CHALMERS
UNIVERSITY OF TECHNOLOGY

The Connected Future of Beekeeping

Market Analysis and Strategic Development for Successful IoT Integration in Beekeeping

Master's thesis in Quality and Operations Management

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2024
www.chalmers.se

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Cover:
The report's authors are standing in bee suits at Ericsson's rooftop in Gothenburg. Amanda Rönnefors is standing to the left and Erica Rickard to the right. Picture taken by Qendresa Shala.

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SUMMARY
The world's bee population has been declining for the last decades. This entails a major threat to humans and nature worldwide since biodiversity depends on pollinators such as bees. Therefore, Ericsson is developing a technological solution, connected beehives, to help beekeepers determine their bee colonies' status and health. This study aimed to analyze the needs and challenges of beekeepers and how technological IoT solutions can promote beekeeping. Also, based on the beekeeping market analysis, the study aimed to develop a suitable market strategy for Ericsson to enable a successful IoT solution within the beekeeping industry. An inductive approach was adopted, and data was collected through 22 interviews with beekeepers, a Kano survey, and literature. The study's findings indicated multiple major needs and challenges for beekeepers. These regarded honey harvesting, inspections, heavy lifting, planning, Varroa mites, viruses and diseases, unknown reasons for unhealthy bees, and that beekeepers cannot determine the bee's status without opening the beehive. The analysis of the beekeeping market showed that beekeepers' needs and challenges relate to multiple factors within the beekeeping market. These factors were social, technological, economic, and environmental. For instance, environmental factors such as climate change and the usage of pesticides and chemicals affect beekeeping negatively as bees' survival depends on their environment. Currently, there are multiple technological solutions within the beekeeping market, however, no solution has yet been completely successful. Therefore, these results showed that Ericsson has the potential to gain large market shares. Also, Ericsson's solution's strengths and weaknesses were analyzed in relation to the market. Its main strength is its superiority to other actor's technological solutions. The interviewed beekeepers saw a potential weakness regarding the solution's costs due to the low-profit margins in the beekeeping industry. Through the market analysis, a market strategy was developed including value proposition, customer segments, revenue streams, channels, and key partnerships. Ericsson's solution creates value for beekeepers by enabling more effective and efficient operations, reducing costs, and promoting the bee colonies' status and health. The most important customers at the beginning of the solution's launch are technology-interested beekeepers. A recommendation for Ericsson is to include the essential functions in the solution as a basic offering, with the option to add additional functions if desired. The solution should be sold through local beekeeping stores and well-known online sites to gain trustworthiness among beekeepers. Finally, Ericsson should further examine the possibility of partnering with governmental agencies, other beekeeping organizations, and competitors.

Keywords: Beekeeping, Apiculture, Ericsson, IoT, Market Analysis, Market Strategy, Business Model

Acknowledgements

This master's thesis was carried out during the spring of 2024 and marks the end of our education at Chalmers University of Technology. This project has been enabled and facilitated thanks to the support and encouragement of several individuals whom we would like to express our gratitude towards.

Firstly, we want to extend special thanks to Lars-Erik Lindberg and Daniel Ljungh for giving us the opportunity to be a part of the project and for supervising us through the process. It has been a pleasure to work together with you and we are very thankful for the support that you have been giving us. We also want to thank all the individuals affiliated with the Innovation Garage at Ericsson Lindholmen and Ericsson ONE who have been a great support and made valuable contributions to our thesis project.

Moreover, we would like to thank our examiner, Frida Lind, and our supervisor, Luciana Alcantara, for supporting us during this spring. Your experience in research and knowledge about market analysis and strategy has guided us through writing this master's thesis, and we are grateful for all the valuable advice you have given us throughout the process.

Lastly, we would like to express our gratitude towards all the beekeepers who participated as interviewees in this study for taking the time to share valuable insights that have contributed to our understanding and knowledge about the beekeeping industry and its future challenges. A special thanks to the beekeeper David Hanson, who invited us to visit one of his apiaries and let us try out beekeeping.

Thank you!

Erica Rickard & Amanda Rönnefors
Gothenburg, May 2024

Definitions

American foulbrood: A brood disease of bees that is caused by the spore-forming bacterium Paenibacillus larvae. It is difficult to eliminate the disease, therefore, beekeepers should burn their beehives and equipment if affected by American foulbrood.

Apiary: The place where the beehives are kept. It is also known as a bee yard.

Apiculture: The science and art of beekeeping, including knowledge of bees and bee products.

Beehive: A shelter built by or for bees. Often a box with movable frames in which the bee colony lives inside.

Beekeeping: The activity or occupation of keeping bees to produce honey and other products.

Biodiversity: The variety of animals, plants, fungi, and microorganisms that can be found in a particular area.

Bottom board: The floor of a beehive which the other hive components rest on top of.

Brood: The brood refers to the eggs, larvae, and pupae of bees.

Cell: The hexagonal section of the comb built by the bees.

Chalkbrood: The chalkbrood disease weakens bee colonies by killing the brood.

Colony: A colony is a group of organisms of the same species or group that live and grow together. A bee colony is formed by three types of bees, namely: a queen, drones, and workers.

Comb: A sheet of six-sided wax cells made by the bees to hold brood, honey, nectar, and pollen.

Comb honey: Honey that is harvested and sold in the comb.

Drone bee: Male bee in a colony whose main role is to mate with the queen bee.

European foulbrood: An infectious disease, caused by the bacteria Streptococcus pluton, that only affects the brood of honeybees. It is more manageable for beekeepers than American foulbrood.

Extracted honey: Liquid honey removed from the comb.

Frame: A rectangular wooden or plastic framework, designed to hold comb and hang in a hive box. There are multiple frame sizes and models.

Intruders: Various pests and insects that get into the beehive and harm the colony, for instance, ants or hornets.

Larva: A white, legless insect which later becomes a bee.

Nectar: Nectar is a sugar-rich liquid within plants that bees collect to produce honey.

Nosema disease: Nosema disease is caused by the spore-forming pathogen called Nosema apis. It is only visible through a microscope.

Pheromones: Pheromones are chemical signals that some animals communicate with. Honeybees secrete many different pheromones.

Pollen: Pollen is a powdery substance consisting of microscopic grains from the male part of a flower. It is collected by bees to be used as their protein source.

Pollination: Pollination regards the transferring of pollen grains from the male part of a flower to the female part. Bees are excellent pollinators.

Propolis: A material that honeybees produce by mixing saliva and bee wax with fluids gathered from different botanical sources. The honeybees use propolis as a sealant for unwanted open spaces in the beehive.

Queen bee: There is one queen in each colony and the queen is the only egg-laying female in the bee colony. The queen bee is larger and longer than the worker bees.

Queen cell: An elongated cell hanging down from the comb where a queen is raised.

Robbing: Honeybees that invade another hive and steal the stored honey or nectar.

Royal jelly: Royal jelly is a milky secretion rich in protein, amino acids, fatty acids, vitamins, and minerals that worker bees produce. Bees that are fed only royal jelly become queen bees.

Small hive beetle: The small hive beetle is a destructive pest that damages the beehive and harms bee colonies.

Splitting: Dividing one bee colony into two or more colonies to produce more colonies.

Swarming: A natural way for a bee colony to undergo reproduction. A single colony splits into two or more distinct colonies by leaving the hive together with the old queen to establish a new colony.

Swarm cell: Swarm cells are queen cells that are usually found at the bottom of the combs before swarming. It is produced to provide a new queen for the colony after the swarm has departed.

Varroa mites: Parasites of honeybees. The mites attach to the bees, weaken them, and transmit multiple bee viruses. As a result, Varroa mites are responsible for the deaths of many colonies.

Wax moth: Wax moth is a pest that damages the bee wax and combs. Combs stored in dark and warm areas attract wax moths to a larger extent, but they can also be present inside living hives.

Worker bee: A female bee in a colony that does all the work in the beehive except for laying fertile eggs. Most of the bees in a colony are worker bees.

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1 Introduction

In this initial section, a background with an introduction to the beekeeping industry will be provided along with a description of the connected beehive project at Ericsson. The concept and objectives of the Ericsson ONE unit will also be explained. Furthermore, the aim of the study, its limitations, and research questions will be presented.

1.1 Background

During the last decades, the bee population has been declining globally, which can be explained by multiple reasons such as habitat loss, air pollution, and pesticides (United Nations Environment Programme [UNEP], 2022). This fact poses a major threat worldwide since bees are a vital part of the biodiversity which human survival depends upon. Another factor affecting bee colonies' survival rate is parasite presence since the main reason for winter colony losses for managed beehives is mites (Amiri et al., 2016). Furthermore, the loss of the queen bee has devastating effects on the colony, as she is essential for its survival. For instance, colonies with a healthy queen have a greater potential to survive the winter as they can store more honey. However, observations of queens dying within their first year have been made, despite the fact they should be able to live for three to four years. As a result, beekeepers usually replace their queen bee within one to two years to promote their bee colony's survival.

According to the Food and Agriculture Organization (FAO, 2023), bees are essential for the health of ecosystems and food security, and they ensure the production of nutritious food. About 35 percent of crop production globally requires pollination from bees and other pollinators, making these animals important to achieve sustainable agriculture (FAO, 2023). Moreover, the survival of bees possesses an economic value, because about 10 percent of the total economic output from agriculture depends on pollinators such as bees (FAO, 2023), and since beekeeping implies a vital source of income in rural livelihoods (UNEP, 2022).

To help beekeepers increase the survival rate of their bee colonies, Ericsson is developing connected beehives (Ericsson, 2024c). By utilizing data, Artificial Intelligence (AI), and Internet-of-Things (IoT), these connected beehives provide the beekeeper with relevant insights into their bees' well-being all year round. Possible risks affecting the bee colony, such as the presence of mites or the queen's health, can effectively be determined by gathering data and applying AI algorithms. Consequently, the state of the bee colony is easily tracked, and appropriate actions can be taken by the beekeeper to support it. The solution promotes beekeepers to work more efficiently, helping them save both time and resources, as they can view the status of their beehives remotely instead of being required to visit them. Furthermore, insights from multiple beehives can be combined, which provides researchers with a geographical macro view of the well-being of bee colonies. Accordingly, farmers are given the possibility to

know where the risk of poor pollination is high and thereby, they are allowed to take preventive measures.

The connected beehive project is one of Ericsson ONE's projects, meaning that the solution has the potential to form a new venture. Ericsson ONE is an internal venture studio at Ericsson that supports Ericsson employees with pioneering new business ideas beyond Ericsson's core business (Ericsson, 2024a). The Ericsson ONE unit offers investments and consists of a diverse team that provides hands-on coaching, support, and advice for any Ericsson employee who has a great idea and wants to start a venture. Furthermore, the Ericsson ONE unit has established a highly effective innovation accelerator process consisting of several stages. Ericsson employees start by presenting their ideas to the Ericsson ONE team that reviews them and takes the most promising ones to the next steps of the process, which involves creating, testing, and validating prototypes and building a viable product. Throughout this process, the intrapreneurs pitch the idea to various stakeholders to secure further investments and if everything goes well the product will be fully developed and added to Ericsson's portfolio. The expertise and knowledge that has been accumulated within Ericsson ONE over the years along with access to Ericsson's global network of both customers and partnerships, industry-leading technologies, and proven go-to-market strategies offers intrapreneurs a great opportunity to build successful ventures.

Börje Ekholm, Ericsson's CEO and President, expresses the company's purpose and vision as *"By creating connections that make the unimaginable possible, we are helping to shape an exciting and positive future. A world where limitless connectivity improves lives, redefines business and pioneers a sustainable future"* (Ericsson, 2024b). Hence, Ericsson ONE is actively examining how they can support the development of sustainable solutions. After the connected beehive project was successfully presented to Ericsson ONE, they chose to make it one of their projects since it supports sustainability in terms of helping the agriculture industry to become more efficient and it promotes biodiversity.

1.2 Aim of the Study

This thesis project aims to analyze the beekeeping market by looking into the needs of different market segments concerning technological beekeeping solutions. Furthermore, the study aims to develop a market strategy for Ericsson, based upon the conclusions from the market analysis. Additionally, the project aims to understand what is required for IoT solutions to be successful within the beekeeping industry.

1.3 Limitations of the Study

The limitations of this study were developed in collaboration with the project manager of the connected beehive project. This study is geographically limited to only examine and analyze the European and the US markets. Europe is chosen because it is geographically close and most European beekeepers use beehive models compatible

with Ericsson’s product. The US is included because of the large scale of commercial beekeeping and the significant challenges faced there (L-E. Lindberg, personal communication, May 19, 2024). Due to the time limitations, each country in Europe and each state in the US are not represented within the sample. Therefore, the analysis of the study was carried out with this taken into consideration.

1.4 Research Questions

In accordance with the aim of this study, two research questions were developed.

RQ1:
What are beekeepers' major needs and challenges, and what factors in the beekeeping market are related to them?

RQ2:
What does the beekeeping market analysis imply for the development of a market strategy?

2 Frame of Reference

This section includes theoretical explanations of concepts relevant to this study's subject. First, it presents what a market is and how it is defined, followed by common market analysis models to utilize when analyzing a market. Thereafter, an explanation of marketing strategy and business models is presented. Finally, an analytical framework is introduced, which was developed for this thesis project to analyze the empirical findings.

2.1 Definition of a Market

A market is a place where supply meets demand (Håkansson, 1982). It consists of buyers and sellers who exchange products or services, usually for money (Nationalencyklopedin, n.d.; Law, 2016). Hence, it is important to analyze both the buyer and seller sides to understand a market (Håkansson, 1982). Arranged agreements between two or more parties can occur within a determined geographical area, or a more abstract area, meaning that a market does not have to be a specific place. According to Robinson (2024), a market covers the whole geographical area where sellers compete to attract customers. All markets contain various regulations that can be formed spontaneously or through governments (Nationalencyklopedin, n.d.). These regulations can, for instance, include price setting or product quality, meaning that the government can determine the required price or quality to be set on a specific product within a market. The demand in a market is measured by the number of buyers in the market (Kurin, 2013). This means that the higher the number of buyers in a market, the higher the demand is. Due to various activities executed by the actors in a market, markets change continuously (Lehtimaki et al., 2023) and should therefore not be seen as static.

Markets are commonly divided into business markets and consumer markets. According to Law (2016), a business market is where organizations buy goods and services to produce other products and services. These products and services are later sold to end users on the consumer market for the organizations to make a profit.

2.2 Market Analysis Models

According to Aaker (1995), a market analysis is based on customer and competitor analyses. A competitor analysis includes gathering an understanding of a competitor's strengths, weaknesses, objectives, and strategies, by analyzing their products and prices (Law, 2016). As a result, sources of competitive advantages can be determined. A customer analysis includes how customers are divided into different segments and how those segments rate various product or service offerings (Jobber and Ellis-Chadwick, 2020). The objectives of a market analysis are to determine the market's attractiveness and understand the market dynamics (Aaker, 1995). Market attractiveness is determined based on the market's profit potential. Whether a market is appropriate for a certain organization also depends on how well an organization's strengths and

weaknesses stand to competing organizations in the same market. To understand the market dynamics emerging key success factors, trends, opportunities, and threats must be identified. There are different dimensions of a market analysis that are highly context-dependent, however, common dimensions to include are: actual and potential market size, market growth, market profitability, cost structure, distribution systems, trends and developments, and key success factors.

When analyzing a market, multiple methods can be applied. According to Melander and Lind (2022), a multi-level approach can be used to understand a market. Moreover, a SWOT analysis can be used to determine an organization's strengths, weaknesses, opportunities, and threats (Jobber & Ellis-Chadwick, 2020), and a PESTLE analysis can be applied to analyze the external factors within the business environment an organization should consider (Washington State University, 2023). These methods are presented in the following three sections.

2.2.1 Levels of a Market

To understand a market, Melander and Lind (2022) stress the importance of using a multi-level approach. This is especially true when both economic and environmental value are created by the specific innovation in the business environment. When using this approach, the innovation is to be analyzed through the perspective of micro-, meso- and macro-level. The micro level regards the individual firm and organization, and the meso level regards business networks with connections and relations between different firms or partnerships. Lastly, the macro level regards environmental and social factors, for instance considering government and policies. The multi-level model can be seen in Figure 2.1.

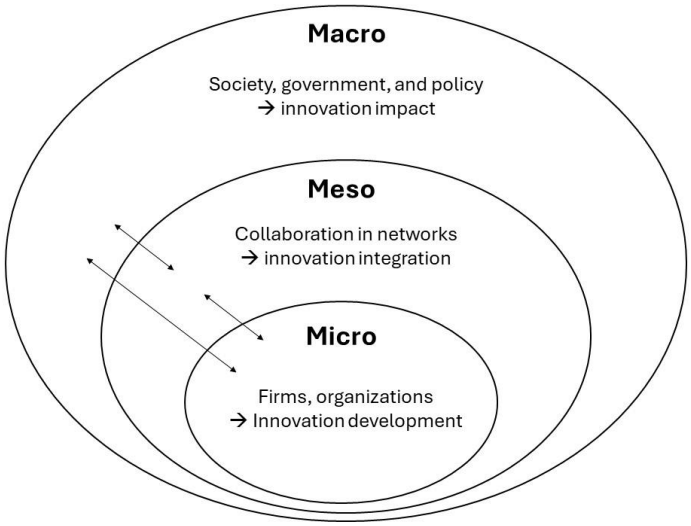


Figure 2.1: *Multi-level perspectives and interaction between levels of innovation (Adapted from Melander & Lind, 2022, p.214).*

The micro level consists of individual organizations and the organization's resources are crucial for value creation at this level (Melander & Lind, 2022). It is important for

organizations to combine the different resources including products, people, systems, and facilities in an effective way. A resource that is particularly important during the innovation process is future customers and users who can provide feedback and insights during the development of a new product.

According to Melander and Lind (2022), multiple firms are interconnected in business networks at the meso level, which are defined through buyer-supplier relationships and the connections of these relationships. As a result, the firms within these networks can share and integrate knowledge, which enables collaboration.

At the macro level, societal, environmental, and governmental factors need to be considered (Melander & Lind, 2022). Firms need to be aware of new regulations and governmental actions while developing new sustainable solutions. New regulations can drive innovation and promote additional networks to be formed where firms can collaborate to innovate. Moreover, policies and regulations can drive sustainable development at the macro level, promoting market change for sustainable innovation (Lehtimaki et al., 2023). Also, the changed behaviors of consumers need to be raised at this level (Melander & Lind, 2022).

2.2.2 SWOT Analysis

SWOT analysis is a tool that can be applied to analyze the market and an organization or a certain initiative within an organization. According to Jobber and Ellis-Chadwick (2020), it is a structured way of evaluating the strategic position of an organization by identifying its strengths, weaknesses, opportunities, and threats.

