular customer segment. ▪ Challenges of start-ups – establishing oneself as a brand. ▪ How to differentiate and create a competitive advantage based on a start-up. ▪ Regulations frame in the EU - their purpose in supporting businesses. ▪ Meeting the EU's sustainability goals by 2030 using drones in agriculture. ▪ Automatization, the future course of autonomous flight, considerations of AI in drones. ▪ The aftermath of changing the general EU regulation about spraying drones. ▪ The essential factors when expanding internationally. ▪ The importance of owning an experimental license and examples from practice. ▪ The future course of legislation on the European level– mutualistic benefit.
Respondent 4	▪ Traditional methods vs. drone technology on farms. ▪ The dominance of Chinese drones on the EU market. ▪ The case of the Macedonian start-up and its future course of action.

Source: own work

6 ANALYSIS AND DISCUSSION

The following section uncovers emerging ideas and business practices that haven't been initially put into the research framework of this study. In this chapter, I outline the critical interview findings based on the information obtained. As discussed, the interviewees offered knowledge from their areas of expertise. The data from the diverse yet related areas converges to further reveal agricultural drone start-ups' potential.

As agricultural drone businesses are the main focus of my research, by having discussions and later transcribing the interviews, I identified five key topics that are at the core of the question of how to achieve internationalization: the emergence of human-drone interaction as a concept in the scientific world, where continuous research is being done on the human approach to drones. They direct the study to the factors that influence this interaction, such as privacy, age, and fear, and encapsulate them within the concept of culture that results in the hesitation of drone adoption. These concepts shape the agricultural drone industry, where artificial intelligence as an anticipated technology defines an evolutionary step in farming. Finally, the disproportional geographical adoption of agriculture is shown as a consequence of different behavior by the host-country legislators.

These topics represent the various elements of the industry that the participants discussed and added practical examples of opportunities and challenges emerging in this field. The following sections are illustrated with figures and summarized with tables that carefully describe the topics.

The themes' core lies within the dialogue between quoting the experts and additional literature reviews related to the newly discovered areas. Therefore, I intend to convey a thorough and layered understanding of agricultural drone start-ups from the perspective of people from industries that are directly involved in the advancement of farming drones.

6.1 Introducing the concept of human-drone interaction

Natural user interfaces' primary objective is to produce an intuitive control mechanism, described as an interface that performs as the user expects. Natural user interfaces enable non-expert users to operate drones with less effort and training time and fewer aircraft crashes (Tezza & Andujar, 2019a). As a natural component of a drone business, it is crucial to discuss the link between pushing drone utilization to unveil its potential and consumers on the other end responsible for that phenomenon. Hence lies the challenge of selling reliable software that is, at the same time, 'approachable enough'.

I first asked about the new branch of computer science, which studies the links between drones and human-computer interaction.

"My mentors and I worked on this area, and we wanted to discover the different functionalities that drones of smaller size (micro drones) offer. We aimed to find out how to make it easier and more convenient for humans to adapt to or use UAVs. This is the moment where we come in – where we experiment with human-drone interaction. The branch focuses on the qualities or design recommendations and the impact of human factors" (Interviewee 1).

The expert has uncovered that human-drone interaction is a new sub-branch in the IT industry and an intersection of drone interface and design with computer systems to bring the designs closer to satisfying the users. Next, the expert introduced his current research area:

"My current research involves bringing a group of drones called a swarm closer to a human. Unfortunately, today, due to factors we will explore later on, drones may appear dangerous to a person who has never seen or operated one before, especially the larger ones" (Interviewee 1).

Hassanalian and Abdelkefi (2017a) describe that the idea of swarms is a novel branch of bio-inspired AI based on the behavioral patterns of swarm flight in birds, ants, and termites.

All in all, the whole point of HCI is to make a device easier for a particular person. Although, as observed from the research of Tezza & Andujar (2019b), topics such as the roles of humans in HDI, new drone control techniques using brain-computer interfaces or gestures, distances, and emotion encoding are out of the scope of this study. Instead, we discussed the anticipated advantages of a scenario where farmers can conveniently and safely fly drones on their land.

6.2 Current role of artificial intelligence in drones

Dharmaraj and Vijayanand (2018) remark that besides the widespread integration of AI using data to spot patterns and generate predictions, the relationship with cognition will be able to create futuristic software models where drones can sense and recognize their surroundings, thus boosting crop yield.

To explore this topic further, one interviewee gave the following insights:

"The concept of drones that we know now is that they are convenient vehicles that can collect and transmit data. And what we are exploring is how we build drones so that they can interact with humans. And when we say 'interact', it is more about acknowledging your presence and emotions. Although I think these things are still two steps ahead from right now, this is a direction we are headed in" (Interviewee 1).

However, drones and swarms are now pre-programmed so that someone can write a script or a line of code. According to Rejeb et al. (2022), although drones can fly autonomously, they still need a pilot to control them, indicating that they have a limited level of intelligence. The drones behave differently depending on how they are programmed. Moreover, drones using AI can better manage soil and crops and avoid collisions while navigating. As a result, if a hand is placed underneath it, it will react differently. In their study, Chandhar et al. (2016) describe a technology enabling drone swarms. Massive multiple-input multiple-output (MIMO) is a new mobile communications technology that uses many antennas at the base station to supply many single-antenna terminals with very high capacity. It implies that drones equipped with AI should be perceptive of their surroundings. Thus, the drone is able to decide how to navigate through obstacles autonomously.

> "Considering this broad domain of micro drones and quadcopters, plenty of people are already working on it. And I think the next frontier is what we call communicating context. A drone would want to communicate something to a human, or vice versa, or maybe a human will want to say something to another human with the help of a drone. This would be another interesting challenge, but these are all open questions, and I think this is what is in front of us right now" (Interviewee 1).

Drones must be increasingly independent and self-sufficient to achieve this communication scenario. One feature of this automatization is their capacity to replenish their batteries without human assistance.

> "We observe that the automatization of drones is progressing annually. For example, you need to recharge your drone's battery when you operate it on the field. The next step may be battery stations, so the drone will fly there and replenish itself automatically. One significant limitation factor is the battery of drones. With the development of batteries, we can keep drones in the air longer. Combining it with a breakthrough in automatic filling of their tank once it is empty, it will be much more convenient, easier, and helpful to use drones with significantly less human intervention" (Interviewee 3).

Technology can be utilized in addition to AI and drones to monitor crops. There is an additional opportunity through satellites because they may supply more data and cover more expansive areas. Before deploying satellites, however, a few security concerns must be addressed.

"Drone operations will change considerably. For example, with AI's assistance, you can have a drone on a farm that will autonomously fly on a predetermined route, finish the appointed task, and come back to charge itself. The data will be processed with a neural network for artificial intelligence. And the second vital thing is that for the observation of crops, we will start using satellites now; the solution is problematic, but the issue is not technical. Instead, it is a security problem" (Interviewee 2).

The discussion at this point skewed the direction of the study and unveiled a topic whose significance demonstrates a crucial link to drone allowance, i.e., the meaning of privacy. With one of the interviewees, it was argued that different cultures have particular privacy concerns. To address and analyze such a matter, the interviewer conducted many interviews required throughout his Ph.D. research, leading the respondent to accumulate experience to deduce conclusions applicable to my study.

6.3 Relation of Age and Privacy with agricultural drone technology

6.3.1 Knowing the importance of the idea of privacy

The discussion continued in the direction of introducing the statistics about food needs and the global population increase that will require drones as a matter of necessity instead of preference. Under those circumstances, agricultural drone start-ups have the ultimate moral obligation to help farmers expand crop production safely. However, the acceptance of new technology differs geographically; hence, the progress among countries is divergent.

“If you travel to Japan, every phone will create this camera-clicking sound when taking a photo. This sound can never be turned off. Some people might be creepy, so they need to know if someone is taking a photo of them, and this is possible only through an implemented regulation. Nevertheless, in other countries, a phone photo can be silently taken. The same thing is true with AI, and the pattern is similar. I have been to other places, for example, America. Their notion of privacy differs greatly from that here in Europe, and it all starts with data collection” (Interviewee 1).

This particular interviewee gave a few more examples from his HCI experience and made reference to a cultural approach to technology:

“The country where I am from, the Philippines, differs from how people approach technology in Europe in the sense that if it works, it works. Such behavior is a consequence of the fact that more significant problems outweigh the subject of AI adoption. In brief, on how AI is accepted: yes, it will vary among cultures. Asian cultures are different from those of Middle Eastern countries like Israel and the United Arab Emirates (UAE). They use a different approach, i.e., open to contingencies and face the ethics later” (Interviewee 1).

Eastern Asian cultures, such as the Chinese and the Koreans, value hard work, so by proposing AI to them, they will probably scrutinize it before accepting it and adapting it to their specific needs. Sindermann et al. (2022) performed a study with a Chinese and German sample examining how individual personality differences relate to variations in general views regarding AI. The study found that neuroticism is a significant factor positively correlated with accepting AI within the German sample. In contrast, within the Chinese representative, acceptance of AI was positively correlated with openness and agreeableness. This research suggests that the insights “could be used to implement personalized strategies to establish positive attitudes towards AI”.

“In my limited experience, Mexicans, for example, have a similar notion of privacy to Filipinos. They are okay with using AI, but not as much as we are. If it facilitates something, then they are open to it. On the contrary, Europeans are generally hesitant about adopting the 4.0 era” (Interviewee 1).

As noted, we extended the discussion to several cultures, considering the binary metric of whether they are ‘open’ to new technology. From the conversation, it can be concluded that every culture shapes its perception of adopting emerging technology. Cugurullo & Acheampong (2023) argue that the psychological dimension is a significant human barrier. Notably, due to our conscious nature, humans feel reluctance and withdrawal if faced with a situation or phenomenon that has triggered fear in the past, whether psychologically or physically. In our case, fear relates to technology's unknown potential, ‘threatening’ the collective or the individual. Side effects such as anxiety are consequently derived from the hesitation as to what extent AI should be welcomed into our daily lives.

Hence, the discussant followed with an example of a data collection method that influences consumers ‘attitudes negatively.

“Most of us are familiar with Roomba, the robot vacuum cleaner. I know that Amazon recently purchased the company to produce Roomba, and the devices have cameras because they need to know if they will hit you and possess visual awareness as they are frequently moving through; hence, they know your house and your corners, which caused nuisance among users. Customers petitioned: “So you mean to tell me Jeff Bezos and Amazon will not have access to the data of a million households with Roomba”? Concerns increased, and customers said they would boycott Roomba” (Interviewee 1).

Related to this particular perspective, it has not been thought of from such a viewpoint before because it was just a vacuum cleaner. Still, this product's users realize that the privacy issue makes sense. Roombas possess intelligence that infringes on privacy by collecting data on our house’s interior.

