Master Thesis

Innovation Ecosystem Strategies of Airlines: An Overarching Perspective for Strategic Alignment

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TUDelft
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Challenge the future

Master Thesis

Innovation Ecosystem Strategies of Airlines: An Overarching Perspective for Strategic Alignment

by

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Acknowledgements

Throughout my childhood, I was an aviation enthusiast. At those days, I have been dreaming about becoming a fighter pilot. The main reason of my interest was my adventurous characteristic, which also led me to leave my home country to study at TU Delft when I was 18. Although I decided to study Architecture at TU Delft, I have never lost my enthusiasm in aviation, hence I decided to follow the minor program "Airport of the Future". I met Arlette during this minor program, and I was fascinated by her motivation for innovation and the efforts of KLM to innovate and pioneer sustainable aviation. From that moment, I knew I would like to conduct my master thesis at KLM in the field of innovation management. After 3 years, when I expressed my interests on the topic of 'innovation ecosystems' to Arlette, our interests matched serendipitously. This gave me even more motivation, as I would be conducting my research in a topic of my interest.

Countless people supported my effort on this thesis. I could not have undertaken this journey without my graduation committee, who generously provided knowledge and expertise. Firstly, I would like to acknowledge and give my warmest thanks to my supervisor Dr. de Bruijne who agreed to be my supervisor and made this work possible. The knowledge and insights of Dr. de Bruijne on the complex systems, provided a much broader perspective to this thesis, while his patience, guidance and knowledge in a variety of scientific topics carried me through all the stages of writing this thesis. Secondly, I would like to thank my company supervisor, Arlette van der Veer. From the second I walked in to the Transformation Office to discuss possible thesis topics, I felt supported. While Arlette's knowledge in innovation management contributed enormously in the content of this thesis, her high energy and always ready to help approach motivated me and helped me to overcome obstacles I had during my research. I would also like to thank Prof. de Bruijn for accepting to be my graduation chair and providing me his valuable time, knowledge and expertise since the first day that I decided to conduct my graduation thesis on this topic and contacted him. I would also like to thank Dr. Schraven for not only proving his valuable time, knowledge and expertise on this thesis but also during my studies in CME as a wonderful coordinator and professor.

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Enjoy!

July 2022, Delft.

Abstract

The airline industry is going through a big transformation. The institutional environment as well as the industry itself has changed. Competition with the entry of the low-cost carriers in a market that used to be dominated by flagship carriers and societal pressure regarding sustainability on airlines with COVID-19 state aids increased, while the shortage in the labour market limited the pace of recovery. The technologies that airlines use to operate have been outdated to cope with today's massive challenges. All of these changes forced airlines to innovate to maintain their services. During the era of technology, these innovations can be better nurtured within an innovation-conducive environment, which might be seen as an ecosystem designed for the co-creation of value through collaboration. In the last decade, both managers and scholars showed an increasing interest in the concept of innovation ecosystems, which provides a holistic perspective for value creation. However, despite its potential, the implementation of the innovation ecosystems in the airline industry and how it can support an airline to implement its innovation strategy has not been investigated. By conducting literature research and qualitative embedded case study, this research concludes that implementation of innovation ecosystems and innovation ecosystem strategies can help an airline to achieve its objectives on innovation and implement its innovation strategy by aligning its innovation processes, overcoming the barriers to innovation that hampers its innovation processes and finally facilitating the collaboration within and beyond the value chain to develop radical innovations that are required to cope with today's complex challenges.

Executive Summary

The flag carrier airlines in Europe were already struggling due to entry of low cost airlines and tight safety regulations of the industry, which makes implementing innovations and adopting environmental policies challenging. In the beginning of the year 2020, the coronavirus pandemic (COVID-19) spread across the globe, bringing destructive economic and social consequences for both governments and enterprises. Many industries put short-term cutting measures in place and paused their green business practices and innovation efforts to overcome this threat to their survival, although these practices and efforts contribute to market competitiveness in the long term. As the world is stepping out of the COVID-19 pandemic and the airline industry is recovering slowly, the topics of innovation and sustainability are put to the forefront again, with even more societal pressure and macroeconomic challenges. Although, the industry seems to have a simple function of transporting people and goods between different locations at first glance, a careful examination reveals a complex industry with a constellation of factors—aviation agreements, a wide range of (safety) constraints, and the economic situation of countries. The relationship between airlines and their respective home country's market conditions is interdependent, much like the relationship between airlines and the economy as a whole. The airlines' overall business strategies are often shaped by the market structures of the countries where the airlines are based. Nowadays, with sustainability constraints, shortage in the labour market and, increasing material and labour costs, airlines are forced to deal with innovation strategically. As the challenges are so varied and complex, none of the companies can offer all the solutions necessary to achieve these ambitions. In addition, aviation industry is formed by strong regulations and standardization therefore, not only the companies and research institutes, but also the policymakers need to be included in these networks. Today, "innovation ecosystems" are considered to be suitable environments where all the necessary actors (e.g., focal firm, business collaborators, suppliers, SMEs, start-ups, customers, policymakers and financial institutions) comes together to rise and materialize innovations by both managers and scholars. There are no studies in the literature that specifically focuses on the innovation ecosystem strategies of airlines, therefore the main research question of this research was:

"How can innovation ecosystems support airlines to implement their innovation strategy?"

This thesis focuses on the innovation ecosystem concept that can support airlines to implement their innovation strategy and achieve their business goals. A literature research and qualitative embedded case study have examined the the barriers that occur through the innovation processes to determine the needed changes from the traditional methods and the innovation ecosystem strategies that are used by airlines to align and position themselves in the innovation ecosystems. A number of insights were gathered as a result of this research.

First, according to literature study, *innovation strategy is a set of coherent and internally consistent resource allocation decisions that are aimed at achieving an organization's specific goals* and formulation of innovation strategy requires the right balance between *exploration and exploitation* and alignment

with the firm's business strategy. Formulating an innovation strategy is not enough by itself for a company to achieve its objectives. In order to achieve the objectives and goals set by the organization, the formulated innovation strategy must be executed. The use of specific innovation management approaches and corresponding techniques might be helpful for execution of the innovation strategy. The contextual approaches and techniques that fits and aligns with their innovation strategy are superior when it comes to success. These contextual factors include: *type of innovation, type of organization, type of industry and type of country/culture.* These are also related to the type of barriers faced by organizations. In line with this perspective, by combining theoretical and empirical study a set of external and internal barriers to radical innovation were identified: *legislation, undeveloped network and ecosystem, regulations; a restrictive mindset, lack of implementation competences, an unsupportive organizational structure and lack of resources* (see Table 6.1).

Following, an analytical framework was built up on the theoretical knowledge gathered in the literature study and further developed and updated with the data from the empirical study. According to this analytical framework and case study data, KLM often partners up with knowledge institutes and other business collaborators (large firms/ SMEs/ startups) to identify and elaborate future opportunities for innovation in the *explorative layer*, which shows the characteristics of an open system and focuses on bringing new knowledge to the company. On the other hand, KLM often partners up with knowledge institutes, other business collaborators (large firms/ SMEs/ startups), suppliers and in particular Air France in the *exploitative layer*, which shows the characteristics of a semi-closed system and focuses on developing and implementing innovations that add value to their operations and customers. These two layers are continuously interacting with each other as the exploitative layer triggers the search and collaboration processes in the explorative layer and the explorative layer gains continuity and validity through the development of concrete innovations. This interaction between these two layers and an example of its application at KLM is shown in Figure 5.7. The actors included in each layer are based on *the rivalry between KLM and the other firm, and their influence on the innovation ecosystem*. An overview of identified innovation ecosystem strategies used by KLM is shown in Table 5.3. Based on the results, this study proposes that the innovation ecosystems and innovation ecosystem strategies can be used by firms to overcome barriers to innovation, which consequently also improves the state of the firm's innovation ecosystem and increases its maturity level. All these changes and actions affect innovation processes of the firm positively. This positive correlation is visualized in Figure 6.5.

Answering the main research question: *"How can innovation ecosystems support airlines to implement their innovation strategy?"*

This study has shown that innovation ecosystems can support airlines to implement their innovation strategy in two ways. Firstly, being part of innovation ecosystems allows the focal firm (in this study KLM) to closely observe and track other actors in the ecosystem. By doing so, the firm can align its innovation strategy and positioning its organization based on the most recent developments in areas such as technology (e.g. introduction of a new (disruptive) relevant technology or new methods and techniques to overcome an identified technological limitation, etc.), science (e.g. new scientific knowledge that can provide improvements in current products and processes), policymaking (e.g. introduction of a new legislation and regulations or financial incentives), industry (e.g. increasing trend of collaboration or competition, differences in services offered etc.) and societal environment (e.g. pressure of citizens and NGOs on carbon reduction goals, noise or shortage in labour market). This will allow the firm to be

up-to-date when the innovation strategy must be formulated and the strategic choices on innovation must be made, mitigate the risks associated with radical innovations and eventually will increase the likelihood of the firm to manage its innovation processes successfully.

Secondly, innovation ecosystems are multilayered structures where a heterogeneous set of actors can align their multilateral interactions to arise (exploration) and materialize (exploitation) the novel value propositions. The results of this study shows that although KLM is considered to be a major player in the Dutch commercial aviation ecosystem, its impact on the global aviation ecosystem is rather limited. KLM and other airlines need other actors to truly disrupt the aviation industry and achieve their objectives on topics like sustainable aviation and automation. Innovation ecosystems and the corresponding innovation ecosystem strategies can promote the interparty collaboration that is needed in the industry for exploration of future opportunities and bring the critical mass and knowledge that is necessary for the exploitation to drive successful innovations. Furthermore, innovation ecosystems can be used to overcome barriers to radical innovation, which will support the execution of innovation strategy and therefore reaching the objectives of the company.

So, this research concludes that in order to achieve company objectives and implement its innovation strategy, KLM should use innovation ecosystems and innovation ecosystem strategies to align its innovation processes, overcome the barriers to innovation that hampers its innovation processes and finally to collaborate within and beyond the value chain to develop radical innovations that are required to cope with today's complex challenges.

Since there are currently no studies in the literature that specifically focuses on the innovation ecosystem strategies of airlines, therefore the results of this thesis will be of added value for both scientific research and for the industry.

Contents

Contents

List of Tables

List of Figures

List of Acronyms

Acronym	Full Name
AI	Artificial Intelligence
AR	Augmented Reality
AV	Autonomous Vehicles
BU	Business Unit
E&M	Engineering & Maintenance
EASA	European Aviation Safety Agency
GPS	Global Positioning System
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IE	Innovation Ecosystems
IMU	Inertial Measurement Unit
IoT	Internet of Things
IP	Intellectual Property
IS	Innovation Studies
KLM	Koninklijke Luchtvaart Maatschappij (Royal Dutch Airlines)
LRQ	Literature Research Question
MRQ	Main Research Question
OI	Open Innovation
PS	Passenger Services
PB	Passenger Businesses
R&D	Research and Development
ROIC	Return On Invested Capital
SME	Small & Medium Enterprises
VR	Systems of Innovation
SRQ	Sub-Research Question
SVP	Senior Vice President
TU Delft	Delft University of Technology
US	United States
VC	Venture Capital
VP	Vice President
VR	Virtual Reality

1

Introduction

The essence of strategy formulation is to cope with competition (Porter, 1989; Stonehouse and Snowdon, 2007). Professor Michael Porter, one of the giants in the field of strategic management, mentions that the most dominant competitive forces determine the profitability of an industry and become fundamental to strategy formulation. According to Porter, return on invested capital (ROIC) is the appropriate measure of profitability for strategy formulation. The ROIC of airlines is 5.9%, which is well below the 14.9% cross-industry average and almost six times less profitable than industries such as soft drinks and prepackaged software (Porter, 2008). Flying has evolved over the last 60 years from a luxury for fortunate individuals to a commodity for many, with more than 4.5 billion people flying yearly and revenue of commercial airlines reaching 838 billion U.S. dollars (Statista, 2022). The intensive competition and deregulation (Chen *et al.*, 2015) within the industry stimulated the years of airline price wars that have affected the industry as a whole (Arshed and Pancholi, 2016). Despite this ever-growing increase (compound annual growth rate of around 5.3% between 2009 and 2019), in 2019 airlines made profits of only $6.12 for every passenger carried, which is just enough to pay investors a normal return on their invested capital (IATA, 2019). Nowadays, airlines need to cooperate with other airlines in forms of alliances such as SkyTeam, Star Alliance or IAG (Crail, Crail) since many airlines are lacking the necessary financial resources to invest due to low profit margins (Maul and Spear, 2018).

High competition in today's globalized market, scarcity of natural resources, and climate change force corporations to increase efficiency in their operations and develop new products and services to create a value proposition for multiple stakeholders (Rabelo and Bernus, 2015). Hence, the base fare and cargo revenues does not even cover the costs of airlines, the net profit per passenger is made by charging for the services such as in-flight meals, seats with extra leg room, and car hire. Therefore, airlines need to stay innovative not only by offering new services to their customers, but also increasing their operational efficiency and cutting down their labour costs (IATA, 2019). While every now and then one could think that innovation has become a buzzword, both empirical and theoretical evidence shows that innovation is and always has been a key driving force of competitiveness (Schmiedel and vom Brocke, 2015). The 2011 Global Innovation 1000 report supports this claim by finding a clear difference in both revenue (11%) and EBITDA (22%) growth in favour of the more innovative organizations (Jaruzelski, 2018). According to McKinsey, 84% of executives say that innovation is important

to their growth strategy. In addition, only 4% of executives have not defined innovation as a strategic priority (McKinsey, 2018).

However, regardless of its popularity, innovation remains a challenging task for many companies. The most common reasons given for this in literature are: lack of an innovation strategy that aligns with the overall business goals and failure to execute innovation strategy (Pisano, 2016; Sull *et al.*, 2015). According to a survey conducted with 1200 executives in 44 countries, 54% of innovating organizations have trouble bridging the gap between innovation strategy and the larger business strategy (Jaruzelski, 2018). Even proven successful innovators are having a hard time sustaining their performance because innovation strategies must also be dynamic to cope with the ever-changing environments. The famous quote from writer Peter Drucker "Culture eats strategy for breakfast" puts emphasis on the importance of powerful and empowering culture on the route to organizational and therefore the execution of the innovation strategy within the company. The aviation industry is formed by strong regulations and standardization, which leads to high operating expenses and challenges of adopting and implementing innovations (Amankwah-Amoah, 2020), is often considered by scholars to be a very rigid and conservative industry (Wensveen, 2018).

As the world is stepping out of COVID-19 and the airline industry recovering slowly, the topics in innovation and sustainability are gaining ground again (Amankwah-Amoah, 2020). According to Franke (2007) the airline industry needs to attract new sources of innovation, find new revenue streams and reinvent their business models. Nowadays, companies rarely develop all their offerings in-house; as both the offerings and the relationships necessary to produce them become much more varied and complex (Normann and Ramírez, 1993). Instead, more inclusive models, such as open innovation, design thinking, and co-creation with partners, customers, and suppliers are gaining popularity among the many companies as a way to enhance innovation capabilities. Almost twice as many companies favour these models over the traditional R&D strategies (Jaruzelski, 2018). Organizations are pushing the boundaries of innovation both internally and externally by breaking down traditional barriers, establishing a much wider ecosystem for ideas, insights, talent, and technology, and incorporating the customer throughout the innovation process (Jaruzelski, 2018). That requires sometimes breaking down the silos within a company. Bringing people from all the relevant business units of an organization into the innovation sandbox from the start is critical to making innovation successful in the long term, rather than having it be a potentially losing proposition (Henkel, 2022; Edmondson *et al.*, 2019). The idea of collaborating to innovate is not unfamiliar, in the literature many frameworks are developed to support this vision (Rabelo and Bernus, 2015). Camarinha-Matos and Afsarmanesh (2008) describe collaboration as the most developed form of interactive cooperation and networked actors should commit to a common vision, strategy, and joint obligations to co-create innovations (Camarinha-Matos and Afsarmanesh, 2008). During the era of technology, these innovations can be better nurtured within an innovation-conducive environment, which might be seen as an ecosystem designed for co-creation of value through collaboration (Smorodinskaya *et al.*, 2017). In the last decade, both the managers and scholars showed an increasing interest in the concept of innovation ecosystems which provides a holistic perspective for value creation. (Moore, 1993; Adner, 2006; Adner and Kapoor, 2010). KLM, the subject of this case study, is one of those companies that considers innovation ecosystems important for its innovation processes and aims to deal with it strategically. Therefore, it serves as a suitable environment to obtain empirical data on the implementation of innovation ecosystems in the airline industry (see Figure 1.1).
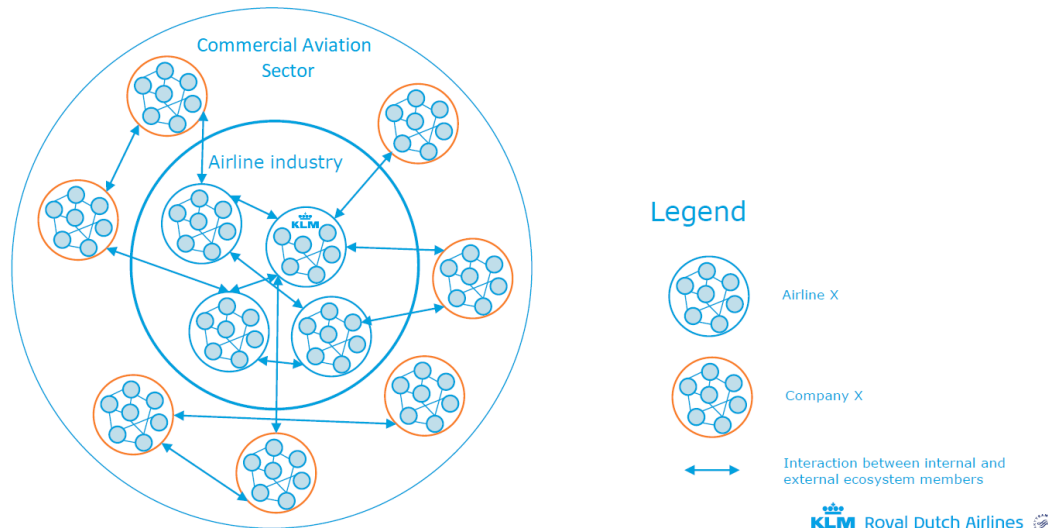
Figure 1.1: Visualization of KLM's position in commercial aviation ecosystem, (KLM, 2022).

1.1. Problem Statement

The problem addressed by this research can be divided into an empirical or practical statement and a theoretical statement.

1.1.1. Practical Problem Statement

Due to its highly competitive nature, the airline industry lacks openness and there is a very limited dose of inter-party collaboration between the actors whereas the innovations demand more alliances and integrated approach (Lind and Haraldson, 2015; Rencher, 2019). The cooperation between the actors is the base of innovation ecosystems which might help airlines to adopt and implement innovations. KLM presented their new strategy which includes ambitious goals on the topic of innovation and sustainability (see Figure 1.2) and, considers innovation ecosystems important for its innovation processes and aims to deal with it strategically (KLM, 2022). However, practical knowledge lacks on the implementation of the concept *innovation ecosystems* in the airline industry. Innovation ecosystem and innovation processes of KLM was studied earlier by another graduate intern (Nefri, 2020), and the adopting innovation ecosystems was mentioned as a promising concept to support execution of KLM's innovation strategy. However, with the innovation ecosystem approach which emphasizes the multilateral interactions between the heterogeneous set of actors, only two employees from the Radical Innovation team of KLM have been interviewed and shared their knowledge and experiences. Therefore, the empirical data gathered in the study reflects only a small part of the innovation ecosystem which includes homogeneous set of actors that are mostly involved in the ideation phase of an innovation and a limited amount of barriers to innovation experienced by these actors. When it comes to a large organization like KLM with 28,000 employees and many different types of work to be done, one needs a broader perspective and approach in order to reach ambitious and highly complex goals. So, it is currently unknown what are the barriers to innovation at KLM and what kind of value innovation ecosystems would bring to the innovation processes of KLM to overcome these barriers. This is necessary to develop innovation ecosystem strategies that will support the successful implementation of the innovation strategy.
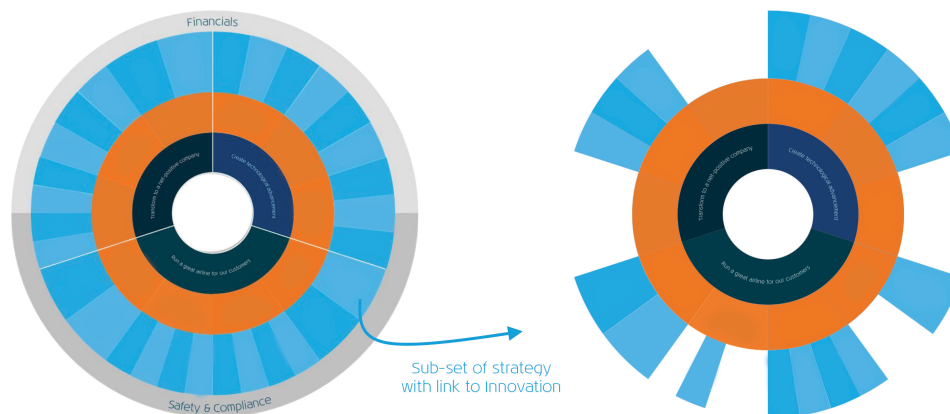
Figure 1.2: Linking KLM Innovation Strategy to KLM Strategy, some content removed due to confidentiality. (KLM, 2022)

1.1.2. Theoretical Problem Statement

While adapting innovation ecosystem concept into a business environment, it is necessary for firms to make some strategic decisions, including with whom to cooperate and with whom to compete (Van de Ven, 1999); how much to invest in the ecosystem as a whole, versus investing in one's own position within it (Autio and Thomas, 2014); and how to align internal innovation activities with technological progress in the ecosystem (Adner and Kapoor, 2010). To address these questions, companies may develop more or less deliberate ecosystem strategies, as a mean to align partners and innovation activities and to secure and advance the role of a company in the ecosystem (Adner, 2017). Current literature on ecosystem strategies (e.g. Bosch and Olsson, 2018; Valkokari *et al.*, 2017) is limited. The majority of the case studies in this topic focuses on hub firms, orchestrators or platform providers (e.g. Dhanaraj and Parkhe, 2006; Gawer and Cusumano, 2014). Visscher et al., (2021) provided a comprehensive overview of how firms of different sizes and ecosystem positions act strategically upon innovation ecosystems and conducted interviews with 98 different companies on the implementation of innovation ecosystems and discussed differences in strategic choices regarding innovation ecosystem implementation. They found out that ecosystem strategies exist with different foci, starting positions, or levels of maturity and in-depth studies at the firm level is necessary to gain a deeper understanding of innovation ecosystem strategies. Their results are in line with the strategy literature (Pisano, 2016; Porter, 1989) which argues that innovation (ecosystem) strategies must align with the overall business strategies. Therefore, it is necessary to investigate the specific conditions of a certain business environment which the firm operates. As far as known, no previous research has investigated the barriers to radical innovation in airlines and innovation ecosystem strategies of airlines. Therefore, the empirical data that will be gathered by this embedded case study is essential to fill this knowledge gap.

1.2. Research Objectives and Deliverables

Despite the exponential growth of the number of articles on innovation ecosystem (IE) (see Figure 1.3), the implementation of IE concept in commoditized services and businesses, and the type of strategies used at the firm level to deal with IE remains to be unclear. Considering that the conceptualization of innovation ecosystems received ample attention in the literature, the added value of this research lies in focusing on innovation ecosystem strategies. The research objective of this thesis is to fill the identified literature gap by studying the innovation ecosystem strategies of airlines at the firm level and, provide a set of recommendations to those airlines that would like to adopt innovation ecosystems concept and develop innovation ecosystem strategies.
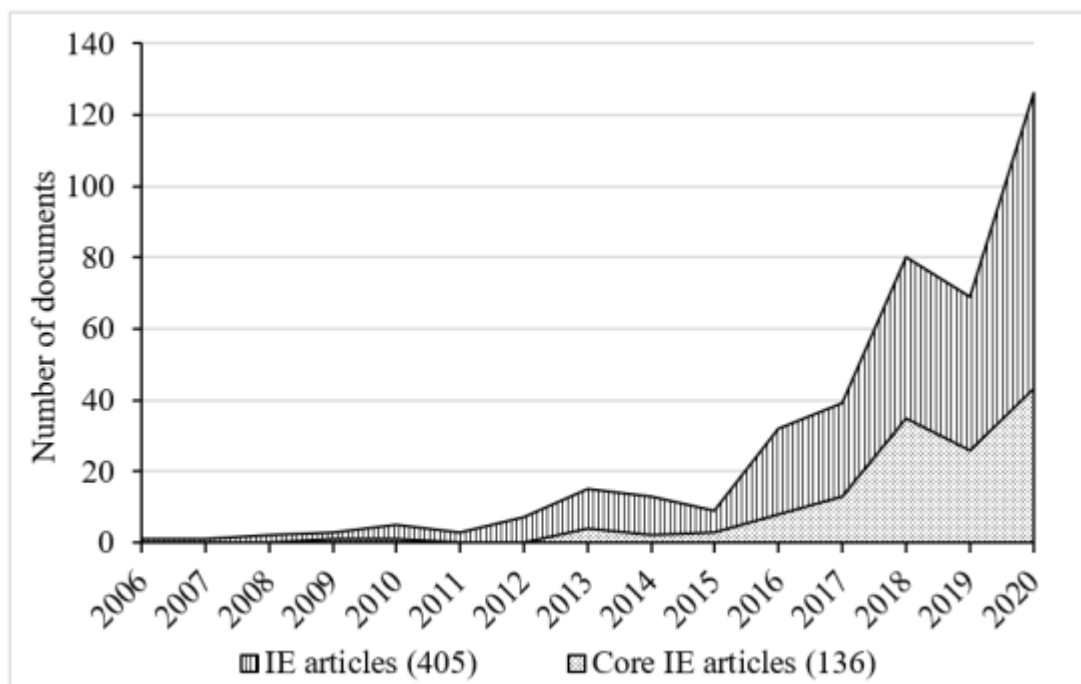
Figure 1.3: Published articles in IE field from 2006 to 2020 (Gu *et al.*, 2021).