Strengths and weaknesses are internal factors the organization has control over (Sarsby, 2016). Strengths are factors that support an opportunity or can help overcome a threat. Weaknesses can make an organization vulnerable to threats or prevent them from taking advantage of an opportunity. Several internal factors that can be strengths or weaknesses within an organization include human resources, physical resources, financial resources, technology, and previous experiences (University of Kansas, n.d). According to Jobber and Ellis-Chadwick (2020), only the resources and capabilities valued by the customers should be considered when evaluating strengths and weaknesses. Opportunities and threats are external factors beyond the organization's control (Sarsby, 2016). These are just as important to evaluate as the internal factors since no organization is immune to outside events and forces (University of Kansas, n.d). Opportunities and threats can arise from different external factors including trends, the economy, funding sources, demographics, the physical environment, competitors, and legislation.

Once a SWOT analysis is done, it can help the organization understand the various factors affecting a certain initiative and put the organization in a better position to take suitable actions (University of Kansas, n.d). The analysis can, for instance, be used to

match an organization's internal strengths with external opportunities, also called a matching strategy (Jobber and Ellis-Chadwick, 2020). Additionally, organizations can use the analysis to turn their weaknesses into strengths and threats into opportunities, this is called a conversion strategy. A visualization of the SWOT analysis can be seen in Figure 2.2.

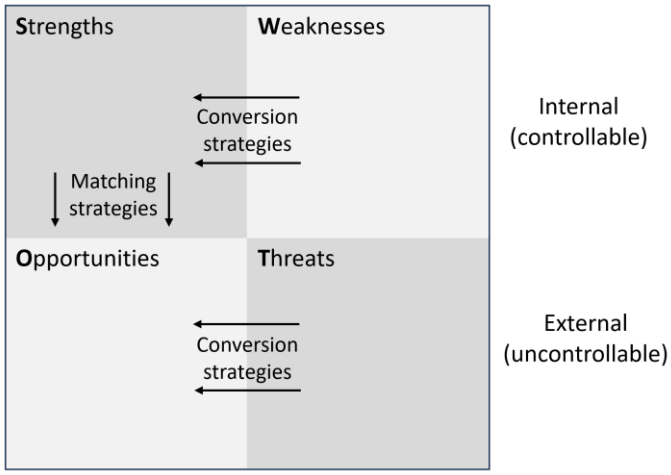


Figure 2.2: *Visual representation of a SWOT analysis model including matching and conversion strategies (Adapted from Jobber and Ellis-Chadwick, 2020, p.605).*

2.2.3 PESTEL Analysis

According to Washington State University (2023), a PESTEL analysis can be used to analyze the macro-environmental factors that can influence an organization or industry. These external factors being examined in the analysis are *political*, *economic*, *social*, *technological*, *environmental*, and *legal*, and they can be used to identify threats or weaknesses of the SWOT analysis. There are different versions of the PESTEL analysis, for instance, Jobber and Ellis-Chadwick (2020) present the PEEST analysis, where the political and legal factors are combined. Moreover, the authors emphasize the importance of analyzing the business environment, which organizations can do using these models.

Washington State University (2023) explains that the *political* factors include regulations, government policies, tax policy, and internal political issues or trends. The *economic* factors regard economic growth, inflation and interest rates, job growth and unemployment, labor costs, and probable changes in the economic environment. The *social* factors include demographics, consumer opinions, and buying patterns, population growth rate, sociocultural changes, ethnic and religious trends, and living standards. Moreover, according to Jobber and Ellis-Chadwick (2020), the *technological* factors cover innovation, communications, technology infrastructure, and smart technologies. The *environmental* factors include global warming, pollution, environmentally friendly components, recycling, and scarce resources such as energy. Finally, according to Washington State University (2023), the *legal* factors include safety and health, equal opportunities, standards, consumer rights and laws, and product labeling and safety.

2.3 Marketing Strategy and Business Models

By evaluating the strategic position of a business, through for instance a SWOT analysis, the desired future state of the business and its marketing objectives are determined (Jobber & Ellis-Chadwick, 2020). By understanding the organization's objectives combined with the competitors' objectives, the organization can develop its strategy (Law, 2016). A core marketing strategy is vital to ensure the business reaches its desired state and its objectives are met (Jobber & Ellis-Chadwick, 2020). This core marketing strategy consists of three interlinked elements, namely target markets, competitors targets, and establishing a competitive advantage, which together enables competitive positioning of the business. The first element, target customers, includes that the business must make decisions about which customer segments to address since, according to Jobber and Ellis-Chadwick (2020), not all customers are suitable for the business capabilities. After selecting the target market, Fifield (1998) stresses the need to include the customers' wants and needs when developing a marketing strategy, instead of what the company is already good at. However, the target market's needs can change over time, meaning that the marketing strategy must be altered (Jobber & Ellis-Chadwick, 2020). Also, in case of a decreased attractiveness of the current target market, a different market segment could be targeted instead. Moreover, competitor targets are businesses which a company competes with directly, meaning that both offer the same type of product in the same market. Resources can be put against weak competitors to overcome them. The third and final element, competitive advantage, implies that the business provides superior performance through differentiation against competitors, for instance by being faster than competitors, having closer customer relationships, offering lower prices, or by providing superior customer value, quality, or service.

Segmenting the market and deciding upon a relevant target market is vital when developing market strategies (Jobber & Ellis-Chadwick, 2020). As a result, the customer's needs within the target market can be met through a tailored market mix package. This marketing mix consists of four components, *product*, *pricing*, *promotion*, and *place*, that together will affect whether the customers within a market will buy the company's product or not (Law, 2016; Jobber & Ellis-Chadwick, 2020). The first component, *product*, regards the quality, branding, packaging, and various features of the product (Law, 2016). *Pricing* covers the retail price, discounts for large orders, and credit terms. Moreover, *promotion* includes activities to increase sales, such as advertising or PR campaigns, free samples or gifts, temporary price reductions, telephone selling, and email marketing. The fourth component, *place*, regards where the product is sold, the choice of distributors and transport services, and preferred stock levels. These four components within the marketing mix are often called the four Ps, but when marketing services there are three more Ps to consider (Law, 2016; Jobber & Ellis-Chadwick, 2020), namely *physical evidence*, *people*, and *process*. *Physical evidence* regards the service's tangible and visible elements that encourage the customer to evaluate the service (Law, 2016). *People* includes the consumers'

evaluation of the knowledge, competence, and politeness of the personnel who are providing the service. Finally, *process* regards the consumer's evaluation of the overall service experience to ensure an interplay between all elements.

When developing a marketing strategy, creating a business model can be part of it. A business model is not the same as a strategy. It describes how the pieces of a business fit together, but it does not regard how to deal with competition, which is an important part of a company's strategy (Magretta, 2002). A business model answers questions like: Who are the customers? What do the customers value? What is the economic logic? How do we make money in this business? A well-known business model tool is the Business Model Canvas, which can be used to develop parts of a strategy. It is presented in the following section, Section 2.3.1. Additionally, the Technology Adoption Life Cycle describes how different market segments adopt new technological innovations, which can be important to consider when marketing innovations. The Technology Adoption Life Cycle model is presented in Section 2.3.2.

2.3.1 Business Model Canvas

The Business Model Canvas is a strategic template that can be used by organizations to develop a new business model and be part of the marketing strategy (Adeniyi, 2023). The template provides a structured and tangible way for organizations to identify, understand, and organize the main components of their business model (Osterwalder, 2013). According to Murray and Scuotto (2015), the Business Model Canvas is a very suitable tool for organizations with a market-driven approach.

The Business Model Canvas template contains nine components useful for organizations to understand and define in the development of a marketing strategy (Adeniyi, 2023). The nine components are: *value proposition* that explains the value that the organization delivers to the customers, *key activities* that explains what key activities are required to create the value, *key resources* that explains what key resources are required to create the value, *key partners* that explains who the key partners are, what activities they perform, and what resources they provide, *customer relationships* that explains which customer relationships that need to be established and how to interact with the customers, *channels* that explains through which channels the customers should be reached, *customer segments* that explains the different types of customers and which ones that are most important, *cost structure* that explains the main costs that the organization have, and *revenue streams* that explains what the customers are willing to pay. Figure 2.3 provides a visualization of the Business Model Canvas and questions that can be helpful to better understand the nine components.

Figure 2.3: *The Business Model Canvas template (Adapted from Osterwalder, 2013).*

2.3.2 Technology Adoption Life Cycle

To understand the acceptance of new products and when different people adopt new technology, the *Technology Adoption Life Cycle* model can be used (Moore, 2014), as seen in Figure 2.4. This model describes the market penetration of discontinuous technological innovations, meaning that the innovation's introduction demands the users to change their present behavior and requires the current products and services in use to be altered. To develop a high-tech market, Moore (2014) explains that the curve should be worked from left to right, focusing on getting established and growing in one segment before moving on to the next.

Moore (2014) describes that the model consists of five distinct segments: *innovators*, *early adopters*, *early majority*, *late majority*, and *laggards*. Each group responds differently to new technology and discontinuous innovations, and according to Moore (2014), it is vital to understand all groups to gather a solid foundation for high-tech marketing. *Innovators* constitute the smallest market segment group, but they are important to win over at the start of the marketing program. New technology intrigues innovators and they are interested in adopting and exploring new product offerings. *Early adopters* are also open to adopting new technologies early on, but compared to innovators they are not technologists. This group bases their buying decision on intuition and vision, and they adopt an innovation if it seems beneficial to them and if they see potential in it. The *early majority* are somewhat interested in technology, but they wait for others to try out the innovation before they buy it themselves. About one-third of the total buying population of a market segment belongs to the early majority, as well as the next group, the *late majority*. The late majority do not buy the product until it has been an established standard as they are not fully comfortable using technological products. Finally, the *laggards* do not want anything to do with new technological products, for instance, because of personal or economic issues.

Therefore, according to Moore (2014), this group is often not worth considering in the marketing program.

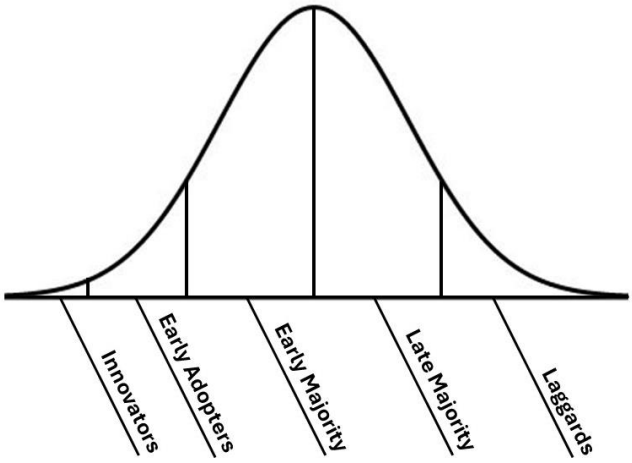


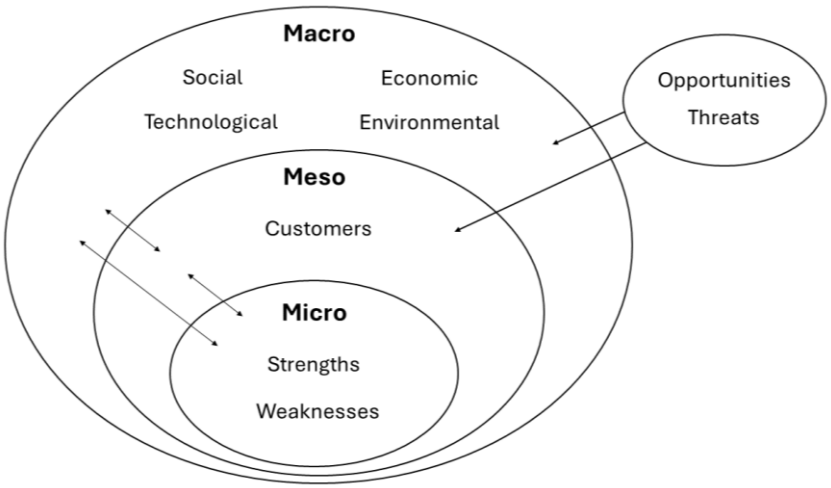
Figure 2.4: *The Technology Adoption Life Cycle (Adapted from Moore, 2014, p.15).*

2.4 Analytical Framework

An analytical framework was developed to analyze the empirical data. It consists of two parts. The first part was used to analyze the beekeeping market, and the next part was used to develop a market strategy for Ericsson. The analytical framework is visually presented in Figure 2.5.

The first part of the framework consists of combined methods to analyze the beekeeping market. The multi-level approach was applied to analyze the market through the micro, meso, and macro perspectives, as presented by Melander and Lind (2022). This was done to gather an understanding of the individual firm's resources at the micro level, the business relation at the meso level, and external factors at the macro level. At the macro level, parts of the PESTEL model (Washington State University, 2023) were applied to analyze technological, social, economic, and environmental factors, as these were the most important macro-environmental factors to consider for the connected beehive innovation. The technological aspects needed to be considered since the project regards a new technological innovation, the social aspects of the macro-environment are vital to analyzing the social aspects of beekeeping, the economic factors are vital to understanding the economic environment of the market, and the environmental aspects are important to include sustainability factors and how the environment affects the innovation and beekeeping in general. Regarding the meso level, the network and relations of the customers were considered since the customers are the most important actors within the business network for this study. At the micro level, the internal factors of the SWOT analysis model (Jobber & Ellis-Chadwick, 2020) were applied, to analyze the strengths and weaknesses of Ericsson's connected beehive innovation. Consequentially, opportunities and threats, the external factors of the SWOT analysis, were considered for the macro and meso levels analyses.

The second part of the framework is used to develop a market strategy for Ericsson. Here, five parts of the Business Model Canvas (Adeniyi, 2023; Osterwalder, 2013) have been used, specifically value proposition, customer segments, revenue streams, channels, and key partnerships. These areas, along with their corresponding questions, were considered to be most suitable to take into account for Ericsson in the project's current state.



Value Proposition	Customer Segments	Revenue Streams	Channels	Key Partnerships
What value should the product deliver to the customers? What customer needs and problems should the product address? What product should be offered to each customer segment?	For whom should the product create value? What are the different customer segments? Who are the most important customers?	What are the customers willing to pay? What should the pricing strategy be?	Through which channels could the customers be reached?	Who are the potential key partners?

Figure 2.5: *Visual representation of an analytical framework for market analysis and market strategy.*

3 Methodology

In this chapter, this study's methodology is presented. First, the study's research design is introduced, followed by a presentation of the study's data collection and analysis methods. Additionally, trustworthiness and ethics are discussed.

3.1 Research Design

The most used distinction of strategies within business research, according to Bell et al. (2022), are qualitative, quantitative, or mixed methods. Qualitative research methods are based on verbal- or written data collection and emphasize words and images rather than numbers and quantification (Bell et al., 2022). Additionally, qualitative research focuses on the understanding of the social world and people's points of view. On the contrary, quantitative research methods emphasize quantifiable and numerical data collection, which can be used to analyze social phenomena and their relationships (Bell et al., 2022). A mixed-method study includes both approaches.

Furthermore, the research approach of a study can be either deductive or inductive (Bell et al., 2022). Deductive approaches begin with a theory or hypothesis which is tested throughout the study, whereas in inductive research, broad generalizations and theories can be drawn from observations. Moreover, deductive approaches are often linear, meaning that the next phase of the study begins only when the previous phase is done. For instance, the data collection can only be done after the hypothesis has been set and thereby the hypothesis cannot be changed. However, inductive approaches can be iterative, implying that the researcher can alternate between the data and theory phases continuously.

Since this study's aim includes analyzing the beekeeping market's needs and challenges and developing a suitable market strategy for Ericsson, without a predefined hypothesis, the inductive approach was the most suitable for the research. Also, the research questions were continuously refined throughout the study, hence an iterative approach was taken. According to Bell et al. (2022), qualitative methods are the most suitable to use in line with the inductive approach. Therefore, qualitative methods such as interviews were used, and the emphasis was put on verbal information. As previously mentioned, Bell et al. (2022) explain that qualitative methods are appropriate to formulate an understanding through individuals, therefore, the qualitative approach was decided to be a suitable approach to analyze the beekeeping market. In addition, this study includes one quantitative method as the respondents were asked to answer a Kano model survey as well.

3.2 Data Collection

To collect data for this study, both primary and secondary data were utilized. Primary data was collected through interviews and a Kano survey. Secondary data was collected by reviewing literature. Simultaneously as the data was collected, a definition list was

compiled to explain certain beekeeping terms to the readers. The definition list was developed through multiple sources to form an understanding of beekeeping terms relevant to this study.

3.2.1 Literature Review

Conducting a literature review is an essential part of a study to understand what has already been researched on the topic and to form a foundation for the study (Bell et al., 2022). Hence, secondary data about market analysis, market strategy, apiculture, and beekeeping practices was collected by searching for articles and academic books in databases like Chalmers Library, Google Scholar, and Google. The literature search included keywords such as "apiculture", "beekeeping", "beekeeping practices", "business model", "market strategy", and "market analysis". The literature review was an iterative process throughout the project and all literature was carefully reviewed. According to Bell et al. (2022), critically reviewing the literature is of high importance to ensure a high level of trustworthiness.

3.2.2 Interviews

Semi-structured interviews with a predefined thematic framework were utilized to collect primary data to analyze the market for technological solutions within beekeeping. To gain a true understanding of the respondent's point of view, Bell et al. (2022) argue that semi-structured interviewing is a useful data collection method since it generates rich and detailed answers. The interviewer has a lot of freedom to adjust the interview questions to emphasize what the respondent believes is most important to explain, rather than to risk leading the respondent in a certain direction based on preconceptions, which might happen during fully structured interviews (Bell et al, 2022). Capturing the respondents' perspectives was very important for this study to truly represent the beekeepers' needs and challenges in the beekeeping market.

Before the semi-structured interviews were conducted, interview guides were prepared. Open-ended questions connected to specific themes were formulated. These themes include general information about the respondent, the respondent's work process when beekeeping and its potential challenges, the respondent's experience regarding technological beekeeping solutions, and presenting and discussing Ericsson's solution. Furthermore, the questions were placed in a logical order in the interview guide, but the interviewers were prepared to be flexible and asked the questions in a different order if it was more suitable during the actual interview. The interviews always began with the interviewers introducing themselves and giving a brief introduction to the project, followed by some introductory questions for the respondents that were simple to answer to make them feel comfortable. More elaborative questions were asked later during the interview. The questions were open-ended in their character since, according to Bell et al. (2022), open-ended questions allow the respondents to answer more freely and in detail compared to using closed-ended questions. In total 22 interviews were carried out either in person or online using Microsoft Teams depending on where the

respondent was located. All interviews were recorded, after the respondents gave their consent, to be able to go back and review what was said. Furthermore, the interviews were transcribed with the transcribe function in Microsoft Teams for the interviews held on Teams, and with the transcribe function in Word for the interviews that were held in person. Before conducting the interviews, an initial pilot interview was carried out. According to Bell et al. (2022), piloting is a way of ensuring that the data collection method functions well and provides the interviewers with experience and a greater sense of confidence for the actual interviews. After the pilot interview was completed, the interview guide and setup were reviewed and assessed to be good and well-functioning. Hence, the pilot interview was utilized in the study's final sample, and the following interviews were carried out similarly.