Specifically in England, a survey in 2022 was conducted on farmers, which resulted in concerning conclusions. The consequences of the wrong long-run estimation of efficiency by utilizing the right technology and over-investing in expensive machinery hinder farmers from exploring the capabilities of modern tools (Agritech Future, 2022).

“With time, when farmers study the potential that UAVs possess, they should push the regulations into a less-rigid domain, i.e., a legal environment with fewer administrative obstacles and fewer restrictions for safe and legitimate usage. On the other hand, the European Union has to see the potential of drones in agriculture; therefore, the EU should aid inventors and start-ups budgetarily and legislatively” (Interviewee 2).

6.3.2 The Impact of the age factor on technology acceptance

It is nearly impossible to describe how one single factor (age in this case) influences the approach to a concept as complex as technology acceptance. Usually, a countable number of factors interfere in the attempt to estimate merely two variables as they intertwine, and it is hard to analyze them separately. I attempted to infer information from the expert’s experience in general about how age affects encountering technology. There are numerous approaches to the influence of age. A person can be elderly and intelligent, yet they have grandchildren who keep up with technological advances; therefore, it should be noted that evaluating how information is related to elders is more important.

> “I guess from my limited experience, age is a factor in adoption. Hard-working and diligent farmers that understand their process of work will always stick to the belief that drones cannot outperform them. We know some subtle things about farming, but we cannot translate them into a drone software program. And probably making older people accept this fact will be difficult. Instead of getting tired, we want our

> elders to enjoy and explore their farm and say, Drones can and will do it for you" (Interviewee 1).

According to Bai et al. (2022), precision farming poses a single opportunity window for scaling the agricultural sector. The authors state, "Older farmers are slower to change their sets of values and slower to respond to changes, which may be a significant barrier to future uptake of precision technologies". The dialogue about age and the discussion from the writers acknowledge the significance of this factor as a gateway into future generations' potential. As such, if I discuss SDGs whose one of the goals is a generational renewal, one of the expert's empirical perspectives on introducing drones among youngsters is as follows:

> "It is necessary to consider that we have a generational renewal issue in agriculture. One possibility to attract younger potential farmers would be to present that you control the drone with a joystick, contrasting with working in a field currently associated with heavy machinery. In the future, it surely can be one of the methods to convince the potential young farmers that they will not be doing repetitive and tedious tasks all day, unlike their grandparents" (Interviewee 3).

It is important to add is that responsibility stems from a combination of elements. For instance, if young farmers perform independently rather than hiring a service, they require mandatory training. Furthermore, spraying drones with customized peripherals can be costly if they are not maintained and maneuvered correctly. Moreover, drone usage costs are proportionally higher the longer they stay in the air (Pathak et al., 2020b). Secondly, spraying disseminates poisonous chemicals, requiring protective equipment and careful control. Finally, different weather occurrences are a responsible challenge for steering while simultaneously focusing on the preciseness of the payload or the dissemination of biopesticides or chemicals.

6.4 Compliance, changes, and the next steps of the EU drone regulations

As already pointed out, the open category consists of drones intended mainly for a public appearance in a recreational/entertainment mode. Considering the discussion about regulation, the discussant confirmed the information from my literature review and further made a bridge with the spraying drones or, more specifically, spraying activities in the EU.

"Let us start with the small drones with cameras that can film and take photos. In this case, the legislation exists, and you must consider privacy and safety issues. For those tasks, you can obtain a certificate based on your operation category (A1, A2, or A3), which are the same as in the EU, and by obtaining one, you can fly with a small drone. They are a completely different category of spray drones because they are normally flown far away from people, so you're not risking a crowd but rather yourself and your crops" (Interviewee 3).

As noted earlier, drones fall under the specific category of EASA if they pose a certain degree of risk during operations. To remark, EASA's website explaining the three risk categories (EASA, n.d.) states whether training for pilots is mandatory and, to this end, declares:

"*For operations falling under the 'specific' category, the training depends on the operation you intend to conduct. So unless the process falls into a standard scenario, after the risk assessment, you must propose a possible training course to the National Aviation Authority. In each case, the authority will evaluate the adequacy of the training, and if they confirm it in the operational authorization, the training will become the required training*".

Firstly, there is ambiguity involved. The terms 'possible training' and 'evaluating adequacy' reveal specifics neither about the origin of the training that has the potential to become official nor about the metric for determining the adequacy of the underlying procedure. Nevertheless, the website of EASA (2022a) clarifies that following a Standard Scenario, which is a predetermined procedure stated in Appendix 1 to Regulation (EU) 2019/947, is one of the options for operators to begin their operations in the particular category. Moreover, starting on January 1st, 2024, the STS will be in effect. Currently, there are two STSs available: STS 01, which is "VLOS over a controlled ground area in a populated environment", and STS 02, which is "beyond visual line of sight (BVLOS) with Airspace Observers over a controlled ground region in a sparsely inhabited environment".

STSs do not explicitly tackle spraying activities, although NAA's role within drone operations was previously discussed. As already stated, operators shall ask for an operational license of the EU member state where they conduct activities that are controlled by authorities such as AESA, CAA, and BCAA. This applies to Spain, the UK, and Belgium, starting from the beginning of 2024. Alternatively, they may submit a new STS to EASA, which would then review it and later publish it if it were to be accepted.

"The European Union has general guidelines on how every country should conduct its laws. Obtaining permission is local, but obtaining a license is uniform on the EU level" (Interviewee 2).

> "It is important to talk about the EU because of two things. Because they have a certificate for drones, there are only a few drone sellers on the EU market, so if somebody wants to sell a spray drone legally on the EU market, they have to possess such a certificate. Concerning spraying with drones, the basic regulations are the same. But presently, only a few countries have a complete set of regulations that allow drones to be thoroughly used in agriculture, especially for spraying" (Interviewee 3).

Considering the EU market area, it has to be taken into account that the technology is excellent; however, it is one or two steps behind the legislation, which is a pity that may play a crucial role in deterring future entrants.

This insight implies that the methodology or information basis for creating drone laws in niche domains should be carefully revised rather than generalized. To emphasize, the following insight from the interview encircles the explanation of the confusion and complexity of EU drone legislation:

“It is crucial that you mentioned the privacy issues since the legislators somehow do not know the difference between the specifics of big spraying drones in agriculture and small agile drones with cameras. When preparing legislation for agricultural drones, legislators mix privacy issues that are a direct consequence of entertainment drones in public, and such considerations interfere with the anticipated potential farming drones hold. You should handle that issue completely independently” (Interviewee 3).

Regarding privacy infringement, EASA regulates, harmonizes, and limits parameters such as MTOM, pilot competencies, drone operator registration, required age, and operational descriptions. All those fall under the A1, A2, and A3 umbrella categories. Most commonly, drone operations include attached cameras if a crowd is involved. In the spraying case, an emphasis on the distinction of functionalities is lacking. Consequently, industries’ progress where drones are not integrated may suffer. One significant advantage of agricultural drone usage is the implementation of various peripherals on drones since someone else’s property or infringing privacy is not at risk. Furthermore, our start-up team strongly avoids flying over public spaces or airports.

The expert from the Macedonian start-up added insights on what the situation is when a customer intends to fly a drone in N. Macedonia:

“We deal with the regulatory issues by following general aviation guidelines, which limit the drone’s height, place, and distance. Considering the country I live in, the regulations are the following: Before flying with a drone, you must notify the Agency for Civil Aviation about where you plan to fly and the anticipated height. Your flight plan must comply with these basic regulations: do not fly close to governmental buildings; avoid flying over crowds; do not exceed the height of 120 meters, and you must remain in VLOS” (Interviewee 4).

The information provided implies that only the basics of drone flight are considered in N. Macedonia. Governmental objects and crowds are non-existent close to small farms, let alone several hundred hectares.

To illustrate the opposites in the EU then and now, one of the discussants provided the following examples:

“I had the freedom when I started flying drones to fly anywhere, for example, over military objects. But then, as restrictions came, the regulations discouraged everyone as they became very rigid. For example, a large field near Škofja Loka allows drone operations to be observed with infrared or multispectral cameras. However, an airport nearby interferes with the freedom here, and it is impossible to fly. You can obtain licenses, but only five companies have licenses in Slovenia" (Interviewee 2).

Therefore, MTOM, VLOS, distance from particular objects (residential structures, residential areas) and crowds, restriction over particular objects (airports, heliports), and the remaining parameters remain rigid when discussing the case of Slovenia (Laws, 2023). On the other hand:

"As we said, in the EU, the biggest limitation is the legislation. Also, there are only three or four countries where drone spraying is fully legalized, and Hungary is one of them to perform spraying activities legally" (Interviewee 3).

6.4.1 Inequality in drone adoption as a direct consequence of regulations

The conversation developed as I learned valuable facts from the discussant's company experience and practice. He provided an example where the implementation of regulation directly interferes with the farmer's opportunity to evolve their working processes. Their uneven application in Europe results in a uniformly inconsistent rate of agricultural drone adoption country-wise. In the words of Wachenheim et al. (2021a), it has been demonstrated that resource endowment, which is broadly defined to include farm and farmer characteristics, attitudes, social networks, technology, and its properties, as well as other external factors like government policies, farmer perceptions, supporting institutions, and infrastructure, influences adoption.

The discussion involved Europe's division into two country categories: countries where it is illegal but people still perform, in this case, restricted drone activities. And secondly, in countries where it is unlawful, locals would instead not perform actions as they are frightened of the authorities.

"From my point of view, I'd say that you can easily reach and expand in markets where activities are illegal because people will still do them. And the funny thing is that in those countries where people are flying drones illegally, they see how beneficial drone aid is. In this context, the extent of 'risk' undertaken by consumers depends on the culture and the authorities" (Interviewee 3).

The discussion in the paragraph above is an example of how excessive regulations, or conversely, ineffective legislation in countries where it is most required, directly confront scalability and may result in opportunity loss for the country.