This thesis's scope is innovation ecosystem strategies of airlines and the respective actors involved in such systems. As ecosystem strategies exist with different focal points, identifying contextual factors of innovation management and the barriers and drivers that occur through the innovation processes is critical for determining the needed changes from the traditional methods. In addition, the identification of the innovation ecosystem maturity level and successful ecosystem strategies could aid to choose right innovation ecosystem strategies and increase the likelihood of a successful innovation strategy execution. In order to achieve this objective, different perspectives need to be taken into account, which will be collected from the literature study and the case study.

1.3. Research Questions

To fulfil the research objective of this study, the main research question will be of the following form:

How can innovation ecosystems support airlines to implement their innovation strategy?

As found in the knowledge gap, it is unknown how the innovation ecosystem concept can support airlines to implement their innovation strategy successfully. The knowledge that is necessary to provide an answer to the main research question, will be gained by answering several sub-questions formulated from the main research question. The sub-questions (SQ) are divided into 2 categories: the more generic ones (1, 2, 3) that can be explained by the literature review and the specific ones (4, 5) that can be explored by the case study.

The research starts with a literature review spread over 2 chapters to gain background knowledge and build the analytical framework necessary for conducting the case study interviews. This was necessary due to structural reasons, hence the literature study takes a relatively large space in this thesis. Moreover, it also allowed to draw conclusions in between the topics to create necessary links and offer guidance to the reader of this thesis.

First, implementing the innovation ecosystem concept into a business is a strategic choice of a firm; in particular, it is part of a firm's innovation strategy and innovation management. Therefore, it is necessary to investigate the factors that form the innovation strategy and understand how a firm manages its innovation processes. Literature suggests that in the past a single mainstream innovation management approach was considered to be the most popular approach for a certain period of time to manage innovation processes of a firm. However, nowadays firms manage their innovation processes based on contextual factors (e.g. type of innovation, type of organization, type of industry and type of culture etc.) (van der Duin *et al.*, 2014). The first sub-question is as follows:

SQ1: *How do companies form their innovation strategy and manage their innovation processes?*

Secondly, identifying the barriers that hamper innovation processes is necessary in order to understand the reasons that may bring an airline to favour the innovation ecosystems concept. The studies on barriers to innovation (Sandberg and Aarikka-Stenroos, 2014) indicate that the barriers vary according to the characteristics of a firm (i.e. size and industrial affiliation). The subject of the case study is a large airliner based in the Netherlands that would like to adopt and implement radical innovations and stimulate innovation within the company, and the case interviews will be conducted with the employees of this airliner. Therefore, the focus lies on the current literature that studies the barriers faced by the large organizations that would like to adopt and implement radical innovations. The second sub-question is as follows:

SQ2: *What are the barriers to radical innovation in large organizations?*

Thirdly, in his book Hadjimanolis (2003) argues that many innovation barriers are due to a lack of innovation drivers, therefore it is important to identify innovation drivers to stimulate innovation within the firm. Knowledge on innovation ecosystems and innovation ecosystem strategies are necessary to understand how innovation ecosystem concept is implemented and what are the innovation ecosystems strategies used by companies to build and maintain their position in innovation ecosystems and, ensure

the alignment between actors within the webs of interdependencies. Therefore, the third sub-question is as follows:

SQ3: *How to drive innovation in an organization, and what are innovation ecosystem strategies implemented by the organizations to drive innovation?*

The fourth and fifth sub-question are directly linked to the object of the case study, KLM Royal Dutch Airlines. By asking and answering these questions, it was aimed to understand the innovation processes of KLM and dynamics of airline industry. In order to gain this knowledge, information will be gathered from the observations during the graduation internship, company documents and the case interviews. The output from the case study is essential to answer the main question, hence no previous research has investigated the innovation ecosystem strategies of airlines. The fourth and fifth sub-questions are as follows:

SQ4: *What are the barriers to radical innovation in airlines?*

SQ5: *What are innovation ecosystem strategies implemented by airlines to drive innovation?*

1.4. Research Approach

This thesis explores the innovation ecosystem strategies of airlines and its link to airlines innovation strategy. Given our research objectives, this thesis has a qualitative constructivist approach and uses qualitative methodologies, which seek to explain and provide conclusions for a specific business environment. Therefore, the thesis has three characteristics: (1) explanatory, (2) interpretive and, (3) explorative. First, it is explanatory as it studies how innovation strategy is formed and how firms manage their innovation processes and what are the barriers and drivers to innovation at a large firm and how can those be linked to innovation ecosystems. Secondly, it is interpretive because it proposes an analytical framework by combining different topics on innovation in literature. Thirdly, it is exploratory because it explores barriers to innovation in an airliner and how innovation ecosystem strategies are currently implemented at the firm level. Based on the exploratory nature of the main research question, the qualitative case study method (see Figure 1.4) described by Yin (1994) is the most appropriate to empirically investigate the implementation of the innovation ecosystem strategies. Similarly, case study method is the most common research method used in the core IE studies (Gu *et al.*, 2021).
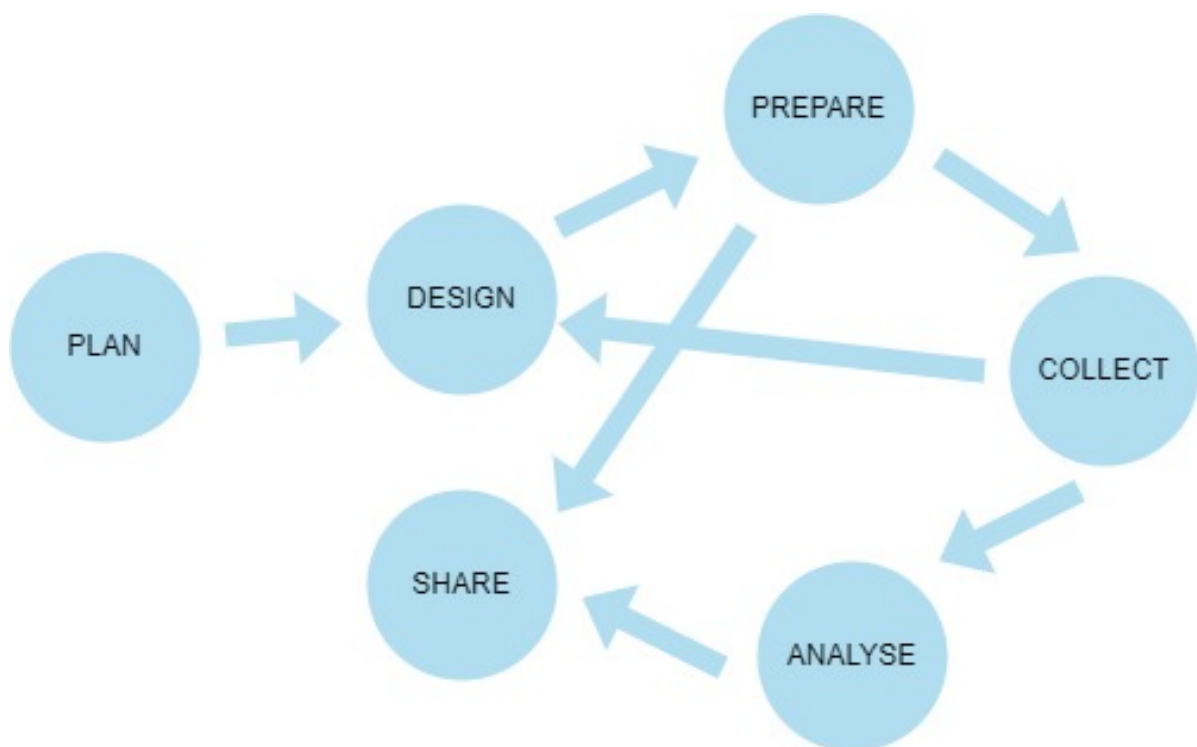
Figure 1.4: Case Study Approach by Yin (1994).

The type of case study is an embedded case study (see Figure 1.5), because three different divisions of KLM (Engineering & Maintenance, Cargo, Ground Services) were studied within the larger context of KLM, as depicted in Figure 1.6. The embedded case studies are often considered more compelling than single-case studies by the scholars and is "more likely to lend (itself) to valid generalization" (Fraenkel and Wallen, 2008, p. 431). Given the 28,000 employees and 3 different business activities of KLM, improved generalizability is beneficial. Furthermore, the cases are *chosen in order that theories can be generated about a larger collection of cases. In this way they employ a very different mode of thinking from the single case study"* (Wellington, 2015, p. 166). By sampling interviewees from 3 different

divisions within the organization, this research aims to achieve results that will be more generalizable and reliable than a single case study conducted at only 1 division. The structure of an embedded case study provides the methodological framework for this study.
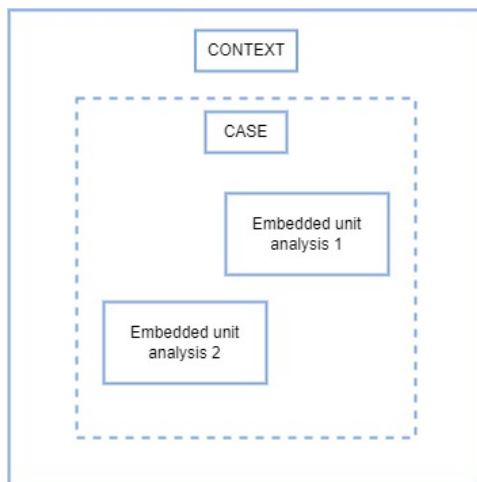
Figure 1.5: Embedded Case Study Approach by Yin (1994).   Figure 1.6: Embedded Case Study of this thesis.
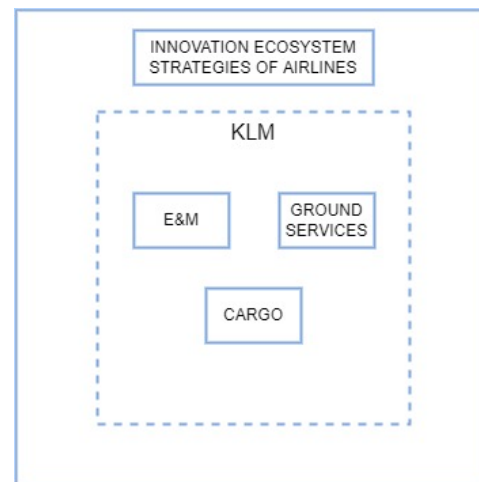
In order to gain insight on how the research question will be answered, a flowchart shown in Figure 1.7 has been constructed. This first chapter gives an introduction into the research and introduced the research questions central to this research. The research starts by conducting a literature review (divided in Chapter 2 and Chapter 3) on the several topics that are related to the research domain to present a broad overview of the state-of-art knowledge this thesis requires. In Chapter 4, the selected cases for the empirical study are substantiated, analytical framework is presented, and details regarding data collection and analysis are provided. The results of the embedded case study in Chapter 5. The move toward interpreting, discussing, and generalizing the research results will be made in Chapter 6 which will also provide a set of recommendations to KLM. Finally, the conclusions of this thesis will be highlighted, and the main research question will be answered in Chapter 7. This chapter will also reflect on the limitations of this study, and offer recommendations for further research.

CHAPTER 2: LITERATURE REVIEW PART I

SQ1: How do companies form their innovation strategy and manage their innovation processes?

Innovation Strategy

Contextual Innovation Management
Ortt & van der Duin (2008)

Innovation Barriers

internal	external	internal	external
Type of organization (Large) (Sandberg and Aarikka-Stenroos, 2014)	Type of country/culture (Dutch companies) Van der Meer (2007)	Type of innovation (Sandberg and Aarikka-Stenroos, 2014)	Type of industry (Airline industry) Case study data collection

SQ2: What are the main barriers to radical innovation in large organizations?

Conclusion Chapter 2 = Answer SQ1 & Answer SQ2

CHAPTER 3: LITERATURE REVIEW PART II

SQ3: How to drive innovation in an organization, and what are innovation ecosystem strategies implemented by the organizations to drive innovation?

Innovation Drivers
Stimulating innovation within the firm

Cultural Approach

Innovative Climate

Structural Approach

Innovation Ecosystems

Visscher et al. (2020)

Innovation Ecosystems
Ecosystem-as-structure
Adner (2006)

Explorative Layer

Exploitative Layer

Conclusion Chapter 3 = Answer SQ3

CHAPTER 4: RESEARCH DESIGN

Analytical Framework

Methodology
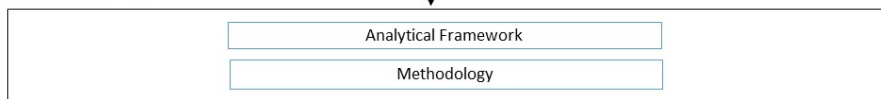
CHAPTER 5: EMBEDDED CASE STUDY

SQ4: What are the barriers to radical innovation in airlines?
SQ5: What are innovation ecosystem strategies implemented by airlines to drive innovation?

Results

Analysis Results = Answer SQ4 & SQ5

Validation

Concluding remarks

CHAPTER 6: DISCUSSION

Interpretation & discussion of the results

Recommendations to KLM

CHAPTER 7: CONCLUSION

MRQ: How can innovation ecosystems support airlines to implement their innovation strategy?

Main Findings & Answer MRQ

Scientific contribution of this study

Limitations

Recommendations for future research

Figure 1.7: Thesis Structure

2

Literature Review

Literature review provides an overview of the relevant topics studied in the context of innovation ecosystems to provide more insights into the scientific context of this research. It covers a range of topics and concepts that are related to innovation ecosystems and necessary to understand the wider context and theoretical background. The literature review is separated into two parts to make a clear distinction between the motives for implementing innovation ecosystems and the description of the concept. The outcomes of both chapters are used to provide necessary foundation, for the analytical framework presented in Chapter 4.

This chapter, thus the first part of the literature review, starts by introducing the innovation strategy and looks at how an innovation strategy is formulated in Section 2.1. In Section 2.2, the contextual innovation management is discussed and based on the contextual factors proposed by literature, a set of barriers to innovation is identified. The chapter ends with some concluding remarks in and answering sub-research question 1 and 2 in Section 2.3.

2.1. Innovation Strategy

Strategy is a set of coherent and internally consistent resource allocation decisions that are aimed at achieving an organization's specific goals. According to Miles and Snow (1978) if a firm wants to become superior, the firm's mission and values should align with its corporate and functional strategies. Therefore, if innovation is part of an organization's overarching corporate strategy, a functional innovation strategy should be formulated to make necessary trade-off decisions and manage innovation processes (Pisano, 2016). Creating an innovation strategy is a complex task that involves determining how innovation will create value for potential customers, how the company will capture that value, and which types of innovation to pursue. Developing and implementing an innovation strategy that aligns with the overall business strategy can help managers to make decisions on choosing the most appropriate option and setting overarching innovation goals that align with the company's business model. (Pisano, 2016). Without such a strategy, companies might fall into the trap of copying trends that do not fit in their overall business strategy (Pisano, 2016). According to Fortuin (2006), just like in the traditional strategy literature, finding the right balance between exploration and exploitation is also relevant for the choice of an innovation strategy. The concept of 'exploration versus exploitation'

is also mentioned in the multilayered perspective of Visscher et al. (2021). Therefore, it is important for this research to discuss it in detail.

2.1.1. Exploration versus exploitation

The difference between exploration and exploitation was first mentioned by Holland (1975). The concept was later further developed by March (1991) (Fortuin, 2006). Exploration focuses on the discovery of new products, resources, knowledge and opportunities, and it is associated with radical changes. Exploitation focuses on the refinement of existing products, resources, knowledge and competencies, and is associated with incremental changes (Benner and Tushman, 2003; March, 1991). In order to generate more revenue for the firm, unknowns need to be discovered or explored, and the known needs to be exploited. Exploration involves activities such as search, variation, risk taking, experimentation, discovery, and innovation while exploitation involves activities such as refinement, efficiency, selection, implementation, and execution (March, 1991). Therefore, exploitation can be planned and controlled, which is important since efficiency is crucial for the competition (Levinthal and March, 1993).

In contrast to exploitation, exploration is an uncertain process and cannot be planned. Returns from exploitation are often positive, proximate and predictable while the returns from exploration are uncertain, more remote in time and organizationally more distant from the locus of action (Levinthal and March, 1993). Performing both tasks are important for firms. Exploitation enables firms to get higher returns on the (large) investments made in existing technology and exploration enables them to develop new technologies on time in the fast-changing market conditions that make existing technology quickly obsolete. In other words, exploitation is necessary in the short run, while exploration is necessary for the long-term survival of the firm (Fortuin, 2006).

Not only the formulation of innovation strategy is important for achieving the innovation goals, but also the execution of this strategy (Pisano, 2016). Literature suggests that the use of specific innovation management approaches and corresponding tools can help companies to implement their innovation strategy. Igurtua et al. (2010), defines innovation management tools as: "techniques, and methodologies intended to support the process of innovation and help companies to meet new market challenges in a systematic way". In the past, companies used the best tools and techniques as prescribed by the dominant innovation approach of their time (see Table 2.1). However, nowadays companies manage their innovation process based on the specific context of the company. This is in parallel with the contingency theory that suggests *"there is no optimal strategy for all organizations and posits that the most desirable choice of strategy variables alters according to certain factors, termed contingency factors"* (Markman and Phan, 2011, p.468). In their paper, Ortt and van der Duin (2008) refer this approach as 'contextual innovation management' which is explained further in Section 2.2.

Period	Innovation Management Approach
1950 - mid 1960s	Technology (science) push
Mid 1960s - early 1970s	Market pull (need-pull)
Early 1970s - Mid 1980s	Market pull and technology push combined
Mid 1980s - Early 2000s	Innovation in alliances; parallel and integrated innovation

Table 2.1: Evolution of innovation management, adapted from (Ortt and van der Duin, 2008)

2.2. Contextual Innovation Management

Innovation management is *"the governance and organization of the innovation processes"* (Ortt and van der Duin, 2008). Innovation processes consist of activities that are performed at each stage of the development of an innovation. Empirical research shows that when it comes to innovation management, a contextual approach rather than a single mainstream approach gives the best results (Miller and Blais, 1993; Hanna *et al.*, 1995). In their paper, Ortt and van der Duin (2008) reviewed the innovation management in large companies and identified the mechanisms of contextual innovation by distinguishing four different contextual factors of innovation processes. The first two factors are related to the internal environment of a firm and the other two factors are related to the external environment of a firm (Ortt and van der Duin, 2008). Capturing both internal and external factors is relevant for the overarching perspective of this thesis:

1. Type of innovation (e.g., incremental, radical)

2. Type of organization (e.g., hierarchical, flat, small, large),

3. Type of industry (e.g., high-tech, airline, software),

4. Type of country/culture (e.g., egalitarian, authoritative).

2.2.1. Types of Innovation

Edwards-Schachter (2018) argues that innovation is a multidimensional concept that includes various meanings and definitions based on the viewpoint of different disciplines. Scholars tried to identify the characteristics of innovation to create common innovation typologies (Linton, 2009; Oke, 2007; Garcia and Calantone, 2002). However, innovation is an umbrella concept that includes variety of innovation types (Edwards-Schachter, 2018). The introduction of new definitions shows that the concept is dynamic and evolving under the influence of historical and sociocultural events (Fagerberg and Verspagen, 2009; Godin, 2015; Gupta *et al.*, 2003). Scholars argue that there is a lack of interest in interrelationship between technological and non-technological factors that influence the generation and diffusion of successful innovation and social dimensions of innovation processes (Edwards-Schachter, 2018; Fagerberg and Verspagen, 2009; Fagerberg *et al.*, 2013; Lundvall, 2013; Martin, 2016). Early definitions of innovation focus on the role of technology and evolution in the production and application of scientific and technological knowledge in manufacturing (Martin, 2016). Although innovation is often associated with "invention", "novelty", and "change", its characteristics change depending on the contextual factors such as purposes, actors, drivers and resources, activities and outcomes, and value generation (Edwards-Schachter, 2018). Transition of these factors influences the classical scope and definitions of innovation, which is often referred as *technological innovation* nowadays. Moreover, early literature considers an innovation successful only if it leads to an economic development or transaction (Freeman, 1974; Schumpeter and Backhaus, 2003). While contemporary literature accentuates the evolution of the concept in the light of societal goals, *"from innovation for wealth creation to innovation for well-being"* (Martin, 2016; Edwards-Schachter, 2018). This new phenomenon that emerged in the last decades is often referred as *"social innovation"* in the literature. Innovations have been categorized in many ways, however, this research focuses on two relevant dimensions of innovation.

Firstly, innovations can be distinguished based on technology newness.

- Incremental innovation: Innovations that involve minor changes in technology and some new

value or differentiation in current products, services and technology to help firms to stay competitive in the short-term (Okuyama, 2017; Hopp *et al.*, 2018)

- Radical innovation: Innovations that involve significant improvements in products and services and the provision of new products and services and focuses on long-term impact (Nguyen, 2018).

- Transformational innovation: Innovations that involves introduction of a technology that creates a new industry and transforms the way people live. This kind of innovation often eliminates existing industries or, at a minimum, completely transforms them.

It is important to note that, innovations do not have to be "radical" in order to be disruptive since "disruption" in this context refers more to a market/business phenomenon rather than a technological breakthrough. Christensen's model refers breakthroughs as "radical" however they may or may not be disruptive, contrarily "incremental" innovations can be massively disruptive (Edwards-Schachter, 2018).

Secondly, according to The Oslo Manual (2021) for measuring innovation, innovations can be distinguished based on their form. These include product innovation, process innovation, marketing innovation and organizational innovation.

- **Product innovation**: Innovations that focus on the development of products or services that are new or significantly improved. They often include some form of new technology or improvements in functional characteristics.

- **Process innovation**: Innovations that focus on a new or significantly improved production or delivery method that includes significant changes in techniques, equipment and/or software.

- **Marketing innovation**: Innovations that focus on new marketing with a significant change in product design or packaging, product placement, product promotion or pricing.

- **Organizational innovation**: Innovations that focus on a new organizational method in business practices, workplace organization or external relations.

The findings of various studies (Tidd and Bodley, 2002; Ortt and Smits, 2006; Tidd, 2001; Drejer, 2002) show that different types of innovations require different approaches. For instance heavyweight project managers and cross functional teams were found more effective for the high-novelty projects, and the likelihood of involvement of customers and suppliers in the development and commercialization for the novel projects was twice as much (van der Duin *et al.*, 2014).

2.2.2. Type of organization

According to Hanna et al. (1995) different types of organizations require different approaches. Ortt and van den Duin (2008), distinguish main variables in this context as following:

- Hierarchical versus flat organization,

- Small versus large organization,

- The firms' competencies, business opportunities, and managerial preferences.

Firstly, according to Brown and Eisenhardt (1997) two sets of companies in the IT-industry developed similar innovations in a completely different way. An overarching long-term vision was the guiding factor for more hierarchical organizations in coordination of their innovative activities while flat organizations

delegated responsibilities to small teams in order to enable their firm's innovative activities. Secondly, due to their limited capacity to absorb outside knowledge, using outside sources of knowledge such as R&D and licenses is less common for small firms. Moreover, they are more dependent on the suppliers and the machinery compared to larger firms (Ortt and van der Duin, 2008). Thirdly, the firms' competencies, business opportunities, and corporate strategy also influences their choices for the modes of innovation (Miller and Blais, 1993).

2.2.3. Type of Industry

Ortt and van den Duin (2008), distinguish main variables in this context as following:

- High-tech versus low-tech market,

- Consumer versus business market,

High-tech and low-tech markets have different success factors for new product development. For instance high-tech firms devote at least 10 percent of their time to new product development and low-tech firms assign their product managers from the marketing department as part of the organization for new product development (van der Duin *et al.*, 2014). Business-product companies often use customers as sources of ideas, and place heavier emphasis on finding new uses or markets for their products while consumer-product companies often use product management and development groups, with focus on new products and line extensions. They also emphasize market analysis and product positioning compared to business-product companies (Hanna *et al.*, 1995).