When selecting the sample for the research a generic purposive sampling method was applied. This means that the sample was selected based on criteria that are connected to the research's aim and allow the research questions to be answered (Bell et al, 2022). The criteria for this study were that the respondent is a beekeeper, and it was desired to reach beekeepers with widespread perspectives, experiences, and geographical locations within Europe and the US. Some respondents were contacted through Ericsson's previous connections with beekeepers. To find additional suitable respondents, the study's authors sent emails to multiple beekeepers found online and published a Facebook post on a Facebook page for beekeepers. Additionally, the snowball sampling technique was applied, meaning that the primary chosen respondents were asked to propose other respondents who they believed were relevant to the study. A risk with this sampling technique is that the sample might not represent the entire population since respondents are likely to recommend other respondents similar to themselves (Bell et al, 2022). To mitigate this risk, a sample representing different market segments was chosen from the start. The final sample with 22 respondents is visible in Table 3.1.

Table 3.1: *The interview sample of the 22 interviewed beekeepers. The beekeeper's location, age, years of experience, and number of apiaries and hives are presented.*

Interviewee	Location	Age	Beekeeping experience	Number of apiaries & hives
Commercial Beekeeper 1	Sweden	54 years	6 years	16 apiaries, 70 hives
Commercial Beekeeper 2	Sweden	25 years	5 years	7 apiaries, 70 hives
Commercial Beekeeper 3	Sweden	48 years	15 years	30-40 apiaries, 500 hives
Commercial Beekeeper 4	Sweden	54 years	5 years	8 apiaries, 60 hives (soon 450 hives)
Commercial Beekeeper 5	Spain	62 years	42 years	10 apiaries, 45 hives
Commercial Beekeeper 6	Florida, US	49 years	20 yers	6000 hives
Mid-level Beekeeper 1	Alabama, US	64 years	4 years	2 apiaries, 38 hives
Mid-level Beekeeper 2	California, US	65 years	7 years	100 hives
Mid-level Beekeeper 3	Sweden	50 years	16 years	3 apiaries, 19 hives
Mid-level Beekeeper 4	Sweden	45 years	7 years	11 apiaries, 50 hives
Hobby Beekeeper 1	Spain	Unknown	3 years	1 apiary, 5 hives
Hobby Beekeeper 2	Sweden	68 years	28 years	4 hives
Hobby Beekeeper 3	Sweden	58 years	18 years	5-6 apiaries, 15 hives
Hobby Beekeeper 4	Sweden	43 years	3 years	2 apiaries, 8 hives
Hobby Beekeeper 5	Sweden	50 years	5 years	1 apiary, 4 hives
Hobby Beekeeper 6	Ohio, US	55 years	22 years	1 apiary, 4 hives
Hobby Beekeeper 7	Alabama, US	67 years	+20 years	1 apiary, 7 hives (had 4 apiaries, 70 hives)
Hobby Beekeeper 8	Alabama, US	23 years	3 years	1 apiary, 20 hives
Hobby Beekeeper 9	California, US	47 years	10 years	1 apiary, 6 hives
Hobby Beekeeper 10	Sweden	63 years	11 years	1 apiary, 5 hives
Hobby Beekeeper 11	Finland	42 years	4 years	5 apiaries, 15 hives
Hobby Beekeeper 12	Ireland	Unknown	+15 years	1 apiary, 3 hives

3.2.3 Kano Survey

The Kano model, which can be seen in Figure 3.1, is a tool that can be used to prioritize customer requirements and understand their impact on customer satisfaction (Hellström & Olsson, 2017). The requirements are classified into five distinct categories, namely: *must-be* requirements, *one-dimensional* requirements, *attractive* requirements, *indifferent* requirements, and *reverse* requirements (Mcshane-Vaughn, 2023). The *must-be* requirements are attributes that the customer assumes will be there, and if they are not the customer will be disappointed or not purchase the product at all. The *one-dimensional* requirements are expected to be fulfilled to a certain level, and anything that exceeds that level will increase customer satisfaction. The presence of *attractive* requirements increases customer satisfaction, but the requirements are not expected. Hence, the absence of attractive requirements will not cause dissatisfaction. *Indifferent* requirements do not cause either satisfaction or dissatisfaction if present and the *reverse* requirements are functions that the customers do not want since they cause dissatisfaction if present.

In this study, the Kano model was utilized to gain insight into the beekeepers' prioritization of different functions of Ericsson's connected beehive according to these five categories. A Kano survey was designed and sent out to all respondents participating in the study right after their interviews were completed. It contained ten different functions Ericsson's connected beehive possibly could include. These functions were: Varroa mite levels, the status of the queen bee, the bees' food supplies, swarming detection and prediction, intruder detection, robbing detection, honey production, pollen levels, type of pollen, and an overview function. At the end of each interview, the Kano model concept was explained, and the respondents were also allowed to ask any questions they had while completing the survey since the interviewers stayed in the Microsoft Teams calls when the surveys were answered.

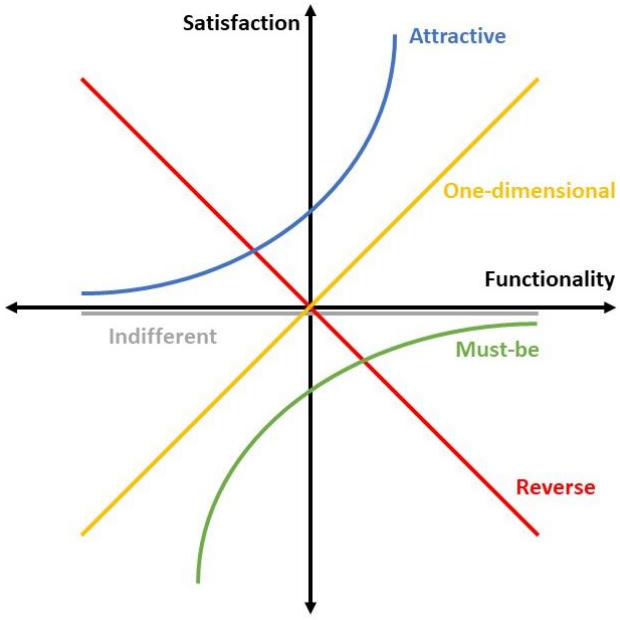


Figure 3.1: *The Kano model (Adapted from Kano et al., 1984).*

3.3 Data Analysis

A thematic analysis was made for the primary and secondary data. However, the answers to the Kano survey were analyzed separately.

3.3.1 Analyzing the Interviews and Literature

To analyze both the data collected through interviews and the literature review, a thematic analysis was performed. According to Bell et al. (2022), this includes finding themes or codes within the qualitative data by for instance looking for repetitions, similarities, differences, and transitions within the data. Therefore, the themes developed for this study were based on topics recurring often in the data and by searching for patterns in the collected data. Also, similarities and differences among interview respondents formed different themes. To ensure the themes were relevant to the study, they were compared to the research questions and the study's aim.

3.3.2 Analyzing the Kano Surveys

The Kano survey was analyzed to determine what classification the different functions of Ericsson's connected beehives belong to. Firstly, the respondents' surveys were analyzed individually to determine each function's classification for each respondent. To do this, the Kano evaluation table was used, which can be seen in Figure 3.2. Thereafter, all respondent's results were combined to compile the overall classification of each function.

Customer requirements → / ↓		Dysfunctional form of the question				
		1. I like it that way	2. It must be that way	3. I am neutral	4. I can live with it that way	5. I dislike it that way
Functional form of the question	1. I like it that way	Q	A	A	A	O
	2. It must be that way	R	Q	I	I	M
	3. I am neutral	R	I	I	I	M
	4. I can live with it that way	R	I	I	Q	M
	5. I dislike it that way	R	R	R	R	Q

Customer requirement is...

A: Attractive
M: Must-be
R: Reverse
O: One-dimensional
Q: Questionable result
I: Indifferent

Figure 3.2: *The Kano evaluation table (Adapted from Shiba et al., 1993).*

3.4 Trustworthiness

Four *trustworthiness* criteria, namely *credibility*, *transferability*, *dependability*, and *confirmability*, can be used to evaluate qualitative research, according to Bell et al. (2022). *Credibility* is high if the collected data is a true representation of reality, and to improve it in this study, all interviews were recorded and transcribed to base the data analysis on the respondents' own words. The *transferability* regards whether the study can be generalized to other contexts. In this study, the goal was to get a diverse sample and a sufficiently large sample size to make the study generalized in the US and Europe. It would have been preferable to include all US states and European countries in the sample to ensure fully generalizable results, however, due to time limitations this was not possible to achieve. Moreover, *dependability* implies that the same result would be achieved if the study were performed once again on another occasion. To ensure this within this study, the researchers were transparent about how the study was performed, the research process was clearly presented, and all interviews were transcribed. Lastly, the interview analysis was based only on the recordings and transcriptions, without

letting the researchers' values and perceptions influence the findings, to achieve *conformability*.

Furthermore, the study's *trustworthiness* was strengthened by including multiple data collection methods, both interviews and a Kano survey. A total of 22 interviews with diverse types of beekeepers from various locations in the US and Europe were conducted, which strengthens the *transferability* of the results. All 22 interviewed beekeepers also answered the Kano survey, which was the goal. Moreover, the study's authors got the opportunity to visit an apiary during the project where they inspected and managed multiple beehives. This strengthened their understanding of beekeeping additionally.

3.5 Ethics

Bell et al. (2022) present four ethical principles: whether there is *harm to participants*, whether there is a *lack of informed consent*, whether there is an *invasion of privacy*, and whether *deception* is involved. The interview respondents were kept anonymous to prevent the risk of harm. To avoid a lack of informed consent, the interview's purpose was clearly presented to the respondents beforehand and they were given the possibility to ask questions throughout the interview process if something was unclear. Furthermore, the recording of the interviews only began once the respondent approved it to prevent invasion of their privacy. To prevent ethical issues of deception there was high transparency throughout the interview process and the study's aim as well as the interview's purpose was clearly presented before the beginning of each interview.

4 Empirical Findings

The empirical findings consist of both secondary data from literature and primary data collected through interviews with beekeepers and a Kano survey. The chapter includes an explanation of beekeeping, beekeepers' challenges, needs, and future plans, current technology within beekeeping, and an explanation of Ericsson's technological beekeeping solution along with the interviewed beekeepers' thoughts about it. Additionally, the results from the Kano survey are presented.

4.1 Apiculture – The Art of Beekeeping

Apiculture, often spoken about as beekeeping, is the practice of raising, managing, and maintaining colonies of bees and their hives (National Agricultural Library, n.d.). Apiculture also includes researching bees, honey production, and the production of other bee products (Kumar et al., 2022). Beekeeping is an important practice within agriculture. It is not only about producing honey and other bee products, many beekeepers also provide pollination services and raise bees, which contribute to food security and biodiversity (Starr, 2021). In 2020, the estimated market worth of the global honey market was approximately USD 9.2 billion (Kumar et al., 2022). The largest consumer base of honey and other bee products is present in Europe and North America, although rapid growth of the honey market is projected in the Asia-Pacific regions.

4.1.1 Common Types of Beehives

Several types of beehives are used among beekeepers. In both Europe and the US, movable-frame hives are commonly used (FAO et al., 2021). These types of hives can be opened and the frames can be removed, enabling beekeepers to examine what is happening inside the beehive and allow them to easier detect viruses and diseases. The movable-frame hives can be differentiated into two types of hives, specifically horizontal and vertical hives. The horizontal hives consist of one single wide chamber. On the contrary, the vertical hives are divided into chambers which are stacked on top of each other, making it possible for beekeepers to optimize the number of chambers suitable for the bee colony size. According to FAO et al. (2021), vertical hives are the most common worldwide, including Europe and the US.

4.1.2 Common Beekeeping Practices

Beekeepers play a vital role in keeping their bees healthy and productive by applying various beekeeping practices (Sperandio et al., 2019). Firstly, the selection of an appropriate location for the beehive needs to be determined (FAO, 2015), meaning that the beehive should not be exposed to pollution sources, cold winds, or humid environments. Moreover, the beekeeper should regularly inspect their bees to verify the health status of their colonies (FAO, 2015). However, in case of unfavorable weather conditions and during winter, these inspections should occur less frequently. Also, appropriate techniques to improve the well-being of the bees must be applied, for

instance, by feeding weak colonies or providing water supplies during summer. Beekeepers play a vital part in preventing colony failures by detecting changes in the bees' behavior and activity levels (FAO et al., 2021). By observing their hives and through experience, the beekeepers can detect early signs of unfavorable health conditions and behavioral distress.

Maintenance of the beehive is important to ensure the health of bees and prevent diseases since a weak colony increases the risk of robbing and illnesses (FAO, 2015). The beehive must have enough capacity for the number of bees in the colony to prevent swarming. Every bee colony's survival is dependent on the health of the queen (Amiri et al., 2017). Therefore, the beekeepers can regularly replace the queen once or twice a year to ensure a strong colony (FAO, 2015).

During the interviews throughout this study, 22 beekeepers were asked what key activities they perform when keeping bees. The answers varied somewhat depending on the location and number of beehives that the beekeeper had. It also became clear that different beekeepers prefer to take care of and maintain their bee colonies in diverse ways. However, some of the most frequently mentioned activities among the beekeepers interviewed in this study are presented in Table 4.1. The explanation of the activities is a summary of the beekeepers' combined answers.

Table 4.1: *Key activities the interviewed beekeepers perform throughout the year. This is a summary of the beekeeper's combined answers.*

Activity	**Explanation**
Varroa Treatment	The Varroa mite is a pest that causes a lot of harm to bee colonies. Most of the beekeepers interviewed in this study have Varroa mites in their beehives and do Varroa treatments at various times throughout the year. The most mentioned treatments are oxalic acid and formic acid.
Spring Inspection	Many of the interviewed beekeepers who are present in colder countries and states explained that they do spring inspections once it starts to get warmer. During the spring inspections, they ensure that the bees and the queen are alive, that the queen is laying eggs, if there are any diseases, and make sure that the bees have enough food.
Regular Inspections	Most of the interviewed beekeepers also perform regular inspections of their beehives, where they, for instance, look at the development of the colony, food levels, queen status, diseases, if there is any damage to the hives, and make sure that the hives have not been stolen.
Swarm Control	This is done by looking for new queen cells and making sure the bees have enough space. Beekeepers can add more boxes to the hives or split colonies to prevent swarming. Swarm controls are commonly done as a part of regular inspections.

Honey Harvesting & Extraction	This is done by most of the beekeepers interviewed, usually during the summer. However, in warmer countries and states, such as California, they can harvest honey throughout the entire year. Also, beekeepers can harvest honey multiple times during one season, and some beekeepers harvest specific kinds of honey.
Adding Boxes to the Beehive	This is done to create more space for growing colonies and to produce honey. If enough boxes are not added, there is a risk of swarming.
Feeding the Bees	This is commonly done before winter and in the spring. In Spain, they must also feed the bees during summer since the heat contributes to a small amount of vegetation during the summer.
Winter Preparation	The bees and the hives need to be prepared for winter to ensure the bees' survival. This can for instance include feeding the bees and cleaning the beehive.
Spring Preparation	Usually involves repairing and cleaning the hive and the material, like scraping of propolis.
Queen Breeding	Some beekeepers interviewed in this study make a business out of breeding queens. That is usually done during spring.

4.1.3 Global Factors Affecting the Market

The Varroa mite is a parasite that is one of the most significant threats to the health of honeybees and can have devastating effects on beekeeping (FAO et al., 2021; Locke, 2023). When the Western honeybee was introduced to the Asian Eastern honeybee the Varroa mite began to spread globally (FAO et al., 2021), particularly in Europe and North America in the early 1980s (Locke, 2023). As a result, beekeepers must apply mite treatments where mites are present to ensure the bee colony's health and survival, otherwise, the bee colony most likely would collapse and die (Locke, 2023).

Environmental threats are other factors influencing the beekeeping market. The climate affects both bees and the vegetation they are present in (FAO et al., 2021). Climate change can have devastating effects on bees since it can reduce the availability of nectar and pollen and cause flowering shrinkages over time. Therefore, bees have a harder time finding resources compared to before. Clearing of rich flowering plant areas is another aspect reducing the availability of the bees' resources since it reduces crop diversity. As a result, bees and other pollinators decline in those areas. Moreover, chemical treatments and overuse of pesticides reduce diversity and can directly cause bee mortality, according to FAO et al. (2021).

United Nation's 17 Sustainable Development Goals (SDG) aim to promote peace and prosperity for the planet and people through environmental, social, and economic aspects of sustainable development (United Nations, n.d.c). Some of the goals are more relevant to beekeeping and technological innovations. SGD 15, called "Life on land", regards conserving life on land and includes restoring and protecting ecosystems, stopping biodiversity loss, and sustainably managing forests (United Nations, n.d.b).

SDG 12, called “Responsible consumption and production”, includes sustainable consumption and production patterns, ensuring the usage of sustainable energy sources and responsible usage of resources (United Nations, n.d.a).

4.1.4 Social Aspects of Beekeeping

During the interviews in this study, most beekeepers mentioned that they are part of beekeeping associations and are part of a network of multiple beekeepers. Beekeepers collaborate with others and often help and support each other. Some interviewed beekeepers explained that they share equipment and knowledge with other beekeepers. In 2020, about 16000 beekeepers were part of Sveriges Biodlares Riksförbund (SBR) in Sweden (Regeringen, 2020). Out of those 16000 beekeepers, 3000 beekeepers operated through a beekeeping business. 3000 additional Swedish beekeepers were estimated to operate in Sweden who were not members of SBR, meaning that most beekeepers are part of SBR in Sweden.

4.2 General Information About the Interviewed Beekeepers

The interviewed beekeepers were asked to explain the purpose of their beekeeping. As seen in Figure 4.1, the most frequently mentioned purpose was giving back to society and contributing to pollination and local diversity. There were only some of the commercial beekeepers that did pollination assignments to earn money, most of the beekeepers did it because it is good for the environment and biodiversity. Another very commonly mentioned purpose was simply that it is fun and interesting. However, most of the beekeepers who mentioned that, as well as wanting to give back to society as their main purpose were hobby beekeepers. To make a living and produce honey and other bee products were commonly mentioned purposes among commercial beekeepers. Mid-level beekeepers usually do beekeeping as a hobby and have a small business from which they do not make a living. Specifically, one of the mid-level beekeepers aspires to make a living out of it one day. Some of the interviewed commercial beekeepers and a hobby beekeeper also teach beekeeping practices as part of their purpose with beekeeping.