"An example of a technology that can fulfill the Green Deal targets is spot-spraying, where you spray precisely at the locations where plant sickness is present. Although researchers and scientists have invented a technology that can solve the problems contained in the big

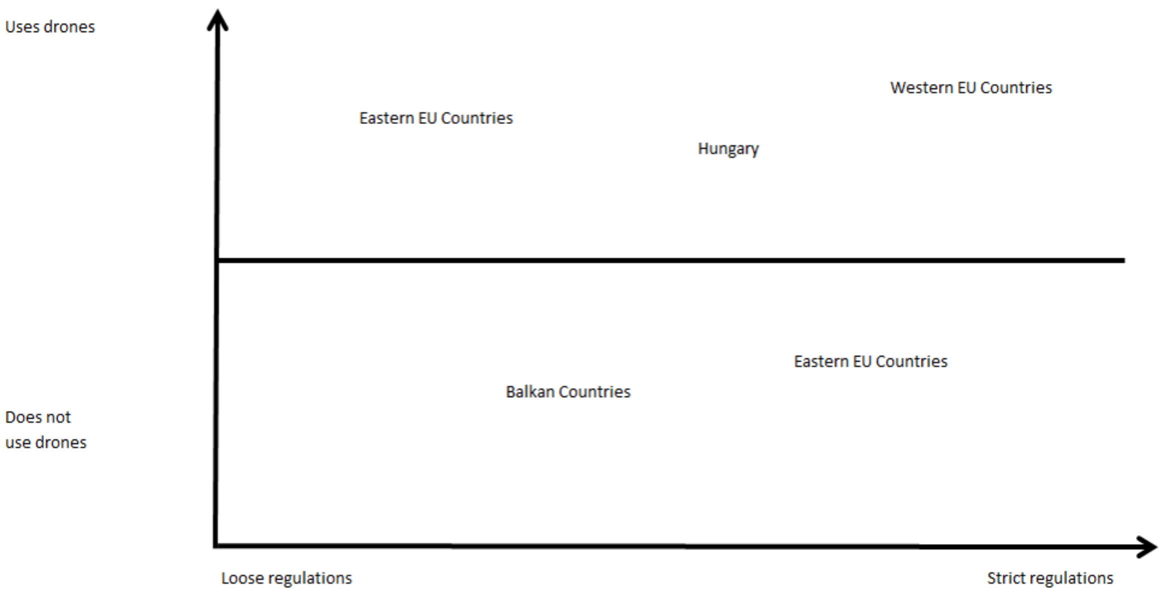
European targets, the EU legislation terms conflict with the means to meet the ends" (Interviewee 3).

In Figure 6 below, I provide a rough categorization estimate Europe-wise considering two parameters: on the x-axis is the parameter about regulations, i.e., whether the regulations are more rigid and operative or more flexible to the extreme or non-existent. On the y-axis is the binary parameter denoting whether farmers include or practice drones in their daily work. Hence, Figure 6 not only roughly illustrates the distribution of regulations but also provides a window to future opportunities for drone utilization, which will make markets evolve across Europe.

"As I mentioned, farmers and customers accumulate much more experience by experimenting and practicing with an agricultural drone in these countries where drone activities are illegal or restricted, resulting in an overall net positive. However, in the Western part of Europe, where one is supposed to convince the legislators about the usefulness of such technology, the legislators and people do not see the advantages because it is illegal" (Interviewee 3).

Note that Figure 6 has the limitation of specificity, i.e., ungrouping the EU regions by country and illustrating a more scattered plot.

Figure 6: Categorization of drone usage and regulations in Europe



Source: own work

"You can sell your drone on markets in countries where drone spraying is not allowed yet. Further, what we believe, back to the difficulties, is that our purpose is to be present in different markets. We see the advantage that customers will be convinced that they have made the right choice and will be served post-sales service immediately when damage or a breakdown occurs. But you have to reach that point" (Interviewee 3).

Important to note is that selling to or buying from a particular country is not prohibited, but rather that since 2014, the European Commission has been working hard to lay the groundwork for a comprehensive EU drone strategy and implement their integration (European Commission, 2022).

Wachenheim et al. (2021b) also state that, given the example of China, rural areas encourage individual farmers to adhere to social standards, and farmers' inclination to adopt specific new technologies is unavoidably impacted by social norms around technology use. That being said, social networks have an impact on disseminating the benefits of agricultural drones culturally.

6.5 The agricultural drone market

6.5.1 The dominance of the Chinese DJI

I have depicted that the regulatory environment is one of the most critical factors shaping the rules of the agricultural drone industry. While the EU drone regulations seek to establish a uniform and secure framework for drone operations, they pose difficulties for the European drone industry to compete with DJI drones, the world's leading manufacturer of drones that dominates the European drone market with its cutting-edge products at affordable prices.

Furthermore, one of the biggest challenges for an unknown brand is paving the way for competing with the big names while simultaneously rivaling the cheap competition.

“In the EU, you can legally sell spraying drones only in a few countries due to legislative limitations. I am considering spraying drones since, for the small monitoring drones, I think there is no problem, and mostly because the big producers are so good at producing these types of drones, I would not say that there are many start-ups that have a chance on the market. You cannot compete with a small DJI drone with a good camera” (Interviewee 3).

Moreover, another interviewee added information on what skills are required when competing with a company such as DJI:

“Since these devices are not ‘famous’, more competitors are entering the production of peripherals for commercial drones. However, the situation in Europe is that it's tough to compete with Chinese hardware, as it is yet one of the most dominant in Europe. To keep up with the competition, you must be a very skilled software developer; you must have a development kit from DJI that is not cheap; and you must have mechanical skills to scheme the mechanism. Payload drop systems are an example of a tool that requires high know-how” (Interviewee 2).

The Macedonian expert discussed the strategy of DJI for internationalizing in Europe, thereby gaining an advantage over local start-ups:

> "DJI is very successful because they have the Chinese government's support. Hence, their drones scale up to two industries: deployment for civil and military purposes. The drone industry is currently in a pre-profit phase; because of this, we need government support to stay competitive in international markets. Because DJI's strategic approach to internationalization involves utilizing the Chinese government, they always have a competitive advantage in the Western market, especially in countries where legislators are not involved much. They also practice lower selling prices and redistribute more budget to R&D" (Interviewee 4).

Table 9: Product comparison of Chinese DJI vs. French Parrot

	DJI Mavic 2 Pro	Parrot Anafi
		
Flight Time	31 minutes	25 minutes
Flight Speed	20 m/s	15.3 m/s
Flight Distance	18 km	4 km
Weight	907 g	320 g
Volume	6518.57 cm^3	2730 cm^3
Dimension	241 × 84 × 322 mm	175 × 65 × 240 mm
Price	$ 1.729 (DJI Store)	$ 700 (Parrot Store)
Video Recording	2160 × 30 fps	2160 × 30 fps
Main Camera	20 MP	21 MP
Field of View	77°	84°
Battery Power	3850 mAh	2700 mAh
External Memory	128 GB	16 GB
Product excellent	Has a serial shot mode Can create panoramas in-camera Obstacle detection	Smaller product dimensions Product price is lower

Source: Khofiyah et al. (2020)

A simple, non-representative, but relevant comparison that supports the claims about the supremacy of DJI from the experts is shown in Table 9 above.

From the discussion, it can be deduced that competing on drones and peripherals intended for monitoring is not a wise move due to the knowledge of the Chinese that has pushed R&D to market dominance in this segment. Nonetheless, three main issues are pointed out as an outcome of Chinese interference in the European market, and moreover:

> "Especially in agriculture, spray drones also come from China, which has several problems. If you look at their agricultural functions, you can use a spraying drone mainly for spraying against insects or fungicides. So you must treat the plants

> immediately or within one or two days. Consequently, if you have a problem with the drone, it may take months to repair, and therefore, it is ineffective on a field, disrupting the flow of activities on the field. So this is one of the problems that are not solved” (Interviewee 3).

This claim asserts the disadvantages of advanced technology. By relying exhaustively on drones, production disruptions will occur due to the postponed delivery of a new drone or the repair of the used one. Furthermore:

“Then we have data security issues because these drones work in a way that they send the information to foreign servers. This is a severe issue if you have photos, videos, or any digital data from a data security point of view. And the third problem is explicitly linked to Europe since it is small compared to the Chinese market. The simple process is developing a drone, selling it in Europe, and thus the final product – taking or leaving it. So you do not have the possibility of making adjustments according to your specific needs” (Interviewee 3).

Time lags in post-sales activities are where the DJI has severe disadvantages for the European market. Start-ups may specialize in agile and reliable customer support by mastering logistics and minimizing the transportation time of replacement parts.

6.5.2 Essential market aspects when managing an agricultural drone business

Freeman and Freeland (2015), discussing the case of the U.S., tackle an important property of any market that strives for technological advancement, which is hype. The authors explain that hyped expectations frequently exceed what technology can communicate, at least in the short run. In 2012, the Congressional mandate to permit extended domestic unmanned flight resulted in an instant increase in media interest in UAVs. This example acknowledges the chain reaction caused by the change in regulations, resulting in adjusting expectations and thus adapting strategies across the agricultural drone industry. Hauben et al. (2018) argue that the difficulty of rigorous evaluation and validation should accompany new technology and methodologies in pharmacovigilance. The agricultural drone industry is likewise faced with this challenge.

Firstly, the young Macedonian entrepreneur and inventor discussed briefly the motivation and inspiration to start a business:

“I came up with the idea because all the rainforests in N. Macedonia have a disease called 'Pine Processionary’. I aimed to eliminate it using my knowledge of UAVs because they are more efficient than traditional systems and they do not harm the environment as much as the current heavy vehicles do. My motivation is to convert my hobby of building drones into a career” (Interviewee 4).

The expert stated that his motivation comes from a hobby rather than a business background. This industry holds the potential to uncover countless solutions applicable to various geographical and spatial scenarios testing the durability, validity, and reliability of drones.

Nonetheless, several issues impair market competition in the industry. As such, companies find it more difficult to be differentiated and stand out technologically or solution-wise. Innovating our own or improving an existing solution in terms of competitive advantage can significantly improve the chances of success. On the other hand, regulations, as mentioned, may hold entrants back from a particular country. Challenges persist the entire time, and no one can hide from them. Hence an expert’s opinion on describing factors that make businesses less resilient to internationalization:

> “First, you need to find the right company to collaborate with and who is willing to sell your product. As a start-up, we have a competitive advantage with excellent post-sales service behind us, and because of the producers of large drones, which everyone knows; you suddenly become a no-name company. And on top of this, you can buy drones on AliExpress reassembled into drones for a lower price. Therefore, you should not start the development from scratch upwards on the vertical chain (developing spare parts). Still, the value added is how you put all the parts together and how well you integrate the software” (Interviewee 3).

The citation implies that one should prioritize building its brand because if customers meet an unknown brand (start-up example), they will buy a drone of lousy quality. One thing to note is that the company where Interviewee #3 works initially started locally (in Hungary). However, in the case of N. Macedonia, considering the low experience and the age of the owners, the start-up comes across difficulties of a financial nature. For example:

“The main underlying challenge is funding. We continuously prepare with financial experts' help to search for the company's right investors and suitable business partners. Our vision is to approach investors already investing in agriculture and business partners with experience in agricultural business, or maybe even an end-user, for example, a winery” (Interviewee 4).

It can be concluded that agricultural drone start-ups face different challenges based on the experience of their managers and owners. However, the stages or categorization of challenges in an international environment narrowed in agriculture, controlling for age, are out of the scope of this research. But for the most part, solving the regulatory challenge could entail building enabling drone policy frameworks that can be used to accelerate particular countries' development of drone rules (Ayamga et al., 2021).