2.2.4. Type of Country/Culture

The country where a company is established can have major impact on innovation management due to practical reasons like legal system of the country as well as the cultural reasons like way of cooperation (Ortt and van der Duin, 2008). The findings of literature suggest that different innovation practices may be developed in different cultures. Some of these differences could be explained by the preferred orientation within a culture, such as an individual versus a collective orientation or national laws applied in a country (Drejer, 2002; Oliver *et al.*, 2004).

2.2.5. Barriers to Innovation

Due to high costs of research, development, and marketing, many innovations do not reach the implementation phase (Huizenga, 2001). A study by Booz-Allen and Hamilton (1982) that collected data from more than 700 US manufacturers found out that less than 2% of the innovative ideas were introduced to the market and commercially successful. To be more specific, out of every 58 new product ideas, only 12 passed an initial screening test, only 3 survived development and from these 3 ideas, 2 appeared to have profit potential after test marketing and only 1 was commercially successful (Booz, 1982). According to Fortuin (2006) innovations that fail are often good ideas but have been suspended due to financial constraints, a lack of skills or poor fit with current goals. He argues that failures are actually a part of the innovation process and most successful innovative firms are ready to absorb certain level of failure. However, if the failure rates are too high they can be a threat to a firm's future (Cobbenhagen, 2000; Huizenga, 2001). Therefore the factors hampering the innovation has attracted wide attention from the literature as well as the practice. In the literature, numerous scholars studied the barriers to innovation in different contexts, such as barriers in relation to manufacturing firms (Baldwin and Lin, 2002; Galia and Legros, 2004), barriers for product innovation (Nagano *et al.*, 2016),

barriers in relation to governments (Meijer, 2015), and barriers in small firms (Hadjimanolis, 2003). According to Das et al. (2018) innovation barriers are dynamic, and their presence and relevance are interdependent on the innovation process and size of the firm.

Both internal and external factors might affect the firm's performance in innovation. Therefore the barriers can also be distinguished as internal and external barriers. By doing so, firms can identify the barriers that they can influence, and the ones that are partially or completely beyond their influence (Piater, 1984). Das et al. (2018) identified most common internal and external barriers mentioned in the literature. The most common internal barriers include; a firm's strategy, organizational architecture, leadership, organizational culture, the organization of research and development, and performance incentives (Baldwin and von Hippel, 2010; Cohen and Levinthal, 1990; Benner and Tushman, 2015; Tushman and O'Reilly, 1996) and the most common external barriers include; market dynamics, competitor behavior, and market and technology turbulence (Alexiev *et al.*, 2016; Hung and Chou, 2013; Lichtenthaler, 2011).

A literature study by Sandberg and Aarikka-Stenroos (2014) identified the critical barriers to radical innovation that were distinguished in two dimensions. The first dimension is the distinction between internal and external barriers, and the second dimension is the distinction between small and large firms. In their study, manufacturing firms, service industries, and governments are considered as large firms. Due to the scope of this thesis and characteristics of the chosen case study, the author will focus on the barriers for large firms. These barriers are shown in Table 2.2.

No.	Barrier	Literature example	Source
	External		
1	Customer resistance	*Customers unable to express their needs*	Füller & Matzler (2007)
2	Undeveloped network and ecosystem	*Lack of support from an innovation's adaptation network*	Chiesa & Frattini (2011)
3	Technological turbulence	*Rapid advancements of technology limits thorough ex-ante exploration of preferences and specifications*	Littler and Sweeting, (1985)
	Internal		
5	A restrictive mindset	*Strong routines inhibiting actions outside pew-existing patterns*	O'Connor (1998)
6	A lack of discovery competences	*Conventional analytic for evaluating market opportunities tend to be appropriate*	Lynn et al. (1996)
7	An unsupportive organizational structure	*Conflicts between mainstream organization and radical innovation teams*	Leifer et al. (2001)

Table 2.2: Barriers to Radical Innovation in Large Firms (Sandberg and Aarikka-Stenroos, 2014).

When it comes to companies based in the Netherlands, literature suggests that the factors hampering innovation in Dutch companies are very similar to those found globally (Meer, 2007; Pricewater-houseCoopers, 2016). In his paper, van der Meer (2007) studied 28 companies that rated themselves in this questionnaire as forerunners in innovation and presented factors that were found to hamper innovation in these companies. Although these factors might be relevant, he argues that the main problems are *"the management wasting scarce time and motivation available for innovation by putting effort into wrong projects and neglecting knowledge already available elsewhere"*. Moreover, *"companies co-operate too little with external parties (such as other companies and research institutes)"* and *"technological aspects of innovation getting far more (management) attention than non-technological ones"* (Meer, 2007).

According to van der Meer (Meer, 2007), the main findings indicate that different barriers to innovation lead to different firms' openness decisions, and different decisions on openness have differentiated influence on innovation performance. Similarly, the findings of another more recent study by Hartano & Rafik (2021) suggests that different barriers to innovation lead to different firms' openness decisions, and different decisions on openness have differentiated influence on innovation performance. According to Hartano & Rafik (2021) the firms that are experiencing human resource and organization related barriers source broadly and deeply external information and perform more cooperation and acquisition activities. They suggest that the external search is a response of firms which face institution barriers. In contrary, if a firm performs less cooperation activities, this can be indicated as a response to their financial and risk constraints. Secondly, the study shows that absorptive capacity (i.e. the innovation activities expenditure and training activities) can help firms to be more open. This means that firms not only need innovation funding, but also skill and knowledge gained from training activities in order to be more innovative. Thirdly, their findings suggest that there is a positive correlation between the firm size and its openness, so larger firms are considered to be more open. Regarding the link between firm openness and innovation performance, their findings indicate that the innovation performance is influenced differently by the decisions firms make. For instance, while external R&D leads to a positive impact on the share of product innovation new to the firms, acquisition activities lead to a negative impact on sales' proportion of product innovation new to the firms. In addition, absorptive capacity have a positive impact on the innovation performance. (Hartono and Rafik, 2021).

2.3. Conclusion

This chapter discussed the first part of the literature that is relevant to achieve the aim of this study. Firstly, a necessary background information on formulation and execution of innovation strategy was provided to answer the first sub-research question:

SQ1: *How do companies formulate their innovation strategy and manage their innovation processes?*

According to literature, one can conclude that *innovation strategy is a set of coherent and internally consistent resource allocation decisions that are aimed at achieving an organization's specific goals* and formulation of innovation strategy requires the right balance between *exploration and exploitation* and *alignment with the firm's business strategy*. It was also found that formulating an innovation strategy is not enough by itself for a company to achieve its objectives. In order to achieve the objectives and goals set by the organization, the formulated innovation strategy must be executed. The use of specific innovation management approaches and corresponding techniques might be helpful for execution of the innovation strategy and in contrast to past, nowadays, companies use contextual approaches and techniques that fits and aligns with their innovation strategy. These contextual factors include: *type of innovation, type of organization, type of industry and type of country/culture.* This chapter discussed further in detail to understand how these factors are related to the firm's innovation management and to the barriers to innovation. Based on the theoretical knowledge, it is safe to assume that the type of barriers to innovation at organizations depends on the contextual factors. This meant that in order to avoid faulty comparisons between the literature barriers and case study barriers, one should focus on those barriers to innovation that demonstrates the characteristics of the case study subject. This objective was achieved by proving an answer to the second sub-research question:

SQ2: *What are the barriers to radical innovation in large organizations?*

The answer to second sub-research question, barriers to radical innovation in large firms found in literature, is provided in Table 2.2. Identifying these barriers are important as they will be compared to those barriers found during the case study to draw conclusions. Moreover, Sandberg & Aarikka-Stenroos (2014) suggest that external barriers are affected by the type of industry and especially the service innovations provides a different perspective, in which external barriers were accentuated; in particular, barriers originating from a restrictive macro environment (Sandberg and Aarikka-Stenroos, 2014). This might be interesting to investigate, as the core business of an airline is providing transportation services. Furthermore, the findings of this chapter indicated that different barriers led to different strategic decisions on the openness of a firm, and different decisions on openness had differentiated influence on innovation performance. This meant that innovation processes of firms should be considered with a holistic approach and necessary links between barriers and drivers should be established.

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Literature Review: Part II

This chapter, thus the second part of the literature review, starts with Section 3.1 introducing the ways to drive innovation within a company, which can be distinguished: (1) culturally (open innovation culture) and, (2) structurally (open innovation mechanisms). Section 3.2 discusses 'Open Innovation' and its transformation to 'Innovation Ecosystems'. Section 3.3 discusses 'Innovation Ecosystems' in detail, describes its characteristics and reviews how it can support the implementation of innovation strategy. Finally, this chapter ends with concluding remarks and answering the sub-research questions 3 in Section 3.4.

3.1. Driving Innovation within the Firm

According to van der Meer (2007), innovation within the firm can be stimulated in two ways:

1. Culturally: creation of an innovative climate.

2. Structurally: systematic use of innovation mechanisms.

3.1.1. Cultural Approach

The cultural approach towards enabling innovation aims to create an innovative climate that composes a set of attitudes and values that are favourable to innovation (Ekvall, 1996; Isaksen and Tidd, 2006). In his paper, van der Meer (2007) defined numerous factors that are important for creating an innovative climate. These factors are presented in Table 3.1. While some scholars believe that the cultural factors and therefore the innovative environment is the essential factor for innovation (Phillips, 1983), there are also scholars who embrace the structural approach.

3.1.2. Structural Approach

The organized use of innovation enabling mechanisms are favoured by the structural approach. These mechanisms can be defined as *"organizational entities that are designed to promote the development and management of new ideas, projects and business"*. Champions, task forces, venture teams, spin-offs, enabling acquisitions, spinins, venture capital, licensing, innovative budgets and partnering can be given as examples for innovation mechanisms (Meer, 2007).

Negative	Factor	Positive
short	horizon	long
kept out	maverick	accepted
punished	failures	tolerated
formal	communication	informal
kept out	uncertainty	accepted
analyses	planning	action
means	planning	opportunities
closed	external co-operation	open
autocratic	decision-making	participative
internal	organization	customer
vague	strategy	clear

Table 3.1: Several Factors Important to an Innovative Climate, (Meer, 2007).

The task for management to enable innovation differs per stage. During the stage where new ideas are initiated and future opportunities are explored, the cultural approach becomes prominent to create an innovative climate to nurture these opportunities. On the other hand, during the stage where explored opportunities and ideas are further developed and implemented, the structural approach stands out by using correct mechanisms to turn these ideas and opportunities into projects (Prokopenko and North, 1996; Meer, 2007). Sometimes these tasks might be in conflict with each other. For instance, some accepted uncertainty might help for an innovative climate however it is contracting with the planning required during the implementation phase. Innovation systems within the companies seem to be in continuous development to cope with these paradoxes, which eventually lead to the open innovation model which will be explained in Section 3.2 (Meer, 2007).

3.2. Open Innovation

The term 'Open Innovation' was invented by Henry Chesbrough, associate professor and head of the Open Innovation Center of the Haas Business School of the University of California, and gained widespread attention after he published his book Open Innovation in 2003. He describes the term as *"the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation"* (Chesbrough, 2021). The model was developed to overcome the limitations of closed systems. In contrast to closed innovation models, open innovation models enhance not only the successful implementation of ideas in the original business domain of a company, but also outside of this domain (Chesbrough, 2003). Moreover, small and medium enterprises (SMEs) can benefit if large companies and research institutes adopt more open and collaborative approach as they do not own huge R&D capacity (Brown and Hagel, 2006). Philips and DSM are examples of larger companies that claim to use the principles of open innovation. The High Tech Campus in Eindhoven where research capacity and laboratory capacity is provided to companies that spun off Philips but also to other high-tech start-ups is an example of open innovation strategy of Philips. According to DSM, open innovation has brought different perspectives to their operation. By using strategic alliances with other companies and research institutes, DSM transformed from a classical mass chemical production

plant to advanced consumer products like Dyneema strong fibres and food specialities (Meer, 2007.
Chesbrough (2003) breaks down open innovation into three elements: culture, structure and business
model. These elements are explained below.

3.2.1. Open Innovation Culture

Open innovation requires a new culture composed of different set of norms, beliefs and values than
closed innovation (Meer, 2007). Table 3.2 represents the basic contrasting principles of open and
closed innovation.

Contrasting Principles of Closed and Open Innovation

Closed Innovation Principles	Open Innovation Principles
The smart people in our field work for us	Not all the smart people work for us. We need to work with smart people inside and outside our company
To profit from R&D, we must discover it, develop it, and ship it ourselves	External R&D can create significant value; internal R&D is needed to claim some portion of that value
If we discover it ourselves, we will get it to market first	We don't have to originate the research to profit from it
The company that gets an innovation to market first will win	Building a better business model is better than getting to market first
If we create the most and the best ideas in the industry, we will win	If we make the best use of internal and external ideas, we will win
We should control our innovation process, so that our competitors don't profit from our ideas	We should profit from others' use of our innovation project, and we should buy others' IP whenever it advances our own business model

Table 3.2: The Culture of Open Innovation (Chesbrough, 2003)

3.2.2. Open Innovation Structure

Just like to other models, open innovation also uses mechanisms for importing and exporting knowledge, ideas and projects. These mechanisms involve methods, structures and systems in each step of
the innovation process that enable in- or outflow. Some of these mechanisms that are identified by
van der Meer (2007) are listed in Table 3.3.

3.2.3. Open Innovation Business Model

Open innovation model is known by its flexibility to use various business models. It is very common
for firms to go beyond their boundaries not only to source innovations to commercialize, but also to
source the very business models that enable such commercialization (Vanhaverbeke and Chesbrough,
2014; West and Bogers, 2016). This is a characteristic feature that eliminates 'Not Sold Here' mindset
of closed innovation companies. By enhancing additional business, firms have a broader spectrum of
business opportunities to make financial gains (Meer, 2007). Joan Magretta (2002) explains the term
business model as following: " at heart, stories — stories that explain how enterprises work. A good
business model answers Peter Drucker's age-old questions, 'Who is the customer? And what does the
customer value?' It also answers the fundamental questions every manager must ask: 'How do we
make money in this business?' 'What is the underlying economic logic that explains how we can deliver

Stage	Importing	Exporting
Concept	Creative sessions networking with universities and scientific institutes	Cluster projects Industry groups Public–private co-operation
	Knowledge clusters 'Open Day'	Licensing out
	Conferences	
	Fairs	
	Suppliers and end-users	
	Licensing in	
Development	Patent search	Patent brokers
	Partnering	Spinning out
	Spinning in	
Business	Venturing in	Venturing out

Table 3.3: Open Innovation Mechanisms, (Meer, 2007).

value to customers at an appropriate cost?' ". Open innovation puts thinking in different business models in the center of attention. Some examples include the Canon's win over Xerox with making money out of paper and toner instead of expensive copy machines, implementation of Teflon technology to clothing which led to global success of Gore-tex and Google making money out of advertising while offering their services for free. Although it might look easy to analyse success factors in the hindsight, designing a winning business model from start is challenging for many companies (Casadesus-Masanell and Ricart, 2011). As a consequence most of the companies become hesitant to go outside of their existing business model and miss a lot of opportunities (Christensen, 1997; Cooper, 2005). According to van der Meer (2007) a business model should:

- Create value for the end user (and the following parties in the value chain),

- Guarantee that the innovator (or creator or other key stakeholders) gets a fair share of the value added.

Open innovation approach allows companies to be aware of their dominant business model and at the same time it also encourages them to create new ones when needed. This way companies can be up to date of new innovative models proposed by outsiders and adopt them if necessary. Literature shows that despite its advantages, it is still a challenge for the most companies when it comes to thinking in alternative business models (Meer, 2007).

According to West & Bogers (2016), the success of open business models is defined by aligning value creation and capture activities to an innovation rather than controlling these activities internally. Sometimes this leads to the locus of value creation and capture activities moving beyond the organizational level to the ecosystem level (Radziwon et al., 2017).

3.2.4. From Open Innovation to Innovation Ecosystems

Organization for Economic Cooperation and Development (OECD) published a report that puts emphasize on "new nature of innovation" that differentiates it from innovation in the industrial era (Prahalad et al., 2009). According to this report, there are four trends behind this gradual transformation of how companies innovate. These trends include: global challenges and changes in the public sector

and welfare policies, global knowledge sourcing, collaborative networks, and new ways of co-creating value with customers and tapping into knowledge concerning users (Edwards-Schachter, 2018). Moreover, The Open Innovation Strategy and Policy Group (OISPG) has published various reports on a new innovation paradigm. Similar to OECD report, intersection of mega-trends such as digitization, mass collaboration, and sustainability needs are the drivers of this new model. The innovations which will be required to deal with these mega-trends and to overcome contemporary global challenges, will require much collaboration and alignment across ecosystems (Curley, 2013). In their paper "Open Innovation: Current Status and Research Opportunities", West & Bogers (2016) reviewed the literature and identified opportunities for future research on OI. According to this paper, in the literature an important extension has been moving beyond the bilateral collaborations of Chesbrough (2003) to various network typologies of collaboration (West and Bogers, 2016). These networks such as ecosystems require firms to orchestrate (or negotiate) the joint value creation and value capture of the firms across the network (Vanhaverbeke, 2006; West, 2014). The evolution of innovation from internal R&D departments, through the era of open innovation, and now to an ecosystem-centric view of innovation is shown in Figure 3.1. Some of the characteristics of each innovation mode are briefly explained below and shown in Table 3.4 to highlight the differences between each mode. Making a comparison between different modes shows that innovation as well as the innovation processes of the firms are dynamic. The way companies approach to innovation changes with time as different problems require different solutions. As today's challenges are often very complex and requires inclusion of multiple stakeholders, this might explain why an ecosystem-centric view of innovation has emerged.
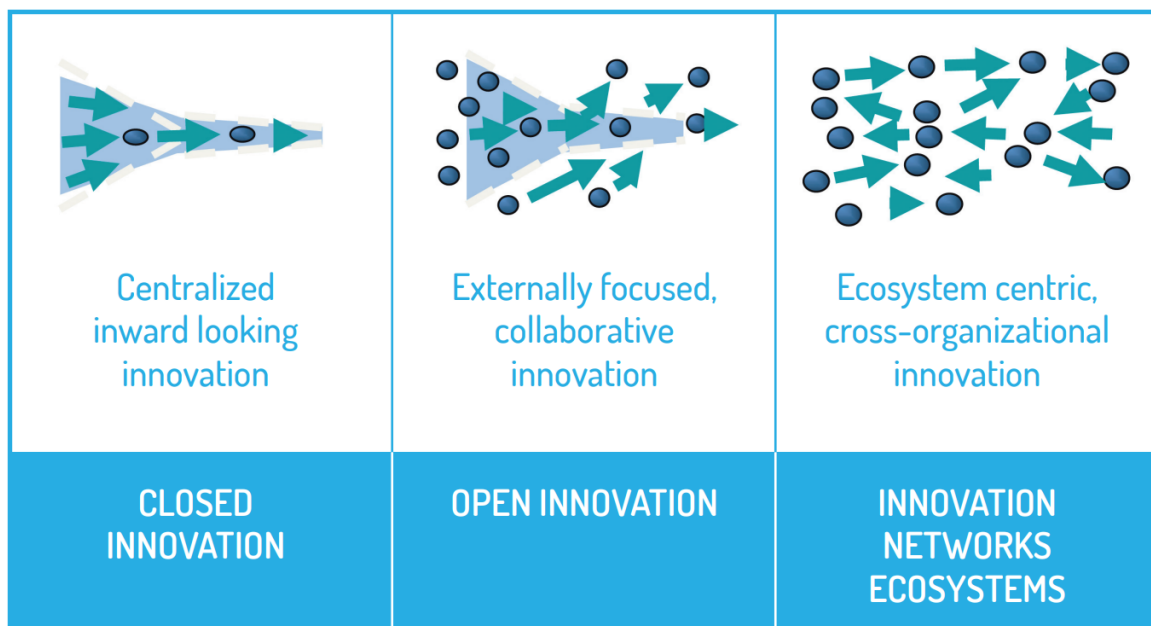
Figure 3.1: The Evolution of Innovation, (EU Open Innovation Strategy and Policy Group, 2013).

Solo > Cluster > Ecosystem

Complexity in combining a wide variety of technologies in rapidly changing environments of today is beyond the knowledge and experience of a single firm. Sector clusters might be helpful, however they lack the needed knowledge base outside the core business. Ecosystems include the users in quadruple

Closed Innovation	Open Innovation	Innovation Ecosystems
Planning	Validation	Experimentation
Solo	Cluster	Ecosystem
Linear	Linear, Leaking	Nonlinear Mash-Up
Planning	Validation	Experimentation
Win-Lose	Win-Win	Win-More: Win-More
Single Entity	Single Discipline	Interdisciplinary
Value Chain	Value Network	Value Constellation

Table 3.4: Different Modes of Innovation, adapted from (Curley, 2013).

helix settings and provides strong interaction at early the early stages of innovation. This is important as it provides feedback and helps stakeholders to see which innovations will go through (Curley, 2013).

Linear > Linear, Leaking > Nonlinear Mash-Up

In earlier approaches, innovation grown sequentially. However, according to Peter Drucker (1985), unexpected events are the simplest and easiest source for innovation. Innovation processes require agility of both project structures and mindset for the actions. Purpose-oriented actions can help companies to move beyond their organizational boundaries and bring different companies together by sharing a common goal (Curley, 2013).

Planning > Validation > Experimentation

Given the today's rapidly changing environment and the complexity of the challenges, plans can become quickly obsolete. Experimenting in real-world settings can help companies to gather feedback and information at the earlier stage. Moreover, technologies such as virtual reality and artificial intelligence might be helpful to imitate real world situations at lower costs (Curley, 2013).

Win-Lose > Win-Win > Win-More

In the closed innovation approach companies often operates in a business environment with high competition amongst rivals, Open Innovation 2.0 targets new markets where there are no competitors or value offerings yet (Curley, 2013).

Single Entity > Single Discipline > Interdisciplinary

Several studies have proven that diversity of employees drives innovation (Hewlett et al., 2014; Schneider and Eckl, 2016). According to these studies the richer the competencies in the team the better innovation and financial performance (Levine, 2022). Employee diversity takes multiple forms such as age, gender, ethnicity, race but also areas of study, industry background and experience. Clusters often represent single discipline approach while innovation ecosystem represents different disciplines, ideas, and stakeholders that share a "common purpose".

Value Chain > Value Network > Value Constellation

The innovation value chain view presents innovation as a sequential and linear process. Value networks present connections between competencies/entities in the system and allows more redundancy. However, changing conditions and uncertainty can be problematic for value networks. In value constellation model, the connection between competencies/entities are dynamic and new links between existing partners can be created over time if necessary (Curley, 2013).

3.3. Innovation Ecosystems

Despite its popularity among scholars, innovation ecosystem was found to be loosely discussed under various backgrounds (Suominen et al., 2019; Dedehayir et al., 2018; Oh et al., 2016), which leads to inconsistent, fragmented and varied IE connotations in the literature (Granstrand and Holgersson, 2020; Gupta et al., 2019; Thomas and Autio, 2020). Multiple scholars reviewed the use of the innovation ecosystems concept in the literature and their findings indicated that the literature does not provide a robust definition of what an innovation ecosystem is (Granstrand and Holgersson, 2020; Oh et al., 2016; Baiyere, 2018). Scholars performed a systematic analysis of the different concepts of innovation ecosystems and proposed a conceptual framework that includes the following features: *"an innovation ecosystem is set for the co-creation, or the joint creation of value. It is composed of interconnected and interdependent networked actors, which includes the focal firm, customers, suppliers, complementary innovators and other agents as regulators. This definition implies that members face cooperation and competition in the innovation ecosystem; and an innovation ecosystem has a life cycle, which follows a co-evolution process"* (Gomes et al., 2018).

According to a recent systematic literature review on IE by Gu et al. (2021), from a longitudinal perspective, IE definitions have become more and more comprehensive and consistent. From 2006 to 2009, IE were referred to as "arrangements" in industry chains (Adner, 2006 or "processes" in innovation clusters (Papaioannou et al., 2009). Following, in the period from 2013 to 2017, the network perspective was used by scholars to define the IE concept (Nambisan and Baron, 2013). From 2018 to present, both the network perspective and system perspective have been favoured to define the concept. According to the recent studies in system perspective, IE refers to a "system" (Holgersson et al., 2018) or "network system" (Ding and Wu, 2017). The systems approach is used in a broad range of disciplines to deal with complex phenomena. The main elements of the approach have been adopted, modified and further developed in the literature. Sometimes these modifications and developments resulted in a new, popular derivative concept. An example of this is the concept of innovation system, which has been widely used in innovation management studies. In fact, scholars argue that IE is rooted in the innovation system concept and, both IE and SI are applications of System Thinking (Faissal Bassis and Armellini, 2018). Few studies examined the connections between IE and innovation systems in the literature (Gomes et al., 2018; Faissal Bassis and Armellini, 2018). However, it is beyond the scope of this thesis to discuss these connections in detail.