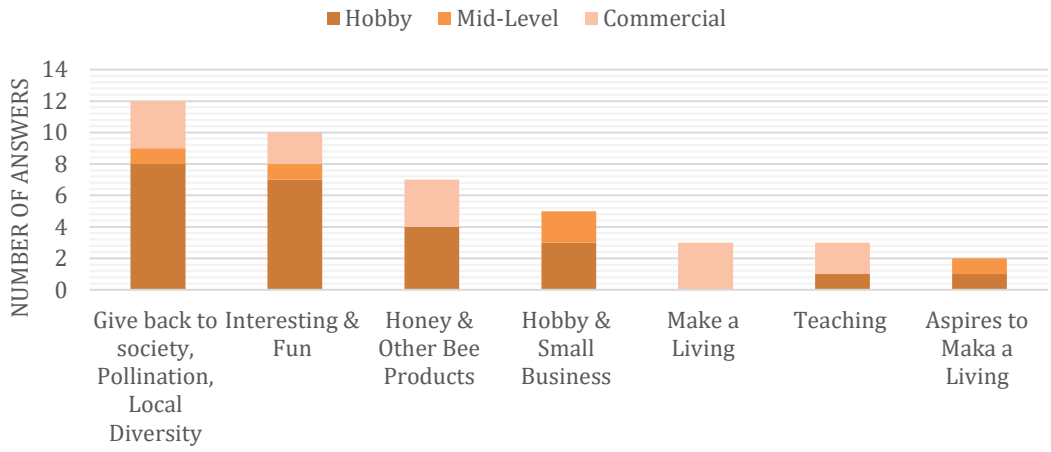


Figure 4.1: *The interviewed beekeepers' different purposes of their beekeeping. Some beekeepers mentioned multiple purposes.*

Figure 4.2 below shows the various kinds of products the beekeepers produce and how they vary between the three segments. Honey is the most common product, but queen and bee breeding is also quite common, especially among commercial beekeepers. Also, about half of the beekeepers interviewed produce wax. Other products that are not as common to produce are propolis, pollen, pollination assignments, beekeeping lessons, and royal jelly.

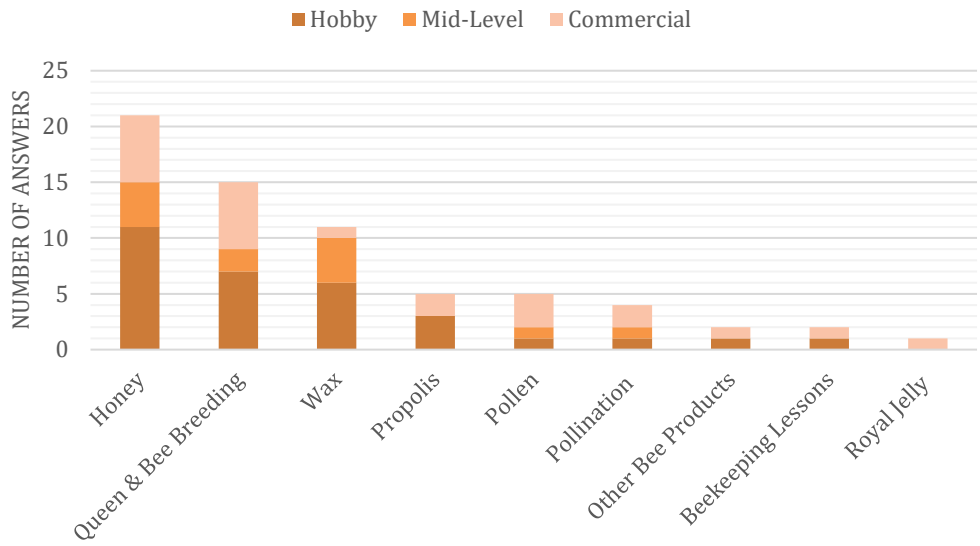


Figure 4.2: *Various products that the interviewed beekeepers produce. Some beekeepers produce multiple products.*

Out of the 22 interviewed beekeepers, 20 do sell some of the products that they produce, and the rest do not sell any products, they only use them themselves and give them away to friends and family. Some of the beekeepers who sell products also give away some of their products to their friends and family. Most beekeepers from all segments sell their products directly to the consumer. Four of them, two commercial, one mid-level, and one hobby beekeeper, sell their honey through grocery stores. Moreover, two commercial beekeepers sell honey together with other beekeepers through economic associations. Also, some beekeepers have their own smaller shop or sell products at farm shops. The ones who produce and sell bees do so directly to other beekeepers. However, as seen in Figure 4.3, there are only a few beekeepers who make a living out of their beekeeping. Some additional beekeepers aspire to make a living out of their beekeeping, while the majority prefer to keep it as a hobby.

Figure 4.3: *A visual representation of how many interviewed beekeepers make a living out of their beekeeping, how many aspire to, and how many do not.*

Furthermore, other general questions such as if the beekeepers move their beehives, if they have connectivity at their apiaries, and where the beekeepers purchase their equipment were asked to generate an understanding of whether the product must be movable, how widespread the connectivity is among apiaries, and what channels to buy equipment that are preferred among the beekeepers. As shown in Figure 4.4, most beekeepers do move their beehives. All commercial beekeepers do it, primarily because they do pollination assignments or to access different nectar flows. Most mid-level beekeepers and approximately half of the hobby beekeepers move their hives as well. All beekeepers have connectivity in their apiaries.

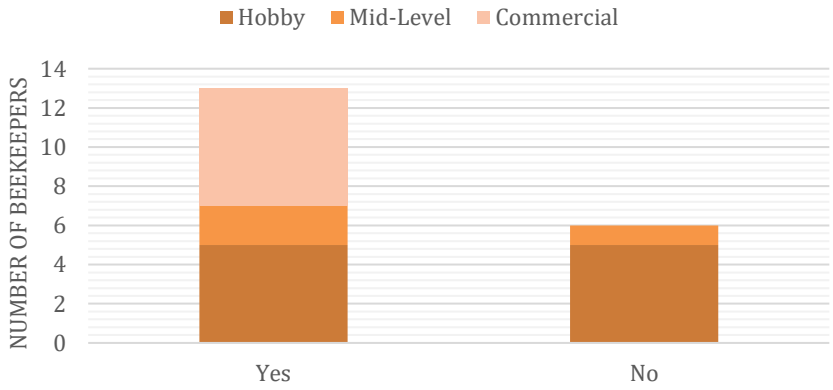


Figure 4.4: *The number of the interviewed beekeepers that move their beehives occasionally. Four beekeepers did not answer this question.*

Moreover, most of the interviewed beekeepers in both the US and Europe purchase their beekeeping equipment at local stores, a lot of them buy their equipment online, and some of them buy their equipment both in local stores and online. The most mentioned Swedish beekeeping stores were “MS Biredskapsfabriken” in Töreboda, “LP:s Biodling” in Säffle, and “Joel Svenssons Vaxfabrik” in Munka-Ljungby, as well as resellers to those companies. In the US, it is common for beekeepers to purchase equipment from “Mann Lake” and “Dadant and Sons”, which are two of the largest American beekeeping equipment companies, and from local stores. Moreover, three beekeepers manufacture their equipment themselves, one prefers to buy second-hand equipment, and one likes to purchase equipment at fairs.

4.3 Beekeepers' Challenges and Needs

The beekeepers' challenges and needs were examined in the interviews, where they were asked which parts of the beekeeping process they believed to be the most difficult and time-consuming. Also, they were asked what they think is the most difficult thing to detect while inspecting the status and health of the hives, as well as if there currently is something they cannot detect while inspecting the hives that they would be interested in knowing. Finally, they were asked which aspects of the beekeeping process they would like to get help with and why.

Honey Harvesting

The most time-consuming activity according to half of the beekeepers is the honey extraction process, and a few beekeepers also think this process is difficult to perform. This process includes removing boxes and frames of honey, removing the wax layer, filtering the honey, and bottling the honey into jars. Commercial Beekeeper 3 explained that *"Harvesting honey is intense, as you bring home boxes full of honey and need to extract it at home while at the same time bring back new boxes to the hives to produce more honey."*.

Inspections

According to the interviewed beekeepers, the second most time-consuming activity of beekeeping is the inspections which most beekeepers perform once a week during the summer period. These inspections are done to prevent swarming, check the queen's health, detect diseases and viruses, if some supplies are missing, and detect the honey levels inside the hives. Commercial Beekeeper 4 mentioned that the time required for the inspections is unnecessary as the inspections could be done remotely and the time saved could be spent on something else. Another commercial beekeeper, Commercial Beekeeper 3, said their hives are scattered around in multiple locations. All hives need to be inspected without knowing their status beforehand, resulting in many unnecessary travels to beehives that did not require any actions. This beekeeper further said *"It is difficult to keep up with everything. During summer it is very intense and there are many tasks to do at the same time."* Detecting swarm cells to prevent swarming is the most time-consuming and difficult part of the inspections according to multiple beekeepers. Specifically, five interviewed beekeepers think swarm prevention is difficult and four believe it is time-consuming. The beekeepers must manually inspect for swarm cells inside the hives, but they can sometimes be hard to detect according to a couple of beekeepers. Regarding this, Mid-level Beekeeper 1 said *"It is all about timing. It takes a lot of intuition and predictions of where the bees will be in two to four weeks to prevent swarms. The plan can also change. If the bees swarm you lose both the bees and the honey production."*

Heavy Lifting

Moreover, lifting boxes and beehives was mentioned by nine beekeepers to be a difficult part of the beekeeping process for them, specifically four of six commercial beekeepers, three of four mid-level beekeepers, and two of twelve hobby beekeepers. Multiple parts of the beekeeping process require much heavy lifting. For instance, checking for swarm cells to prevent swarming includes much lifting since the swarm cells are found deep inside the hive and the beekeepers must ensure all possible boxes are free from swarm cells. Also, extracting honey is heavy for the beekeepers as one box filled with honey can weigh a lot. Mid-level Beekeeper 3 said *"The boxes with*

honey are very heavy and it is tough for the body to bring it from the hive down to the ground. This is done two to three times a year as a professional beekeeper when you are going to extract honey, more if you check in the hive, but professional beekeepers usually do not do that. You need to carry the boxes ergonomically and try not to hurt the bees and make them angry. It is a stressful task and you cannot drop it while carrying it."

Planning

Another aspect four beekeepers, two commercial and two mid-level beekeepers, found difficult was planning. Commercial Beekeeper 1 said there is no clever way to keep track of the hives and plan, as this beekeeper currently uses paper cards to keep track of the planning and information of the hives. Moreover, Commercial Beekeeper 4 explained that unplanned things will always happen within beekeeping, requiring the current plan to change. This can for instance be due to swarming, the loss of a queen, or the weather outside, and these aspects will affect how the bees should be fed and when the honey should be harvested. Regarding feeding the bees, Mid-level Beekeeper 3 explained that you do not know how much food to bring to the hives beforehand, which results in unnecessary drives and transportation of resources. Furthermore, Mid-level Beekeeper 1 explained *"You can have a plan before you inspect the hive, but it changes when you look inside the hive."*

Varroa Mites

Only the two Spanish beekeepers interviewed mentioned Varroa mite controls when asked which activities are the most difficult and time-consuming within beekeeping. However, Varroa was also discussed as a problem during the interview with Commercial Beekeeper 6 from Florida *"We are struggling with the disease called the Varroa mite. It's been overtaking our industry and it's very, very hard to control it, even though we're trying everything we can."* For Hobby Beekeeper 1 from Spain, the Varroa treatment process included treatments with oxalic acid and counting the amount of Varroa mites inside the hives. Due to the warm climate in Spain, Varroa mites are an increased problem for beekeepers, according to Commercial Beekeeper 5 from Spain. Additionally, when asked what aspects of beekeeping the beekeepers find difficult to detect regarding the bees' status and health, a couple more beekeepers apart from the ones from Spain and Florida mentioned Varroa mites, especially regarding that it is hard to grasp how much Varroa mites are inside the hives. For instance, this was expressed by Commercial Beekeeper 3 who said *"It is difficult to get a feeling of how major the varroa attack is. If it is a major attack, you can see it on the brood frames or the bees, but then it is often too late to do something about it. Varroa is present in all hives, but it is hard to grasp the critical level of Varroa in a colony. You can take samples in some hives to count the mites, but the tests are not always correct. The amount of Varroa can differ within the same apiary."* Also, some beekeepers mentioned that mites and viruses are becoming resistant to their current treatments, which is a major problem.

Viruses and Diseases

The beekeepers were asked which part of the beekeeping they believe is the most difficult thing to detect regarding the bees' status and health, as well as if there currently is something they cannot determine when examining the bees' status and health that they would be interested in knowing. Bee sicknesses, viruses, and pests were the most frequently mentioned answers, as it was brought up by eleven of the beekeepers. These

sicknesses, viruses, and pests include Nosema, American and European foulbrood, wax moths, Varroa mites, chalkbrood, and small hive beetles. Many of the bee viruses are not visible or are too small to notice, which makes them difficult for beekeepers to detect before the bees die because of it. Hobby Beekeeper 7 expressed *"It is frustrating if all the bees have left a hive, but there is still honey and pollen left in the box. My guess is that there must be viruses in the wax that we cannot see, and that drove the queen to take off with the bees."*

Unknown Reasons for Unhealthy Bees

Another issue multiple beekeepers struggle with is figuring out the reasons for an unhealthy hive, for instance, why all the bees suddenly left the hive or why all bees died. This was mentioned during six interviews. Many beekeepers think it can be difficult to pinpoint the issue with the bees and believe that it is very frustrating. Commercial Beekeeper 6 said *"When we have a collapse that we don't understand, that's the most difficult. For example, I have several locations during the summertime, and last year, there was one location where we lost almost 80% of the hives and the bees dropped dead and we still don't know why. I got the state involved and we did the chemical testing, we did everything you can imagine testing-wise to figure out why the bees died. I mean, you just showed up and all the bees are dead in front of the hives and there are not any bees left inside the hives. To this day, we still can't figure out what it is. I have a bee yard a kilometer away from the same location and it was perfectly fine. It was doing exactly what it was supposed to do. So, for me, the hardest part is to not understand what is happening and why, what is the cause."* Some beekeepers believe the causes of an unhealthy hive could be due to undetected viruses inside the hives. A few beekeepers explained that mites are often used as the main explanation, as presented by Hobby Beekeeper 9 *"It is common to blame every issue on mites, but there are so many pests and issues that can cause an unhealthy hive."* Moreover, two beekeepers mentioned that it is difficult to predict an issue before it arises and before the bees begin to show signs that something is wrong. For instance, it is possible to miss the signs that the queen will leave the beehive soon according to Hobby Beekeeper 8.

Can not Determine Bee Status without Opening the Beehive

The bees' status and health cannot be determined without opening the hive. Consequentially, the bees' status is difficult to determine during the winter as the hives cannot be opened when it is too cold outside, which would cause the bees to die. Hobby Beekeeper 3 said *"It is hard to detect the status if you are not inspecting the hives, for example, if you would go on vacation for a month you would have no idea what has happened. […] I prefer to know their status by doing the inspections, even though the bees are disturbed."*

Additional Tasks for Which Beekeepers Seek Assistance

When asked what aspect of beekeeping the beekeepers would like to get help with, the most frequent answers included some way to monitor the beehive. It was mentioned by eight beekeepers. Some beekeepers wanted to know the status of the beehive without being required to inspect it manually and to minimize the number of visits to the apiaries during the busiest months in the summer. For instance, Hobby Beekeeper 1 stated *"It would be ideal to monitor the hive and get information and parameters about the hive without having to be there."* Also, six beekeepers want help with lifting boxes and hives,

as beekeeping includes much heavy lifting as mentioned before. Other aspects the beekeepers want assistance with are harvesting the honey, increasing security and surveillance of the beehive, and Varroa mites.

4.4 Beekeepers' Future Plans

Lastly, the beekeepers were asked what plans they have for their beekeeping in the future. Approximately half of them want to expand and increase the number of beehives, which beekeepers among all the different segments mentioned. Some current mid-level beekeepers want to become commercial, and some hobby beekeepers want more hives when retiring. Time and financial resources are the biggest challenges to expanding, while some beekeepers do not see any challenges to expand.

Also, some of the beekeepers want to expand their product offering, mainly by getting into the business of raising and selling bees. Hobby Beekeeper 4 mentioned that a challenge to do so is that the knowledge base about queen breeding is way lower compared to, for instance, producing honey. Making time for it was also mentioned as a challenge.

Wanting to optimize their way of beekeeping was also brought up by some of the beekeepers. According to Commercial Beekeeper 1 planning is important within beekeeping, which said *"To plan so you do not need to drive those extra travels, planning is the most important within beekeeping."* Mid-level Beekeeper 1 explained that planning is important to optimize honey production and generate as much profit as possible. It was also mentioned that you can save yourself from many unnecessary drives if you plan well. Hobby Beekeeper 8 said they would like to hire someone who can manage the hives while away, but it is hard to find people who want to do manual labor. Due to time concerns, two interviewed beekeepers want to scale down their beekeeping to enjoy it. Commercial Beekeeper 5 wants to make the business more modern and believes that a solution like Ericsson's could improve the beekeeping business greatly.

4.5 Technology Within Beekeeping

This section presents how experienced the interviewed beekeepers are with technological solutions within their beekeeping. The beekeepers explained what current solutions there are within the market and presented their thoughts on them.

4.5.1 Beekeepers' Experience with Technology

During the interviews, the beekeepers were asked if they had used any technology in their beekeeping, but the majority had not. Specifically, 17 beekeepers had never tried any technology in their beekeeping, while 5 beekeepers had tried it. Economic reasons were the main factor for why they have not used any technology since many beekeepers believe it is too expensive. Other factors for not using technology mentioned during the interviews were that they do not have any electricity in the apiaries, they do not feel a

need due to small-scale operations, had not had time to implement it, and they do not want any expensive technology in the hive due to an increased risk of theft. Although a small amount of the interviewed beekeepers had tried to use technology, most of them are open to using technology in the future if the usefulness is high enough compared to the price. Hobby Beekeeper 2 was the only one who initially did not want to use technology in the future due to their old age, however, the beekeepers' skepticism about technology decreased towards the end of the interview when more information about the solution was given.