Afterward, the Hungarian company’s vision was to expand internationally as a brand whose name lived up to the standards they promoted. On being asked what challenges they faced when growing in target markets, the third respondent answered from his company's past situation:

"It would help you to research whether your desired market is saturated with competition. For example, although drone spraying is not fully legalized in Austria, Italy, Germany, and France, Trichogramma dissemination is widely used. So, for example, if drone spraying and Trichogramma are legalized, that would mean a market is present in that particular country" (Interviewee 3).

The passage above implies that a demand for a tailored solution defines a market structure. But such solutions are conditioned on the geography where drone activities are anticipated to be performed and the cultural preparedness of the customers. Therefore, the industry's future course underlies the discussion, and potential entrants may benefit from its insights.

"The innovation is there already because we have the technology. There is a prediction that in 2024 there will be a legal solution to legalize drone spraying in the EU. Then there will be a huge explosion on the market, and people will start using it legally" (Interviewee 3).

Furthermore, when asked about the accountability his firm takes when approaching farmers, the expert added:

"It is neither legal nor moral to perform spraying activities by a poorly trained person. Otherwise, such behavior damages the dissemination of this new technology. So our company must bear social responsibility. And further, when you want to present a positive example of this technology to farmers for the first time, we observe that first impressions are crucial" (Interviewee 3).

As previously stated, STS action in 2024 will take place among EU Member States. Consequently, a surge of entrants in the agricultural drone market will be the result leading to an increase in consumers' bargaining power due to lower switching costs. The takeaway to be noted is that a weakly established brand (which is what start-ups by default most commonly are) needs to take care of building networks of distributors and suppliers of its products and services.

"We have development and production in Hungary, and we are now on the way to establishing our international distributor network. It means that in all European countries and outside Europe, we try to find companies that will become our distributors, preferably packed with our after-sale service. Considering the Balkans, we practically have a distributor in Serbia, but across the remaining Balkan countries, we are enthusiastic and dedicate ourselves to looking for partners" (Interviewee 3).

It can be implied that the expert's company has a strategy that searches for partnerships with similar business models. A specific segment to practice expertise on is the topic of post-sales activities, which are of great advantage in customer retention and reputation building. As it turned out, after-sales is one of the Hungarian company's keys to success.

> "Because one of the strong points of our business model is that continuity must not be hampered if issues appear, our potential partner must have a replacement drone to offer the client. If you are a farmer and break your drone, you should bring it in, get a replacement drone, and continue to work until it is repaired. We believe these particular companies should be local for being our distributors but avoid sister companies; we practice contracts with private companies" (Interviewee 3).

It is important to realize that they aim to manufacture rather than acquire their items to offer agile support and further build the brand on reliability. Moreover, the company continuously searches for partnering companies with a similar vertical chain that produce their drones and deliver aftersales.

The expert from the Macedonian drone start-up clarified the company's vision and goals and how to achieve them:

"The central vision is to catch up to the Chinese competition and implement drone technology into wider European agricultural use. The price will be lower by producing a reliable product that is applicable in many situations. We will have a modular design so more peripherals can be attached" (Interviewee 4).

Because of the nature of the drone, which can support more than one peripheral, it can be inferred that more issues will be present as it offers more solutions, and specialization in agricultural engineering is mandatory to catch up with the competition specializing in one niche segment.

7 ACHIEVING AND SUSTAINING COMPETITIVE ADVANTAGE IN THE AGRICULTURAL DRONE INDUSTRY

Resource-based competencies, business processes, and adaptive innovation comprise the core of competitive strategy, which lays forth a plan for maintaining a company's profitability, primarily through innovation (McGuigan et al., 2016). The authors also claim that businesses must prepare for such shifts as industries form, develop, and morph into different product sectors. They must decide how to maintain their market share and eventually expand into new industries.

The following chapter studies the ways of diversifying an agricultural drone start-up. A business that develops its network when establishing itself as a brand may transform into a sustainable and profitable long-term relationship.

7.1 Diversification

The goal here is to give a helping hand and optimize the processes on land for farmers to produce food because statistics say that the population will reach nearly 10 billion in less than three decades. Therefore, if an agricultural drone start-up introduces our products to the right customers, i.e., farmers in our case, they will not perform any detrimental activities since agriculture is one of their primary sources of income. Moreover, they will become interested in how you can eliminate a portion of manual labor on the field.

“What we have been doing, for example, is entering a market and listening to customers' feedback, where we were supposed to adjust the software to tailored needs. For the present series of drones we put on the market, we implemented a beta testing phase where we rented drones cheaply for our clients in different countries. So the customers in the post-testing phase had to provide feedback. Still, they held the advantage that their opinions and suggestions would be considered and implemented in finalizing the product” (Interviewee 3).

Against the backdrop of rapid innovation by competitors, a company can quickly lose its cutting-edge position on the market due to technology's shift and direction (Christensen, 2001). As a result, from a drone business perspective, companies are by default in compliance with the rapid progress since that is the nature of drone R&D. On the contrary, farmers are obliged to comply with and acknowledge these aerial tools as the population continuously grows. Barney (1995) argues that the rareness and complexity of inputs are the initial points of differentiation over competitors. Furthermore, a crucial point the author makes in the paper is that the competitive advantage declines or fails when factors like consumer preferences shift or steer the whole industry.

The previously discussed concept is one of the key concepts upon which my interviewee’s viewpoint agrees. The market strategy that they presently practice matches the above author’s statement.

“There is a great market demand for a specific solution that research institutes and private individuals need. Also, you need access to open-source software because the big producers have a closed system. Therefore, we removed the spray part and were left with a freely payload-carrying drone with open-source software. So this is a market segment where we can perform besides selling agricultural services” (Interviewee 3).

The expert’s statement can be linked with the opinion of Daponte et al. (2019), who write that drone images and ground sensor data will be mostly utilized in precision agriculture research. The authors also explain that these systems “are only designed to do a single task (such as classifying various vegetation types, water bodies, urban areas, bare soil, etc.)”, without having the capacity to create an overall picture of agricultural operations.

First of all, let us note several theoretical approaches that tackle the concept of diversification:

a. The company can develop an ultimate competitive advantage by delivering customized solutions to farmers on different farms, i.e., by ‘individualizing’ their service or product. The dialogue suggests that proximity to consumers and considering recommendations and ideas generate unique value for the firm. As this company produces drones in-house, in combination with customized solutions, such an action can differentiate one’s brand on the market.
b. Referring to the previous chapter, our discussion involved insights into competitive advantages. The method of searching for a partnering company whose specifics in (after-sales) performance intersect with the discussant’s firm acknowledges geographical diversification. Besides, the essence of internationalization, if referring to the initial definition of my research, is that it aims at “higher expertise in customization of its product to satisfy the local mass on a larger scale”. Partnering with a company that utilizes its geographical position adds an advantage over customized solutions, as they are tailored but expanded internationally.

Thus, the ideas of differentiation for this particular agricultural drone business consist of the following:

> “The EU market is ready to accept good quality and reliable products. The second thing is that we are flexible, as we can meet the specific needs of farmers. And the third one is after-sales service, which means we must discern ourselves from those merely selling. Such dedication can make you very competitive, and as we discussed, we expect the market to explode. Many new companies and start-ups will start selling drones, sometimes even AliExpress-spare-parts-assembled-cheap drones. But you will have a competitive advantage if you are already an established company with your network” (Interviewee 3).

The dialogue implies that after the first accidents and breakdowns of drones, customers will realize that the price of maintaining a B2C relationship is essential and that in the future, the feedback from the service will create unique value for the consumer and sustainable profit for the agricultural drone business. Finally, this chapter involves the example of the Macedonian start-up with the model of a unique peripheral that the expert has invented:

“Our competitive advantage and unique selling point are high-quality drones that we will customize solutions for every customer and that will be produced in N. Macedonia. An example of such a customized solution is a drone spraying grapes and rice (traditional machinery is either monotonous or manual work is required). Our peripheral, with the help of an agricultural engineer, will suffice for spraying both cultures. Also, no competitive company can deliver the same solution as we do. But we will need significant investment, dedication, and trust from our investors and partners" (Interviewee 4).

The chapter's conclusion suggests several approaches for achieving diversification. In question, agricultural drone start-ups in Europe can have a diversified effect on the industry if:

a. It includes a testing phase where companies rent their drones, services, or a combination of both to clients.
b. Regarding the first point, customer feedback, criticism, suggestions, and implementation are crucial in maintaining long-term relations and sustainable improvement.
c. If faced with competition in a segment by the big players such as Parrot or DJI, start-ups must find a peripheral intended for niche solutions and implement their know-how in a component whose scarcity presents a competitive advantage.
d. It offers reliable after-sales service and quality training. However, it requires geographical positioning due to logistical lags.
e. Timing is crucial; every company should continuously follow local and EU's changes in legislation. As the main factor, regulations widen or restrict opportunities for future entrants.
f. Maintaining business relations builds trust, which has long-term benefits for stakeholders and newly motivated agricultural drone start-ups.

7.1.1 Exhibiting drone swarms and utilizing AI

Fortunately, our start-up operates in the agricultural world; therefore, crowd risk or moral considerations are not present or are not subject to when performing work on the field. A business setting where a company translates its uniqueness and knowledge/know-how into its products and services is discussed next. It is widely accepted that developing software for niche structures is one of the main competitive advantages of any drone start-up. Therefore, we discussed the significance of implementing AI in the future; where new or existing functionalities will perform exceptionally well over market competition.

We started from the point that several drones in an agricultural setup will be more challenging to operate in larger groups because the group requires synchronization. More drones will cover more ground, which is when AI appears. Afterward, the expert discussed:

> "If AI is properly designed, we know the drones can perform the appointed activities. The meaningfulness of competitive advantage appears when research on how easy it is to manage or operate a drone is performed and an AI optimizes the activities. For example, you want the drone to ensure every crop has the same amount of pesticide. Drone software can be conveniently programmed with

> existing technologies to fulfill this task. However, the main challenge of such a unique cutting-edge is if, for example, a farmer is reluctant to attend training, rejects technology due to cultural or psychological factors, or poor word of mouth surrounds him” (Interviewee 1).

Considering the risks mentioned above, they can all be avoided. First, due to generational renewal, future young farmers are being educated on technologies that can aid farming, such as drones. Waite and Bourke (2015) concluded that based on their study, with a sample of children aged 16 to 19, young people are active participants in shaping and questioning technology. Secondly, since consumers’ opinions and criticism in this industry matter, firms can attain a competitive advantage by further enhancing an existing solution with niche customizations.

“The competitive advantage comes in the following ways: the ways an interface makes drone activities supported by AI easier for a farmer to use and seamless for the farming business to work. So no matter the agricultural area size, the interface is supposed to provide easier use. Moreover, it must be scalable because the outcome should be the same even if you cover an extra hectare of land with the drone flying autonomously” (Interviewee 1).