As a result, numerous literature reviews on IE were performed in the last years to define the concept explicitly to provide comprehensive recognition of this field (Oh et al., 2016; Granstrand and Holgersson, Granstrand and Holgersson; Gomes et al., 2018; Thomas and Autio, 2020). According to these studies, the innovation ecosystem concept synthesizes two main concepts: "innovation" and "ecosystem". The origin of the ecosystem as a concept lies in the science of ecology (Granstrand and Holgersson, 2020). As this thesis focuses on the innovation ecosystems, only a brief overview of this construct will be presented as it forms the basis of the innovation ecosystems and business ecosystems. Shaw and Allen (2018, p. 90) describe ecosystem as "recycling flows of nutrients along pathways made up of living subsystems which are organized into process-orientated roles; connects living and non-living subsystems; energy gradients power recycling of scarce nutrients, e.g. a rainforest". According to Bertalanffy's complex systems definition, an ecosystem is a self-organizing, self-regulating, and self-developing complex system where different biological organisms and their habitat are directly and indirectly connected by the exchange of substances and energy (Shevchuk, Dmitrii et al., 2021).

At the foundation of the innovation ecosystems lies the concept of business ecosystem, invented by Moore (1993). According to Moore, the frameworks related to networks, such as strategic alliances and virtual organizations, lacked the guidance for managers who would like to understand the relationships between firms and change. Building on the concept related to the biological fields, Moore proposed that companies should be seen as a part of an ecosystem where multiple actors co-evolve their capabilities around a new innovation. Moore suggested that a company can be viewed as part of a business ecosystem that crosses a variety of industries, in which companies co-evolve capabilities around a new innovation (Moore, 1993). In their paper, Anggraeni et al. (2007), developed the business ecosystems concept as a research perspective and identified its characteristics as:

1. *"Individual unit or organizational success requires a healthy ecosystem.*

2. *The importance of unpredictable, nonlinear, and natural consequences is underscored.*

3. *Influence is achieved by managing initial conditions and the underlying forces, or attractors, which organize the system.*

4. *Systemic change is a continuous, relentless process.*

5. *Self-organization triggers transformation.*

6. *Cultural integrity is the basis for establishing relevant boundaries. Given the emphasis on community and the recognition of attractors, complexity-based strategies rely on shared values and common purposes, rather than procedures to guide behavior."*(Anggraeni et al., 2007)

Throughout the years, the concept evolved and different conceptualizations of business ecosystem emerged (Gómez-Uranga *et al.*, 2014). The innovation ecosystem concept gained popularity after the publication of a Harvard Business Review article in which Adner (2006) considered business ecosystems as innovation ecosystems. He described the innovation ecosystems as *"the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution"* (Adner, 2006) and since then, business ecosystems started to be considered as innovation ecosystems. Gomes et al. (2018) argue that the innovation ecosystem concept put more emphasis on value creation and collaboration while the business ecosystems concept focuses on value capture and competition. It seems like the global shift from competition to collaboration shifted the focus of companies from the concept of business ecosystems to innovation ecosystems (Gomes *et al.*, 2018).

From a horizontal perspective, Granstrand and Holgersson (2020), identifies five types of keywords (actors, activities, relations, artefacts, and evolution) that are widely used in the literature to define or structure innovation ecosystem. It is worth to mention that while actors (e.g., organizations, suppliers, customers, and governments) and activities (e.g., create and capture value, promote innovation, develop products and services) were included in all studies to define IE, the relations (e.g., collaborative, cooperative and, competitive), artefacts, (e.g., offerings, resources, technologies, and information) and, evolution (e.g., dynamic, evolutionary, coevolve, and lifecycle) were not always included. In other words, while the actors and activities are unalterable elements of an innovation ecosystem, the other elements such as relations, artefacts and evolution vary per study and context (Gu *et al.*, 2021). Therefore, it is important to mention which elements structured the definition of IE concept used in a particular study. This thesis is built on the IE definition of Adner (2017), which proposes four basic

elements that structure an ecosystem:

1. *"Activities: The discrete actions to be undertaken in order for the value proposition to materialize.*

2. *Actors: The entities that undertake the activities. A single actor may undertake multiple activities; conversely, multiple actors may undertake a single activity.*

3. *Positions: It specifies where in the flow of activities across the system actors are located and characterize who hands off to whom.*

4. *Links: The transfers across actors. The content of these transfers can vary—matériel, information, influence, funds. Critically, these links need not have any direct connection to the focal actor."*

Not only the elements are important, but also their order, as different departure points leads to different strategic constructions and therefore different IE perspectives (see Figure 3.2). A distinction has been made between two general perspectives in the literature on innovation ecosystems: ecosystems-as-affiliation and ecosystems-as-structure (Adner, 2017).
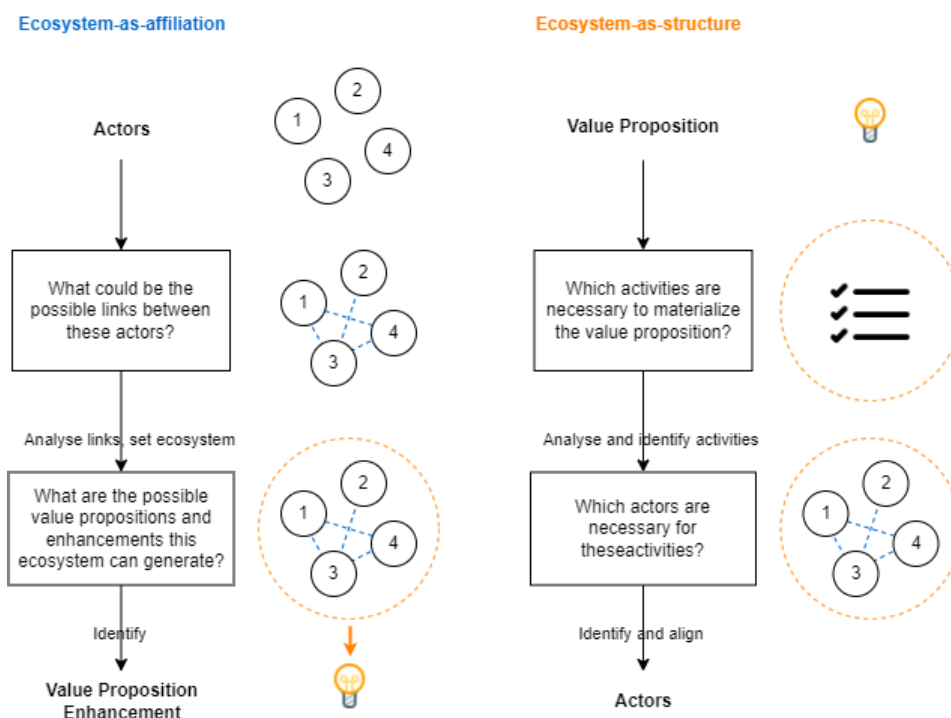
Figure 3.2: Affiliation vs Structure Process, based on (Adner, 2017)

3.3.1. Ecosystem as Affiliation

Ecosystem-as-affiliation perspective is similar to the analogy of ecosystems that has been introduced by Moore (1993). Similarly, Iansiti and Levien (2004) builds their theory on the biological ecosystems concept and refer business networks as ecosystems. According to their definition: *"like an individual species in a biological ecosystem, each member of a business ecosystem ultimately shares the fate of the network as a whole, regardless of that member's apparent strength"* (Iansiti and Levien, 2004). In the literature, similar definitions of ecosystems by the different scholars can be found (e.g., Autio and

Thomas, 2014; Jacobides *et al.*, 2018; Rong and Shi, 2014).

The ecosystem-as-affiliation approach begins with the actors, continues with analysing the links among these actors, and ends with the possible value propositions and enhancements that the ecosystem can generate. In this perspective, ecosystems are communities of companies and other actors that are associated by membership of certain geographical or industry networks around anchor tenants or industry platforms (Visscher *et al.*, 2021). It often includes the actors that are directly related to the focal firm (Adner, 2017). Examples of this type of ecosystems are: "healthcare ecosystem", the "Silicon Valley ecosystem", or the "entrepreneurial ecosystem" (Adner, 2017).

In this perspective, access to knowledge and openness plays an important role as well as the number of partners, network density, and actors' centrality in larger networks. By increasing the number of actors that link to a focal actor or platform, the focal actor increases its bargaining power (e.g. Nalebuff *et al.*, 1996; Jacobides *et al.*, 2006), increases system value through direct and indirect network externalities (Parker *et al.*, 2016), and increases the likelihood of serendipitous interactions between partners that may eventually lead to increase in the overall value creation of the system by the new interactions (Adner, 2017).

Ecosystem-as-affiliation might be helpful to explain interactions at a macro level however, it is hard to differentiate its characteristics from the other approaches to interdependence such as networks and platforms. Similar to other macro level approaches (e.g. systems of innovation) (Faissal Bassis and Armellini, 2018), the strategy guidance offered by this perspective tends to focus on governance and community enhancements rather than the value creation (Adner, 2017).

3.3.2. Ecosystem as Structure

The ecosystem-as-structure view begins the value proposition, analyses the activities required for its implementation, and ends with actors that should be aligned for this purpose. In this perspective, ecosystems are process configurations with a common purpose (Adner, 2017). Different stakeholders are part of this ecosystem because their innovation processes are directly or indirectly coupled to processes of others, together resulting in innovations. This structural perspective is in parallel with the technological innovation system perspective (Visscher *et al.*, 2021). Unlike the national or regional innovation systems, technological innovation systems draws its system boundaries in terms of actors and interactions that are relevant for the successful generation and implementation of new technologies, rather than in terms of geography, industry or membership of a network. However, while the technological innovation system literature deals with policymakers and actors at a macro level (Hekkert *et al.*, 2007), the innovation ecosystem literature approaches technological innovation at a micro or meso level, dealing with corporate actors and focusing on the creation of novel value propositions in specific innovative products and services (Adner and Kapoor, 2010).

Much of Adner's work is directed at this perspective in ecosystems, and he defines ecosystems as: *"the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize"* and discusses the components of ecosystem-as-structure and their implications (Adner and Kapoor, 2010). The components of this definition which form a theoretical base for innovation ecosystem strategy are explained below.

Aspects	Ecosystem-as-affiliation	Ecosystem-as-structure
Starting point	Actors	Value propositions
Related concepts	Business ecosystems	Technological innovation systems
Strategy guidance	Governance	Value creation
Explains interactions in	Macro level	Micro or meso level
Focuses on	Increasing the number of actors in the ecosystem	alignment of the actors in the ecosystem
Actors are part of this ecosystem because	They are associated by membership of certain geographical or industry networks around anchor tenants or industry platforms	their innovation processes are directly or indirectly coupled to processes of others, together resulting in innovations

Table 3.5: Affiliation vs Structure, based on (Adner, 2017).

Alignment Structure

Alignment between the actors that comes together for a new value creation is critical for innovation ecosystems (Adner, 2017). Alignment is the agreement about purposes, knowledge flows, rules of engagement and complementary contributions of the different actors. Various decision-making processes and coordination activities of these actors leads to alignment (or misalignment) inside the ecosystem (Visscher *et al.*, 2021). It is common that different actors have different end states and end goals in mind, for a successful ecosystem it is important that all actors are satisfied with their positions (i.e., one that achieves, at least temporarily, a Pareto equilibrium) (Adner, 2017). The role of system orchestrator (Gawer and Cusumano, 2014), hub firm or keystone (Iansiti and Levien, 2004) can coordinate alignment between the actors however this is not a necessity (Visscher *et al.*, 2021.

In the cases where there is no need for alignment between actors (i.e. introduction of an incremental product variant into an existing supply chain), there is no added value to use the ecosystem logic. In this case, ecosystem logic can be ignored until the time conditions change and there is a need for the alignment of new or existing actors (Adner, 2017).

Multilateral

Adner (2017) describes the multilateral nature of an ecosystem as *"not only a multiplicity of partners, but also a set of relationships that are not decomposable to an aggregation of bilateral interactions"*. He argues that not multilateral interdependence that can be decomposed into an aggregation of bilateral relationships does not require an ecosystem approach unless there is a critical interaction across these relationships (Adner, 2017).

Set of partners

This component focuses on the conditions of the "membership" rather than the participating members. According to Adner (2017) different actors may have different plans and perceptions regarding the composition of the set however the general goal is a joint value creation. Whether the goal is ultimately achieved or not is not important. The selection criteria of partners to participate depends on the value proposition, regardless of whether or not they have direct links to the focal firm (Adner, 2017).

Materializing the focal value proposition

According to Adner (2017), the value proposition —the promised benefit that the target of the effort is to receive, as opposed to what a firm is to deliver- stimulates partners to incorporate. Focusing on materialization requires partners to reach a threshold level of coordination. He argues that by placing the value proposition in the foundation, an ecosystem can survive the divergence between the partners and still deliver the promised value (Adner, 2017).

3.3.3. Ecosystem Strategy

Due to its highly complex nature with many actors, flows and technological uncertainties involved, scholars developed different perspectives to conceptualize innovation ecosystems. The approach of Valkokari (2015) is particularly interesting since it brings an exploration and an exploitation perspective (March, 1991) on ecosystems. As we discussed in Subsection 2.1.1 because right balance between exploration and exploitation is highly relevant for the company's innovation strategy (Fortuin, 2006). According to Valkokari (2015) ecosystems bring the exploration of new knowledge with the exploitation for collective value creation together. Based on the exploration and exploitation approach from Valkokari (2015), Visscher et al. (2021), developed a multilayered perspective to capture the strategically relevant complexity of innovation ecosystems. In this perspective both layers have different purpose and mode of alignment yet reciprocally related since their interaction is essential to impact the system positively (Gilsing and Nooteboom, 2006; Gupta *et al.*, 2006). Visscher et al., (2021) describes this perspective as: *"The explorative layer captures the flows among heterogeneous actors that relate to variation, experimentation and discovery of new innovation opportunities to arise, whereas the exploitative layer comprises the selection, implementation and materialization of these opportunities in innovations that add value"* (Visscher *et al.*, 2021).

Innovation ecosystems are dynamic structures (Gobble, 2014). This dynamic component of ecosystems is the result of the strategic actions of the actors, within and between the different layers of the system, such as scientists, policymakers, managers and others. The literature distinguishes two complementary perspectives on innovation ecosystem strategies: (1) strategies that focus on the roles or positions of actors in the ecosystem (Iansiti and Levien, 2004; Valkokari *et al.*, 2017), (2) strategies that focus on the collaborative processes within ecosystems for the alignment of the actors (Autio and Thomas, 2014; Walrave *et al.*, 2018). In their paper, Visscher et al. (2021) combines these two perspectives describes ecosystem strategies as: *"deliberate and coherent ways in which firms approach the alignment of their innovation activities within the different layers (explorative and exploitative) of an ecosystem and the ways in which they secure their position in relation to other actors and to the ecosystem as a whole*. Their empirical study with 98 companies from different sizes and sectors based in Germany and the Netherlands substantiated a multilayered innovation ecosystem model and identified strategies that companies employ for acting upon the different layers of the ecosystem (Visscher *et al.*, 2021). Table 3.6 gives an overview of these strategies.

According to this study, in the explorative layer companies use aligning strategies to create and sustain networks that had certain flows of knowledge, people and financial resources in common. Some examples of aligning strategies in the explorative layer included setting up a centre of excellence by organizing informal 'barbecue and beer' gatherings to bring different actors together for knowledge sharing, or setting up a campus where different sets of companies and research institutes can share and develop ideas. These events and campuses can be helpful to bring actors that share a common problem

Dimension	Second-order themes	First-order themes
Explorative layer strategies	Aligning	
		• exchanging knowledge within networks and associations
		• conducting pre-competitive (European) research projects
		• sponsoring PhD research and professorships
		• contributing to industry roadmaps and foresight activities
		• establishing or joining research and innovation campuses
	Strategic Positioning	
		• publicly demonstrating innovative capabilitiess
		• taking initiative in setting up consortia and network activities, organizing conferences and establishing campuses conducting pre-competitive (European) research projects
Exploitative layer strategies	Aligning	
		• bringing complementary firms together in projects
		• creating platforms, living labs and dedicated innovation campuses
		• including customers and suppliers
	Strategic Positioning	
		• showing that they are a competent and reliable innovation partner
		• acquiring or building alliances with pivotal ecosystem partners and start-ups
		• engaging in multiple, expanding networks
		• technology brokering

Table 3.6: Ecosystem Strategies, (Visscher *et al.*, 2021).

together, arise solutions, and create the critical mass needed for the materialization of innovations. Other types of aligning strategies in the explorative layer were related to specific knowledge flows. These included establishing bilateral or multilateral partnerships with universities and research institutes to learn about new technologies and methods and steer knowledge development. When it comes to securing a position in the ecosystem, it was considered important to have an innovative reputation. The more innovative reputation a company had, the more actors wanted to collaborate and be in an ecosystem with them. Therefore, companies aimed to increase their innovative reputation by publicity. In the exploitative layer, aligning strategies were related to the creation and maintenance of multilateral partnerships and strategic alliances that are needed for the materialization of the new products and

services. Although the partners in this layer could be chosen from the networks established in the explorative layer, this is not always necessary. While customers were rarely included in the explorative layer, they often had an important role in the exploitative layer. On the other hand, some actors who were part of the explorative layer (e.g. competitors, government agencies and universities) were generally not included in the exploitative layer. In this layer, partnerships were formed with the ambition of creating concrete innovations that create value for customers (Visscher *et al.*, 2021).

3.3.4. Ecosystem Maturity Levels

Visscher et al. (2021) suggest that there are differences in the stage of development of innovation ecosystem strategies between companies. Moreoever, they argue that the most elaborate strategies could be found within medium-sized or larger firms that had worked for several years on building and expanding the explorative layer of an ecosystem; and were active in stimulating the rise of partnerships with necessary actors for value creation. Whether companies with higher maturity levels are superior in innovation compared to those with lower maturity levels, cannot be concluded from their study. However, they recommend those companies that consider ecosystems important, and they aim to deal with it strategically, to focus on the two highest levels. The maturity model for the development of innovation ecosystem strategies proposed by Visscher et al. (2021) is shown in Table 3.7.

Level	Description
0	The company is not aware of the potential relevance of ecosystems for its innovation processes. It hardly collaborates, or only on the initiative of others, and with a limited number of known partners from the value chain. No effort is put into building an innovative reputation or a deliberate innovation ecosystem strategy.
1	The company is aware of the relevance of ecosystems for its innovation processes. It collaborates with others, but mostly within the value chain, and occasionally puts effort into building its reputation as an innovative company. There is no coherent and overarching innovation ecosystem strategy.
2	The company has a coherent innovation ecosystem strategy. It deliberately aligns its innovation with a variety of other companies, knowledge institutes, etc. It is aware of its position in the ecosystem and deliberately aims to strengthen this position. The strategy covers both layers, or, when the company choses to focus on only one layer, it ensures that it receives sufficient input from the other layer.
3	The company has a coherent and encompassing innovation ecosystem strategy, covering both layers. It proactively aligns innovation efforts and knowledge flows, anticipates future requirements regarding technologies and partners and aims for a central or indispensable position in the ecosystem. It has a systemic view of innovation processes, fostering the functioning of the ecosystem as a whole and allowing value capturing for all involved actors.

Table 3.7: Ecosystem Maturity Levels, (Visscher *et al.*, 2021).

3.4. Conclusion

This chapter provided an answer to third the sub-research question:

> SQ3: *How to drive innovation in an organization, and what are innovation ecosystem strategies implemented by the organizations to drive innovation?*

Hereby, it can be concluded that organizations can drive innovation *culturally and structurally*. While cultural approach includes a set of attitudes and values that are favourable for innovation to create an innovative climate, structural approach includes mechanisms and means that enable innovation. Moreover, the innovation modes and the corresponding cultural and structural aspects evolve over time to cope better with new challenges in ever-changing environments. Due to today's complex challenges that require multiple institutions to collaborate, innovation ecosystem concept is seen as a promising concept in literature. In a similar vein to the structural approach, innovation ecosystems are described as *the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize*. Organizations use innovation ecosystem strategies in order to implement this concept, these innovation ecosystem strategies are described as *deliberate and coherent ways in which firms approach the alignment of their innovation activities within the different layers (explorative and exploitative) of an ecosystem and the ways in which they secure their position in relation to other actors and to the ecosystem as a whole*. Organizations use different strategies in each layer for aligning and positioning, an overview of these strategies identified in the literature is presented in Table 3.6. Moreover, according to literature, organizations differ in the stage of development of innovation ecosystem strategies. The identification of the desired/aimed innovation ecosystem maturity level and successful ecosystem strategies can help companies to choose right innovation ecosystem strategies and increase the likelihood of a successful innovation strategy execution.

4

Research Design

Previously in Chapter 1, the research approach of this thesis was discussed and defined as "embedded case study" which refers to a case that is embedded within a larger case study (Scholz and Tietje, 2002; Yin, 2002). In this chapter, insights on the methods to conduct an empirical investigation will be discussed. Firstly, this chapter starts with discussing the position of this thesis in the scientific research in Section 4.1, then continues with presenting the analytical framework in Section 4.2. Here after, the methods of data collection and analysis for this case study is presented to provide transparency in Section 4.3. Following the structure by Aguinis and Solarino (2019), the research setting, the sampling procedure, the interviewees and their importance, the documentation of the interviews, first-order codes, and higher order codes are described and justified.

4.1. Positioning This Thesis in Scientific Research

After reviewing the theoretical concepts that are relevant for the innovation ecosystems, the relations between the concepts have been identified and captured into a conceptual model (see 4.1). The purpose of the model is twofold. First, it provides an overview of the scientific concepts discussed in the literature review of this thesis and the relationship between these concept that can be established to create an analytical framework. Second, it guides the research by highlighting key concepts and needs that should be further investigated in the case study of this thesis. What sets this research apart from the existing literature on innovation ecosystems is that it combines the two research streams (barriers to innovation and innovation ecosystems) from a strategy perspective. The research not only focuses on the implementation of the innovation ecosystem concept, but also reviews the relationship between the barriers and innovation ecosystems with a strategy perspective to stimulate innovation within the firm. Existing literature mainly focuses on the definition of innovation ecosystem concept and, its implementation in large industrial firms. However, no previous study has investigated the implementation of innovation ecosystems concept in airline industry. In addition, there is little known about barriers to radical innovation at airlines. This research bridges these two research streams and shows the complementarity between them.
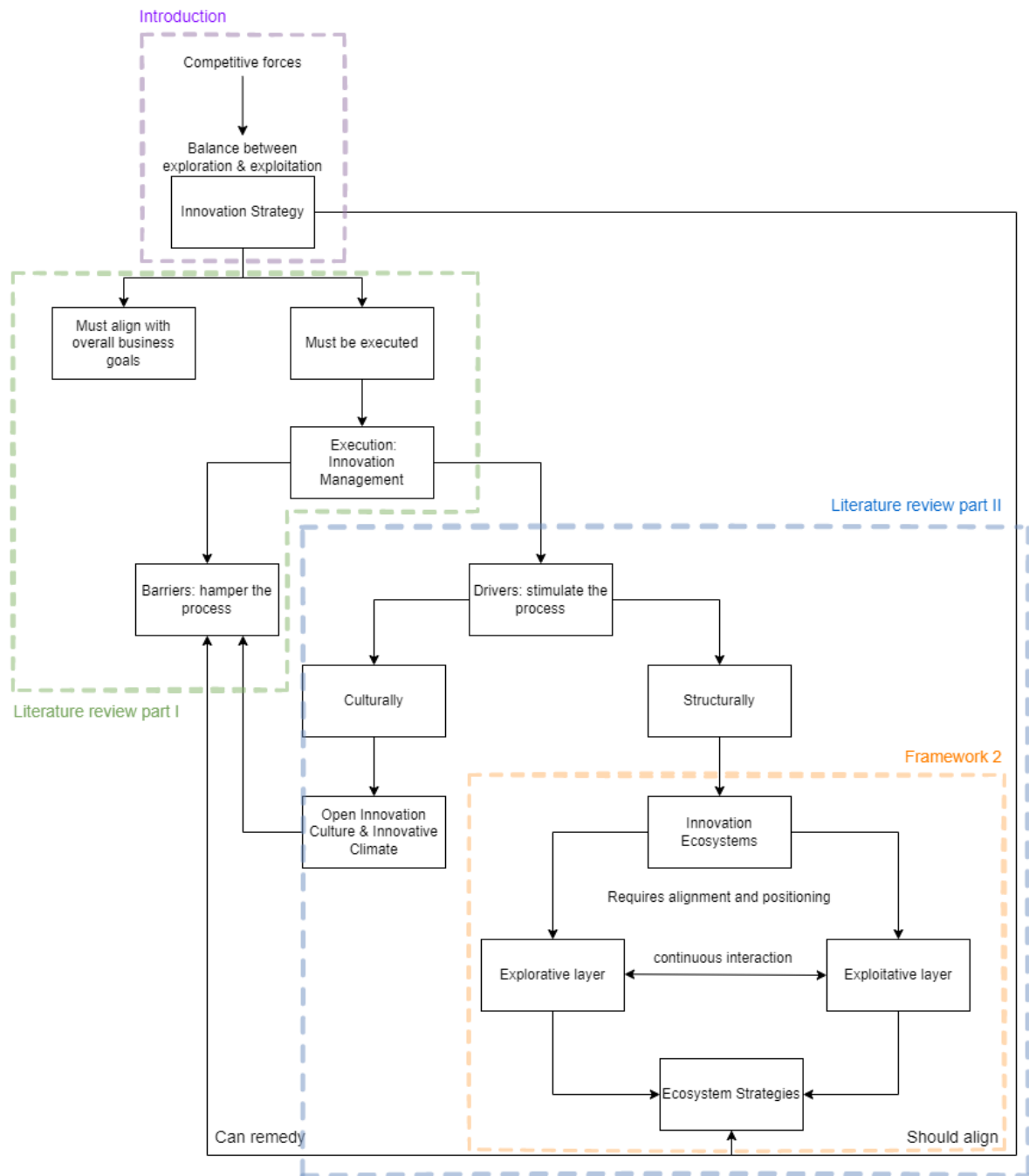
Figure 4.1: Position of this research in the current literature