4.5.2 Current Technology Within Beekeeping

Furthermore, the beekeepers who had tried technology in their beekeeping were asked to describe their experience. All other beekeepers were also asked if they had heard about any technical solutions within beekeeping and if they could share their thoughts about those solutions. The most mentioned technical aid the beekeepers had either used or heard about is beekeeping scales, which were mentioned by approximately half of the beekeepers. Many beekeepers described how the weight of the beehive is a good indication of the bees' strengths and health. The weight lets the beekeeper know, for instance, how much honey there is inside the hive, when they need to feed the bees, and when it is time to add another box on top of the hive. However, there does not seem to be an ultimate weight solution on the market yet. Commercial Beekeeper 4 shared their thoughts on the various solutions they are familiar with *"There are different types of bottoms that give you weight information, but that is not enough. I want more information, such as surveillance and monitoring of the hive. Those weight solutions are usually expensive compared to the benefits. The products I have seen also require you to visit the hive to look at the information, but I want to access the information remotely in a cloud-based service, to be able to see the status on the computer or my phone. There should be limits that warn you if something is wrong."*

Another type of technical solution that was mentioned quite frequently during the interviews was various kinds of technical aids related to Varroa mite control. "BeeScanning" is an existing AI tool that analyzes pictures of frames from beekeepers, and then lets the beekeepers know the amount of Varroa mites. Commercial Beekeeper 2 believes this could work and thinks it is great that you do not have to sacrifice any bees to do the Varroa mite testing. Both Commercial Beekeeper 1 and Hobby Beekeeper 5 had used "BeeScanning" and said that it did not provide them with correct information since it told them that there were no Varroa mites even though there were. Commercial Beekeeper 1 believes the reason was that many Varroa mites are hidden below the bees.

Also, some beekeepers had heard about different solutions that measure temperature, some of them with the help of an infrared tool. Mid-level Beekeeper 3 believes that measuring the temperature could be useful in research but does not think it is necessary for a beekeeper. Commercial Beekeeper 3 adds to that, by explaining that it is unclear

what to do with temperature and humidity data since beekeepers cannot do much about it anyway. The bees take care of the temperature and humidity themselves. Moreover, Commercial Beekeeper 2 talked about a solution called “Hive Heart”, which is placed inside the beehive and measures both the weight and temperature. This beekeeper believes it would be nice to see how the colony behaves without being required to visit the hive but has not tried “Hive Heart” due to the high costs. Commercial Beekeeper 1 also explained that they have a digital hive from “BeeLab” in their apiary. It has sensors that measure weight, temperature, humidity, and air pressure, but it has not been functioning since the app is not working properly.

Hobby Beekeeper 9 has tried a sound recording technology that records the sound of the bees to determine the queen’s status and the bee colony’s health. However, the product did not work properly, and the beekeeper explained how they had been a beekeeper long enough to determine the bee’s status by listening to the sound from outside the hive. This beekeeper also explained that bees in different locations have different accents, which must be considered when developing these solutions.

Some beekeepers have tried to develop their own technical solutions for their beehives. Commercial Beekeeper 5 tracks data on pollen and honey levels, the queen’s, and Varroa mites. Then they compare this information from year to year and between different weeks, it is a way for them to predict when they need to work in the apiary and how they can improve further. Mid-level Beekeeper 4 and a technology-interested person are developing a technical solution to measure the hive’s weight, temperature, and humidity. They are looking into the possibility of using cameras and doing a weather forecast. Moreover, Hobby Beekeeper 11 has tested some homemade solutions using frequency to detect swarming but says that a massive amount of data is needed for it to work.

Other technical solutions mentioned by the beekeepers are “Broodminder”, “BeeZum”, and “Know your honey”. A common theme among many beekeepers seems to be that they are curious about the benefits technology can generate, however, most solutions on the market are too expensive for them to make the investment worth it. Also, some beekeepers expressed concerns about technology not working properly, which can take away time from other things they must do.

4.6 Ericsson’s Solution

This section describes Ericsson’s solution, followed by empirical findings from beekeepers, which are categorized based on their perspectives on the solution.

4.6.1 Description of Ericsson’s Solution

Ericsson is developing a technological solution to enable beekeepers to see their bee colonies’ status remotely through a user-friendly application. The solution includes a beehive bottom board integrated with sensors, such as a camera, microphone,

thermometer, and scale, to gather data from the beehive it is applied to. By utilizing IoT and AI algorithms, the gathered data is analyzed to provide the beekeepers with useful information about the bee colonies' health and status. Thereby, the beekeeper is informed of various status updates and functions, such as:

- Varroa mite levels: The beekeeper would know how many Varroa mites are inside the hive.
- Queen's status: It would be possible to know if the queen is alive or dead and if she is laying eggs.
- Swarming: The solution will let the beekeeper know when the bees swarm and predict when the bees will swarm.
- Food levels: The beekeeper receives information about the food levels inside the hive, to know if the bees do not have enough food and have a starvation risk.
- Intruders: The beekeeper will be notified if there are any intruders inside the beehive. Possible intruders could be ants, hornets, or wasps.
- Robbing: The beekeepers will be notified if other bees are robbing the beehive, i.e., other bees steal the honey of the beehive.
- Honey production and nectar flow: The beekeeper would know how much honey the bees produce inside the hive, by detecting the nectar flow.
- Pollen: The beekeeper would know how much pollen the bees bring into the beehive. Also, it can detect what type of pollen the bees collect.
- Overview function: This function would provide the beekeeper with an overview of the state of health of the bees and ecosystem in a larger geographical area. For instance, you would see an overview of where Varroa mites, diseases, and nectar flows are present. For example, it would be possible to see infection spreading in various locations, meaning that beekeepers could take preventive actions against it. Also, it would be possible to see the nectar flow in various regions so the beekeepers would know when the honey production inside the beehive will start and end.

The beekeepers must replace their current bottom board with this new bottom board integrated with all the sensors. As it is designed now, the solution will fit the common vertical beehive models. Additionally, power supply is required at the apiary, for instance, through solar panels since many apiaries do not have access to power through cable. Moreover, wireless connectivity is required where the product is placed, enabling the product to collect and send data.

4.6.2 Beekeepers' Positive Impressions of Ericsson's Solution

During the interviews, the beekeepers received a description of the connected beehive that Ericsson is developing, how it is supposed to work, and what functions it will include. After receiving this description, the beekeepers got the opportunity to express their thoughts on the product. Both positive feedback and critical comments were received, and all the feedback is important for Ericsson to consider during the development of this solution.

Most beekeepers, from all the different segments, believed that having this solution would increase the efficiency and effectiveness of their work. Many beekeepers mentioned that they would not have to do as many inspections as they currently do, which would save them a lot of time and reduce the number of drives to the apiaries. In locations where there are warm summers and cold winters, most of the inspections are done during summer, so that is when the beekeepers would save most time. Hobby Beekeeper 12 also mentioned that getting an assessment of the hive's health during the winter when you usually do not inspect the hive would be useful. On the other hand, some beekeepers mentioned that it does not matter, since you cannot do much about it during the winter anyway. Moreover, Hobby Beekeepers 1, 3, and 11 mentioned that not having to open the beehive as often due to fewer inspections is good since bees do not like to be disturbed and you risk losing bees every time you open the hive. Hobby Beekeeper 3 even mentioned that decreasing the disturbance of the bee colony due to not having to open the hives as often could lead to increased honey production. Fewer inspections would also reduce the number of heavy lifts, which many beekeepers brought up as a big ergonomic problem.

Commercial and mid-level beekeepers also described how this solution would help them plan, reduce stress, and enable them to focus their work on the right things. As articulated by Mid-level Beekeeper 1 *"I don't focus on the strong hives; I focus on the hives that are in trouble. What you described gives me a tool to know where to go and prioritize my work."*

Furthermore, commercial beekeepers in Sweden described how getting the status on queen health and swarm prediction could be helpful when wanting to focus on specific beekeeping activities such as queen breeding. Getting the status of nectar flow is also described as a good indication of the possibility of collecting various kinds of honey, and information about pollen levels lets you know when you need to feed the bees. However, no hobby beekeepers mentioned benefits related to planning and the possibility to focus your work. However, Hobby Beekeepers 5 and 6 explained that it would make their life easier and enable them to go away for a week without having to worry that the colony would swarm.

Additionally, beekeepers from all the different segments saw opportunities to increase their production, increase their revenues, and save costs with the help of Ericsson's solution. As Hobby Beekeeper 10 articulated *"It is possible to be more effective, as you can harvest the honey and begin feeding the bees at the peak. Then you would increase the production levels."*

Some beekeepers also see the potential to reduce the number of hive losses, which would increase honey production and save them financial resources by not having to buy new colonies. Another cost saver mentioned by Commercial Beekeepers 1, 3, and 4 is fuel and driving costs. Additionally, Commercial Beekeeper 3 mentioned how

getting swarm predictions could reduce the number of emergency drives. Commercial Beekeeper 4 also explained that they could have more beehives due to the increased efficiency and effectiveness, which also means more honey production and more possibilities to increase profits.

Receiving the status of how many Varroa mites there are seems interesting for the beekeepers. Commercial Beekeeper 3 from Sweden and Commercial Beekeeper 5 from Spain mentioned that Varroa mites are the biggest problem for beekeepers in their corresponding countries. Another advantage pointed out by Hobby Beekeeper 5 is the possibility of tracking and analyzing the data day by day, which enables you to find fast changes, which would not be possible when inspecting the hives manually once a week.

4.6.3 Beekeepers' Critical Evaluation of Ericsson's Solution

Although the beekeepers saw many benefits with Ericsson's solution, they also expressed some concerns. The biggest one is the solution's price, which was brought up by more than half of the beekeepers. Ericsson does not have a price on the solution yet, however, many beekeepers were guessing that it will be high since this type of technology usually is expensive. Hobby Beekeeper 4 believes it will be hard to sell this kind of solution at a reasonable price to small-scale beekeepers. Some commercial beekeepers also saw the cost as a big problem, since it would be a huge investment to buy this solution for all their beehives.

The second biggest concern is energy supply. It could be challenging since some beekeepers explained how their apiaries are placed in rural areas, and installing solar panels will drive up the cost even more. Hobby Beekeeper 12 from Ireland also explained how they do not get a lot of sun during winter. Hence, large batteries would be necessary to store the energy and batteries tend not to like extreme temperatures, such as the cold in the winter. Also, if it is snowing, you must keep the snow off the solar panels, which adds extra work. Mid-level Beekeeper 4 from Sweden adds to that by explaining that exposure to weather and wind might be challenging when the technology is supposed to be outside and work all year around. However, Commercial Beekeeper 4 from Sweden said having solar panels in the apiary would not be a problem. Also, Commercial Beekeeper 6 from Florida explained that they already have solar panels in the apiaries to provide power for bear fences.

Beekeepers from various segments also expressed maintenance concerns, what they would do if the solution did not work as expected, and how expensive it would be to repair it. For instance, Commercial Beekeeper 4 would like a warranty on the product. If the solution stops working, Commercial Beekeeper 6 expressed concerns about being required to act as a technician, focusing more on fixing the device than acting as a regular beekeeper. Also, this beekeeper explained that there could be devastating effects on the beekeeping business if the solution provides false information or is not working as intended. Additionally, many beekeepers recommend Ericsson to keep the

solution simple and easy to use, since beekeepers usually are not that used to working with technology. Mid-level Beekeeper 3 does not want Ericsson to add a lot of unnecessary functions to the solution and thinks it is better to keep it simple and focus on the most necessary things and functions.

Another concern is the increased risk of getting the beehive stolen since many interviewed beekeepers explained that the beehives are valuable already, and it is relatively common for hives to get stolen. Multiple beekeepers believe that adding expensive technology to the beehives will increase the risk of theft. Hobby Beekeeper 7 wonders what would happen if the beehive got stolen and if it would be possible to track it and get it back.

A decreased need for inspections is not only seen as positive by the beekeepers. Hobby Beekeeper 7 believes that doing fewer inspections would result in lost knowledge over time and make beekeepers weaker. Hobby Beekeeper 3 adds to that by explaining how beekeepers would lose their own beekeeping sense by not visiting and looking inside the hives as often. Additionally, fewer inspections would also mean that you miss out on being aware of what is happening in the nature around the apiaries, this was explained by Commercial Beekeeper 3 *"If you decrease the number of inspections based on the data you also miss out on inspecting the nature around the hives. For example, you cannot see if the flowers will bloom soon and then miss that opportunity."*

Another issue expressed by a few beekeepers is that Ericsson's solution does not fit all kinds of beehive models. Two of the interviewed beekeepers had beehive models not compatible with the solution Ericsson is developing. Some beekeepers, one being Mid-level Beekeeper 2, also mentioned a risk that the bees will cover the technology inside the beehive with propolis. Moreover, Hobby Beekeeper 6 believes that it is necessary to experiment and test if the electric frequency affects the bees in any way. If it does not, this beekeeper believes the tool would be very helpful.

The strongest criticism against the solution was expressed by Hobby Beekeeper 9 from California, who believes that the solution is very idealistic and that humans do not have enough knowledge about bees to apply an AI model to it. *"I don't know how you can apply any technology to our current knowledge base that can enhance beekeeping. Our understanding of the bees isn't there to translate it into technology. You can't apply AI to something that we don't know of yet. If we don't have the intelligence of it, then you can't apply that to any type of thing. It is going to be false because we don't have research enough to figure that out."*

4.6.4 Suitable Users of Ericsson's Solution

Some beekeepers discussed what type of beekeeper Ericsson's solution is the most suitable for. Hobby Beekeeper 4 did not believe themselves to have enough beehives to make the investment worth it, as this beekeeper had two apiaries including eight

beehives. In addition, Mid-level Beekeeper 1 expressed that the solution probably would make a bigger impact for beekeepers with bigger operations "*If you're only running a couple of hives I don't know that I see a lot of value, but for me running 30 hives, the more information I'm going to have and prioritize my time and where I go and what I'm going to do, helps me be more effective when I get to the apiary and know what my job for the day is."* This argument was agreed upon by Mid-level Beekeeper 3, who believed that the price would be a major drawback for hobby beekeepers and that the solution would be more beneficial for commercial beekeepers who make a bigger profit from their beekeeping. Commercial Beekeeper 4 thought the connected beehives could be established for two tracks. Firstly, for hobby beekeepers who find the solution cool and exciting, and secondly, for commercial beekeepers who would save on it financially. However, Commercial Beekeeper 6, which has 6000 beehives, did not think the solution would be suitable for commercial beekeeping and thought it would have a better potential with hobbyists "*I don't see it happening for the commercial operation. It will target more like the sideliners or small hobbyists. […] Let's say your product cost a couple $100. For beekeepers that have it as a hobby, they are willing to spend that kind of money to install that device on their hive. But for us, the commercial beekeepers, it's almost impossible to do that."*

4.6.5 Savings Generated by Ericsson's Solution

When asked what the beekeepers would save financially by having this connected beehive, most thought they would save multiple costs but thought it was hard to know exactly how much and in which aspects. However, two hobby beekeepers did not think they would save anything by having the solution within their small-scale beekeeping. Also, Commercial Beekeeper 6, who was quite skeptical about the solution overall, said *"What would I save? I don't know... I mean, I just heard about the product… If everything works 100%, there are huge savings, but obviously, with technology, nothing works 100%. So, the question is what works and what doesn't."*

The major thing the beekeepers thought they would save by having Ericsson's solution was fewer colony losses, which was mentioned by eight beekeepers. Firstly, fewer colonies would be lost due to swarm prevention since when the bees swarm, the beekeeper loses both the bees, the queen, and the upcoming honey production. Secondly, some beekeepers believed the solution would make it possible for them to optimize how much to feed the bees, saving money on both resources and fewer deaths caused by starvation. Thirdly, colonies can die due to Varroa-related sicknesses. If the solution can prevent the loss of a bee colony due to one of these reasons, the beekeepers explained that they would save money since a bee colony is worth approximately 2000 SEK according to some of the beekeepers. Commercial Beekeeper 3 explained that a bee colony is worth more in the spring before the honey is produced than at the end of summer. "*A bee colony is worth a couple of thousands. 5000 SEK in the spring before producing 50kg of honey, and 1000 SEK in the fall."* Moreover, if fewer colonies were lost, some beekeepers said they would gain more profit by being able to produce more

honey. Commercial Beekeeper 4 said that if the bees swarm, you lose 15-20 kilograms of honey which could have been sold for about 4000 SEK.

Furthermore, many beekeepers thought major savings could be made by saving time and less traveling. Specifically, six beekeepers from different segments thought they would save time, and five commercial beekeepers thought they would save financial resources on less traveling. Mid-level Beekeeper 3 said *"I am sure this product would help to create more time in the business and beekeeping, so you would generate more profit."* Regarding traveling, all Swedish commercial beekeepers thought they would save car fuel costs and car wear by not being required to visit their apiaries as often. Commercial Beekeeper 4 did a fast calculation and figured out saved car fuel costs of 4000 SEK and saved labor costs by less traveling of 10000 SEK a year.

4.6.6 Willingness to Buy Ericsson's Solution

During the interviews, beekeepers were also asked if they would be open to buying or leasing this type of solution. The majority, more precisely 13 beekeepers said yes, 6 said maybe, and 2 said they were not open to buying or leasing this type of solution. Most beekeepers who expressed willingness to purchase or lease the solution emphasized that their decision would ultimately depend on its cost-effectiveness, as the solution must provide economic benefits. The price was also a major concern for those who answered maybe.

However, Hobby Beekeepers 4 and 10 articulated that they would consider buying it since they are very interested in technology and believe that it is a fun and cool product, more than they believe it would be financially beneficial for them to have this solution as small-scale hobby beekeepers. Furthermore, Commercial Beekeepers 3 and 4 explained that if they invest in this product, they would probably only use it on a few beehives per apiary since the investment would be too big if they were going to use it on all the beehives. This way it would be more affordable and give an approximate indication of how all colonies are doing, but then there is a risk that the data will be misleading since there is no guarantee the status is the same for all the other beehives that are not connected. Some beekeepers also explained how they wanted to see effective results of how the solution works before they considered investing in it. Hobby Beekeeper 7 said *"I wait for everybody else to buy and try it for a couple of years, and then I might buy it."*

Hobby Beekeeper 9, one of the beekeepers who were not willing to invest in the solution, explained that the main reason for that is that this beekeeper does not believe that people have all the required knowledge about bees to be able to apply AI to it, hence the solution would not be reliable. This beekeeper believes that a better strategy for Ericsson would be to sell a security product for beehives since the theft of beehives, unfortunately, is common. If it was a security item, this beekeeper might be willing to invest in it. As Hobby Beekeeper 9 chose to put it *"So as a marketing sales pitch, I'm*

not sold on it. Right now, there's not a price that I would pay for it because I just know from doing all the research and knowing that this type of AI is not there yet. So you're selling it as an AI that can do everything for me, that's bull shit because, with all the knowledge we have about bees, we don't have enough data to do those analytics against it. So, if you're selling me a security item or something else, then I might be willing."