Referring back to Isaac Asimov, one rule is that a drone should never harm a human. So that is why it's essential that, if autonomous, they know whether they will hit someone, which is an initial concern in drone R&D.

“Drones, considering this theoretical and ethical framework, are tough to operate with right now based on the amount of research we do. At the same time, from a historical point of view, any software or app has been famous because they have been easy to use” (Interviewee 1).

It can be concluded that, above all else, AI research within drone devices must always consider contextual awareness. Important to mention is that functionalities and benefits to farmers are considered in this study over the technicalities of how swarms in different scenarios would work.

Nonetheless, a byproduct insight has been created: it would theoretically be of great benefit to introduce not just a drone but the idea of swarms to farmers. Hassanalian and Abdelkefi (2017b) state that a swarm can continue operating on a farm if one of the drones malfunctions while performing a specific task, hence being more efficient than flying only one drone. The interface must be approachable and appropriate for older people using it. The dialogue continued in the direction of discussing examples where drone swarms would eliminate the manual labor of farmers. ‘Eliminate’ denotes easing the burden on farmers during fieldwork.

> "The swarm of drones stands between the end product and the farmer and fully removes all manual effort. The utilizations depend on how we program the drones - whether to cut something or distribute biomaterial, or they can be programmed to monitor and survey an area. We have been trained that whenever we develop technologies, they are never actually intended to replace people or make their work simpler. There is one guiding principle that says to balance humans and computers. So that means an ideal setup would be: you have a human who designs a concept, and anything deduced from it that is repetitive or difficult to work with, you hand it to the computer or, in this case, the drone" (Interviewee 1).

One recommendation that can be deduced from the chapter is that agricultural drone start-ups should seriously consider partnering with IT experts in the long run. Implementing concepts such as 'spatial awareness' or 'avoiding harm' is far from easy, and the AI field is yet to be explored. Moreover, it is essential that for companies, with scaling of production and farm area, the solution becomes more complex; hence, drone swarms appear to be the ultimate long-run solution. A challenge for the IT industry is programming and synchronizing swarms while respecting the rules of Asimov.

7.2 Concerns about replacing farming jobs with drones

The last dialogue implies the existence of distress in agriculture about the extent to which machines are substituting humans on farms. However, the possibilities of utilizing drones in agriculture are numerous if the relationship between drones and farmers is mutualistic and complementing rather than mutually exclusive. Because of this, the advantages that have resulted (and will result) from the link between humans and drones cannot entirely develop if the fear of complete substitution by machines is present (Liu, 2020).

"Replacement is not about replacing humans, and the drone is at your disposal to be given a difficult or repetitive task. As the saying goes, you can tell if a person is a farmer if you look at their hands, which are strong and dirty; we associate it with hard work. If, for example, we need to cut the plants, water them, or distribute a chemical, the drone can eliminate the hard work and let the drones take care of it. Our sole responsibility is to recharge the battery as drones do not tire" (Interviewee 1).

According to Van Der Merwe et al. (2020), drones will undoubtedly improve the sophistication and safety of dangerous jobs presently handled by machines directly involving a human during operations, exposing them to risk.

"If you go to the countryside, especially in France, Greece, and Germany, vineyards have big slopes, and approachability and reachability issues appear since less labor is willing to perform such activities. If you have to fly by drone, it does not matter because it reaches slopes easily" (Interviewee 3).

Future potential farmers should focus on studying drones instead of losing time while being unable to reach or work on a particular part of the field. As mentioned, drones are currently the best tool for performing different activities in vineyards. Computer vision technology-equipped UAVs will make it possible to perform selective spraying and watering only where it is essential and in the areas of the field that require the treatment (Tripicchio et al., 2015b). The authors also mention that it is also feasible to examine the watering level of plants using the photographs that were collected, allowing for more precise crop planning.

“To answer your question, can you perform the tasks in minutes under ‘unfriendly’ weather conditions? It depends on how much work they’re going to do. One similar example is that if you draw a figure, you tell your computer to fill the shape with color because the process is repetitive. Our task as a business would be to find the use case where repetitiveness by a drone in an agricultural setup can be utilized to the extent of replacing it completely” (Interviewee 1).

The theoretical analysis suggests the following points:

a. Drones do not substitute the noble farming profession; rather, they aid farmers in their complex and monotonous tasks. Instead of spending time and risking their health, it is suggested that farmers educate themselves on drone capabilities.
b. Farmers bear the responsibility of handling UAVs on their farms. Irresponsible or unprepared farmers will face costly consequences and health risks associated with dangerous drone activities that should be carefully managed.
c. Adding drones to farms motivates farmers to uncover tailored drone utilization in specific conditions.

7.3 Examples of drone advantages over heavy machinery

By now, drone advantages have been described on several occasions. One example is when Krishna (2017c) states that fertilizers account for 85% of the total costs under UAV monitoring.

> “Consider the statistics of 10 billion people by 2050, the United Nations setting the sustainability goals, and the EU promoting the Green Deal, which says that by 2030 you should reduce the use of chemicals by 50%. Certainly, we have drone technology that, from our experience, shows it is possible to save approximately 97% of used water. So, instead of the conventional 300 liters of water for one hectare, we did it with just 10 liters. And because of the better spraying capabilities and quality of the liquid, droplets, and airflow, which can direct the jet on the plants, you can practically use the least amount of chemicals” (Interviewee 3).

Concerning performance in heavy weather conditions, drones in practice have shown that equally important is immediate intervention when the terrain is inaccessible.

“Since we ought to use fewer chemicals with sustainability goals in mind, given population increase and less fertile soil, it can be deduced that we should find a way to produce everything sustainably for more people on less land. Some studies state that if you ride heavy machinery, such as several-ton weighting tractors, you compact the soil with them, resulting in negative effects for up to 15 years. There will be less air and fewer biological processes in the soil, so soil fertility is reduced and even eliminated” (Interviewee 3).

Khan et al. (2009) argued that in the case of India and China, the soil had experienced intense degradation and a decrease in fertility due to “producing more food from the same or limited resource base”. Hence, although arable land is not equal in size and fertility, drones eliminate the opportunity to negatively impact soil.

“By using drones, not only is there less compaction on the soil, but you also destroy fewer crops likewise. Moreover, the more it rains, the harder it is to navigate heavy machinery on the field since the mud blocks the tractors from moving. In this case, you can save the crops if you can spray the crops immediately after the rain, which is a reality by using a drone” (Interviewee 3).

As understood from practice, drones reduce inputs required for farming activities; hence, farmers should focus on other activities such as management or selling strategies; hence the traditional notion of farming as a concept is going to be redefined. An implied recommendation is that agricultural drone integration will alter the mindset of farmers, and they will buy and specialize in drones and invest in digital knowledge rather than heavy vehicles. Finally, the fourth interviewee discussed the impact and value of our start-up for our customers:

“The most significant advantage of using this system is not exposing people to dangerous chemicals currently used in agriculture and using redistribution of chemicals in a lesser area. Drones are a solution that can be applied to a specifically marked, precisely planned area on the farm, whether it is a small family business or hundreds of hectares of land” (Interviewee 4).

7.4 Foreign government support and the experimental drone license

7.4.1 The significance of experimental license

During the literature review, the regulations considering drones operating on EU territory were covered. Additionally, this study focuses on the specific category, considering the categories that drones have been assigned to, described, and distinguished earlier. Puri et al. (2017) mention several types of drones for precision agriculture. The first one is a

Kevlar fiber composite-made drone that can withstand all conditions, making it durable and versatile for various applications. DJI Matrice 100 is a dual-battery drone that is regarded as being able to perform complex tasks in various environmental conditions. Finally, Lancaster's 5 Precision Hawk is an adjustable UAV for various payloads and unpredictable weather conditions, having different built-in sensors.

For farmers using such advanced aerial devices, from a business viewpoint, by introducing the experimental license, the drone or the service capabilities are being tested. Suppose a start-up adheres to the principles of prompt post-sales intervention for breakages or replacement. In that case, this can translate into a long-term relationship and, hence, a method for building one's network.

"There is always the possibility of having an experimental license if you are a company that wants to test new technology. Afterward, we focused just on testing and training people who could turn out to be future farmers. The license is not uniform on the EU level but rather country-specific and depends on the government's willingness to practice it. Our country was among the first in the EU where the agriculture minister made legislation for legalizing drone spraying" (Interviewee 3).

The passage suggests that there are prospects for success if the business has a clear strategy, plan, and execution in nations where the government is open, with a vision of new technologies and the ability to anticipate new difficulties.

The interviewee uncovered that a company providing agricultural drone services or selling specialized agricultural drones identifies unique solutions that can be perceived as an ultimate competitive advantage on the market. At the same time, the government's involvement is critical to managing the well-established relations between businesses and farm managers.

The approach of managers adding experimental licenses for flight to an agricultural start-up suggests that it has sound potential for an unknown brand to attempt to establish its network.

7.4.2 Government's Role in motivating businesses

The push initiated by a foreign government to allow certain drone activities in their country's territory signals opening opportunities for businesses and reliability. Grosse's (2010d) study states that Jean Boddewyn's main "underlying concern is that company managers will ignore to their immense detriment the importance of governments in their business and thus either lose opportunities for profitable business or even lose their ability to compete due to nationalization or prejudicial regulation". The statement implies that nationalization locks out the chances available to foreign firms that may uniquely present themselves in the local market.

“We were the first to legalize drone spraying in the country, allowing this new technology to aid in meeting the Green Deal’s sustainability targets. Some officials are in a position to write applicable legislation, but they need input and information from the sector. It implies that there has to be excellent cooperation between the authorities, the stakeholders, and the politicians” (Interviewee 3).

Otherwise, sprayer drones are treated under the applicable regulatory framework in the same manner as ground-based equipment for applying pesticides (Klauser & Pauschinger, 2021). Here, the authors also mention that the main position was that drones, which are more precise and hence more environmentally friendly than helicopters, produce less spray drift.

Politically, it can be a win-win situation because, besides endless considerations, not only environmental improvements but also benefits to the farmers and, of course, for the users have been achieved. Moreover, a minister who has been the first in Europe to take action in Hungary will be very proud. From the discussion, the case of Hungary demonstrates that within the European framework legislation, governments can safely and fully legalize drone spraying and further allow this technology to spread.

“This is what we have done and are currently trying to do in other countries: we want to establish our distributor network and offer the possibility to governments and stakeholders. We would be pleased to demonstrate our approach to other countries, and if they stick to the same or adapt to local specific features, their politicians can prescribe them such a huge achievement” (Interviewee 3).