4.2. Analytical Framework

As a conclusion to the theoretical research, two analytical frameworks have been constructed. Due to explanatory, interpretive and explorative nature of this thesis (see Section 1.4), casual mapping was used to construct these frameworks. Although they look like two different frameworks at first glance, the second framework is actually a part of the first framework. The reason for constructing two frameworks is the emphasis this thesis puts on the innovation ecosystems. The first framework (see Figure 4.2) aims to explain how different topics on innovation discussed in the literature study can be linked to each other. Blue circles represent the root causes. The changes in industry and institutional environ-

ment represented in red were considered as a consequence of these root causes such as digitalization, sustainability concerns, increasing competition and shortage in the labour market. Then, the necessity of the change in the industry and institutional environment triggered the need for invention of new technologies and processes, thus the innovation which is the key theme of this thesis and many commercial and public organizations. Literature suggests that formulating an innovation strategy that aligns with overall business goals and execution of this strategy, is crucial to increase the innovation capacity of the firm. However, during the phase of execution, external and internal barriers can be problematic for organizations and hamper their innovation processes. It is not surprising, then, that many organizations try to overcome these barriers to innovate successfully. Literature suggests that the type of these barriers depends on contextual factors, and they might occur due to lack of innovation drivers. Embracing an open innovation culture and using structural mechanisms like innovation ecosystems might be used as solutions to overcome these barriers and positively contribute to innovation capacity of the firm. In the literature, innovation ecosystems are described as *multilayered structures aligning the multilateral interactions of a heterogeneous set of actors aiming for novel value propositions to arise (exploration) and materialize (exploitation)*. These two layers are continuously trigger each other and, increase of activities in one layer leads to increase in the activity of the other layer, showing the characteristic of a reinforcing loop (R2). The second framework (see Figure 4.3) aims to capture this interaction and explain the multilayered perspective on innovation ecosystems. Lastly, as the interest in the innovation ecosystems are growing, so does the use of innovation ecosystem strategies to deal with innovation ecosystems, although there had been no links established between the barriers and innovation ecosystem strategies in the literature, from a systems' perspective it is important to investigate whether a link between these two elements can be established or captured with the case study.
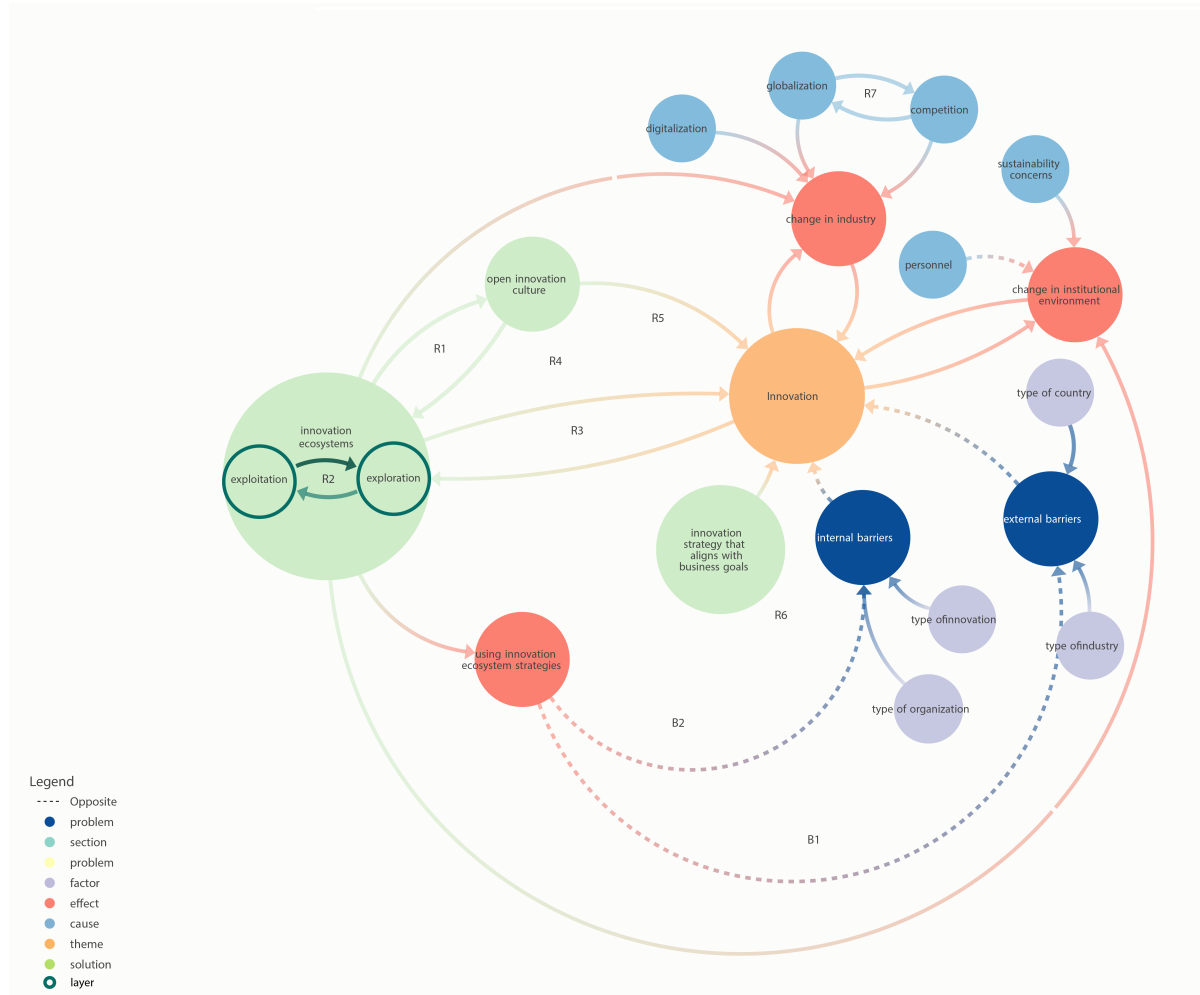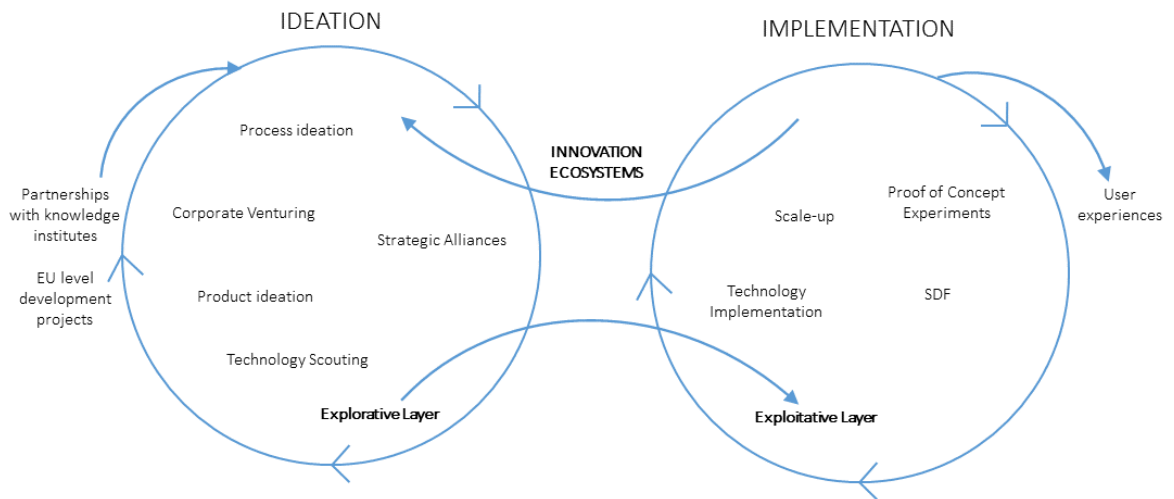
Figure 4.2: Analytical Framework, see Appendix G

Figure 4.3: The Interaction Between Explorative and Exploitative Layer

4.3. Methodology

4.3.1. Data Collection

The aim of this case study was to further develop the analytical framework presented, identify the "industry" barriers (Ortt and van der Duin, 2008), and gather empirical data on the company and airline industry to translate findings of the literature presented in the analytical framework to a specific business environment in order to fill the gap mentioned in the literature. A mixed method including participant observations, interviews and expert session was used. Direct observations were made during the graduation internship at KLM Royal Airlines at the headquarters in Amstelveen. Formal observations included participation in weekly team meetings, deep-dive innovation sessions and Sustainable Flight Challenge marketplace. Informal observations included coffee talks and lunches with the employees from different teams, and a Q&A session with the CEO. Daily business operations were observed using the participant as observer stance (Cassell and Symon, 1994). This approach enabled the researcher to participate in the business activities as desired to collect necessary data, while protecting the objectivity of this research. In total 18 standard, semi-structured interviews were conducted, which enabled deeper exploration and cross-checking of issues raised in innovation processes. Once case interviews were finalized, an online expert session with 15 experts was held. The main purposes of this session were: (1) validating the case study results, (2) assessing to what extend the findings of this study can be generalized to draw organization wide conclusions and, (3) building further in-depth knowledge on how can the current KLM ecosystem be improved in order to give recommendations (see Section 6.2) in the final stage of this study. Case interviews and expert session allowed participants to share their opinion on the same topics, despite the questions used were not identical.

The purpose of choosing participants from both corporate office and business units with different functions was not to select a sample that would be representative of a certain department of KLM, but to select a variety of interviewees that represents different functions and departments at KLM. An overview of interviewees is presented in Table 4.1.

Interview questions were defined in an interactive and dynamic manner. This process is shown in Appendix E. The full list of interview questions, divided into the different categories based on the relevance of the topic for the team, can be found in Appendix A, B, C. The characteristics of main innovation challenges at KLM was one of the key questions that was asked to every interviewee regardless of their division, role and experience. This question was asked to identify the problems in implementation phase and experiences with current processes. In a similar vein, the questions on the topic of innovation ecosystems, which is the key focus of this thesis, were also asked every interviewee regardless of their division, role and experience. This was done to identify the different innovation ecosystem strategies and perspectives on innovation ecosystems within the company. Finally, each division was asked expertise-specific questions, which added more dimensions to this study and helped to triangulate the findings.

Both Radical Innovation team and Strategy team interviews were conducted at the headquarters in Amstelveen. Regarding the topic of innovation ecosystems, interviewees were asked about (1) the relevance of ecosystems for KLM innovation processes; (2) the interactions with other actors and the importance of these actors for KLM innovation processes; (3) KLM's position in the ecosystem; and (4) their strategies to influence the ecosystem and their position in it. Although both teams fall under the Transformation Office, each has a different expertise. Therefore, it is beneficial to include not only

common questions but also expertise-specific questions in interviews to achieve the objective of this thesis.

During the internship period, the Radical Innovation team was the first point of contact, hence this team is responsible for setting up the innovation ecosystem of KLM. Semi-structured interviews were conducted with 3 team members (2 senior project managers and 1 innovation director). An interview took about 1 hour and followed an interview guideline that focused on internal and external innovation management practices, current innovation challenges at KLM and the airline industry, innovation ecosystems of KLM (current challenges with the KLM ecosystems as well as the possible ecosystem strategies) and foresight activities.

The Strategy team was the second point of contact since this team works together with Radical Innovation team to link KLM's innovation strategy to KLM's overall strategy and also defines the long term vision of KLM together with the senior management. Semi-structured interviews were conducted with 3 team members (3 consultants and 1 manager). An interview took about 45 minutes and followed an interview guideline that focused on new KLM strategy and its link to KLM innovation strategy, current (innovation) challenges at KLM and the airline industry, innovation ecosystems of KLM, relevance of this concept to strategy and possible ecosystem strategies. Adding more dimensions to interviews helped to gain information about the new strategy of KLM and their position in the multi-actor environment.

After the first two sets of interviews, a technology was chosen from the strategic innovation topics of KLM to conduct interviews within the different business units of KLM. Following the determination of the technology, selection of the business units were made: Engineering & Maintenance, Ground Services and Cargo. Following the determination of the business units, the selection of interviewees were made. Selected interviewees included project managers, innovation leads, and management trainees which had/have a key role in the implementation of this technology within the business unit. An overview of use cases, business unit and number of interviewees are shown in Table 4.1.

It is worth to mention that although the first set of interviewees were selected with the company supervisor, a second set of interviewees were added based on the recommendations of the interviewees (the snowballing interview technique) from the business unit. This helped to gain even deeper knowledge of the business unit dynamics, hence the second set of interviewees appointed by the business units themselves. Semi-structured interviews were conducted with 4 members from Ground Services, 4 members from Engineering and Maintenance and 2 members from Cargo. (2 senior project managers and 1 innovation director). An interview took about 45 minutes and followed a more open approach than the corporate interviews. There was particular interest in the experiences from the execution of projects and daily operations. Interviewees were first asked about the factors hampering the innovation in the daily business. Identifying the daily challenges are not only important to validate theoretical findings of this thesis, but also important to choose an ecosystems strategy that aligns with the overall business goals (Pisano, 2016). On the topic of innovation ecosystems which is the key focus of this thesis, the interviews conducted with the business units focused more on the exploitative questions about (1) the relevance of ecosystems for their innovation processes; (2) the actors they often work with for their innovation processes; (3) their collaboration with the internal and external partners; and (4) their strategies to increase the internal and external interaction to innovate.

No.	Business title	Division	Topics discussed
1	Strategy consultant	KLM HQ	Strategy, innovation strategy, barriers to innovation, innovation ecosystems
2	Strategy consultant	KLM HQ	Strategy, innovation strategy, barriers to innovation, innovation ecosystems
3	Strategy consultant	KLM HQ	Strategy, innovation strategy, barriers to innovation, innovation ecosystems
4	Strategy consultant	KLM HQ	Strategy, innovation strategy, barriers to innovation, innovation ecosystems
5	Senior Project Manager	KLM HQ	Innovation strategy, innovation management, barriers to innovation, innovation ecosystems
6	Senior Project Manager	KLM HQ	Innovation strategy, innovation management, barriers to innovation, innovation ecosystems
7	Team Leader	KLM E&M	Barriers to innovation, innovation ecosystems
8	Team Leader	KLM E&M	Barriers to innovation, innovation ecosystems
9	Program Lead	KLM E&M	Barriers to innovation, innovation ecosystems
10	Project & Process Manager	KLM E&M	Barriers to innovation, innovation ecosystems
11	Team Lead	KLM E&M	Barriers to innovation, innovation ecosystems
12	Project Manager	KLM GS	Barriers to innovation, innovation ecosystems
13	Manager Projects & Process Improvement	KLM GS	Barriers to innovation, innovation ecosystems
14	Standards & Procedures Expert	KLM GS	Barriers to innovation, innovation ecosystems
15	Project Manager	KLM Cargo	Barriers to innovation, innovation ecosystems
16	Program Manager	KLM Cargo	Barriers to innovation, innovation ecosystems
17	Program Manager	KLM HQ	Barriers to innovation, innovation ecosystems
18	Program Manager	SkyTeam HQ	Barriers to innovation, innovation ecosystems

Table 4.1: The overview of interviewees, business title, division and the topics discussed.

4.3.2. Data Analysis

All interviews were carried out in English. Almost all interviews with the interviewees from the corporate office were done face-to-face and on-site. All interviews with interviewees from the business units were done digitally via Microsoft Teams. In order to analyse interviews, notes and transcripts were made. The transcribed interviews were analysed using a combination of deductive and inductive approaches. By using the deductive approach, the initial framework developed from literature and its underlying assumptions were validated. Inductive approach was used to gather data about new concepts (Corbin and Strauss, 2008); like the innovation ecosystem strategies of airlines.

According to Miles and Huberman (1994), qualitative data analysis consists of three steps: (1) data

reduction where the obtained data is reduced and organized (2) data display where obtained data is displayed for conclusions to be drawn, and (3) conclusions drawing where conclusions are drawn from the study. Hence the interviews from the corporate office and business units had a difference in nature (more structured vs more open), they had different questions. The first focus in the analysis of the interview transcripts, was on the common questions that were asked to every interviewee. This information was organised on excel as: (1) question; (2) answer; (3) team; (4) function. This helped to compare the results of the interviews (e.g. corporate vs business unit, Radical Innovation vs Strategy, Ground Services vs Engineering and Maintenance etc.) and write case summary and conclusions on barriers to innovation at KLM, implementation of innovation ecosystems and corresponding ecosystem strategies. Regarding the innovation ecosystems topic, the coding framework proposed by Visscher et al. (2021) to identify ecosystem strategies used at KLM was used. According to this framework, first-order concepts are the concrete activities that managers told their companies carried out to deal with innovation ecosystems. The second-order themes include the two core elements of an ecosystem strategy (Adner, 2017) "aligning" and "strategic positioning" and the aggregate dimension represents the multilayer perspective on explorative and exploitative ecosystem strategies.

Finally, the topic specific and department specific questions were analysed. This provided data on topics mentioned in developed framework such as innovation strategy and innovation management, the same organization structure scheme was used. The table in Appendix D includes the codes used and their descriptions in detail.

4.3.3. Reliability and Validity

Reliability and validity is described by Campbell and Fiske (1959, p. 39) as: "Reliability is the agreement between two efforts to measure the same trait through maximally similar methods. Validity is represented in the agreement between two attempts to measure the same trait through maximally different methods."

According to this view, a reliable study must be consistent over time, a transparent data collection and analysis is therefore essential. According to Lincoln & Guba (1985) reliability strongly relates to dependability in qualitative studies. They argue that one must strive for credibility, neutrality and applicability to achieve a reliable, and thus dependable, qualitative study. In this thesis, semi-structured interviews which is a qualitative research method was used to gather empirical evidence. Probing questions were used not only to clarify responses and probable inconsistencies to reach dependable results (Hutchinson and Skodol-Wilson, 1992; Louise Barriball and While, 1994) but also to create the opportunity to explore delicate matters and elicit valuable information (Nay-Brock, 1984; Gorden, 1975; Bailey, 1987).

According to Golafshani (2003), the concept of validity is referred by a wide range of terms in qualitative studies. Many researchers have developed their own concepts of validity however this thesis uses the traditional criteria for validity. Joppe (2000) describes validity as follows: "Validity determines whether the research truly measures that which it was intended to measure." Creswell & Miller (2000) argues that in qualitative studies, the validity is affected by the researcher's perception of validity in the study and his/her choice of paradigm assumption. Lincoln & Guba (1985) argues that the findings of a valid study (or a trustworthy study) must be confined and sustained throughout the research. In case of this study, on the topic of innovation ecosystems which is the key focus of this thesis, inter-

viewees were asked whether they were familiar with the concept of innovation ecosystems. Hence innovation ecosystem concept is used in wide range of variety, the concept is described in very general terms, as the interdependencies firms have, related to their innovation processes with collaborators, suppliers, customers, complementors, public research bodies, other infrastructure, finance and regulators to create a common ground for the interview and to set the scope of interactions for which there was interest. Following the recommendations of Visscher et al. (2021), a clearly demarcated innovation ecosystem to discuss is not defined or chosen but the interviewees were followed in their view of relevant actors (such as suppliers, customers, public research bodies and regulators) and flows (such as money, employees and knowledge) for innovation and their scope of the ecosystem. By doing so, the interviewees were allowed to define their perspective on innovation ecosystem. Moreover, the summary of the interview was presented to the interviewee to assure the correctness of the report of the interview.

The results derived from the literature research and case analysis were validated in an expert session. The main purposes of this session were to assess: (1) the validation of the case study interview results, (2) to what extend the findings of this study can be generalized to draw organization wide conclusions and, (3) build further in-depth knowledge on how can the current KLM ecosystem be improved in order to achieve the company's objectives on innovation.

All 15 experts (see Table 4.2) were chosen from the "Innovation Ecosystem Ambassadors" in the current KLM innovation ecosystem, shown in Figure 5.2. Innovation Ecosystem Ambassadors are responsible for the innovation activities and the recognition of KLM innovation ecosystems within their department. The session was organized in Microsoft Teams and took an hour. During the validation session, the research objectives were explained, and analytical frameworks were presented. Afterwards, both case studies were explained and results were shared, and the expert opinions were asked.

No.	Business title	Division
1	Strategy consultant	KLM HQ
2	Program director	KLM PS
3	Project manager innovation	KLM HQ
4	Product manager digitalization	KLM IT
5	Director	KLM HQ
6	Strategy consultant	KLM HQ
7	Program manager transformation	KLM HQ
8	Strategy consultant	KLM HQ
9	Project manager	KLM HQ
10	Business development & innovation manager	KLM GS
11	Service designer	KLM HQ
12	Project Manager Technology	KLM HQ
13	Project manager	KLM Cargo
14	Sustainability manager	KLM HQ
15	Director	KLM HQ

Table 4.2: The overview of experts, business title and division

4.3.4. Triangulation to improve reliability and validity

In qualitative studies, triangulation is a strategy that is often used for improving the validity and reliability of research or evaluation of findings. Patton (2001) argues that "triangulation strengthens a study by combining methods. This can mean using several kinds of methods or data, including using both quantitative and qualitative approaches" (p. 247). To be able to triangulate part of the findings from the interviews, additional data were collected in the form of company documents, industry reports, the literature on the various range of topics. The importance of using diverse sources in this thesis is explained by Golafshani as "engaging multiple methods, such as, observation, interviews and recordings will lead to more valid, reliable and diverse construction of realities" (Golafshani, 2003, p. 604).

5

Embedded Case Study: KLM Royal Dutch Airlines

This chapter reports the results of the case study that was conducted to identify the barriers to innovation at KLM to answer SQ4 and provide a comprehensive overview of innovation ecosystem strategies of airlines to answer SQ5:

> SQ4: *What are the barriers to radical innovation in airlines?*

> SQ5: *What are innovation ecosystem strategies implemented by airlines to drive innovation?*

The chapter starts with an introduction of the larger case and the selected embedded unit analysis in Section 5.1. In Section 5.2, the results of the case study are presented. Following, a step towards connecting Barriers to Innovation Ecosystems is made in Section 5.3. In Section 5.4 the results of the expert session are presented. This chapter ends with Section 5.5 where results of the case is evaluated and the answers to the sub-research question 4 and 5 are provided.

5.1. KLM Royal Dutch Airlines

Since May 2004, Air France and KLM Royal Dutch Airlines have merged and become the largest European airline group. Following the merger with Air France in 2004, KLM has pursued the concept of 1 Air France-KLM Group, 2 airlines, and 3 core activities (passengers, cargo and engineering & maintenance). Each airline has retained its individual identity, trade name and brand. Both airlines run their own operations from their respective hubs Paris-Charles de Gaulle and Amsterdam-Schiphol. Koninklijke Luchtvaart Maatschappij (KLM) is the flag carrier airline of the Netherlands. KLM was established on 7 October 1919, and currently is the world's oldest airline still operating under its original name (KLM, 2022).

KLM Group carries 34.1 million passengers and 621,000 tonnes cargo, and offers direct services to 92 European cities and 70 intercontinental destinations. Besides the KLM and KLM Cityhopper that form the heart of the KLM Group, the group also wholly owns the subsidiaries such as the Dutch low-cost airline Transavia and Dutch cargo airline Martinair. Moreover, KLM is a partner in the SkyTeam Alliance,

which they jointly serve 1,063 destinations in 173 countries with other partner airlines that are part of the alliance (KLM, 2022).

KLM recently presented their new KLM strategy (see Figure 5.1) which is build on three pillars (KLM, 2022):

1. Transform to a net positive company,

2. Run a great airline for our customers,

3. Create technological advancement.

Figure 5.1: New KLM Strategy, (KLM, 2022).