The other beekeeper that was not willing to buy this type of solution was Commercial Beekeeper 6 from Florida who has about 6000 hives. This beekeeper thought buying it would be too big of an investment for them and thought it would be better suited for hobby beekeepers than commercial beekeepers. *"I think you'll have a better potential with the hobbyist, which is the market of basically people that have a couple hives or up to 10 hives in their backyards. But in the commercial industry, I have seen and I do believe that something like this will help us, but at the same time, it needs to make sense to us why we can spend that kind of money."*

4.6.7 Willingness to Pay for Ericsson's Solution

Thereafter, the beekeepers were asked if they preferred a one-time investment or a monthly subscription to pay for the solution. Some beekeepers thought that both options would work and explained that it depends on the different contracts and what the two options include. For instance, Commercial Beekeeper 4 explained that leasing would be in favor if updates and services are included, however, if the solution is simpler, it could be more beneficial to pay for it one time and discard it every three to five years. Also, Hobby Beekeeper 10 said they would choose the cheapest option of the two. Nine of the interviewed beekeepers favored a one-time investment, for instance, due to avoiding monthly payments and since they preferred to own their equipment themselves. Moreover, five beekeepers preferred to lease and pay monthly for the solution. Specifically, Hobby Beekeeper 7 said a leasing agreement including maintenance would be good. Two of these five beekeepers who preferred to pay monthly, Mid-level Beekeeper 1 and Mid-level Beekeeper 3, preferred to rent the solution to be able to try it out first. Mid-level Beekeeper 1 said *"Leaning toward leasing, to pay as I go and is not stuck with the product if it does not work for me. It would be possible for me to put more of the products in service if I'm leasing versus buying."*

Moreover, the beekeepers were asked what they thought they would be willing to pay for this solution, either as a one-time investment or a monthly subscription. Although most of the beekeepers indicated an approximate value of their willingness to pay, four beekeepers found it difficult to provide a specific price during the interview or did not want to. Hobby Beekeeper 8 explained that they could not provide a price since there are too many uncontrollable variables to say yes to such an investment, for instance, the weather will affect how much honey is produced to make up for the investment. Moreover, Commercial Beekeeper 6 did not want to provide a price and explained *"It*

will be worth a lot of money for me if I know the product works. But till then, there's no way I can give you a price."

Most beekeepers only presented what they would be willing to pay as a one-time payment, some only per month, and a few mentioned both options. The results of the one-time investment and the monthly willingness to pay can be seen in Figure 4.5 and Figure 4.6. It is important to remember that these diagrams only indicate the willingness to pay, as most beekeepers only presented an approximate price without explaining how long they expected the hardware to last and what was included in the offer. For instance, Mid-level Beekeeper 3 explained that the price depends on how long the hardware lasts, how the customer service is, what happens if the hardware breaks, and if service and guarantees are included. If there is a monthly subscription for the solution, this beekeeper thought customer service, repairs, and software updates should be included in the price. Commercial Beekeeper 1 was willing to pay up to 5000 SEK if a solar panel is included, however, only if the hardware lasts at least so long to get the investment back. Mid-level Beekeeper 1 said that if the solution prevents the bee colony from dying in one hive, $50 a year is saved just on honey production, and came thereby up with a monthly price between $5-7.5 per hive for the solution. Moreover, Hobby Beekeeper 10, who presented themself as a technical nerd, explained that if the solution costs 2000 SEK they would buy five of them for all five hives. However, if it costs 5000 SEK they would only buy one.

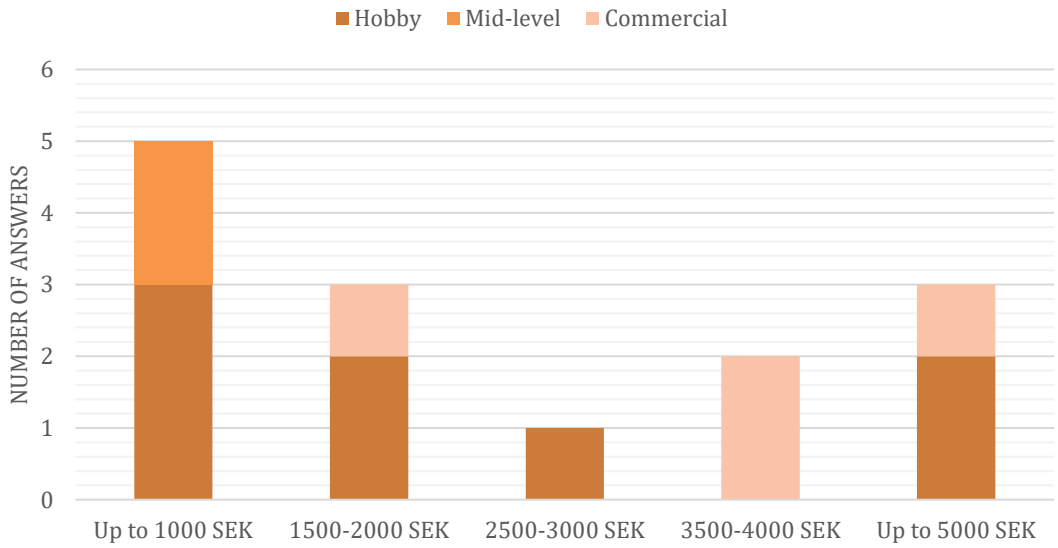


Figure 4.5: *Willingness to pay, one-time investment. All interviewed beekeepers did not answer this question.*

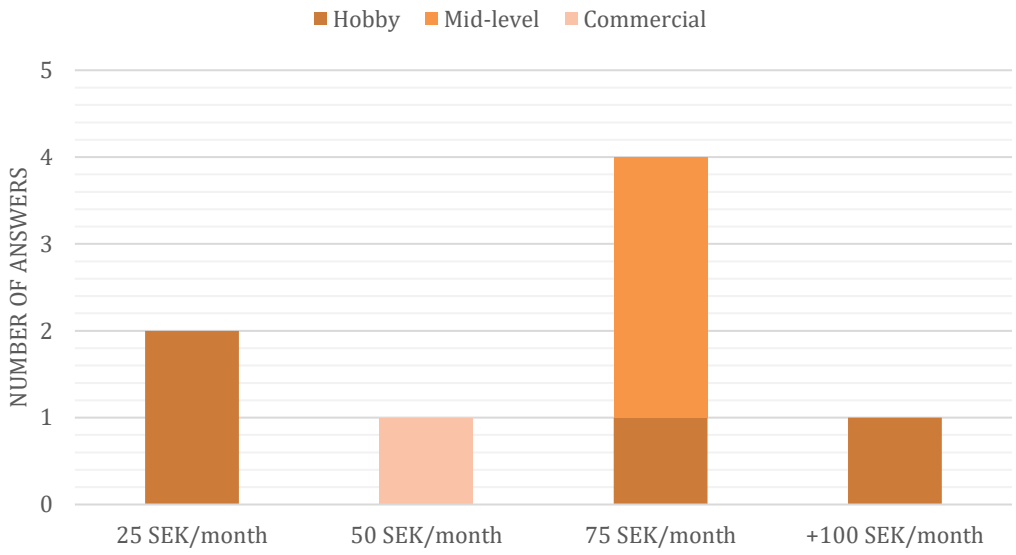


Figure 4.6: *Willingness to pay, monthly subscription. All interviewed beekeepers did not answer this question.*

4.6.8 Additional Functions the Beekeepers Would Appreciate

The beekeepers were asked if any other functions would add value for them, than the ones Ericsson is currently planning to include in the solution. About one-fourth of the beekeepers would like some protection against hive theft. Cameras, geofencing, burglar alarms, and GPS trackers were mentioned as possible solutions. Hobby Beekeeper 9 from California stated *"There is a huge issue with people stealing beehives in the US. Beekeepers lose a lot of money due to this. Security would be very important for a product like this."*

Moreover, American foulbrood was quite frequently brought up as one of the worst things that could happen to an apiary. If your beehives get infected with it, you must burn the whole apiary down. Even though a lot of beekeepers expressed that it would be great if the solution could detect and warn them about this sickness, there were not that many ideas on how that could be done that were brought up during the interviews, except smell and pheromone sensors that might be a possible way to detect it. However, when the sensors detect the smell of American foulbrood it would be too late to do anything about it. The thing this function would help with is to prevent the sickness from spreading to other apiaries.

Other desired functions are weather conditions outside the hive, humidity, receiving information about the number of bees inside the hive, and warnings about wax moths. Additionally, it is desired to receive a notification if an error occurs, so the beekeepers do not have to inspect the bottom plate to see if the product is working properly.

4.7 Kano Survey Result

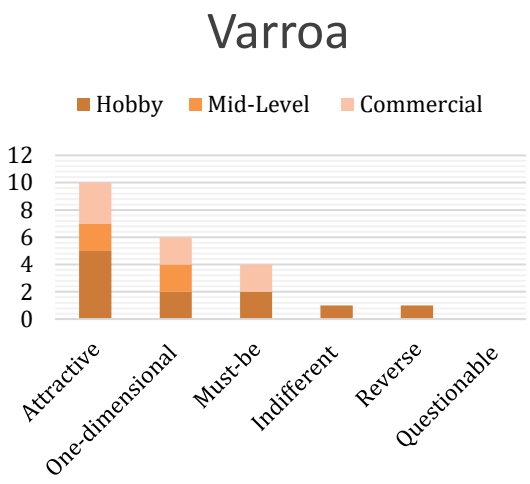
In the Kano survey, the interviewed beekeepers' thoughts on ten different functions Ericsson's technological solution could include were examined. These functions were

Varroa mite levels, *the queen's status, swarm prediction, intruders, robbing, food supplies, honey production, pollen levels, type of pollen,* and *an overview function*. In Figure 4.6 a compilation of the results from the Kano survey is presented. It is visible to what extent the beekeepers value each function and how this varies between the hobby, mid-level, and commercial beekeepers. Overall, the results were quite scattered for each function, meaning that the beekeepers did not fully agree on which kind of attribute the functions should be classified as.

The functions classified as one-dimension and must-be attributes are most important to consider since the beekeepers will be dissatisfied with the product if they are not included. The survey's results show that the function most beekeepers believe is important is *food supplies*, which 13 beekeepers think is either a one-dimensional or must-be attribute. Moreover, ten beekeepers classify *Varroa levels* and *swarming* as one-dimensional or must-be attributes by ten beekeepers. Finally, eight beekeepers consider the *queen's status* and *honey production* as one-dimensional or must-be attributes. Therefore, these five functions are vital to include in the solution to avoid disappointed customers.

Many functions were also seen as attractive attributes by the interviewed beekeepers, meaning that those functions could increase customer satisfaction if they were included in the solution, but they would not cause any dissatisfaction if they were not included. The five functions that are one-dimensional or must-be attributes to many beekeepers are also considered attractive attributes to other beekeepers. Firstly, the *queen's status* and the *overview function* are attractive attributes according to twelve beekeepers. Also, eleven beekeepers consider *honey production* an attractive attribute, and ten beekeepers thought *Varroa levels* and *pollen levels* are attractive attributes. Moreover, *swarm prediction* and *intruders* are attractive attributes according to nine beekeepers. Finally, eight beekeepers think *food supplies*, *robbing*, and *type of pollen* are attractive attributes.

However, three of the functions that many beekeepers see as attractive attributes are seen as indifferent by many other beekeepers, meaning that the function will not affect customer satisfaction if it is included in the solution. The first function, the *type of pollen*, is seen as indifferent by ten beekeepers. The other two functions, *pollen levels*, and *intruders*, are indifferent to eight beekeepers.


Varroa
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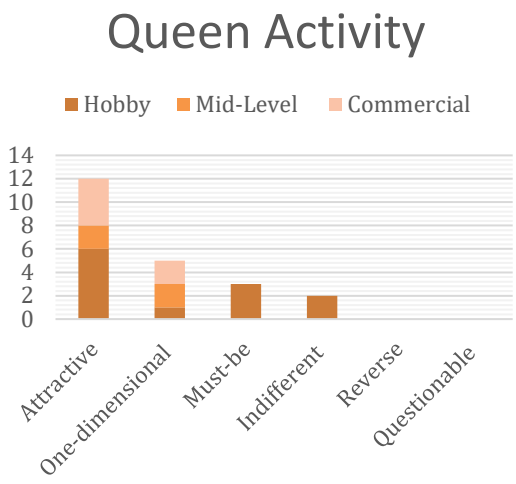
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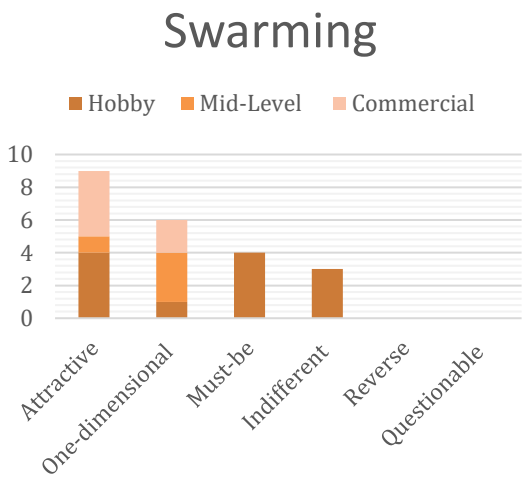
Swarming
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Food Supplies
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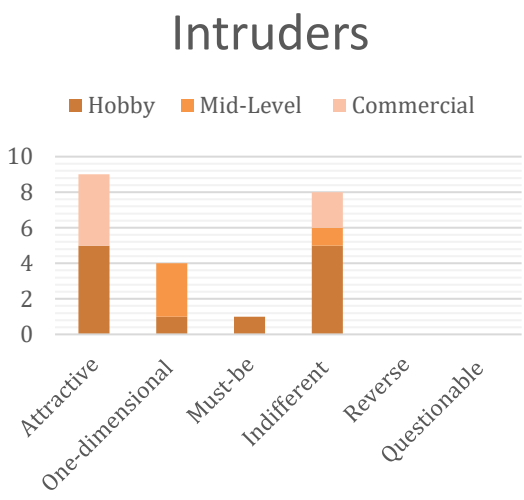
Intruders
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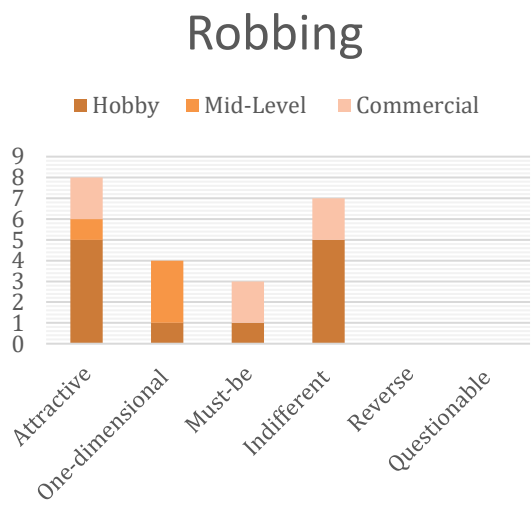
Robbing
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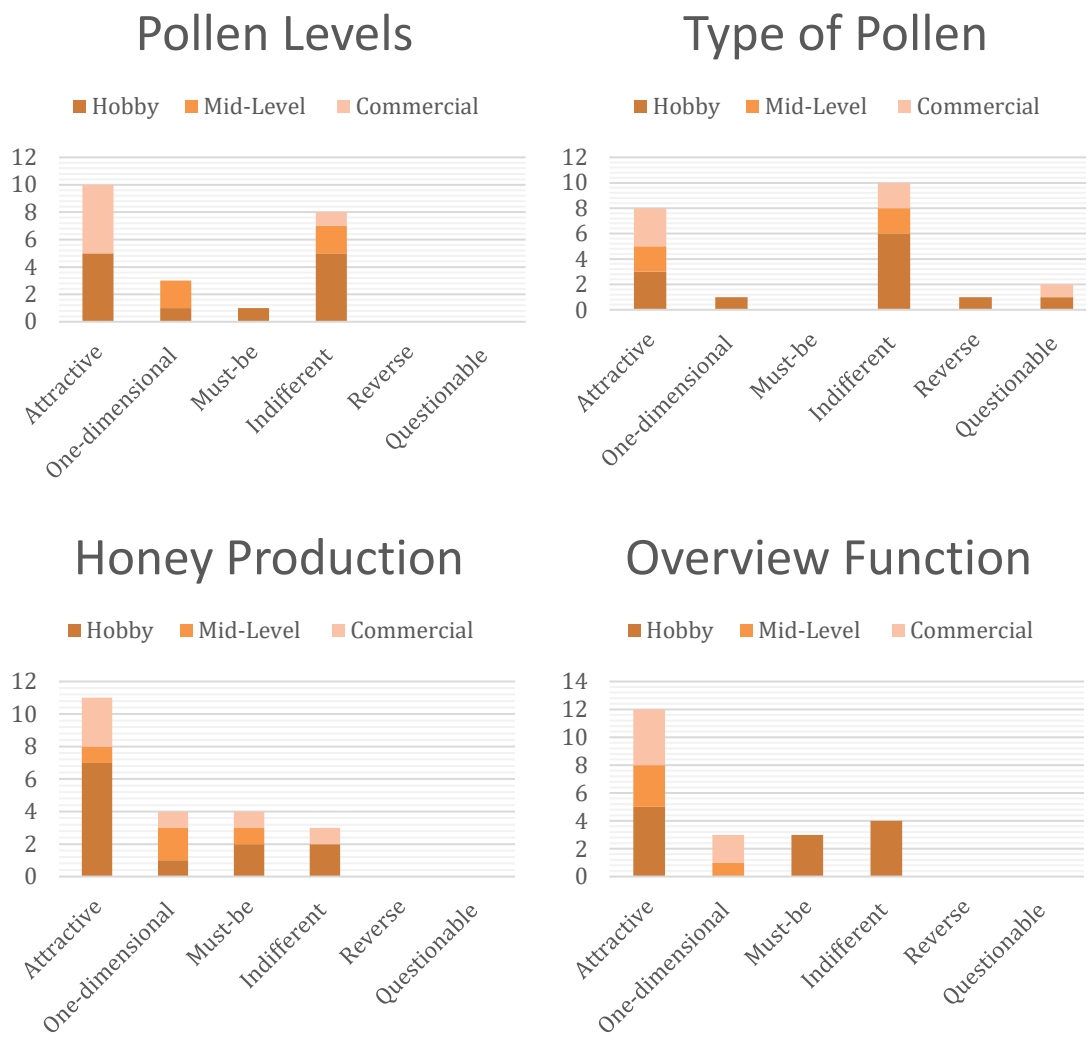

Figure 4.7: *Visual representation of the attribute classification of each function. The classification is based on the results from the Kano surveys.*

5 Analysis of the Beekeeping Market

In this section, the empirical findings from Chapter 4 are analyzed through the analytical framework presented in Section 2.4. Thereby, the first research question *What are beekeepers' major needs and challenges, and what factors in the beekeeping market are related to them?* is answered, through the macro, meso, and micro levels.