The main findings from the interview are valuable if and only if the agricultural drone companies in a particular country have converging aims with the government, which must not stray away from its applications. However, as discussed, governments and legislators require inside information from companies. Kitonsa and Agbozo (2020) suggest that regulators and policymakers will be able to devise plans for using UAVs to both protect society and advance socio-economic growth. Furthermore, the authors claim that policymakers and regulators may ensure that UAVs coexist peacefully with society by having a thorough understanding of socio-technical systems theory and its sub-components. The investment should be bilateral for this mutualistic bond to work in practice. On one side, a company has to sell reliable and high-quality drones. Farmers' voices must be raised so that their farms benefit from the different applications. Finally, as Hungary’s example shows, it can be shown that the local decision-makers can be convinced to accept aiding technology and modify the local legislation.

A game-changing move by agricultural drone start-ups and stakeholders is to convince the host government through its actions that regulation changes are a must. By tailoring the regulations for local farms, host governments and regulators can be proud that a market change has foundations yet to be sustained. Table 10 outlines key recommendations that emerged throughout my research. They are supposed to suggest practical actions for an agricultural drone start-up.

Table 10: Summary of recommendations

Domain	Recommendation
Drone swarms and AI	Being involved and following the trends in the IT industry relevant to data acquisition creating relationships with experts in the field.
Drones as a replacement for farming jobs	The experiments carried out on farms run counter to farmers' worries about replacing them with drones. Drones complement farmers. However, they should be controlled responsibly, and farmers should educate themselves on drone capabilities.
Benefits gained from drones over large machinery	Cutting costs, reducing water and chemical requirements, and saving time motivate farmers to self-initiate an interest in drones.
Experimental licenses	A mandatory step in the process of selling a service. This phase allows potential customers to uncover, test, and potentially partner with a start-up based on solutions offered on the market.
Acknowledging the influence of governments	Governments require feedback from the industry. To systematically reshape the competitive habits of companies, legislators should also be incentivized to initiate changes.

Source: own work

8 LIMITATIONS AND FUTURE RESEARCH DIRECTION

This study, while providing ground-breaking insights into the topic, has several limitations, primarily considering examples and practices within real-life scenarios. The sample size consists of different profiles of experts who have provided unique and valuable inputs to the research. As a result, the study builds upon inputs from entrepreneurial, legislative, political, computer science, farmer, and sociological experts. That being said, future research would benefit from expanding the sample of interviewees. While the objective of expert interviewing is not to achieve representativeness, increasing the sample would help balance different expert insights against each other. Another way to improve the quality of the study would be to increase the number of countries from which insights are gathered. Since restrictions are being modified locally due to the requirements for obtaining permissions, an interview with a company representative from every country should be done. As the topic covers the European Union, if-else scenarios in business performance cannot be generalized from one success story to other territories. Agricultural drone business performance has the potential to be a separate research topic country-wise because different cultural profiles of farmers appear as if they have accumulated different experiences with dissimilar socio-economic factors, although they are similar. However, what can be generalized are the currently dormant practices that have yet to be applied in realistic settings.

The second limitation directly results from the scope of geographical expansion that this thesis could not cover due to time and access constraints. A term as broad as ‘prospects’ is a concept that would be measured more precisely by a separate country-wise case analysis. Otherwise, one-size-fits-all is not adequate for this research phenomenon.

Different countries pose a challenge in describing the competitive advantage from a diversification theory perspective. It would be nearly impossible to list most of the niche applications of agricultural drones, as the size of farms, management, soil quality, weather, and terrain differ everywhere. On top of that, the cultural dimension previously mentioned during technology acceptance would be a study on its own.

An insightful and rich idea for the future would be categorizing and providing a network analysis on different cultural profiles, considering the interaction with a drone interface. Moreover, it can be divided into two default categories controlling for age. One example would be that potential young farmers are grouped separately from the old ones. It can be researched in what subparts the interaction converges and where it parts ways due to the age division.

Future research could also take into account insights from human-drone interaction, a topic that exceeds the scope of this thesis. It is merely described as having the ability to provide for and have links with my research topic as a separate one.

Research that will further push the direction of tailored drone aid is studying various crops and their relevance within drone presence. Important parameters should be researched in different settings across fields or forests. Further generalizations may be made about fauna, not only plants.

9 CONCLUSION

Dependence on technology is a phenomenon that almost every human globally is aware of. Devices we regularly and sometimes unconsciously use daily are due to humans having become used to performing a given task easier or merely for entertainment goals. With attention to the concept of ‘easier use’, researchers provided us with the opportunity to enjoy simpler interfaces with the help of AI. Farmers of all ages (specifically older farmers) will enjoy controllers that will allow them to control pesticide levels at a distance and make real-time decisions during farm management. However, the value hidden within the known and yet-to-be-discovered scenarios in which drones in agriculture may be applied unveils a discussion that can reflect on the current global challenges considering food needs. Thus, start-ups are discovering convenient options for starting a business in a country where farmers require tailored solutions on their farms that are a mixture of distinct weather, types of crops, terrain, area length, soil fertility, plans, and expectations of farm owners.

This research topic aimed to address why it is convenient to approach specific challenges in the EU at this time from the viewpoint of the (agricultural) drone industry. Furthermore, it covered the research questions hence serving as an illustration of how to enter and, later on, remain present in a particular country market in the EU whose service on farms is provided with a drone. More specifically, it focused on a start-up in its first phases of establishing itself as a brand on the market. The analysis entails the concept of internationalization, which appears to be a direction that shareholders must consider due to the apparent lack of regulatory customization. During internationalization, an agricultural drone start-up faces the regulatory environment as the most hostile obstacle to its activities. Every country is a challenge on its own, which requires unique and different approaches to legislation.

Next, considering the industry growth, from the expert interviews, we conclude that besides the increasing popularity of drones, agricultural drone start-ups are expected to grow rapidly in the EU market due to the focus on drone spraying. For now, young companies are encouraged to establish their brands in countries with and without regulations.

Regarding the competitive advantage, start-ups possess the ultimate competitive advantage if they build personal relationships with businesses where both parties will benefit in the long run. The results suggest that drone companies should create and enhance customized solutions for farms.

Finally, it is recommended that agricultural drone start-ups narrow their focus to establishing their brand in the industry.

The research acknowledges that social factors combined with undeveloped legislation for drone actions on farms hamper the approach to the SDGs and numerous business opportunities. While the lack of representative countries (countries with different levels of drone adoption) limits the generalizability of results related to drone business management and strategic aspects of drone operations, the study gives insights into macro phenomena present in the industry and what should be offered to farmers within the next few years using technological advancement.

Since the introduction of drones in farming is conditioned on farmers' acceptance and hesitation and technological advancement in the HDI field, crop production boosts will vary across countries in the EU. Also, because of the relationships that drone businesses and farms maintain, new insights into solutions will be invented to improve farm management as well as farmers' welfare. But it's important to remember what Figure 4 shows: Europe's challenge lies in the retention of farmers, especially young ones. Some of the reasons behind this statistic are low income, an abundance of manual work, a lack of knowledge and training, low profitability, and low availability to land and credit. As discussed, by introducing drones in combination with the SDGs and CAP goals, the previously mentioned obstacles can be overcome. Nevertheless, due to the complexity of the nature of human behavior, one should approach with caution. Young farmers' interest may link with drone opportunities, but only in the first stage of experimenting and testing the service or product. Maneuvering such devices bears huge responsibility and should be taken seriously since the controller's health is at risk if he/she is not wearing the right equipment. Based on these conclusions, managers can consider the recommendations addressed in this study.

Finally, the examples of drone usage in agriculture presented in the thesis demonstrate to other countries that the drone use cases in agriculture are feasible and can stimulate interest among companies and farmers. The future of farming is the inevitable integration of agricultural drones.

REFERENCE LIST

1. Agritech Future. (2022, January 26). *A lack of agritech knowledge is 'holding farmers back.'* https://www.agritechfuture.com/smart-farming/a-lack-of-agri-tech-knowledge-is-holding-farmers-back/

2. American Institute of Aeronautics and Astronautics. (n.d.). *Aerospace history timeline.* https://www.aiaa.org/about/History-and-Heritage/History-Timeline#2016

3. Ahirwar, S., Swarnkar, R., Bhukya, S., & Namwade, G. (2019). Application of Drone in Agriculture. *International Journal of Current Microbiology, and Applied Sciences, 8*(01), 2500–2505. https://doi.org/10.20546/ijcmas.2019.801.264

4. Alamouri, A., Lampert, A., & Gerke, M. (2021). An exploratory investigation of UAS regulations in Europe and the impact on effective use and economic potential. *Drones, 5*(3), 63. https://doi.org/10.3390/drones5030063

5. All Answers Ltd. (2022, July 29). *Uppsala Model and the Network Approaches to Internationalization*. https://www.ukessays.com/essays/international-studies/uppsala-model-and-the-network-approaches-to-internationalisation.php

6. Antunes, J. (2021). 2021 Edition: 5 THINGS TO KNOW About How Drones are Being Used in Agriculture Across Europe | Commercial UAV News. *Commercial UAV News*. https://www.commercialuavnews.com/reports/europe/5-things-about-agriculture

7. Ayamga, M., Akaba, S., & Nyaaba, A. A. (2021b). Multifaceted applicability of drones: A review. *Technological Forecasting and Social Change*, *167*, 120677. https://doi.org/10.1016/j.techfore.2021.120677

8. Bai, A., Kovách, I., Czibere, I., Megyesi, B., & Balogh, P. (2022). Examining the Adoption of Drones and Categorisation of Precision Elements among Hungarian Precision Farmers Using a Trans-Theoretical Model. *Drones*, *6*(8), 200. https://doi.org/10.3390/drones6080200

9. Baldwin, R. E., & Wyplosz, C. (2020). *The Economics of European Integration* (6th ed.). McGraw-Hill Education / Europe, Middle East, and Africa.