The Strategy team describes the role of innovation at KLM as follows:

• *"Innovation is a way to achieve KLM strategy, it is an enabler of the three pillars"*

Meanwhile the Radical Innovation team describes the role of innovation at KLM as follows:

• *"The KLM innovation strategy is in the DNA of the KLM strategy"*

During the internship period the author was able to take an active role within the Radical Innovation team thanks to her company supervisor. The network of her company supervisor made it possible to gather necessary information for this research. The Radical Innovation team are responsible for all innovation initiatives within KLM and their main objective is to "orchestrate the innovation ecosystem (see Figure 5.2) and locally accelerate innovation on key strategic topics by co-creating and embedding skills and competences" (Radical Innovation Team, 2020). This goal perfectly matches the problem statement of this thesis. The main tasks of Radical Innovation team includes the development and orchestration of all innovative initiatives across the 3 core activities of KLM: passengers, cargo and engineering & maintenance. KLM Passenger Services is responsible for passenger related activities, beginning from the moment they enter the airport of origin till when they leave one of destinations, KLM E&M deals with the maintenance, repair, and overhaul of all aircrafts and, KLM Cargo focuses on

the transport of cargo and freight.
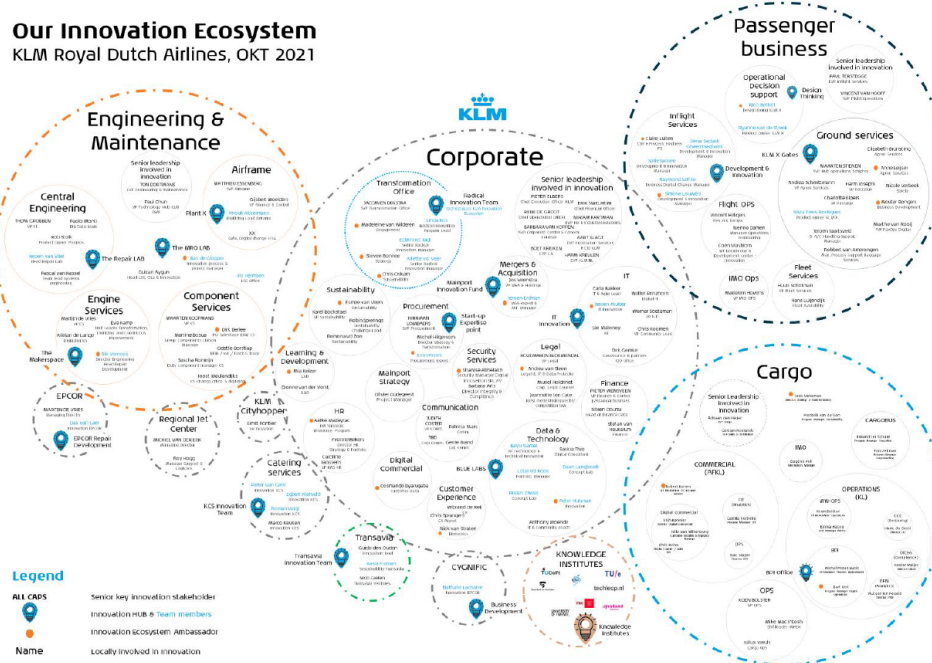
Figure 5.2: Current KLM innovation ecosystem, (KLM, 2022).

There are 3 innovation methods that are widely used at KLM: Design Thinking, Agile-Lean and Scrum. The responsible project lead chooses one of these methods based on various aspects such as the nature of the project itself, the challenges and the division in which it is carried out. It is worth to mention that the way these methods are used at KLM does not completely match to their description in the literature and an extensive analysis of these frameworks is beyond the scope of this thesis. However, it is important to briefly explain these frameworks, since certain business units seem to have preference over certain frameworks and this might be important to take into account for the case conclusions. Besides the project related reasons senior project manager from the Radical Innovation team explains this as:

- "If a division has traditionally been using one method, then its employees are most likely used to that specific technique. As the more technical employees within the airline industry have little flexibility, they often choose the most convenient method for them, that is why each of the 3 methods are generally associated to a specific division."

A brief KLM description of these 3 methods and the divisions that are associated with it is shown in Table 5.1.

Framework	KLM Description	Department
Design Thinking	A human-centered innovation approach that is fairly new to KLM. Projects are often part of the cooperation agreement between KLM and TU Delft that aims to develop new products and optimise KLM processes in a real-life operational environment	E&M
Agile-Lean	Process that incorporates elements of both continuous delivery and continuous improvement, optimized across the entire value stream iterative. It includes incremental innovation projects with rigid set of requirements that require a lot of up-front planning and careful monitoring of its processes (agile) and constant optimization of services to improve processes (lean)	Cargo
Scrum	A framework within which people can address complex adaptive problems, while productively and creatively delivering products of the highest possible value, it includes projects that require more flexibility with rapidly changing deliverables. Project teams are often self-organizing and cross-functional	PS

Table 5.1: Description of the innovation frameworks at KLM and the associated KLM divisions.

5.1.1. Strategic Innovation Topics of KLM

Based on the KLM strategy, current needs and future trends, KLM identifies a set of innovative technologies with potential strategic impact for the business in the coming years. These are the technologies that can support achieving strategic goals set by KLM. Strategic Innovation Topics of KLM is formed by linking the relevant technologies and strategic goals and is shown in Figure 5.3.
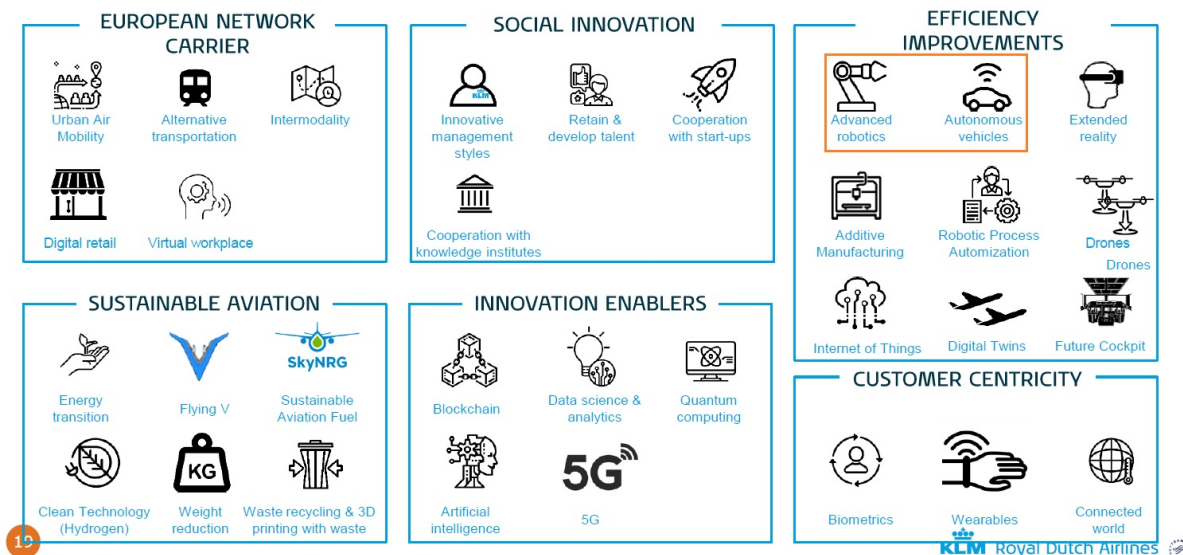

Figure 5.3: Strategic Innovation Topics of KLM.

Given the time limits, it is beyond the scope of this thesis to extensively discuss all technologies. Therefore, the focus is on one technology from the strategic innovation topics of KLM to gather empirical

data. In order to choose this technology, three requirements are set.

1. The technology is mentioned in the previous KLM strategy as well as in the new KLM strategy presented in 2022;

2. The technology is relevant for more than one business unit, it is mentioned in business unit's innovation strategy and the collaboration would bring added value for the business units;

3. There are ongoing projects where this technology is applied or will be applied in the future.

Based on an analysis in close collaboration with the company supervisor, the strategic topic "automated vehicles" was selected.

Autonomous Vehicles

The COVID-19 crisis and highly competitive market forces airlines to be cheaper, more economical and more agile to survive and remain a relevant player. Becoming more efficient requires an accelerated digitization of KLM's core processes. Advanced technology like autonomous robotics in the operation could create more productive and flexible operational workforce, therefore this topic is directly linked to the new KLM Strategy (see Figure 5.4). AF-KLM Group believes that human tasks can be substituted with the use of robots in many domains: from traveller support in airports, to complex logistics in aircraft part warehouses, or even performing maintenance tasks with high precision. Also, autonomous vehicles on land or in the air, such as drones, have a valuable potential for airline environments. An autonomous vehicle (AV) is a self-driving ground vehicle that is capable of sensing its environment and moving without any human interaction. The system combines a variety of sensors to perceive its surroundings such as radar, lidar, GPS, odometry and IMU (AF-KLM, 2022).
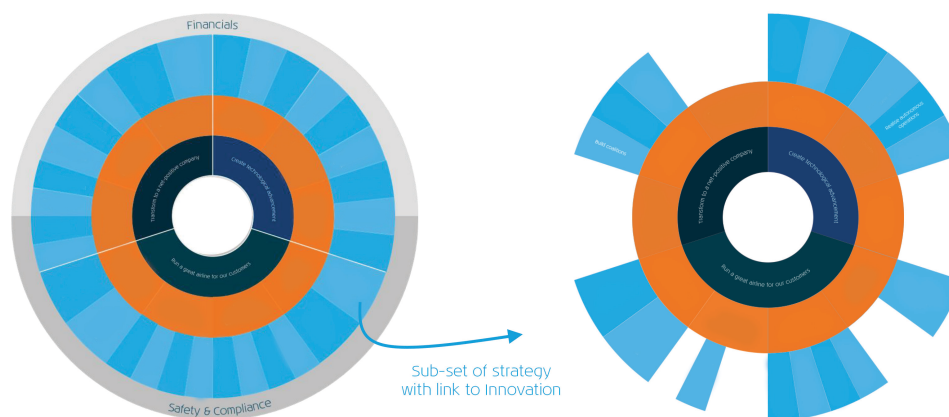
Figure 5.4: Autonomous operations in KLM Strategy, some content removed due to confidentiality (KLM, 2022).

IATA has identified 41 use cases of AV for airports and airlines. AF-KLM sees opportunities for the implementation of autonomous vehicles in various use cases including baggage/cargo carts & dollies,

catering trucks, baggage and cargo loaders, aircraft tugs, PRM wheelchairs, maintenance parts/tools across airfield deliveries, crew transportation, airside passenger buses, etc. Combined with other technologies (IoT, AI, Digital Twin, etc.), AV will take part in Smart Airport creation. AF-KLM expects that AV will increase efficiency of all airport processes, and drastically reduce costs thanks to lower payroll, better punctuality, fewer work accidents and opportunity to make ground support equipment pooling with others airlines. Therefore AV are part of KLM Strategic Innovation Topics under the category "Efficiency Improvements" (AF-KLM, 2022).

5.2. Results

This section presents the results of the case interviews which provides answers to SQ4 and SQ5.

5.2.1. Innovation Strategy

Airlines are operating in a legacy industry that uses technologies and procedures that are outdated. Especially with the importance of sustainability it is important to be more innovative. KLM employs 28,000 people, so there are many different processes, many different tools, many different work to be done. The old strategy -*to become a European leading network carrier in customer centricity, efficiency, sustainability and innovation*- was very broad and stimulating the silo thinking within the company. In the new KLM strategy framework innovation takes a large place and the Strategy Team remarks innovation as highly important in their business strategy.

> *"[...] Strategy is nothing more than making choices [...] we try to lay sustainability as the groundwork underneath new our strategy. So, we said the purpose of our strategy is based on the sustainable aviation. This is a very clear choice and we've never made such a clear choice before [..] if you look at our previous strategy, there's no choice in there, they're like big blocks [...] everybody could go their own way, and then you get the silos"*

KLM innovation strategy emphasizes *"supporting current processes and markets"* the most which is followed up by *"developing next generation products and processes"*. *"Establishing new businesses (in new value domains)"* is currently not emphasized in the innovation strategy. This is considered as one of the weak points of KLM innovation strategy that should be improved.

> *"This is something that we have to do because if we remain purely dependent on flying, that's a huge risk [...] we believe that flying is something that people will still want to do in 10 years from now, [...] we are in a globalised world so there will be people travelling to other continents so, we will most likely remain as an airline but we should also explore new domains [...] because if we remain purely dependent on flying, that's a huge risk."*

COVID-19 crisis was a hampering factor for developing a long term strategy for the future of innovation at KLM. Before the crisis the company had more room to focus on longer term vision, during the COVID-19 the priority was "the moment". However, now that the COVID-19 seems to fade away focus on longer term seems to come back.

The management perspective for innovation changed significantly in the last 10 years at KLM. The senior level management started to look further on the horizon. Innovation and sustainability became important elements of the new strategy. Moreover, besides the development of technological innovations, the company started to integrate social innovation in their business activities, which is considered as the firm's key innovation in last 5 years.

"[...], if I would describe the key innovation which I think made the biggest impact is that there has been a shift going on within the company. This can be linked to social innovation in the view of the importance of sustainability, in the view of the importance of adopting new innovation processes such as 'design thinking' that you go way much earlier in the process talking to your customers. Another example is the introduction of Bold Moves because it was the the mix of C level and VP level colleagues and working together with the interns, trainees, people from the operation [...]."

At the moment there's no official mechanism to integrate innovation in the overall strategy. Mostly the Radical Innovation team updates and informs the Strategy team about their work by sending summaries of workshops and local innovation strategies such as the innovation strategy of in flight services, ground services, engineering and maintenance etc. The main actors in decision-making process about innovation are divisional management teams, senior vice presidents and the Radical Innovation team.

Innovation strategy of KLM is based on the local vision statements of the departments for the year 2035. Radical Innovation team asks each division how their division, environment and job will look like in 2035. Following, each division describes their vision and reasoning behind it. Finally, the Radical Innovation team prepares an overarching summary from this information per division. The concept is changing per division, but the scope remains the same, which is in this case 2035. This process is shown in Figure 5.5. KLM's core competency is "safely bringing people and cargo from A to B, thus not innovation". The balance between technical and non-technical innovation changed since KLM adopted sustainability development goals in 2015 in order to achieve more social innovation in the work floor.
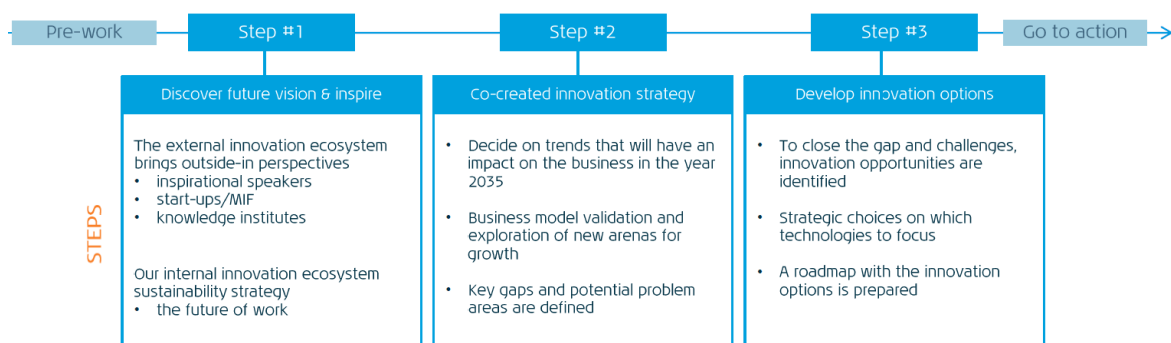
Figure 5.5: Process of Creating KLM Innovation Strategy, (KLM, 2022).

Airline industry is very competitive in the nature so, sharing knowledge with other airlines does not often occur. KLM often works together with public research institutes when it comes to importing knowledge, they also have their own investment fund (Mainport Innovation Fund I-II & SHIFT). However, cross-industry collaboration offers a potential.

"[...] So, as an innovation team we heavily rely on collaborations with the knowledge institutes, and the amount of these collaborations should increase even more because when we get involved with students, we get inspired [...] however, really one on one implementing student research is still very difficult [...] we should look into manufacturing technologies that are used in other industries but are not yet implemented in our industry, so the easiest example which I have is of course Formula 1. In Formula 1, they have all mechanical processes and all the technologies we

should use and implement in our industry, [...], this is a key thing which I would like to source outside KLM."

The journey of innovation at KLM often starts with the problem statement or identifying a challenge. This is the first stage and, it is followed by experimentation. Then more into the upscaling phase, where a prototype should be upscaled and implemented, problems that hamper the innovation process seem to occur:

"[...] Because the prototyping and experimenting you can usually do with limited resources, especially money wise [...] If you then want to scale it, yeah, bigger investments are needed, and even if there's a good business case, sometimes it still fails because there's no budget available[...]"

The most common cross-functional teams include employees from the customer experience, local innovation hubs, and senior level management. Although there are some exceptions where the cross functional teams are very well coordinated, in general it is one of the weaknesses of KLM.

"On the one hand, KLM likes to centralise things but on the other hand they're also very allergic to centralising things.[...] A central team assessing all innovation won't work [...] because our company is so large and therefore, the reporting lines are currently informal and local [...] Putting the responsibility lower and more local in the company results in a way much better engagement[...]"

In the last years innovation became more structured by the introduction of the methods, workshops and masterclasses.

"Yes it changed from nothing to what we have now, [...] for example, 10 years ago company wide innovation methods were not existent, now there are 3 [..] We also see that the people are adapting to the new methods over the time. First, they often used Agile-Lean and then Scrum and now more an more innovation teams prefer design thinking (Agile Lean-> Scrum-> Design thinking)."

5.2.2. Factors Hampering Innovation at KLM

KLM strategy defines the goals and objectives of the organization, for instance flying net zero, however often **these goals are not supported by a clear planning and commitment**. Here it is referred to the commitment from the management level in terms of budget, human capital and time to turn these ambitious goals into a reality.

" [...] One of the main blocking points in my opinion is the lack of leadership on the innovation topic. The current management has no idea or shows any interest in innovation, we talk a lot but not a lot is actually happening. If this attitude doesn't change, innovation will never be a strong point of the company [...]"

"We say this is what we want to achieve, disrupt the business [...] but if you're actually doing it, or when you need resources, people, or money then you see that there's not that much commitment."

Most of the business units experience **lack of financial resources, time and human capital**. The extend of each changes per business unit, for example in E&M lack of financial resources is the biggest problem and on the other hand, in Cargo and Ground Services lack of time and human capital are the biggest problems.

"In my previous job we had a clear budget for innovation, the development budget, which basically meant, you needed to spend it on radical innovations [...] there were innovations that we spent 100,000 euros and it was not a success [...] but we also had very simple innovations that costed us 10 cents and they were successful [...] at KLM sometimes people are like, 'but then only do the thing of 10 cents and forget about the about the one that cost you 100,000 euros' [...] however the thing is, you need to do both because if you don't do the first one, you would not have thought about the second one[...]"

"With COVID-19 a lot of people left. Now that the business is coming back to levels it used to be before COVID-19, the same work has to be done with the a lot less people. So then with a lot of things you see, innovation comes not as a priority and therefore it is lack of subject matter, lack of experts, lack of people participating, also the management teams [...]"

The workload in some departments in day to day business is heavy in some divisions. As a manager from the KLM Cargo defines it, **KLM is an 'operation-driven' organization**. More interestingly, there are even some cases which causes KLM to become an 'incident-driven' organization. Many employees in the business units are absorbed by the daily business problems and incidents therefore, they do not have enough time to think about the future.

"Maybe the reason that it goes wrong is that we have a split world [...] So we have people thinking in the future that are not enough connected to the daily operations [...] and, we have people who are connected to the daily operations but those are absorbed by incidents so they are not able to to really think structurally about the future [...]"

This brings us to another factor that hampers innovation: **lack of alignment between the headquarters and business units.** Sometimes business units are pushed by the headquarters to implement a technology or method that is not necessarily relevant for their business.

"We could work better together. I think we should be more focused on scouting for technologies and sharing our problems. We used to do that in the past, so we could reintroduce that [...] Sometimes I experience that the headquarters is pushing some technologies or some way of working that does not fits in the way we work"

"To have an example, the headquarters tell us that we need to make an ecosystem web page of our department, instead I would prefer if headquarters would have asked how can we help you getting more innovation in place [...] because this ecosystem, with all due respect, will not be used hence I know the ecosystem of the department myself and I don't think it's very helpful for others to know this department ecosystem"

The last common internal barrier identified during the interviews is: **lack of structure on innovation**. KLM is very used to innovating and working in silos. This causes often reinventing the wheel. The knowledge within the company can be used much more effectively if there is a structure on the innovation. There is a demand for setting up a simple and central knowledge system that improves the knowledge flow between business units. It is important to emphasize the word "simple" in here because business units would like to have a more specialized and extensive version of this knowledge system within their business unit to share more necessary and detailed information.

Besides the internal barriers to innovation, various external barriers were identified during the interviews. **Legislation, regulations and norms** were the most common external barriers mentioned.

Aviation industry is strictly regulated when it comes to safety. "Anything that is not safe, will also not fly", therefore the number one priority of airlines is safety. Although this is logical, it also causes slow certification processes which leads to long lead times for innovation cycles. This is one of the reasons why we still fly with the aircrafts that were introduced into markets in 60s or 70s. After the retirement of Concorde, there haven't been any radical aircraft introduced into the market. An example of this is the ongoing "Flying-V" project between Airbus, TU Delft and KLM. The Flying-V was conceived in 2014, TU Delft and KLM announced the start of the design of the Flying-V in 2019 and researchers hope that they'll have a prototype ready only by 2041.

> "[...] And to be honest, there hasn't been anybody in the world that has 'truly' disrupted aviation [...] 20-30 years ago aviation was disrupted by low cost airlines because airlines haven't been doing everything extremely efficiently right? So they have been lowering the costs of flying [...], but at the end they still fly with same aircrafts and offer the same product [..] similar to what we have done before with hub-spoke model and joint venture with Northwest [...] however, 'truly' disrupting the business is extremely difficult in aviation."

An example of legislation hampering the innovation is the restriction of knowledge sharing between airlines. KLM is the initiator of The Sustainable Flight Challenge, which is organized for the first time this year. This year, only the SkyTeam member airlines are participating in this challenge. However, KLM hopes other airlines will follow as well in the upcoming years. This initiative challenges participating airlines to operate one single flight in their existing networks the most sustainable way. The main motivation behind this challenge was "not competing in sustainability". Thus all the learnings and innovations from these dedicated flights would be shared openly between participants to help changing the mindset of the industry and flying more sustainably. However, as competition law restricts sharing any knowledge that might lead to a competitive advantage between competitors, sharing this knowledge in sustainability between participating airlines becomes a highly sensitive subject. Another example is the certification process of Flying-V. Flying-V is in development for nearly 8 years and it is still unknown if EASA can actually certify the aircraft due to its odd shape when the prototype is ready.

> "The authorities should update the legislation on the sustainability. Hence flying sustainability requires collaboration between many parties, the authorities should act as a stimulating mechanism rather than restricting."

As worldwide air traffic increased, OEMs were put under market pressure for providing in-service support. However, OEMs failed to meet this expectation as their service strategies are not always properly designed. So different business models of service offerings emerged. A model emerged where some operators such as big airlines and air forces have established their own maintenance centres to reduce their dependency from manufacturers and increase maintenance service levels to their fleet (Goncalves and Kokkolaras, 2018). KLM is one of those airlines that have MRO division (KLM E&M) and sharing knowledge with OEMs can also be challenging not only due to customer-client relationship between airlines and OEMs but also the reasons such as monopoly position of the OEMs and shared IP.

> " [...] There is always a sensitive relation between the OEM's. Because you tend to be picky what you share with whom, because you don't want them to take over your idea. You want to have the idea, being yours. [...]"

No.	Description of barrier
	Internal
1	Lack of commitment [1]
2	Lack of financial resources [2]
3	Lack of available personnel [3]
4	Lack of focus on innovation caused by daily problems in daily operations [4]
5	Inertia caused by compliance focus
6	Problems in scaling up ideas for large-scale use [5]
7	Lack of alignment between the headquarters and business units [6]
8	Unsupportive organizational structure [7]
9	Resistance to change in enterprise [8]
10	Risk-averse organization see quote on page 53
11	Lack of innovation structure [9]
12	Lateral communication problems [10]
	External
13	Regulations on safety [11]
14	Legislation on knowledge sharing [12]
15	No system alignment in EU or international level [13]
16	An undeveloped network and ecosystem dynamics with policy makers [14]
17	Inertia caused by long certification processes for aircrafts [15]
18	Lack of knowledge sharing between actors (OEMs, MROs & Airlines) [16]
19	Problems with joint IP [17]

Table 5.2: List of barriers to innovation identified in the interviews

[1] see quote on page 52
[2] see quote on page 53
[3] see quote on page 53
[4] see quote on page 54
[5] see quote on page 54
[6] see quote on page 53
[7] based on the case study interviews and direct observations
[8] based on the direct observations
[9] see quote on page 54
[10] based on the case study interviews
[11] see quote on page 54
[12] see quote on page 54
[13] see quote on page 56
[14] see quote on page 56
[15] based on the case study interviews and direct observations
[16] see quote on page 54
[17] based on the direct observations

Figure 5.6

5.2.3. Ecosystems

It was acknowledged that nowadays innovations are produced by multiple organizations in settings like innovation ecosystems rather than, by one organization or in-house. The actors that were identified included: research institutes, suppliers, and other business collaborators. KLM is not the centre of attention in the ecosystem. Compared to past, KLM wants to be more collaborative and take a humble

approach in a multi-stakeholder environment. The importance of each stakeholder changes per department; Strategy Team a has more balancing approach, business units (E&M, Cargo, GS) are leaning for towards the suppliers and the knowledge institutes and finally, Radical Innovation Team is leaning more towards the knowledge institutes and customers.