5.1 Macro Level Analysis

As presented in Section 2.4, the macro level analysis in this project is made through the social, technological, economic, and environmental factors of the PESTEL model. Additionally, opportunities and threats for Ericsson's connected beehives are considered here.

5.1.1 Social Factors

It is very common for beekeepers to be part of a beekeeping association. Beekeepers from all different market segments and regions explained how there is a strong community among beekeepers where they come together and share their knowledge and experiences. The tight network of beekeepers creates a good opportunity for Ericsson to reach multiple beekeepers through word of mouth. On the other hand, this fact increases the pressure to develop a well-functioning solution from the start that truly satisfies the customer needs, otherwise, there is a risk that negative thoughts about the solution will spread and cause skepticism against the solution.

Moreover, there are significantly more hobby beekeepers than commercial and mid-level beekeepers, meaning that there are relatively few beekeepers who make a living out of their beekeeping. Many beekeepers do beekeeping simply because they think it is fun and interesting, which might reduce their willingness to invest in expensive technology compared to when the beekeeping purpose is to have a business with as high revenue streams as possible. Considering the general demographics of the beekeepers many are relatively old at this moment, but it seems to be moving towards a younger generation of beekeepers that eventually will take over. Since younger generations generally are more familiar with technology this creates an opportunity for Ericsson to sell their solution to the younger beekeepers that are starting to enter the beekeeping industry.

Furthermore, there seems to be a culture among some beekeepers where it is preferred to be "hands-on" and do the work manually. Some beekeepers expressed concerns about missing out on being close to nature and losing their beekeeping sense if involving technology. This culture and skepticism against technology can be seen as a threat to Ericsson's solution. Moreover, there is a threat within beekeeping that people steal beehives in various locations, which affects the beekeepers negatively. Additional technology increases the value of the beehives even more, which worries many beekeepers. They are scared that the risk of people stealing their beehives will increase.

However, this threat could become an opportunity by utilizing a conversion strategy, as mentioned in Section 2.2.2. For instance, Ericsson could take advantage of this issue by including a safety system in the product, which could be a good selling point for beekeepers worried about theft.

5.1.2 Technological Factors

There are technical beekeeping solutions on the market that are trying to solve similar problems as Ericsson, which indicates that the problems they are trying to solve are real. However, no one has launched a complete successful solution yet. Various products are solving separate issues, for instance, one application for Varroa mite detection and another product for weighting the beehive. As a result, beekeepers are required to buy multiple actors' solutions to access various functions. Technology solutions are not commonly used among beekeepers, only 5 out of the 22 interviewed beekeepers in this study had tried using technology within their beekeeping. However, most of the beekeepers had a positive attitude toward using technology in the future. That along with the fact that no other actor has managed to launch a successful solution that completely fulfills the beekeepers' needs creates a great opportunity for Ericsson to gain a lot of market shares if they manage to release a solution that satisfies those needs at a reasonable price.

In terms of infrastructure, all interviewed beekeepers do have mobile connection at their apiaries, which is a prerequisite for Ericsson's solution to work properly. This makes Ericsson superior compared to many other actors who use Wi-Fi to collect and send data, which usually is not as accessible at apiaries. However, a challenge when it comes to infrastructure is power supply since many apiaries are placed in rural areas. Solar panels are a solution that could work but would increase the cost and some beekeepers have also expressed that the weather can threaten the usage of solar panels.

As previously mentioned, the beekeeping industry is undergoing a generation shift, creating an opportunity to sell the solution to the younger generation that generally is comfortable using technology in their work. It also creates an opportunity to make the solution easy to use so it can be sold to elderly beekeepers as well. An easy-to-use and simple solution is vital to improve the product's performance and to target a larger market share. Many beekeepers participating in this study mentioned that product simplicity is a must for them to be willing to use it because they do not want to spend any extra time dealing with complex technology that is difficult to understand.

5.1.3 Economic Factors

Some of the interviewed beekeepers mentioned that beekeeping is a costly activity, the equipment is expensive, and profit margins are generally low within the industry. These aspects affect the beekeeper's willingness to pay, which is relatively low, and it indicates that Ericsson must keep costs down to sell their solution at an affordable price for beekeepers. Additionally, the economy in the US and Europe is currently in a

downturn (Sor, 2024; Sellgren, 2024), which makes it even more difficult for beekeepers to sell their products and make a profit. However, forecasts indicate that the economy is predicted to improve in the coming years (Sellgren, 2024), which could potentially increase beekeepers' willingness to pay if it affects their profit margins positively. Despite this, it will still be of high importance for Ericsson to do their best to deliver their solution at a price as low as possible since one of the major concerns the beekeepers in this study expressed was the cost of the product.

5.1.4 Environmental Factors

Climate change is a major threat to bees and beekeepers since it affects bees' resource availability such as reduced access to nectar and pollen (FAO et al., 2021). Changes in the environment and the vegetation the bees are present in result in a decreased bee population, making it harder for bees to survive. According to the interviewed beekeepers from Spain, the problem with Varroa mites has increased due to their warmer climate and the problem is hard to control. Moreover, the use of pesticides and chemical treatments affects bees' health, and at worst, the bees die because of it (FAO et al., 2021).

Increased bee mortality is a threat to the whole world since pollinators such as bees are vital for human survival (UNEP, 2022). Therefore, it is important to find tools to support beekeepers and to favor bee survival, such as Ericsson's solution since it is supposed to help beekeepers track their bees' status and ensure healthy bees. By utilizing this technological solution, the aim is to protect ecosystems and stop biodiversity losses, contributing to United Nation's Sustainable Development Goal (SDG) 15 "Life on land". Moreover, SDG 12 "Responsible consumption and production" should be contributed to by ensuring sustainable usage of resources during the development and usage of the product. For instance, by including sustainable materials into the product, making it reusable and recyclable, making it energy efficient, and using sustainable power supplies such as solar panels. Thereby, Ericsson has the opportunity to market the solution as a sustainable choice within beekeeping.

Currently, most beekeepers do weekly inspections during the beekeeping season, meaning they drive their cars around to all apiaries in scattered areas. The beekeepers do not know the bee colonies' status beforehand which sometimes results in drives to apiaries where no actions are required, making the drive unnecessary. Since Ericsson's solution would decrease the required number of manual inspections there is an opportunity to reduce pollution generated by the cars.

5.2 Meso Level Analysis

In this section, the meso level analysis is presented. The meso level consists of buyer-supplier relationships. Throughout this project, a relationship with beekeepers, Ericsson's potential future customers, has been developed to gain valuable insights

about their current needs and challenges. The issues the beekeepers currently have serve as a basis for the offer Ericsson should create.

5.2.1 Analyzing Beekeepers' Challenges and Needs

After gathering insights from the beekeepers, it turned out that the major challenges they are dealing with right now in terms of what is most time-consuming is honey harvesting and inspections. The activities most of the beekeepers found difficult were heavy lifts and planning. Another difficult activity brought up during the interviews was dealing with Varroa mites, which especially seems to be an issue where the climate is warmer like in Spain and Florida. Moreover, some beekeepers think detecting various viruses and diseases and understanding the reasons behind an unhealthy hive are difficult.

It is an opportunity for Ericsson to deliver value to the beekeepers by helping them with these challenges. Ericsson's solution has the potential to reduce the number of inspections, which is beneficial for beekeepers since they would save time and be able to make their work process more effective and efficient. Performing fewer inspections will also reduce the number of heavy lifts. Many beekeepers also believe the solution will help with planning. Currently, the solution will not directly help with honey harvesting which seems to be the most time-consuming activity for many beekeepers. However, since the solution most likely will make other parts of the beekeeping process more efficient and effective, more time will be left to harvest honey. Moreover, the solution will help detect levels of Varroa mites, which the beekeepers explained as important to be aware of. Ericsson has an opportunity to further improve their solution by enabling it to detect other diseases and reasons behind an unhealthy hive. However, before considering adding new functions it needs to be evaluated whether the development costs will be worth it. Only some beekeepers mentioned other diseases and the possibility of detecting the reasons behind an unhealthy hive as something they would like to get help with. Hence, it must be further investigated how big of a problem it is and how difficult it would be to improve the solution to detect it.

In the future, multiple beekeepers want to expand and optimize their businesses, but a lack of time and financial resources challenge these goals. Potentially, Ericsson's solution could help beekeepers expand their business since some beekeepers think it would give them more time to manage more beehives. Also, it could help them put more beehives to use and optimize their beekeeping more through better planning opportunities generated by Ericsson's solution.

5.2.2 Analyzing Beekeepers' Willingness to Pay

As indicated by the interviewed beekeepers, it differs a lot between what different beekeepers are willing to pay for a technological solution to be applied in their beekeeping. Moreover, it differed somewhat between the hobby and commercial beekeepers, where commercial beekeepers seem to be willing to pay more than the

hobby beekeepers. Specifically, most commercial beekeepers could imagine themselves paying 3500-5000 SEK for Ericsson's solution, whereas most hobby beekeepers would be open to paying up to 2000 SEK and some hobby beekeepers would be open to paying up to 5000 SEK. Hobby beekeepers mostly do beekeeping for fun, live close to their apiaries, and do not generate much profit, making it difficult and not economically feasible for them to invest a couple of thousand SEK in a technological solution. However, some interviewed hobby beekeepers explained that they would be willing to buy it simply because of the new technology since they believe that type of solution is exciting and cool to have. Commercial beekeepers have more apiaries and beehives, making it possible for them to save more time and money by reducing their traveling to apiaries and by saving more bee colonies. In addition, they generate more profit and have more resources compared to hobbyists, and they aim to make a living out of their beekeeping business.

5.3 Micro Level Analysis

In this section, the strengths and weaknesses of Ericsson's solution are presented based on the interviewed beekeepers' feedback, as part of the micro level analysis. The strengths and weaknesses are the internal factors of the SWOT analysis, which are controllable and can be changed.

5.3.1 Strengths of Ericsson's Solution

The product's main strength is its superiority compared to the other technological products within the market. The current products on the market do not satisfy the various needs of the beekeepers, which entails possibilities for Ericsson. By providing superior performance and additional functions solving more customer needs than competitors, Ericsson can gain more market shares and demand a higher price for their offering than the other actors. Ericsson's solution reduces the most common challenges and issues for beekeepers and has great potential to make beekeeping more effective and efficient. For instance, by helping with planning, saving time, and reducing the number of inspections. Additionally, the hardware including all the sensors is very useful for multiple purposes and the software connected to it can be updated with additional functions, if necessary, without having to change the hardware. This is beneficial since it usually is a smaller operation to update the software compared to changing the hardware. Moreover, the use of mobile connectivity to collect and send data appears to be more beneficial compared to using Wi-Fi, as mobile connectivity is more widespread among apiaries.

Another strength of the development and marketing of the solution is that Ericsson provides many resources, such as knowledgeable personnel, developers, financing, and a well-known name that can be used for credibility in marketing. Later, when launching and distributing the solution there is a greater possibility to access more sales and distribution channels in comparison to smaller companies with fewer resources. Therefore, Ericsson's solution has multiple advantages compared to solutions of start-

ups that do not have support from a bigger organization, making it possible to penetrate a larger part of the market.

Ericsson's solution is compatible with the vertical beehive models, which most of the interviewed beekeepers use. Standardizing the hardware in that sense, is beneficial since it provides conditions to be able to mass produce the hardware in a cost-efficient way. This standard will most likely be compatible with the larger parts of the market. However, two interviewed beekeepers explained that they use other beehive models that would not be compatible with this product, meaning that Ericsson would exclude some potential customers because of it. If Ericsson were to make the solution compatible with multiple beehive models it would most likely drive up the production and development costs, hence it is important to consider both the advantages and disadvantages of standardizing or making the solution compatible with multiple models.

5.3.2 Weaknesses of Ericsson's Solution

Despite the benefits Ericsson's solution has, there are still some challenges that need to be addressed. One of the major ones regards keeping costs down to be able to meet the customers' willingness to pay. Ericsson needs to explore potential ways to keep development and production costs down, because if the solution is too expensive it will most likely not be possible to sell it since profit margins are low within the beekeeping industry, and beekeepers do not generally have that much extra resources to spend on more equipment. However, this solution could potentially lead to cost savings for beekeepers, which can benefit beekeepers financially in the long run. While marketing the solution, the long-term benefits could advantageously be communicated and explained.

Power supply is another major challenge. The solution does not work without electricity and since many apiaries are in rural areas this is somewhat problematic. It requires the installation of solar panels, which drives up the costs for the beekeepers even further and solar panels do not work optimally in all locations and weather conditions. Additionally, most beekeepers move their beehives, hence the product, along with the solar panels, should preferably be movable. However, as the hardware is designed right now, there are risks of breakage when moving it. This is a weakness that can be limited by making the hardware more robust.

Moreover, a weakness of the solution is that it cannot detect everything, there might be factors causing the bees to be unhealthy that the solution is not trained to detect. Hence, the solution cannot replace the beekeepers fully, it should be seen as more of an aid, and it is still necessary for the beekeepers to have knowledge about bee health and do some manual inspections. This creates a challenge regarding warranty. Some interviewed beekeepers expressed that they wanted a warranty and wondered if the solution could be entirely trusted. Ericsson needs to decide how they are going to market the solution, perhaps the most suitable way is as an aid to beekeepers rather than

a complete solution that will solve all the issues for beekeepers. They also need to figure out what should be included in a warranty and how they will provide maintenance if something with the solution is not working as it is supposed to or needs to be updated. Another potential weakness regards how the solution would perform in multiple countries with different types of bees. According to Hobby Beekeeper 9, bees have several accents, so bees in various locations sound different. As a result, problems could arise when Ericsson's solution analyzes new data from different locations if the analysis is based on old data from other places. Therefore, this statement must be verified and needs to be considered when further developing the solution. Apart from bees' different accents, there is a possibility that the pollen and nectar look different in one place compared to another.

6 Market Strategy

Based on the collected data and analysis, a market strategy has been formulated using the framework outlined in Section 2.4. The most relevant components of the Business Model Canvas for this project have been selected and are presented below, with each subheading corresponding to a specific part of the framework. In this section, the second research question *What does the beekeeping market analysis imply for the development of a market strategy?* is answered.

6.1 Value Proposition

In this section, the value proposition of Ericsson's solution is presented. The subsections are based on the questions regarding the value proposition of the analytical framework presented in Section 2.4.

6.1.1 What Value Should the Solution Deliver to the Customers?

Ericsson's solution should be an aid for beekeepers that can be utilized to increase the effectiveness and efficiency of their beekeeping, by for example providing beekeepers with better planning opportunities and forecasts on when different actions must be done. More effective and efficient operations and better planning opportunities also enable beekeepers to save costs and increase their revenue streams. For instance, being provided with data on the peak for harvesting can help beekeepers maximize their honey production. A huge cost-saving possibility enabled by this solution is the minimization of the number of colony losses that can be gained with the help of swarm predictions and health status updates.

Furthermore, being provided with data on the beehives' status will deliver value to the customers by reducing stress and relieving anxiety over ambiguities regarding the bee's health. It could also satisfy the curiosity over the status of the beehives without having to open them and disturb the bees. Additionally, adding a security function to Ericsson's solution could generate great customer value by preventing and hindering theft, because anxiety about getting the beehives stolen was mentioned by many of the interviewed beekeepers.

6.1.2 What Customer Needs and Problems Should the Solution Address?

The major problems and difficulties Ericsson's solution will help the beekeepers with are firstly reducing the time and effort needed to do inspections and thereby also the number of drives to apiaries. This will also reduce the number of heavy lifts, which currently is an ergonomic challenge among beekeepers. Additionally, opening the beehives less frequently leads to less disturbance of the bee colonies and minimizes the risk of squeezing the bees to death when putting the boxes back.

Secondly, the solution will entail beekeepers with better opportunities to plan and focus their work. The data will provide information indicating what actions need to be taken

and when the actions need to be taken, instead of guessing and sometimes wasting time on unnecessary inspections. For instance, if the solution detects that the bee colony dies during winter, the beekeeper can plan how to replace the colony before spring arrives. Furthermore, some interviewed beekeepers expressed concerns about not being able to go on vacation far away from the beehives due to worries about the bees. With this solution, they could plan to go away when no actions are needed and feel less stressed when they are away since they can see the status of their colonies in the application without visiting the beehives physically.

Lastly, Ericsson's solution will help the beekeepers detect Varroa mite levels and other potential issues like swarming. This will reduce hive losses by giving the beekeepers better opportunities to save their colonies before they collapse due to a disease or swarming. Additionally, the data can be used to increase the knowledge and understanding of why a colony behaves the way it does.

6.1.3 What Solution Should Be Offered to Each Customer Segment?

Different functions of the solution are under development, and during this project, it has been examined which functions are most valued by the potential customers and satisfy their needs the best. The results of the Kano survey show that there are five functions beekeepers classified as one-dimensional or must-be attributes. These functions are *food levels*, *swarm detection*, *Varroa levels*, *honey production*, and *the queen's status*. Those functions must be included in the solution to satisfy the customer's needs, otherwise, the customers will be dissatisfied or not buy the solution. Moreover, there were some functions that some beekeepers believe are attractive, which would add additional value rather than just satisfying their basic needs. Those functions were the *overview function*, *pollen levels*, *intruders*, and *robbing*. Hence, those functions can be developed to generate more value for customers, but if they are excluded from the offering most beekeepers will not be dissatisfied. The function that would tell the beekeepers what *type of pollen* there is in the hive was seen as attractive by eight beekeepers, but ten beekeepers chose to classify it as indifferent. Most of the beekeepers who believe this function is attractive were commercial beekeepers. This indicates that there is a greater need to know the type of pollen inside the beehive among commercial beekeepers than there is among hobby and mid-level beekeepers.

Other than *type of pollen*, the answers to the functions differed much between the different segments of beekeepers. That makes it difficult to say that one type of offering is more suitable for one of these segments than the other. When interviewing the beekeepers, it became clear that what functions they value has more to do with what they focus on as beekeepers, if they for instance focus on honey production, pollination, or queen breeding and what climate they are active in rather than if they are a hobby, mid-level, or commercial beekeepers. A common theme among all levels of beekeepers though, is that they want a simple solution that is easy to use. Hence, a basic solution including the functions classified as must-be and one-dimensional should be developed

to satisfy the most common customer needs. Additionally, the beekeepers should have the option to tailor their solutions by adding additional functions if wanted. The functions classified as attractive are good to have as add-on functions since everyone does not want to pay for them, but they might add extra value for some beekeepers. This way, the basic solution offering is simple and satisfies the most common customer needs at a lower price compared to if all the functions were included from the start. However, the beekeepers who are interested in more functions still have the opportunity to choose to include more functions if they want to. Potentially, it could be strategically beneficial for Ericsson to offer some must-be and one-dimensional functions as add-on functions to get more customers to purchase the add-ons.