10. Barney, J. B. (1995). Looking inside for competitive advantage. *Academy of Management Perspectives*, *9*(4), 49–61. https://doi.org/10.5465/ame.1995.9512032192

11. European Commission. (2023, May 19). *Common agricultural policy funds*. Agriculture and Rural Development. https://agriculture.ec.europa.eu/common-agricultural-policy/financing-cap/cap-funds_en

12. Chakrasthitha. (2020). Drones – *Unmanned Aerial Vehicles (UAVs), Types, components, works*. electricalfundablog.com. https://electricalfundablog.com/drones-unmanned-aerial-vehicles-uavs/

13. Chandhar, P., Danev, D., & Larsson, E. G. (2016). Massive MIMO as enabler for communications with drone swarms. In *2016 International Conference on Unmanned Aircraft Systems (ICUAS)* (pp. 347-354). IEEE. https://doi.org/10.1109/ICUAS.2016.7502655

14. Christensen, C. M. (2001). The Past and Future of competitive advantage. *MIT Sloan Management Review, 42*(2), 105-109. https://doi.org/10.1109/EMR.2002.998758

15. Cugurullo, F., & Acheampong, R. A. (2023). Fear of AI: an inquiry into the adoption of autonomous cars in spite of fear, and a theoretical framework for the study of artificial intelligence technology acceptance. *AI & SOCIETY*, 1-16. https://doi.org/10.1007/s00146-022-01598-6

16. Custers, B. (2016). Drones here, there, and everywhere introduction, and overview. In *Information Technology, and Law Series* (pp. 3–20). T.M.C. Asser Press. https://doi.org/10.1007/978-94-6265-132-6_1

17. Daly, D. (2020, June 10). *A Not-So-Short History of Unmanned Aerial Vehicles (UAV).* Consortiq. https://consortiq.com/uas-resources/short-history-unmanned-aerial-vehicles-uavs

18. Daponte, P., De Vito, L., Glielmo, L., Iannelli, L., Liuzza, D., Picariello, F., & Silano, G. (2019). A review on the use of drones for precision agriculture. *IOP Conference Series*, *275*(1), 012022. https://doi.org/10.1088/1755-1315/275/1/012022

19. Dharmaraj, V., & Vijayanand, C. (2018). Artificial Intelligence (AI) in Agriculture. *International Journal of Current Microbiology, and Applied Sciences*, *7*(12), 2122–2128. https://doi.org/10.20546/ijcmas.2018.712.241

20. Dormehl, L. (2018, September 11). *The history of drones in 10 milestones*. Digital Trends. https://www.digitaltrends.com/cool-tech/history-of-drones/

21. Dorussen, H., Lenz, H., & Blavoukos, S. (2005). Assessing the Reliability and Validity of Expert Interviews. *European Union Politics, 6*(3), 315–337. https://doi.org/10.1177/1465116505054835

22. Insider Intelligence. (2021, January 12). *Drone technology uses and applications for commercial, industrial, and military drones in 2021 and the future.* Insider. https://www.businessinsider.com/drone-technology-uses-applications?international=true&r=US&IR=T

23. EASA. (n,d.). *Drones (UAS)*. EASA. https://www.easa.europa.eu/en/the-agency/faqs/drones-uas

24. European Commission. (2022, November 29). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions: An EU strategy to harness the potential of offshore renewable energy for a climate-neutral future*. [Dataset]. In *Climate Change and Law Collection*. https://doi.org/10.1163/9789004322714_cclc_2020-0164-0816

25. Eurostat. (n.d.). *Farmers and the agricultural labour force - statistics*. Europa. Eu. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farmers_and_the_agricultural_labour_force_-_statistics

26. Floreano, D., & Wood, R. J. (2015). Science, technology, and the future of small autonomous drones. *Nature, 521*(7553), 460–466. https://doi.org/10.1038/nature14542

27. Freeman, P. K., & Freeland, R. S. (2015). Agricultural UAVs in the U.S.: potential, policy, and hype. *Remote Sensing Applications: Society and Environment*, *2*, 35–43. https://doi.org/10.1016/j.rsase.2015.10.002

28. Goyal, A. (2020). A critical analysis of Porter's 5 forces model of competitive advantage. *Journal of Emerging Technologies and Innovative Research*, *7*(7), 149–152. https://www.jetir.org/papers/JETIR2007313.pdf
29. Grosse, R. (2010). A Review of Jean Boddewyn's Contributions to the Theory of International Business-Government Relations. *International Studies of Management and Organization*, *40*(4), 25–36. https://doi.org/10.2753/imo0020-8825400403
30. Grundy, T. (2006). Rethinking and reinventing Michael Porter's five forces model. *Strategic Change*, *15*(5), 213-229. https://doi.org/10.1002/jsc.764
31. Harvard Business Review. (2012, March 30). *Disruptive Innovation Explained* [Video]. YouTube. https://www.youtube.com/watch?v=qDrMAzCHFUU
32. Hassanalian, M., & Abdelkefi, A. (2017). Classifications, applications, and design challenges of drones: A review. *Progress in Aerospace Sciences*, *91*, 99–131. https://doi.org/10.1016/j.paerosci.2017.04.003
33. Hassler, S. C., & Baysal-Gurel, F. (2019). Unmanned Aircraft System (UAS) Technology and Applications in Agriculture. *Agronomy*, *9*(10), 618. https://doi.org/10.3390/agronomy9100618
34. Hauben, M., Reynolds, R. F., & Caubel, P. (2018). Deconstructing the pharmacovigilance hype cycle. *Clinical Therapeutics*, *40*(12), 1981-1990.e3. https://doi.org/10.1016/j.clinthera.2018.10.021
35. Hollensen, S. (2010). *Global Marketing: A Decision-oriented Approach*. Financial Times/Prentice Hall. https://doi.org/10.1007/s00146-022-01598-6
36. Janke, C., & Uijt de Haag, M. (2022). Implementation of European drone regulations - Status quo and assessment. *Journal of Intelligent & Robotic Systems*, *106*(1), 33. https://doi.org/10.1007/s10846-022-01714-0
37. Jones, T., RAND Justice, I., & Rand Corporation. (2017). *International Commercial Drone Regulation and Drone Delivery Services*. RAND.
38. Kardasz, P., & Doskocz, J. (2016). Drones and Possibilities of Their Using. *Journal of Civil &Amp; Environmental Engineering*, *6*(3). https://doi.org/10.4172/2165-784x.1000233
39. Ken Research Private Limited. (2022). *Europe agricultural drones market outlook and forecast to 2027 - Driven by the rise in need for precision farming, increasing labor shortage, and increasing demand for global food production*. https://www.researchandmarkets.com/reports/5644036/europe-agricultural-drones-market-outlook-and
40. European Commission. (2023, May 19). *Key policy objectives of the CAP 2023-27*. Agriculture and Rural Development. https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27/key-policy-objectives-cap-2023-27_en
41. Khan, S., Khan, M. I., Hanjra, M. A., & Mu, J. (2009). Pathways to reduce the environmental footprints of water and energy inputs in food production. *Food Policy*, *34*(2), 141–149. https://doi.org/10.1016/j.foodpol.2008.11.002

42. Khofiyah, N. A., Sutopo, W., & Ardiansyah, R. (2020, August). Global business strategy for commercializing a technology of drone - A lesson learned from DJI drones and Parrot drones. In *Proceedings of the 5th NA International Conference on Industrial Engineering and Operations Management Detroit* (pp. 10-14).
43. Kirby, D. A., & Kaiser, S. (2003). Joint ventures as an internationalisation strategy for SMEs. *Small Business Economics, 21*, 229-242.
44. Kitonsa, H., & Agbozo, E. (2020). A systematic review on unmanned aerial vehicles in Sub-Saharan Africa: A socio-technical perspective. *Technology in Society, 63*, 101357. https://doi.org/10.1016/j.techsoc.2020.101357
45. Klauser, F., & Pauschinger, D. (2021). Entrepreneurs of the air: Sprayer drones as mediators of volumetric agriculture. *Journal of Rural Studies*, *84*, 55–62. https://doi.org/10.1016/j.jrurstud.2021.02.016
46. Krishna, K. R. (2017). *Agricultural Drones: A Peaceful Pursuit*. Amsterdam University Press.
47. Kuivalainen, O., Saarenketo, S., & Puumalainen, K. (2012). Start-up patterns of internationalization: A framework, and its application in the context of knowledge-intensive SMEs. *European Management Journal*, *30*(4), 372–385. https://doi.org/10.1016/j.emj.2012.01.001
48. Kuivalainen, O., Sundqvist, S., & Servais, P. (2007). Firms' degree of born-globalness, international entrepreneurial orientation and export performance. *Journal of World Business*, *42*(3), 253–267. https://doi.org/10.1016/j.jwb.2007.04.010
49. Lasi, H., Fettke, P., Kemper, H. G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. *Business &Amp; Information Systems Engineering*, *6*(4), 239–242. https://doi.org/10.1007/s12599-014-0334-4
50. Laws, M. a. D. (2023). *Drone Laws in Slovenia*. Drone Laws. https://drone-laws.com/drone-laws-in-slovenia/
51. Lehrer, M., & Almor, T. (2022). Startups internationalizing in quest of a business model: The global prospecting of process niche firms. *Journal of International Management*, *28*(1), 100906. https://doi.org/10.1016/j.intman.2021.100906
52. Mazoyer, M., & Roudart, L. (2006). A history of world agriculture: From the neolithic age to the current crisis. *Earthscan*.
53. McCauley, L. (2007). AI Armageddon and the three laws of robotics. *Ethics and Information Technology*, *9*(2), 153–164. https://doi.org/10.1007/s10676-007-9138-2
54. McGuigan, J. R., Moyer, R. C., & Harris, F. H. (2016). *Managerial Economics: Applications, Strategies and Tactics*. Cengage Learning.
55. Merkert, R., & Bushell, J. (2020). Managing the drone revolution: A systematic literature review into the current use of airborne drones and future strategic directions for their effective control. *Journal of Air Transport Management*, *89*, 101929. https://doi.org/10.1016/j.jairtraman.2020.101929
56. Meuser, M., & Nagel, U. (2009). The expert interview and changes in knowledge production. In *Palgrave Macmillan UK eBooks* (pp. 17–42). https://doi.org/10.1057/9780230244276_2

57. Molina, M. D. M., & Campos, V. S. (2020). *Ethics and Civil Drones: European Policies, and Proposals for the Industry*. Saint Philip Street Press.

58. Nonami, K. (2018). Research and Development of Drone and Roadmap to Evolution. *Journal of Robotics, and Mechatronics, 30*(3), 322–336. https://doi.org/10.20965/jrm.2018.p0322

59. Palik, M., & Nagy, M. (2019). Brief history of UAV development. *Repüléstudományi Közlemények*, *31*(1), 155–166. https://doi.org/10.32560/rk.2019.1.13

60. Pathak, H., Kumar, G., Mohapatra, S. D., Gaikwad, B. B., & Rane, J. (2020). Use of drones in agriculture: Potentials, Problems and Policy Needs. *ICAR-National Institute of Abiotic Stress Management,* 4-5.