> *"They're all very important [...] in this new strategy we are trying to look much more into a multi stakeholder model, like the ecosystem approach [...] now we see ourselves as a part of society that includes the government organizations, suppliers, customers [...] so everything you are naming here actually [...] and we operate thanks to that society because that society needs our product. So the better we understand the needs of all those, the better we can design our processes [...] You cannot do all of this at one time [...] you should be continuously elaborating on and continuously trying to make it better"* (Strategy Team)

> *"For our team, currently it is customers and the research bodies because we mostly get our new information or knowledge from the cooperations with the research bodies [...] so first we need to get the knowledge and test it with customers and then see how other parties are involved with it [...]"* (Radical Innovation Team)

The need for a broader perspective on ecosystems for the aviation industry was mentioned explicitly by the Strategy Team. Interviewees from the team confirmed the relevance of macroeconomic environment and the interdependent relationship between airlines and their home country. A member of ST explains this as:

> *"Airlines have great deal to do with geography and their home country, some examples include: Turkish Airlines' geopolitical advantage to operate more narrow body airplanes which leads to lower operational costs, efficiency of Asia-US connection via Amsterdam [....] almost all countries first have an anthem then a flag and following an airline… It is very popular to have your national airline, governments spend money in aviation due to reputation. This makes the competition even harder."*

> *"Governmental influence has grown due to financial supports. They can create right incentives to accelerate changes."*

Moreover, two members from ST mentioned that the global cooperation between the governmental bodies and regulators to work towards aligned solutions is necessary for the industry. However, in the current ecosystem, the policymakers and are often not included. This is not specific to aviation, rail transportation seems to have similar issues when it comes to establishing a common European system of standards for railways. More initiative at macro level based on the industry needs, such as Single European Sky, certification of new aircraft, regulations on access to markets can stimulate the innovation and collaboration in the aviation industry. In the literature, it was mentioned that innovation ecosystems affect the "technological innovation systems" and more alignment and interaction between these two systems can be beneficial for both systems.

> *"Operational issues like air traffic control. They should be more aligned, nations should work together and have their system aligned. Similar issues are also experienced in railways because countries tend to develop first their domestic traffic and then later on the international traffic. This is hindering innovation and operations. It should be otherwise first international then, domestic."*

It was found out that the regulators and knowledge institutes are the major influencers of the ecosystem. However, the majority of the interviewees mentioned that it is hard to define one actor as the most important.

> *"Aviation is an industry that is highly influenced by regulators [...] but it's difficult to say one [...] in general, I believe that the governments and the international authorities [...] but the customers are extremely essential for our business I mean, if a customer doesn't want to fly with us, then we don't need any finance and, we don't need any regulations [...] and you need also the employees to your daily operations[...] It's really a sort of puzzle [...] you need to have a holistic view."* (Strategy Team)

> *"Part of the characteristics of an ecosystem is that everybody has influence and everybody mutually influences each other. But if I have to choose one of the above, then I'd say the public research bodies [...]"* (Radical Innovation Team)

Although the position of KLM was not defined by the interviewees, it was stated that KLM seeks to influence the ecosystem and a clear innovation ecosystem strategy is seen as the main lever to achieve this. However, it was admitted that influencing the aviation ecosystem might me too ambitious for KLM.

> *"We have our own priorities and of course we want to pursue those priorities together with the partners within the ecosystem. But, we do seek to influence it. and I believe if you have a clear strategy on innovation, you know where you want to go and, you are very clear about it, that definitely helps you to influence the ecosystem."*

> *"[...] You want to be the influencer in the network where you can make change and where you can really be impactful. Like the network with the airport and the authorities. You want to be the one at the table when new agreements are being made. You want to make sure that your concerns and your wishes basically are heard [...] however, when it comes to OEMs like Boeing or Airbus, it is very hard to be really at the table. You can't influence them by saying this is what we're looking for and if you would come up with a product like this or this, then we would be interested. It's really hard to influence those companies so it's not really worth the effort just because you know that they probably won't move in your direction[...]".*

During the case study interviews, a perspective difference between business units and headquarters on the innovation ecosystems was identified. The business units defined ecosystem actors as *actors that are directly related to their core business activities and share a 'common purpose'.* These included business collaborators (large firms/ SMEs/ startups), suppliers and public research bodies. Their priority is implementation of technological innovations that can improve their daily operations. On the other hand, the headquarters emphasize the importance of including a broad spectrum of stakeholders. However, making a direct distinction between divisions (headquarters and business units) and the layers (explorative and exploitative) is not possible. For instance, the senior project manager from the Radical Innovation team who was responsible for exploring the future opportunities for the Cargo Volume Scanner project was also actively involved during the materialization phase and although the majority of the interviewees from the business units mentioned that they were mainly interested and active in the exploitative layer, one business unit (E&M) clearly stated that they are active in both explorative and exploitative layer:

> "At E&M, we do a lot of standard maintenance, and that's when we work with integrators or with suppliers [...] you go to the supplier, you hand them your question and they give you the solution. It's quite straightforward. [...] on the other hand, my team is also working on developing new techniques. So if we talk about robotics, we're looking at new ways of using these in the normal work. So this is really, really explorative and that's something we do ourselves, [...] For example with Bright Sky ecosystem, we are looking at robotics from explorative and research kind of way. We are really thinking outside of the box and we are working together with TU Delft and other partners. We tell them we don't have a specific problem, but we just want to look forward to the future and ask if they can help us to achieve a future where the robots are part of our normal work [...] they are really contributing and we are working together with the partners and that's not just as straightforward as I said before, so our ecosystems are split."

In the explorative layer, KLM often partners up not only with knowledge institutes but also with other business collaborators (large firms/ SMEs/ startups) like NS, Port of Amsterdam, Airbus and airlines to identify and elaborate future opportunities for innovation. This layer has the characteristics of an open system and focuses on bringing new knowledge to the company. As some of these actors such as OEMs and airlines are direct or indirect competitors of KLM, the company is not always comfortable with sharing the knowledge, therefore those actors are often not included in the exploitative layer. On the other hand, the knowledge institutes are included in both layers hence they are not a competitor of KLM, the company feels comfortable with sharing the knowledge and collaborating with students and researchers.

> "We have collaborations with NLR, different universities, start-ups, suppliers and MRO Lab in Paris. Of course we also have connections with OEMs, but in our collaboration with OEMs we tend to be very picky on what to share. So, we're in open innovation system but, still we are selective on what to share and with whom to share."

So, in the exploitative layer, KLM often partners up with knowledge institutes, other business collaborators (large firms/ SMEs/ startups), suppliers and in particular Air France as both airlines are part of overarching AF-KLM group. This layer has the characteristics of a semi-closed system and focuses on developing and implementing innovations that add value to their operations and customers. These two layers are continuously interacting with each other as exploitative layer triggers the search and collaboration processes in the explorative layer and the explorative layer gains continuity and validity through the development of concrete innovations. This interaction between these two layers and an example of its application at KLM is shown in Figure 5.7.

An overview of identified innovation ecosystem strategies used by KLM is shown in Table 5.3. These strategies are used by the headquarters as well as the business units.

5.3. Connecting Barriers to Innovation Ecosystems

Besides the identified innovation ecosystem strategies used by KLM, participants were asked about the best practices in the business and how could current innovation ecosystems be improved. Some employees shared their opinions on improvement of the ecosystem based on 'the experiences (including current innovation ecosystem strategies) that worked very well in the past' while others used identified barriers as a starting point and based their opinions on 'how could these barriers be prevented or
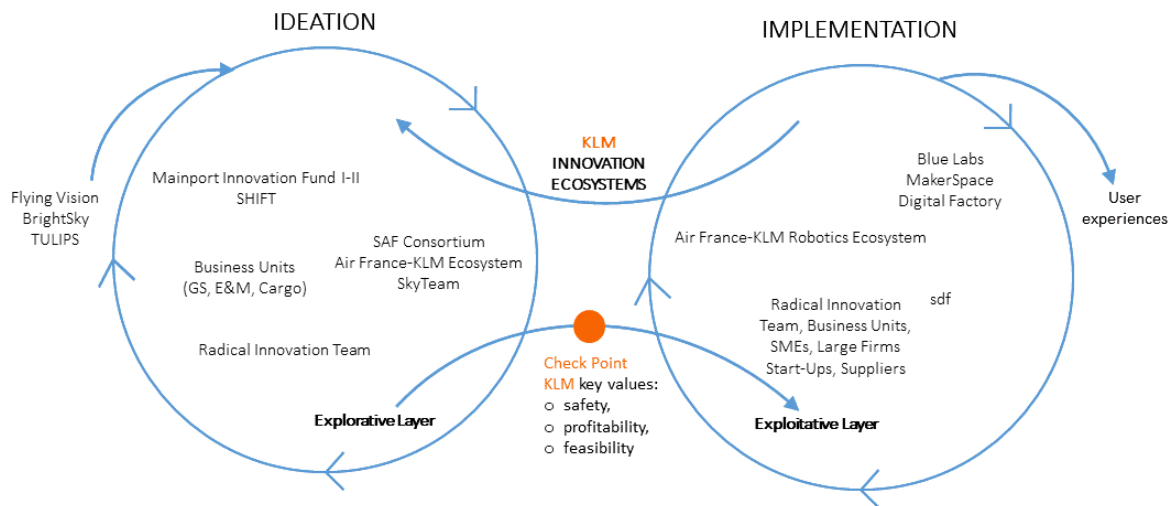
Figure 5.7: The Interaction Between Explorative and Exploitative Layer of KLM Ecosystem

overcome by deploying various strategies'. Interestingly, the preferences of employees for different strategies varied per business unit. For example, some interviewees argued that face to face events would be preferred over digitalizing the innovation ecosystem, while others argued that face to face events would consume too much time, so they would prefer to have a website where they can log in and see ongoing projects. The majority of participants agreed with the statement that stimulating collaboration internally as well as external with a good project portfolio management would be highly beneficial for the innovation processes of KLM.

> "What can help in the marketing side of an ecosystem is the success stories [...] we share too less success stories about what is happening so far[...], those kinds of stories also give you an image of the person, and what is happening in the your company [...] When you would sell a change or technology, use those success stories to show people what they can achieve [...] I think people ask themselves questions like: 'Why should I implement this? What's in it for me? Why should I use this ecosystem? Why shouldn't I do things on my own? Because I think I'm doing great already' [...] people should see what's in it for them[..]"

> "Boldness of a group of people throughout the different levels of the company took the chance to challenge the Executive Committee and that pushed innovation [...] So I think the awareness of the EC is necessary, from top to bottom, people should get enough time. In this case I could make sure that people got enough time and resources but if they are on their own, they don't really get the opportunity to reach their EVP. Maybe because they find this step too big."

> "[..] I think the face to face events where people can meet it really helps. That's why I said of course you can do a newsletter, but people will have to read it, and they will also have to recognize that it's something that's interesting for them.However, if you speak with a person face to face, they will tell you what they did and which department they're from, so you can see the connections much faster to help each other[...]"

Dimension	Second-order themes	First-order themes
Explorative layer strategies	Aligning	• BrightSky • Flying Vision • TULIPS • SESAR • Offering graduation thesis opportunities for MSc • Participating educational projects (JIP and other curriculum projects)
	Strategic Positioning	• Sustainable Flight Challenge • Interviews
Exploitative layer strategies	Aligning	• Pilots with Air France (Electrification of ground vehicles etc.) • BlueLabs • Makerspace • Digital Factory • MRO Lab
	Strategic Positioning	• Mainport Innovation Fund I-II • SHIFT Fund • Cargo Volume Scanner Ecosystem • AF-KLM Robotics Ecosystem • E&M 3D printing Ecosystem

Table 5.3: Ecosystem Strategies of KLM

5.4. Validation

The results derived from the literature research and case analysis were validated in an expert session. The main purposes of this session were to assess: (1) to what extend the findings of this study can be generalized to draw organization wide conclusions; (2) how can the current KLM ecosystem be improved in order to achieve the company's objectives on innovation and; (3) the validation of the case study results.

All 15 experts (see Table 4.2) were chosen from the "Innovation Ecosystem Ambassadors" in the current KLM innovation ecosystem, shown in Figure 5.2. Innovation Ecosystem Ambassadors are responsible for the innovation activities and the recognition of KLM innovation ecosystems within their department. The session was organized in Microsoft Teams and took an hour. During the validation session, the research objectives were explained, and analytical frameworks were presented. Afterwards, both case studies were explained and results were shared, and the expert opinions were asked.

5.4.1. Barriers to Radical Innovation at KLM

First, the experts were asked to rate whether they agree on the barriers to radical innovation identified in the case interviews. As evident from Figure 5.8, not every barrier was recognized by each expert. This could mean that some barriers might be related to contextual factors such as the department expert works at, the innovation project expert was part of, the organizational ranking of the expert etc. However, some barriers received relatively high recognition, this could mean that barrier might be generalized to the whole organization, and it might require extra attention. A list of these barriers is shown in Table 5.4.

No.	Description of barrier
1	Innovation goals are not supported by a good planning (lack of commitment)
2	KLM being operation-driven company
3	Unsupportive organizational structure
4	Lack of innovation structure
5	Risk-averse organization
6	Lateral communication problems (reinventing the wheel)

Table 5.4: List of barriers to innovation that received high recogntion by experts.

5.4.2. Innovation Ecosystems

Secondly, the experts were asked whether KLM should focus more on exploration, exploitation or both. The majority of the experts (67%) answered this question as both, followed up by exploitation with 27%. One expert thought that KLM should focus more on exploration. So, these results meant that KLM should have a balancing approach between exploration and exploitation.

Thirdly, experts were asked to rate the importance of each identified ecosystem actor in the innovation processes. None of the actors were considered as not important, however some were considered more important than others. The results are shown in Figure 5.9. The importance of research institutes were in line with the earlier conducted case interviews. What stands out in the table is the importance of suppliers and customer, since these actors were not mentioned as prominent actors of the ecosystem during the earlier interviews.

Fourthly, experts were asked to vote for the most important 3 innovation ecosystem strategies from the identified innovation ecosystem strategies shown in Table 5.5. The aim of this question was to understand how can the current KLM ecosystem be improved in order to achieve company's objectives on innovation. According to these results, KLM should focus on innovation ecosystem strategies that

Figure 5.8: Expert session results on barriers to radical innovation at KLM.

include more collaboration with suppliers, SkyTeam member airlines and research institutes. Moreover, the pilots should be divided better between different divisions of KLM. Finally, more collaboration with SkyTeam airlines and the research institutes (WO, HBO e.g. Bright Sky) is favoured.
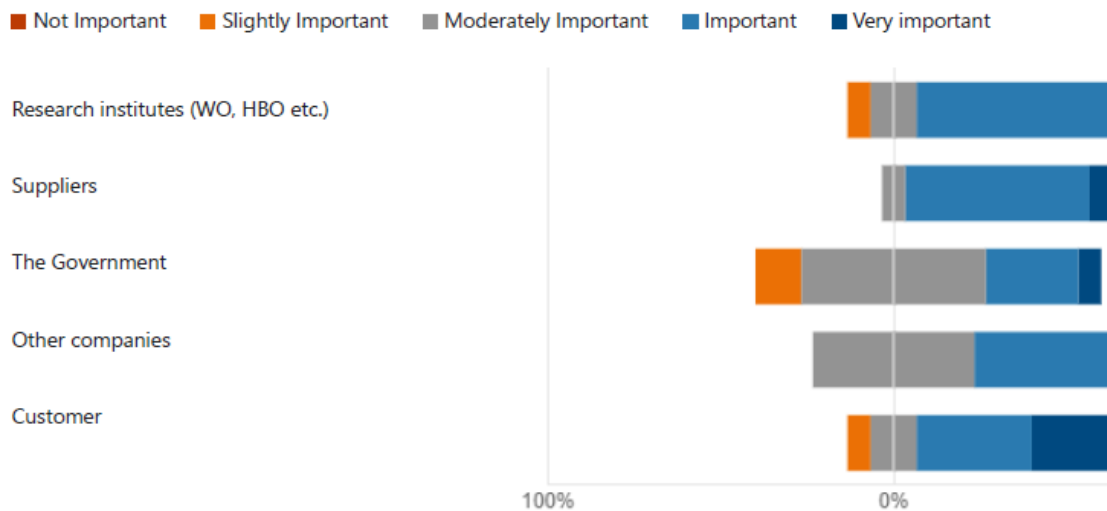
Figure 5.9: Importance of innovation ecosystem actors in innovation processes.

No.	Innovation Ecosystem Strategies	No. of expert votes
1	Organizing periodical and time efficient events where people can share knowledge on a certain topic/purpose from the different divisions (e.g. Sustainable Flight Challenge Marketplace, E&M Innovation Cafe, etc.)	2
2	Digitalizing and further developing innovation ecosystem (website)	2
3	Taking part in EU project networks (e.g. TULIPS. SESAR)	2
4	More focus on Innovation Fund and engage more start-ups	4
5	More collaboration with SkyTeam member airlines on innovation and a better distribution of pilot projects	5
6	Better distribution of pilot projects within KLM (each division tries different solutions, no duplication of pilots)	8
7	More collaboration with suppliers	10
8	More collaboration with the research institutes (WO, HBO e.g. Bright Sky)	5

Table 5.5: How could KLM innovation ecosystem be improved? Expert answers

5.5. Conclusion

This chapter aimed to answer the following sub-research questions:

> SQ4: *What are the barriers to radical innovation in airlines?*

> SQ5: *What are innovation ecosystem strategies implemented by airlines to drive innovation?*

The airline industry is going through a big transformation. The institutional environment as well as the industry itself has changed by increasing competition and the entry of the low-cost carriers in a market that used to be dominated by flagship carriers. Furthermore, societal pressure regarding sustainability on airlines with COVID-19 state aids increased, while the shortage in the labour market limited the pace of recovery. Finally, the technologies that airlines use to operate have outdated to

cope with today's complex challenges. All of these changes forced airlines to innovate to maintain their services. However, some internal and external factors inhibit organization's ability to innovate. Table 5.2 summarizes the barriers to radical innovation at KLM. A comparison of these barriers to those identified during the literature review and what could the findings of this case study mean theoretically is discussed in Chapter 6.

What is interesting about the data in this table is that 12 out of 19 barriers identified during the interviews were internal. This meant that KLM might be able to influence the majority of the barriers that hamper KLM's innovation processes. It is worth to mention that different barriers require different coping strategies, actions and mechanisms. However, theoretically, it would be expected that these coping strategies could be categorized under two main concepts: (1) cultural and (2) structural strategies. Furthermore, in Chapter 3 open innovation culture and innovation ecosystems were identified as theoretical concepts that could provide those strategies. This chapter, provided insight into how a flag carrier airline in the Netherlands applied these theoretical concepts on their attempts to arise and materialize innovations to cope with the changes in the institutional environment and the industry. From the results of this case study, it can be concluded that KLM is aware of the relevance of ecosystems for its innovation processes and puts effort into building its reputation as an innovative airline in the aviation ecosystem. In order to facilitate this, KLM collaborates with others within and beyond the value chain including a variety of other companies and knowledge institutes, and uses different innovation ecosystem strategies. However, KLM did not define its position in the ecosystem, lacks an overarching innovation ecosystem strategy and alignment between the ecosystem actors. This might be due to earlier identified barriers as well as the perspective (affiliation vs structure) Radical Innovation team and business units looks at the concept of innovation ecosystems. Theoretical knowledge, gained in Chapter 2, suggests that two different perspectives on innovation ecosystems can be found in the literature: (1) ecosystem-as-affiliation and (2) ecosystem-as-structure. The current innovation ecosystem perspective of KLM resembles ecosystem-as-affiliation concept, which aims to increase openness, number of actors and access to knowledge. However, the strategy guidance offered by this perspective focuses on governance and community enhancements rather than the value creation. This might explain the weakness of KLM in the implementation of ideas and radical innovations, and the absence of an overarching innovation ecosystem strategy. The findings of this chapter are interpreted and discussed further in detail in Chapter 6.

6

Discussion

The aim of this chapter is to contextualize the case study results within the literature which is covered in the literature review (Chapter 2 & 3), relate back to the sub-research questions posed in the introduction and provide recommendations to KLM. In order to achieve this first the results presented in Chapter 5 are interpreted and discussed based on the analytical framework and the learnings from the theory in Section 6.1. Then, in Section 6.2 recommendations to KLM are provided.

6.1. Interpretation of the results

6.1.1. The importance of the contextual factors in innovation strategy

Firstly, this study sought to explain how the innovation strategy of an organization was formed. Observations that were made during the internship period by attending the weekly team meetings and having informal discussions with the actual employees show that although innovation has high importance in the new KLM strategy, it is not a goal on itself. At KLM, innovation is regarded as a supporting mechanism to achieve strategic goals mentioned in the strategy. With reference to theoretical knowledge on the importance of exploration and exploitation balance in the formulation of innovation strategy, based on the answers from several employees and the quote from a strategy consultant presented in Subsection 5.2.1, KLM currently focuses on exploitation. The majority of the resources (financial, human capital and time) are put on dealing with operational disturbances [1] and "supporting current processes and markets" (also called as horizon 1 innovations). This outcome is interesting since KLM wants to adopt and implement radical innovations, names its innovation team as "Radical Innovation Team" and the objectives of KLM such as flying net-zero requires far more than just incremental technology improvements such as upgrading fleets to new more fuel efficient models, using lighter materials on board, flying more direct routes, cruising at optimal altitude but truly disruptive technologies (also called as horizon 3 innovations) such as flying with battery and hydrogen-powered aircraft (see Figure 6.2). So, the data collected from the interviews and observations seems to be contradicting with the company documents (see Figure 6.1).

From a theoretical perspective, this might be related to lack of an innovation strategy that aligns

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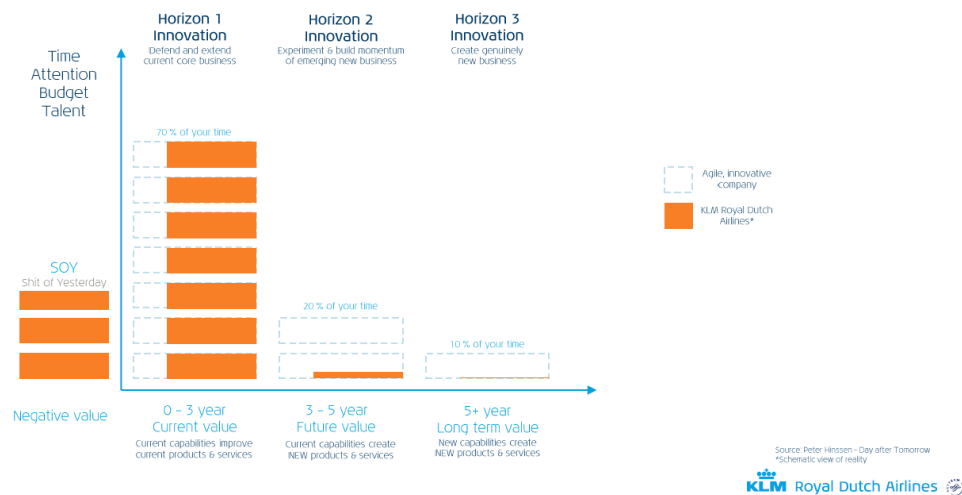[1]"KLM is an 'operation-driven' organization" see quote on page 53

Figure 6.1: How many hours did you spend on H3 innovations in September 2021? Results: An agile company vs KLM, (KLM, 2022)

with the overall business goals (Pisano, 2016). Some factors that are identified in the case interviews and company documents [2] such as *lack of alignment between headquarters and business units on innovation, absence of innovation structure and central project portfolio management and innovation strategies being formed locally* may support this hypothesis. However, this study [3] also showed that from an industry perspective, this might be related to the limited influence of KLM as an aviation ecosystem actor. Compared to magnitudes of OEMs like Boeing and Airbus and their economies of scale, the influence of a single airline on the development of the radical innovations that will truly transform the industry and facilitate the flying net-zero ambitions, such as battery and hydrogen-powered aircraft and new aircraft design, is very limited. This is particularly interesting because it encourages the collaboration between actors and innovation ecosystem concept to create the necessary critical mass that is needed for driving radical innovations in the aviation sector. Therefore, it provides further support for the relevance of innovation ecosystems for KLM's innovation processes.