6.2 Customer Segments

In this section, the customer segments of Ericsson's solution are presented. The subsections are based on the questions regarding customer segments of the analytical framework presented in Section 2.4.

6.2.1 For Whom Should the Solution Create Value?

The solution creates value for beekeepers who add the solution to their beehives. By having access to the solution, beekeepers can track their beehives' status and health, helping them to ensure well-functioning and healthy bee colonies. Given that the health of the bees is expected to improve through the utilization of this solution, it thereby generates value for the bees themselves as well. Additionally, the solution creates value for society and the environment by decreasing bee mortality and improving bee health. It is vital to ensure bees' survival since they contribute to pollinating flowers and plants in nature.

6.2.2 What Are the Different Market Segments?

Within the market, there are various segments. The beekeepers can be segmented into hobby, mid-level, and commercial beekeepers. Most of the beekeepers are hobbyists who have a couple of beehives in their backyard, they do beekeeping for fun and usually want to contribute to the community. Moreover, commercial beekeepers do beekeeping as a professional business and make a living on their beekeeping. Generally, they have hundreds or thousands of beehives within their business. In between hobby and commercial beekeepers are the mid-level beekeepers who have a beekeeping business they cannot fully make a living off, however, some of them aspire to do so in the future.

Furthermore, beekeepers are present all around the globe and their needs differ depending on their location. In this study, beekeepers from the US and Europe were interviewed, and no great differences between different states or countries were found. However, the climate and weather conditions in the various locations seem to be crucial for beekeeping conditions, meaning that beekeepers in locations with similar climates have similar needs and challenges as each other. Thereby, the market could also be segmented into various climate conditions. For instance, the data collected in this study

show that beekeepers present in warmer areas, such as Spain and Florida, seem to have larger problems with Varroa mites.

6.2.3 Who Are the Most Important Customers?

At the beginning of the solution's launch and while marketing the solution, it is vital to attract the innovators and early adopters within the market. These groups are beekeepers with large technological interests, and they are not afraid to adopt new technology and products early on. These types of beekeepers can be found in all market segments and locations. Therefore, hobby, mid-level, and commercial beekeepers with a technical interest are important customers to target in the early stages. Later, when it has been proven that the solution works well for the innovators and early adopters it will be easier to attract even more customers. With time it will also be important to refine the offer to attract a larger part of the market and hopefully, it will be possible to lower the costs due to increased production volumes. Additionally, commercial beekeepers who would save financially by having access to the solution are vital customers since they generate more profit than hobbyists and seem to be willing to pay more for technological solutions to facilitate beekeeping.

Since most beekeepers are part of beekeeping associations and communities, it is important to ensure a reliable and well-functioning solution from the start of the solution's launch to later attract a larger number of beekeepers within the market, because if the solution is working well and as expected the word will easily spread to more beekeepers who will want to have access to the solution. On the contrary, if the solution does not work as intended there is a risk of critical thoughts being spread rapidly and widely to other beekeepers.

6.3 Revenue Streams

In this section, the revenue streams of Ericsson's solution are presented. The subsections are based on the questions regarding revenue streams of the analytical framework presented in Section 2.4.

6.3.1 What Are the Customers Willing to Pay?

During the interviews in this study, it became clear that it differs a lot from what the beekeepers are willing to pay for a technological beekeeping solution. Commercial beekeepers seem to be willing to pay more than hobby beekeepers since commercial beekeepers generate larger profits within their beekeeping businesses and have bigger opportunities to save time and money by having access to Ericsson's solution. On the contrary, hobby beekeepers do not make as much profit, live close to their apiaries, and often do beekeeping for fun. Therefore, it might not be as economically feasible for hobby beekeepers to invest in expensive technology. Specifically, commercial beekeepers seem to be willing to pay around 3500-5000 SEK for Ericsson's product, whereas most hobby beekeepers do not want to pay more than 2000 SEK, and a few hobby beekeepers are willing to pay up to 5000 SEK. Some interviewed beekeepers

indicated how much they would be willing to pay for Ericsson's solution per month. Most of them explained that they would be willing to pay around 75SEK/month per product, which was answered by four of the beekeepers.

6.3.2 What Should the Pricing Strategy Be?

During the interviews, the beekeepers were asked if they would prefer to pay for the solution monthly through a subscription or lease, or if they would prefer a one-time investment. Nine of the interviewed beekeepers preferred a one-time investment, five preferred a monthly cost, and the rest explained that they would consider both options depending on the offers and what would be most favorable for them. Since this solution is new to the market, it is a good idea to keep the barriers to trying it out as low as possible to attract as many customers as possible when entering the market. Offering a basic solution package that includes only the most necessary functions is a way to keep the cost barrier down for beekeepers interested in trying out the solution. Those who want additional functions could get the opportunity to pay for them separately. Additionally, a leasing or subscription option might be favorable since it does not require a major initial investment cost for the beekeepers. A leasing or subscription option could also include services like maintenance, regular updates, and warranty. Since many of the interviewed beekeepers expressed concerns about maintenance and warranty, it would be a good option to include these in the subscription or lease agreement to make customers more comfortable trying the solution. However, it needs to be considered that a leasing or subscription model requires a significant initial investment from Ericsson, which hopefully will be earned back over time, but is not guaranteed. Another consideration to take into account if leasing the product, as explained by Tukker (2004), regards the possibility that the beekeeper might use the product less carefully compared to if they owned the product themselves.

Most of the beekeepers expressed a preference of purchasing the solution with a one-time investment. Hence, this is an important alternative to consider as well. Another possible option is to allow the customers to purchase the hardware and then add a monthly cost for the software and service, similar to how most mobile phone subscriptions work. However, it is important to keep in mind that this data is based on relatively spontaneous answers from the beekeepers. If they had been given more information about the different alternatives and more time to decide between them, their answers might have been different. Therefore, none of the alternatives should be excluded too soon. A good approach is to present and test the different options with potential customers and see which one receives the most positive response. This process can help clarify what works best over time and whether there are differences in preferences among various segments. For instance, there might be differences in the preferred payment method between hobbyists, who would finance the solution privately, and commercial beekeepers, who would finance the solution through their company. Additionally, many legal issues regarding warranties must be considered in the pricing model.

6.4 Channels

In this section, the channels of Ericsson's solution are presented. The subsection is based on the question regarding channels of the analytical framework presented in Section 2.4.

6.4.1 Through Which Channels Could the Customers be Reached?

During the interviews of this study, it became evident that most beekeepers purchase their beekeeping equipment at local beekeeping stores, such as "LP:s Biodling", "MS Biredskapsfabriken", and "Joel Svenssons Vaxfabrik" in Sweden, and "Mann Lake" and "Dadant and Sons" in the US. Additionally, many beekeepers purchase beekeeping equipment from common online beekeeping stores. For instance, the common stores previously mentioned have online web shops as well. Many beekeepers explained that they prefer to purchase equipment where they are used to and stick to the local stores or well-known online shops which they are familiar with. Therefore, Ericsson should preferably sell their solution through common and well-known beekeeping shops or online sites to reach many beekeepers. Potentially, Ericsson could even try to involve some of the well-known stores in the development process to enhance the collaboration and make the stores more comfortable selling the solution. That is also a way to increase the credibility of the solution and reach more potential customers. Presumably, beekeepers would view the solution as more appealing since they trust the well-known stores to sell well-functioning products.

6.5 Key Partnerships

In this section, the key partnerships of Ericsson's solution are presented. The subsection is based on the question regarding key partnerships of the analytical framework presented in Section 2.4.

6.5.1 Who Are the Potential Key Partners?

As mentioned, Ericsson's solution can provide value to society and the environment by enhancing the bees' health and survival, which is important since bees are vital pollinators. Therefore, potential key partners could be governmental agencies, such as Jordbruksverket in Sweden. Potentially, if these types of agencies see the potential societal benefits of the solution, they could provide funding, for instance, to reduce the costs for beekeepers to purchase the solution and to enable more beekeepers to utilize the solution. Moreover, organizations promoting bee health and research about bees could be potential partners to team up with, such as "BeeLife" (https://www.bee-life.eu/) and "Save the Bees" (https://savethebees.com/). Additionally, competitors delivering similar solutions might have knowledge and expertise within certain areas that can also be valuable for Ericsson. Hence, it could be considered to partner with some of these other actors if synergies can be gained.

7 Conclusion

This study aimed to analyze the beekeeping market by examining the needs of different market segments concerning technological beekeeping solutions. The study also aimed to develop a market strategy for Ericsson based on the results from the market analysis and to understand what is required for IoT solutions to be successful within the beekeeping industry. In more detail, the study has been guided by two research questions: (RQ1) *What are beekeepers' major needs and challenges, and what factors in the beekeeping market are related to them?* and (RQ2) *What does the beekeeping market analysis imply for the development of a market strategy?* In this chapter, answers to the research questions are provided and implications for managers and future research are presented.

By reviewing the literature, an analytical framework based on the multi-level approach, PESTLE analysis, SWOT analysis, and Business Model Canvas was developed and tailored to support the beekeeping market analysis and market strategy development.

For RQ1, interviews with beekeepers and secondary data about the beekeeping industry revealed that beekeepers' major challenges and needs are related to honey harvesting, inspections, heavy lifting, planning, Varroa mites, viruses and diseases, unknown reasons for unhealthy bees, and that beekeepers cannot determine the bee's status without opening the beehive. For Ericsson to gain market shares, these major challenges and needs of the beekeepers must be met. Multiple factors related to the beekeepers' needs and challenges at the micro, meso, and macro levels were found. For instance, climate change and the usage of pesticides and chemicals are major threats to beekeeping since bees are highly dependent on the environment and nature. Moreover, it was evident that many beekeepers are not very used to technology, implying that a technological beekeeping solution must be simple and easy to use. Currently, there are various technological beekeeping solutions on the market, however, there has not yet been a completely successful solution to solving the beekeepers' challenges. Ericsson's main strength is its superiority compared to other solutions and therefore has a great opportunity to gain market shares. Furthermore, many beekeepers are part of beekeeping associations where they collaborate, which creates an opportunity for Ericsson's solution to reach many beekeepers if it proves well-functioning.

For RQ2, the results from the market analysis were utilized to develop a market strategy using the analytical framework. The analysis implies that the major value Ericsson should deliver is an aid to help beekeepers achieve more effective and efficient operations and the possibility to reduce costs and increase revenue streams. Additionally, Ericsson's solution is expected to help beekeepers reduce stress and relieve anxiety about not knowing their bee colonies' status. Furthermore, customer value can be enhanced if Ericsson develops a security function to prevent theft of beehives. The customer segments Ericsson should serve include hobby, mid-level, and commercial beekeepers. No major differences in the needs and challenges between

these segments were found; rather the needs and challenges vary based on the focus of the beekeepers' operations and the climate they operate in. Initially, the most important customers will be beekeepers with a high technology interest who are curious about this solution, also known as innovators and early adopters. Once the solution has been proven successful among these customers, the strategy should be refined to target additional market segments. To lower the barrier for beekeepers to try this new solution, the initial offer should include only the most essential functions, with the option to add more functions if desired. The pricing strategy needs further review, as this study implies that potential customers are interested in both leasing the solution and purchasing it with a one-time investment. The solution should be sold at local beekeeping stores and well-known online stores, as these are the places where beekeepers typically buy their equipment. Collaborating with these well-known stores can enhance the credibility of Ericsson's solution. Furthermore, there may be opportunities for Ericsson to partner with governmental agencies, other beekeeping organizations, and competitors.

The outcome of this study contributes to research on the beekeeping industry and how to develop successful IoT solutions in the beekeeping market. The study has contributed valuable insights into how Ericsson can improve its solution, what functions to include in the offer, what customers and markets are most relevant to the solution, and what strategy can be utilized to reach those customers. Additionally, the analytical framework developed to analyze the beekeeping market and develop a market strategy for this project can also be applied to other market research and projects. The framework can be utilized to analyze any market and develop a suitable strategy based on the analysis. The framework can be adapted and tailored to fit various markets and circumstances.

Finally, there are areas where further research can be made. Further research could examine various pricing strategies, meaning Ericsson must properly evaluate different alternatives and test what fits the customers best. It could also be beneficial to evaluate the solution’s functions further, perhaps by conducting another Kano survey with a larger sample to ensure alignment with the findings of this study. Additionally, it would be advantageous for Ericsson to interview and collaborate with more beekeepers in geographies that were not represented in this study's sample to obtain a more precise representation of similarities and differences across various markets. The solution's hardware also needs to be more robust than it currently is to ensure it is movable. Moreover, Ericsson could explore the potential opportunities that might come with various partnerships.

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Appendix

A – Interview Guide

Introduction:

Hi! We are two Master Students at Chalmers University of Technology in Sweden. We are doing our master's thesis in collaboration with Ericsson.

Our study aims to analyze the beekeeping market for technological solutions within beekeeping and to gain an understanding of beekeepers' needs regarding this.

Is it okay if we record the audio of this interview so we can easily go back to analyze what has been discussed? The recording will be deleted after the completion of this project at the end of May.

You will be kept anonymous in the study. Please feel free to ask questions throughout the interview if anything is unclear.

Questions:

General information of the beekeeper (5min)

How old are you and how long have you been a beekeeper?

How many apiaries do you have? How many beehives are in each apiary?

In what city/cities are your beehives placed?

What types of beehive models do you have?

Do you move your beehives? If yes, how often and how far?

Purpose and Business Logic (5min)

What is the overall purpose of why you do beekeeping?

What products do you produce?

Are you selling the products that you produce? Who are your end customers?
(Do you make money by having beehives?)

Do you make a living out of your beekeeping?

Do you work together with any other collaboration partners?

Suppliers and Equipment Today (1min)

Where do you usually buy your beekeeping equipment?

Work process & Challenges (15min)

What are the key activities that you perform as a beekeeper? And how do the activities vary over the different seasons?

What parts of the beekeeping process are most difficult to do? Why?

What are the most time-consuming parts of beekeeping? Why?

When controlling the bee colonies' status and health, what do you think is the most difficult thing to detect?

Is there currently something that you cannot determine by checking the beehive's status that you would be interested in knowing?

If there would be a possibility to get help with a part of the beekeeping process, what part would that be and why?

Other actors' solutions (15min)

Have you ever used technology while beekeeping?

If yes: What have you tried and how was your experience using it?

If no: Why not?

Have you heard of other solutions? What are your thoughts on that solution?

Would you consider using technology while beekeeping in the future?

Ericsson's solution – Present the solution (15min)

Explanation of Ericsson's solution:
Ericsson is in the process of developing a technical solution that could help beekeepers see the status of the bee colonies from a computer or in a mobile app. This solution would provide the beekeepers with the status of: Varroa, swarming, queen activity, pollen levels, nectar flow, honey production, intruders, starvation, and robbing. For example, the beekeeper could see if the queen is dead or alive and it is laying eggs. Also, it is possible to see the amount of Varroa mites in the beehive.

For this to work, the beekeepers would have to change the base plate of the beehive (fits the vertical beehive models), need some power source in the apiary (e.g., solar panels), and wireless connectivity.

How would your life change if you had this product?

Could you think of any possible benefits you would gain by having this product?

Could you think of any possible drawbacks for you by having this product?

Would you be open to buying or leasing this type of product? Would you then prefer a one-time investment, or would you like to have a monthly subscription?

What would you save financially by having this product?

What would you be willing to pay for this product?

If beekeepers use this solution and share the data collected by the product, it would be possible to get an overview of the state of health of the bees and ecosystem in a larger geographical location (e.g., heatmap of Varroa in Sweden, spread of infection in different locations, and nectar flow). What are your thoughts on this? How would this function create value for you? And would you be willing to share your data to make this possible?

Anything that we have not mentioned that you would like to be able to see the status of?

Connectivity (1min)

Do you have mobile connection by the beehives?

Future plans (3min)

What are your future plans for your beekeeping, and what are the biggest challenges with doing that?

Checklist:

- ✓ We have the respondent's consent to record the interview.
- ✓ We know which customer segment the respondent belongs to.
- ✓ We know the purpose of the respondent's beekeeping.
- ✓ We are aware of the respondents' biggest challenges.
- ✓ We know the respondent's view on other solutions.
- ✓ We know the respondent's view on Ericsson's solution.

B – Kano Survey

[Introduction]
Hi! We are two master's students at Chalmers University of Technology in Sweden, conducting our master's thesis in collaboration with Ericsson. The aim of our study is to analyze the beehive market for technical solutions within beekeeping and gain an understanding of beekeepers' needs in this regard. Ericsson is in the process of developing a technical solution that can help beekeepers monitor the status of bee colonies via a computer or mobile app. Your input is extremely valuable to our study. Thank you for taking the time to respond to this survey!

Name: _____

[Information about the survey]
In this survey, you will indicate your level of interest in various functions that could be part of the technical solution to help beekeepers determine the status of their beehives.

Q1: Varroa
This function would let the beekeeper know if there are varroa mites in the beehive and the amount of varroa mites.

[The following alternatives were asked in all ten questions]

If the solution can [detect this function], how would you feel?
- I like it that way
- It must be that way
- I am neutral
- I can live with it that way
- I dislike it that way

If the solution **cannot** [detect this function], how would you feel?
- I like it that way
- It must be that way
- I am neutral
- I can live with it that way
- I dislike it that way

Q2: Queen activity
This function would let the beekeeper know the status of the queen, i.e. if the queen is alive and active (produce eggs).

Q3: Swarming
This function would let the beekeeper know when the bees swarm and predict when the bees are going to swarm.

Q4: Food supplies
This function would let the beekeeper know if the bees do not have enough food and have a risk of starving.

Q5: Intruders
This function would let the beekeeper know if there are any intruders inside the beehive. Possible intruders could be e.g. ants, hornets or wasps.

Q6: Robbing
This function would let the beekeeper know if other bees are robbing the beehive.

Q7: Honey production
This function would let the beekeeper know the amount of honey the bees are producing.

Q8: Amount of pollen
This function would let the beekeeper know how much pollen the bees are bringing into the beehive.

Q9: Type of pollen
This function would let the beekeeper know what type of pollen the bees are bringing into the beehive.

Q10: Overview
This function would provide the beekeeper with an overview of the state of health of the bees and ecosystem in a larger geographical area. For instance you would be able to see an overview of where varroa mites, diseases, and nectar flow is present in different locations. For example, if your neighbor has varroa mites in their beehives you would be able to know that and can take preventive actions.

Thank you for taking the time to participate in our study!

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