61. Pe'er, G., Zinngrebe, Y., Moreira, F., Sirami, C., Schindler, S., Müller, R., Bontzorlos, V., Clough, D., Bezák, P., Bonn, A., Hansjürgens, B., Lomba, A., Möckel, S., Passoni, G., Schleyer, C., Schmidt, J., & Lakner, S. (2019). A greener path for the EU Common Agricultural Policy. *Science*, *365*(6452), 449–451. https://doi.org/10.1126/science.aax3146

62. Porters Industry Analysis. (n.d.). *The Dawn of the Drones*. The Drone Industry. https://thedroneindustry.weebly.com/porters-industry-analysis.html

63. Precedence Research. (2022, July 22). Commercial drones market size is to be worth around USD 504.5 bn by 2030. *Yahoo Finance*. https://finance.yahoo.com/news/commercial-drones-market-size-worth-220000386.html

64. Rejeb, A., Abdollahi, A., Rejeb, K., & Treiblmaier, H. (2022). Drones in agriculture: A review and bibliometric analysis. *Computers and Electronics in Agriculture*, *198*, 107017. https://doi.org/10.1016/j.compag.2022.107017

65. Saunders, M., Lewis, P., & Thornhill, A. (2009). Research Methods for Business Students (5th edn). In *Pearson Education eBooks*. https://epubs.surrey.ac.uk/816026/

66. SESAR Joint Undertaking. (2019). *European ATM master plan: digitalizing Europe's aviation infrastructure*. https://www.sesarju.eu/masterplan2020

67. Sindermann, C., Yang, H., Elhai, J. D., Yang, S., Ling, Q., Mei, L., & Montag, C. (2022). Acceptance and Fear of Artificial Intelligence: associations with personality in a German and a Chinese sample. *Discover Psychology*, *2*(1). https://doi.org/10.1007/s44202-022-00020-y

68. EASA. (2022, September 28). *Standard Scenario (STS).* EASA. https://www.easa.europa.eu/en/domains/civil-drones-rpas/specific-category-civil-drones/standard-scenario-sts

69. Statista. (2023). *Size of the smart agriculture drone market worldwide from 2021 to 2028 (in billion U.S. dollars)*. https://www.statista.com/statistics/729533/forecasted-market-size-of-drones-in-smart-agriculture-worldwide/

70. Tezza, D., & Andujar, M. (2019b). The State-of-the-Art of Human–Drone Interaction: A Survey. *IEEE Access*, *7*, 167438–167454. https://doi.org/10.1109/access.2019.2953900

71. Fact.MR. (2023, September 12). *U.S. Drone Market to Reach US$ 82.9 billion, at CAGR of 22.2% by 2032*. Yahoo Finance. https://finance.yahoo.com/news/u-drone-market-reach-us-120000321.html?guccounter=1
72. *Transforming our world: the 2030 Agenda for Sustainable Development* | Department of Economic and Social Affairs. (n.d.). https://sdgs.un.org/2030agenda
73. Tripicchio, P., Satler, M., Dabisias, G., Ruffaldi, E., & Avizzano, C. A. (2015). *Towards Smart Farming and Sustainable Agriculture with Drones*. https://doi.org/10.1109/ie.2015.29
74. Tsouros, D. C., Bibi, S., & Sarigiannidis, P. G. (2019). A Review on UAV-Based Applications for Precision Agriculture. *Information*, *10*(11), 349. https://doi.org/10.3390/info10110349
75. Van Audenhove, L. (2007). *Expert interviews and interview techniques for policy analysis*. Vrije University, Brussel. https://www.researchgate.net/profile/Leo-Van-Audenhove/publication/228795228_Expert_Interviews_and_Interview_Techniques_for_Policy_Analysis/links/00b7d52bb31d0b2587000000.pdf
76. Van Der Merwe, D., Burchfield, D. J., Witt, T., Price, K. P., & Sharda, A. (2020). Drones in agriculture. In *Advances in Agronomy* (pp. 1–30). Elsevier BV. https://doi.org/10.1016/bs.agron.2020.03.001
77. van Dijk, M., Morley, T., Rau, M. L., & Saghai, Y. (2021). A meta-analysis of projected global food demand and the population at risk of hunger for the period 2010–2050. *Nature Food*, *2*(7), 494–501. https://doi.org/10.1038/s43016-021-00322-9
78. Von Gelderen, M., Frese, M., & Thurik, R. (2000). Strategies, uncertainty and performance of small business startups. *Small Business Economics*, *15*, 165-181.
79. Wachenheim, C. J., Fan, L., & Zheng, S. (2021). Adoption of unmanned aerial vehicles for pesticide application: Role of social network, resource endowment, and perceptions. *Technology in Society*, *64*, 101470. https://doi.org/10.1016/j.techsoc.2020.101470
80. Waite, C., & Bourke, L. (2015). Using the cyborg to re-think young people's uses of Facebook. *Journal of Sociology*, *51*(3), 537-552. https://doi.org/10.1177/1440783314553318
81. Liu, J. A. (2020, May). *Will Robots Take Over Human Agricultural Labour?*. FoodUnfolded. https://www.foodunfolded.com/article/will-robots-take-over-human-agricultural-labour-opinion
82. MacroTrends. *World Population Growth Rate 1950-2022*. (n.d.). MacroTrends. https://www.macrotrends.net/countries/WLD/world/population-growth-rate

APPENDICES

Appendix 1: Povzetek (Summary in Slovene language)

Naprave, ki jih redno in velikokrat nezavedno uporabljamo, nam pogosto olajšajo dnevne navade. Najnovejša tehnologija uporabe brezilotnih letal v kmetijstvu razkriva, ki ponuja odgovore na trenutne svetovne izzive glede izpolnitve potreb po hrani. Na drugi strani pa novoustanovljena podjetja čedalje intenzivneje odkrivajo priročne možnosti za ustanovitev podjetja v državah, kjer kmetje potrebujejo prilagojene tehnološke rešitve na svojih kmetijah.V magistrski nalogi raziskujemo, zakaj je v tem času primerno pristopiti k specifičnim izzivom v Evropski Uniji z vidika (kmetijske) industrije dronov. Natančneje, osredotočamo se na start-up podjetja v prvih fazah uveljavljanja blagovne znamke na evropskem trgu. Analiza vključuje koncept internacionalizacije, ki ponuja konceptualni okvir, ki ga morajo deležniki upoštevati zaradi očitnega pomanjkanja prilagajanja predpisov. Rezultati raziskave so potrdili, da družbeni dejavniki v kombinaciji z nerazvito zakonodajo za delovanje brezpilotnih letal na kmetijah ovirajo pristop k ciljem trajnostnega razvoja in zamejujejo številne poslovne priložnosti.V magisterski nalogi se oprimemo primera Madžarske, ki predstavlja zgled ostalim državam, da so tovrstni primeri uporabe dronov v kmetijstvu izvedljivi, obenem pa spodbujajo tudi zanimanje podjetij ter kmetijcev. Poglobljena študija zajema ponazoritev, kako vstopiti na tržišče posamezne družbe. Zlasti pa ponuja odgovore na to, katere kmetijske storitve je mogoče opravljati z uporabo drone.

Appendix 2: First interview questions

Preliminary questions:

a) Please, tell me slightly about your educational background.

b) What has your past research about drones included? / What is your current drone research about ?)

c) What is human-drone interaction, and to what extent has this term been researched?

d) In which ways does the fusion of AI and drones appear?

Specific questions:

1. Where did human-computer interaction has first appeared during your drone research? In which applicable ways/forms are you currently implementing it?

2. One of the main competitive advantages of a drone start-up is the company's know-how translated into the uniqueness of its product and service. How significant is the AI-adjacency of the R&D department in a company to win the market competition over? Is researching and understanding AI crucial/conditional on performing well in a rapidly growing market?

3. Are there any examples where AI aid in agricultural drones would eliminate manual labor and drudgery on farms?

4. What limitations exist while presenting and adopting AI drone solutions to farmers?

5. Is age a significant contributor to the familiarizing implementation of drones to farmers? Does the higher knowledge cap require more time to get acquainted with advanced machine-learning solutions?

6. Do you have any examples of different cultural profiles featured by a different approach to AI in general (not tailored to drones in agriculture)? If yes, how would you order (assign to an ordered scale) the different cultures/nationalities you have been in contact with, considering the pace of adopting AI knowledge and understanding?

Appendix 3: Second interview questions

<u>Preliminary questions</u>

a) Tell me slightly about your past drone research and educational background.

b) What has made you decide to sell products over services?

c) Is the company international? If yes, where is your company operating? What has motivated you to make such a move?

d) What problems does internationalization present in managing a drone start-up?

e) What are some internal challenges about drone start-ups when it comes down to management? What sort of phenomena influences the decision-making process? (limited budget, regulatory environment, etc.)

<u>Specific questions</u>

1. What are the most significant barriers to entry in the drone industry? Are there any existing barriers that are inherent to a particular company?

2. What is the pace of R&D among competitors? How does the information disseminate in the industry?

3. What preparation is required to initiate a business in this industry? For example, legislative and technological knowledge for setting up a business in a specific environment.

4. Do regulations noticeably impact your market performance or revenue? How strict is the regulation where you operate, and how do you overcome this barrier (if it is a barrier at all)?

5. How would you assess your business' post-pandemic performance? What has involuntarily changed considering managing the company to 'smoothly' continue operations?

6. Are you producing your products in-house? If not, how did the B2B relationships with suppliers change in the post-pandemic era?

7. Please describe how the model 'Insprayer 1' works. Is it applicable in agriculture, i.e., can the peripheral spray liquids other than water? What is the competitive advantage of Insprayer1 over other agricultural drones used for spraying?

Appendix 4: Third interview questions

<u>Specific questions</u>

1. Based on your experience with agriculture/drone start-ups, what are your most significant challenges when internationalizing the business? Can you provide any examples of successful international expansions by agricultural drone start-ups? What strategies or factors contributed to your success?

2. How do these challenges differ between various global markets, particularly regarding regulations, market saturation, and cultural factors? (emphasis on the European market) How would you assess the current market landscape for European agricultural drones compared to other regions? What factors make it unique?

3. What are the main barriers to entry for new agricultural drone start-ups in Europe and other international markets?

4. How saturated is the agricultural drone market in terms of competition? What opportunities exist for new start-ups to differentiate themselves?

5. What competitive advantages should agricultural drone start-ups focus on to stand out in a crowded market?

6. How do you see the future of agricultural drone technology evolving in the European market? What trends or innovations could drive growth in this sector?

7. What advice would you give to an agricultural drone start-up considering international expansion? What factors should they prioritize when selecting target markets or regions?

8. Can you provide any insights into the specific competitive advantages of the agricultural drone in question and how could it be positioned for success in the international market?

9. How is AI currently used in agricultural drones, and what are some cutting-edge applications?

Appendix 5: Fourth interview questions

Specific questions

1. How did you come up with the idea of starting an agricultural drone start-up? What was your motivation and inspiration?

2. What are the main goals and vision of your start-up? How do you plan to achieve them?

3. What are the main challenges you face or expect to face in running your start-up? How do you cope or prepare for them?

4. How do you differentiate your start-up from other competitors in the market? What are your unique selling points or competitive advantages?

5. How do you deal with the regulatory and ethical issues related to using drones in agriculture? How do you ensure compliance and safety?

6. How do you measure the impact and value of your start-up for your customers and stakeholders? What are the key indicators or metrics you use?