6.1.2. Barriers to Radical Innovation at KLM

Secondly, this study aimed to explore the contextual factors that affect KLM's innovation management and the barriers that hinder its innovation processes. In Chapter 2, 3 external and 3 internal barriers to radical innovation at large firms were identified by the literature study as a baseline to determine whether the barriers to radical innovation at KLM were similar to those found in the literature. Due to the scope of this thesis, the list of selected barriers from the literature was limited to main barriers to radical innovation in large firms. What is meant here by the word "main" is the barriers mostly mentioned in studies on radical innovation in the literature (Sandberg and Aarikka-Stenroos, 2014). In Section 5.2, 12 internal and 7 external barriers to radical innovation were identified in the empirical study. However, these data must be interpreted with caution because the higher number of barriers identified in empirical study might be the result of difference in the level of detailing in between the studies (i.e. "lack of financial resources" and "lack of available personnel" is classified under "lack of

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[2]see interview quotes on page 53 and subsection 5.2.1
[3]see interview quote on page 57

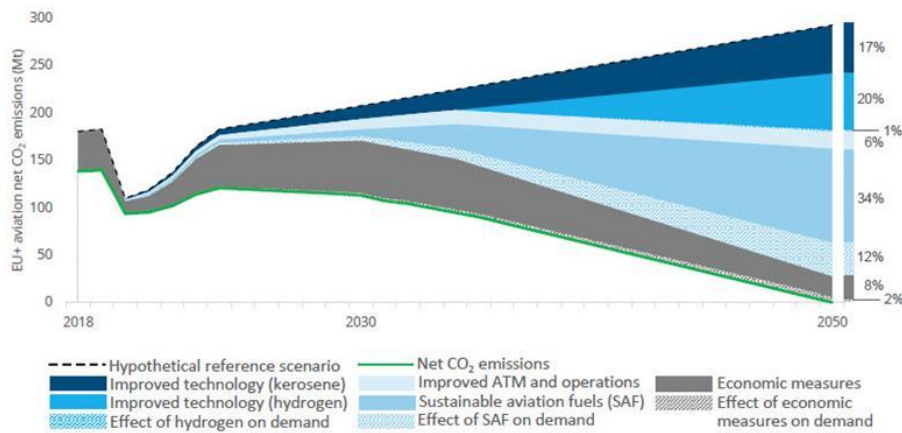## Decarbonisation Roadmap for European Aviation

All flights in scope

Figure 6.2: Path to Net-Zero, (Destination2050, 2022)

resources" in the literature, see Figure 6.3). In order to make a more accurate comparison between the theory and practice, empirical study barriers are classified in one higher category, shown in Table 6.1.
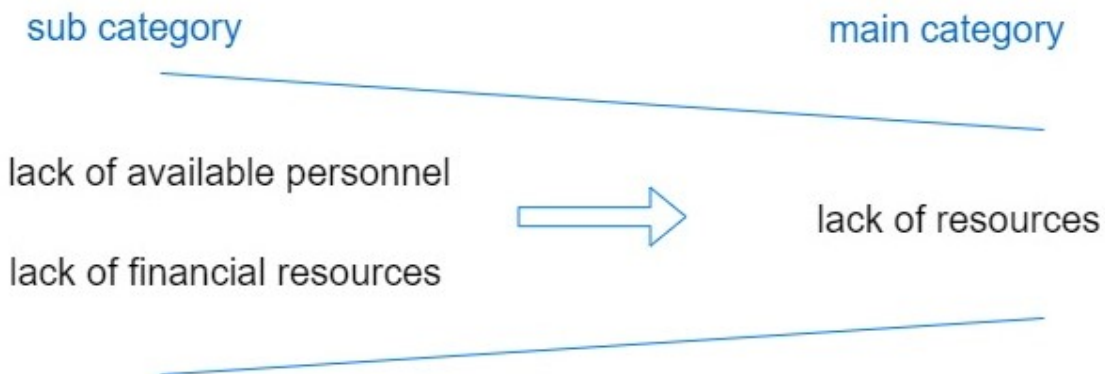

Figure 6.3: Level of detailing

By comparing both lists, it can be concluded that the internal barriers to radical innovation in large firms identified in the literature are similar to those identified at KLM in the empirical study. This seems logical as KLM, with almost 30,000 employees, is considered as a *large* firm. However, when it comes to external barriers, the type of barriers are relatively different. This might be due to contextual factors such as industry. In the study of Sandberg & Aarikka-Stenroos (2014) the barriers in various industries were included in order to provide a comprehensive overview. However, they acknowledge that industry seems to affect barriers. Moreover, according to their study, service innovations provided a marginally different perspective, in which external barriers were accentuated; in particular, barriers originating from a restrictive macro environment (Sandberg and Aarikka-Stenroos, 2014). Hence, the

No.	Barrier	Empirical study (case) example	Mentioned in the literature
	External		
1	Legislation	Legislation on knowledge sharing; Problems with joint IP	
2	Undeveloped network and ecosystems	No system alignment in EU or international level; Lack of knowledge sharing between actors (OEMs, MROs & Airlines)	√
3	Regulations	Inertia caused by long certification processes for aircrafts; Regulations on safety	
	Internal		
4	A restrictive mindset	Risk-averse organization; Resistance to change in enterprise	√
5	A lack of implementation competences	Lack of innovation structure; Problems in scaling up ideas for large-scale use	
6	An unsupportive organizational structure	Lack of alignment between the headquarters and business units; Lateral communication problems; Lack of commitment by the management when it comes to making clear agreements to achieve innovation or sustainability goals; Lack of focus on innovation caused by daily problems in daily operation; Inertia caused by compliance focus	√
7	Lack of resources	Lack of financial resources; Lack of available personnel; Lack of time to focus on innovation caused by problems in daily operations	

Table 6.1: Barriers to Radical Innovation at KLM Royal Dutch Airlines categorized in main categories deducted from the interviews

core business of an airliner is providing air transport *services* for travelling passengers and freight, this might explain the accentuated external barriers on legislation and regulations at KLM. Built on this theoretical and practical knowledge, one can argue that the contextual factors that have the most influence in innovation management at KLM included: type of organization and type of industry. Another interesting finding of this thesis was the exploration of the link between SRQ1 and SRQ2. According to theoretical and empirical findings of this study, contextual factors identified in Section 2.2 such as type of innovation, type of industry, type of organization and type of country affects innovation management of a firm as well as the type of barriers to innovation in a firm. This meant that empirical evidence collected in this study support the contextual innovation management approach proposed by Ortt & van der Duin (2008) and the data gathered to answer these two questions feed each other.

It is important to note that, in the case of KLM, the majority of the barriers identified in the case study (visualized in Figure 6.4) were related to a *unsupportive organizational structure*. This could be explained by the unfavourable climate for innovation at KLM. The results of the theoretical study on the factors that are important for creating an innovative climate identified by van der Meer (2007) in Subsection 3.1.1 and the results of the case study, shown in Table 6.2, point out an unfavourable climate for innovation at KLM.

Factor	Experience at KLM
innovation horizon	short
failures	avoided
communication	formal
uncertainty	kept out
external co-operation	mostly closed
opportunities	ignored
decision-making	autocratic
organization	internal
strategy	vague

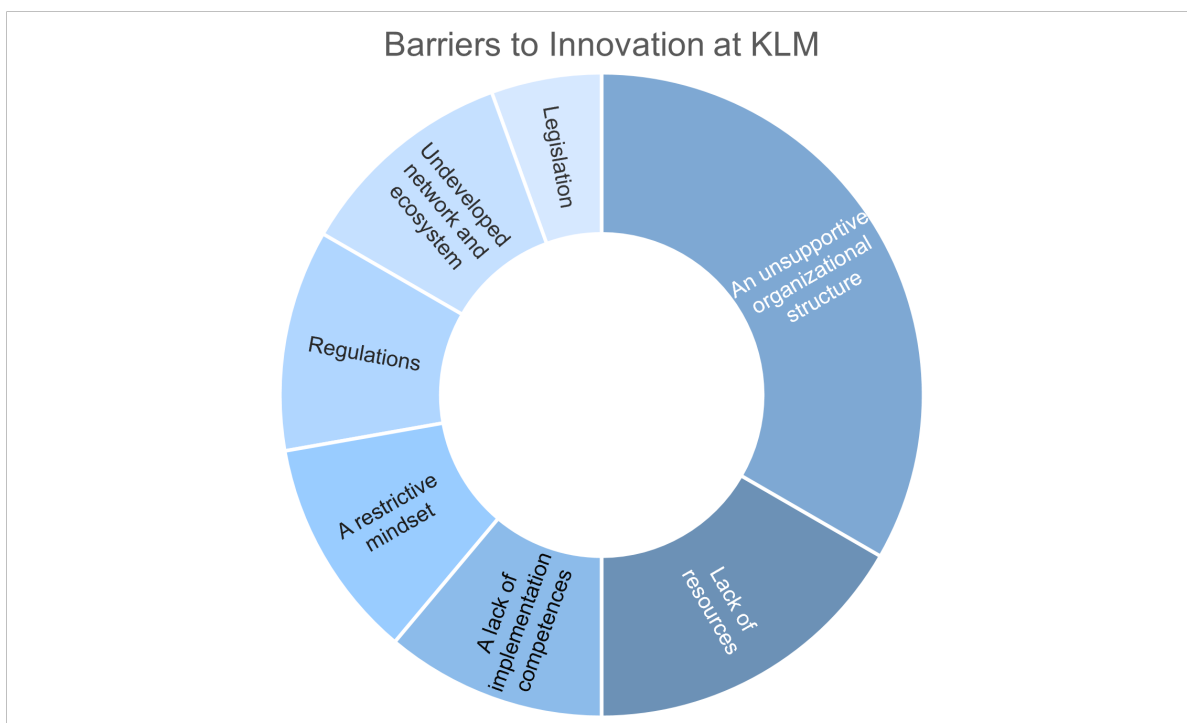Table 6.2: Innovation climate at KLM deducted from the interviews.

Figure 6.4: Barriers to Innovation at KLM deducted from the interviews.

6.1.3. Innovation Ecosystems

Thirdly, this study sought to investigate the relevance of 'innovation ecosystems' concept to KLM's innovation processes. One of the most important finding of this study was the acknowledgment of the need for collaboration in the aviation and the increasing relevance of innovation ecosystem concept to facilitate this need. The statements of the interviewees presented in Section 5.2.2 as well as in Section 5.2.3 support this claim.

Fourthly, this case study is set out with the aim of gathering practical knowledge on the implementation of the concept innovation ecosystems in airline industry. At the beginning of this research, some KLM employees mentioned that the current ecosystem was not mature enough, hence depart-

mental silos occurred. So, the solution in mind was maturing the ecosystem by further digitalizing the innovation ecosystem to a more interactive version. However, the literature review and empirical evidence show that what KLM regards currently as their 'Innovation Ecosystem' (see Figure 5.2) is a knowledge platform or a tool to share information internally to prevent lateral communication problems and departmental silos. However, this outcome should not be interpreted as KLM does not have an innovation ecosystem, in contrary, if one looks at the extended partnerships KLM established with research institutes, VC arm and pre-competitive EU projects, it becomes clear that KLM uses innovation ecosystems to increase its innovation capacity. Regarding the ecosystems-as-affiliation and ecosystems-as-structure distinction in the literature, the answers of interviewees [4] suggest that the best practices of innovation ecosystem implementation at KLM such as SFC and Flying V are formed around a 'common goal'. According to these interviewees, aligning actors around a value proposition played a crucial role in the success of these projects. This meant that innovation-as-structure perspective is more relevant for KLM and its innovation processes.

Actors

According to literature review, different entities such as private commercial companies, universities and research institutes, government policymakers and finance institutions participate in innovation ecosystems. In the case study conducted by Visscher et al. (2021) research and knowledge institutes were favoured as possible strategic innovation partners and mentioned the most as an actor in the ecosystem where focal firm is part of. However, in this study, the majority of the interviewees [5] had a more balancing approach. Moreover, the results of the expert session represented in Section 5.4 shows that suppliers and customers are also important innovation ecosystem actors for KLM. So this meant that in contrary to study of Visscher et al. (2021), in the case of KLM, the most important or mentioned actor cannot be defined. This can be explained by three factors: (1) the complex multi-actor environment KLM operates and their dependence as an airline on the macroeconomic environment (Heshmati and Kim, 2016), (2) difference in the company types included in both studies and, (3) the difference in the functions of interviewees within the company in both studies. Regarding the third factor, there is evidence that supports this claim. Similar to the study of Visscher et al. (2021) the statements of interviewees [6] represented in Subsection 5.2.3 shows that the Radical Innovation team considers research and knowledge institutes as focal innovation ecosystem actors. This could be expected as the Radical Innovation team is responsible for innovation at KLM and the study of Visscher et al. (2021) was conducted with employees who are responsible for innovation at the firm.

When it comes to other private companies and business collaborators, OEMs were often not mentioned as an ecosystem actor by the interviewees. Based on the case study interviews [7] it can be concluded that knowledge sharing with OEMs is a sensitive topic for MROs like KLM E&M, despite the results of the numerical study (Goncalves and Kokkolaras, 2018) show that an effective and structured collaboration between OEMs and MROs can deliver higher added value to airlines. This does not mean that KLM do not share any knowledge with OEMs. However, they are very selective on what to share and not within these ecosystems, this phenomenon is referred as 'selective revealing' in the literature (Henkel et al., 2007). Another explanation for this result could be the duopoly position of OEMs, some interviewees believe that airlines have very limited power to influence OEMs for implementing their

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[4]see interview quote on page 59
[5]based on the results of the interviews represented in Subsection 3.3.3
[6]see interview quotes on page 56
[7]see interview quote on page 58

wish [8].

Another interesting finding was that, although finance institutions were mentioned in the literature as an ecosystem actor, none of the interviewees mentioned finance institutions as an innovation ecosystem actor. This could mean that there is no rigid list of innovation ecosystem actors in practice and the actors involved in an ecosystem can vary on contextual factors such as type of industry, type of innovation but also the common goal and value proposition. This supports the relevance of innovation-as-structure perspective of Adner (2017), which takes the value proposition as a starting point of an innovation ecosystem and then aims to identify actors who are necessary to materialize the value proposition. Unless like the innovation-as-affiliation perspective, in this perspective actors who are not necessary for materializing the value proposition are not part of the innovation ecosystem, which could lead to reduced system complexity.

As exemplified in the research [9], KLM set up the Sustainable Flight Challenge to stimulate knowledge sharing between airlines and accelerate sustainable aviation. Each of the 13 airlines that participated created innovations that will contribute to the topic of sustainable aviation. However, only recently it was found out that sharing knowledge obtained by this challenge with other airlines might be prohibited by the competition law. Similarly, it was only recently discovered by the stakeholders that there is a risk that EASA might not be able to certify the Flying V due to its odd shape when the prototype is ready, despite the fact that it is in development for nearly 8 years. This meant that some necessary actors such as policymakers are not very well included in the current ecosystem. Similar difficulties with policies and legislation were observed in other industries, such as railways with ERTMS and automotive industry with autonomous cars. These examples show that alignment of the actors, including policymakers, is necessary for coping with today's highly complex challenges.

Regarding the influence of actors on ecosystems, two actors that were mentioned as the greatest influencer on ecosystems included regulators and knowledge institutes. The reasons for this outcome might include the abundance of safety related regulations in aviation industry and the research capacity of knowledge institutes that can provide knowledge that will change the industry.

Innovation Ecosystem Strategies

Based on the maturity model for the development of innovation ecosystem strategies proposed by Visscher et al. (2021), several factors that could help to determine the maturity level of KLM's innovation ecosystem were identified. An analysis of the current state of innovation ecosystem [10] on these factors is shown in Table 6.3. It is important to bear in mind that within KLM there are multiple innovation ecosystems (e.g. E&M ecosystem, Cargo Ecosystem, Robotics Ecosystem, GS Ecosystem), and there are significant differences in maturity levels between these ecosystems. In this assessment, the generic KLM Innovation Ecosystem orchestrated by the Radical Innovation Team (see figure 5.2) is considered. According to this table and the framework suggested by Visscher et al. (2021), the bottlenecks for KLM's innovation ecosystem to reach higher maturity levels are: (1) lack of overarching innovation ecosystem strategy that covers both layers, (2) lack of explicit positioning of KLM in the innovation ecosystems and (3) lack of holistic view on innovation ecosystems. As discussed earlier in this section,

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[8]see interview quote on page 57
[9]see page 54
[10]based on the results presented in Subsection 5.2.3

these bottlenecks cannot be solved with the solution KLM had in mind for maturing its innovation ecosystem. Nonetheless, the efforts of KLM to establish a knowledge platform or a tool that aims to align the actors in the exploitative layer is interesting because theoretically, it shows that KLM uses an innovation ecosystem strategy to overcome one of the barriers to radical innovation identified in the case study. In a similar vein, Pickard and Pasqualino (2022) argue that in the era of decarbonization in the aviation sector, challenges such as lack of resources and strict regulations (which is identified as a barrier to radical innovation in this study [11]) can be overcome by global collaboration between public and private organizations and systems thinking. These findings meant that innovation ecosystems and, in particular, the innovation ecosystem strategies can be used to overcome barriers to radical innovation at KLM. Based on the theoretical and empirical data collected in this thesis, some use cases where innovation ecosystem strategies can be used to overcome the barriers to innovation at KLM are identified. This would also help to improve the innovation ecosystem and increase the maturity level.

Factors	Current State
Innovation ecosystem awareness	Company is aware of the relevance of ecosystems for its innovation processes
Collaboration	It collaborates with others within and beyond the value chain including variety of other companies and knowledge institutes
Effort to build an innovative reputation	Company puts effort into building its reputation as an innovative airline
Position in the ecosystem	Company did not define its position explicitly in the ecosystem
Alignment of innovation processes	Company aligns its innovation with knowledge institutes
Innovation ecosystem strategy	Current strategy covers only one layer (exploration) and there is no coherent and overarching innovation ecosystem strategy
Systemic view of innovation processes	Currently there are no mechanisms to view innovation processes systemically
Fostering innovation ecosystem as a whole	Innovation ecosystem is fragmented, each business unit have their own innovation ecosystem

Table 6.3: Maturity level assessment for KLM Royal Dutch Airlines based on the framework proposed by Visscher et al., (2021)

6.1.4. Concluding remarks

An overarching innovation ecosystem strategy is crucial for a company that considers ecosystems important for its innovation processes, because even though the explorative layer stimulates the new ideas, rises the likelihood of finding solutions to problems and unveils the opportunities for innovation, studies suggest that the real value creation occurs in the exploitative layer, as this layer is where innovations are materialized (Autio and Thomas, 2014). Furthermore, both layers and the flow of knowledge and other resources in between them are essential for the system to function (March, 1991; Gupta et al., 2003; Visscher et al., 2021). This meant that a successful innovation ecosystem strategy is a virtuous cycle where these two layers are in constant interaction and the outcomes of each feeding one other (Clarysse et al., 2014; Visscher et al., 2021). However, KLM currently lacks such an overarching strategy and, due to identified barriers (e.g. lack of resources, lack of innovation structure etc.), most of the opportunities explored in the explorative layer do not turn into concrete innovations. Moreover,

[11]see Subsection 5.2.2

the opportunities identified in the explorative layer are not getting validated by turning these opportunities into concrete innovations, which leads to a negative impact on the innovation climate at KLM. Many employees believe that [12] KLM has more than enough innovation capability and knowledge, but the organization fails at transferring the innovation into adoption and implementation at the business side. From CEO [13] to project manager, employees of KLM admit the lateral communication problems within the organization. This leads to various problems such as silo thinking, reinventing the wheel and lack of alignment between different departments. Currently, there is a generic KLM Innovation Ecosystem (explorative layer) orchestrated by the Radical Innovation team and various more specific business unit innovation ecosystems (exploitative layer). However, a strategy or mechanism that brings the KLM innovation ecosystem (see Figure 5.2 and business unit's innovation ecosystems together is still missing. During the personal conducted interviews, a number of options identified via the literature research were presented. The majority of the interviewees believe that the alignment problem could be solved by strategies or mechanisms such as, central project portfolio management, organizing innovation events with a certain purpose/topic where people can share knowledge and introducing a (digital) knowledge sharing platform that demonstrates the ongoing innovation projects within the different departments. These measures could help to break departmental silos, enhance knowledge sharing, accelerate the long innovation lead times and therefore help to execution of the innovation strategy.

6.2. Recommendations for KLM

Concluding remarks discussed in the previous section led to a set of recommendations for KLM to improve its innovation processes and in particular its innovation ecosystem.

6.2.1. Recommendations on overcoming the barriers to innovation

In order to give a better overview, the barriers were divided into 3 groups. The first group of barriers can be overcome with the cultural approach, in other words, with the strategies that aim to create an innovative climate that composes a set of attitudes and values that are favourable to innovation. These barriers and corresponding strategies are shown in Table 6.4. A climate favourable to innovation supports the innovation mechanisms. Since without people willing and daring to innovate, the tools, mechanisms and concepts will not be used. A climate favourable to innovation requires longer horizons, better balance between managing yesterday's problems, and organizing for the future, acceptance of risks and mistakes, participative decision-making, leaving free space for responsibility and expertise and recognizing opportunities. It is important to bear in mind that changing the culture of an organization requires time and the effect of these strategies will only be seen in the long term.

The second group of barriers can be overcome with a structural approach, or in other words, with the organized use of innovation enabling mechanisms, in particular using innovation ecosystem strategies to mitigate the root causes of barriers. These barriers and corresponding strategies are shown in Table 6.5. Hereby, reviewing the past innovation processes and identify the red flags and best practices can be highly beneficial. Furthermore, results showed that innovation can be sometimes too theoretical at KLM, so make sure everybody gets familiar with concepts in practice. In order to prevent the internal barriers in this group, it is important to understand the magnitude of airlines as an organization.

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[12]stated during the expert session in Section 5.4
[13]stated during informal Q&A session with the CEO

No.	Barrier	Corresponding Strategy
1	Unsupportive organizational structure	Promote participative decision-making by letting the employees take on the responsibility to innovation as well as the accountability that goes along with it, accommodate room for divisional expertise
2	Resistance to change in enterprise	Educate employees on innovation by using use simple, straight forward language and preventing too many terms and hindsight bias in presentations (e.g. close-minded nature of aviation industry), motivate employees by giving reasons for the necessary actions, reminding the bigger picture, promoting innovation systematically
3	Risk-averse organization	Tolerate failures and accept uncertainty that comes with radical innovation by knowledge sharing on experimentation
4	Lack of focus on innovation caused by problems in daily operations	Extend innovation horizon by giving necessary time and resources for employees to think about big picture view
5	Inertia caused by compliance focus	Aviation is passion for many employees, make them believe that they can contribute to the transformation of the industry by emphasizing the importance of long-term objectives and sustainability for the future of aviation

Table 6.4: List of barriers identified at KLM Royal Dutch Airlines that can be prevented culturally and the corresponding recommendations.

KLM operates in a broad range of businesses and offers different types of products and services from catering to pilot training, transporting people and goods to offering technical services, all based on different technologies and aimed at different markets with different requirements. Furthermore, besides the core organization, they often own various subsidiaries. On the one hand, centralizing such organizations on innovation might be too rigid. Like other companies of this size, decentralized structure and giving more room and responsibility to business units to design their own innovation processes and putting expertise over hierarchy can stimulate innovation (van der Duin *et al.*, 2014). However, on the other hand, decentralization might stimulate further departmental silos within the organization and cause wasting valuable time and money to solve a problem someone else could help with, or has already solved. That is why central project portfolio management can be highly beneficial to prevent duplication of work across disconnected teams. Not to mention, the results show that there is sufficient support to distribute pilot projects between different business units. Lastly, it is important to bear in mind that although external barriers (8, 9, 10, 11) are covered with aligning strategies in the explorative layer, it is most likely that these strategies will not lead to significant change, because even though airlines are large enterprises, their influence in the aviation sector is limited. So, it is beneficial for airlines to cooperate with other airlines, suppliers and other business collaborators to create the necessary critical mass and lobbying that is needed for driving radical innovations.

The third group of barriers includes the barriers that are beyond the control of KLM. This means that KLM has no influence on these barriers, or their influence is so little that it can be ignored. These barriers include: regulations on safety; inertia caused by long certification processes of aircrafts and;

problems with joint IP. It is important to identify these barriers because putting commitment and effort into overcoming these barriers can waste the valuable resources that can be better used for overcoming the barriers within control of KLM.

No.	Barrier	Corresponding Strategy
	Internal	
1	Lack of management commitment	Create innovation budgets and planning by applying 70-20-10 rule (core-adjacent-transformational innovation), focusing on niche market in sustainability might be beneficial
2	Lack of financial resources	Extend KLM's external network by bringing complementary firms together in projects; Bring in more financial resources by using financial incentives and subsidies for sustainability (Guidelines on State Aid for Climate, Environmental Protection and Energy)
3	Lack of available personnel	Bring new scientific knowledge and attract talent by strengthening the partnerships with research institutes; Increase human capital by acquiring and building alliances with pivotal ecosystem partners and start-ups
4	Problems in scaling up ideas for large-scale use	Prevent unexpected events and uncertainties by including customers and suppliers in innovation processes, running more pilots and experimenting in real-world settings at lower costs by using technologies such as VR and AI, teach how to use new technologies on the work floor by using online interactive games
5	Lack of alignment between the headquarters and business units	Align around the value proposition and remind the common goal by moving from ecosystem-as-affiliation to ecosystem-as-structure, align actors around the value proposition
6	Lack of innovation structure	Introduce structure to innovation by establishing project portfolio management where initiatives, pilots and opportunities can be reviewed and endorsed
7	Lateral communication problems	Prevent silos and reinventing the wheel by organizing lunch lectures, periodical events where people can share knowledge on value propositions from the different divisions; Stimulate free flow of knowledge by spreading innovation news/updates through monthly newsletter, podcast, and improving the digital knowledge sharing platform
	External	
8	Legislation on knowledge sharing	Participate in pre-competitive (European) research projects; New revised Guidelines (from 2023) on Competition Law might be beneficial to share more knowledge on sustainability
9	No system alignment in EU or international level	Initiate and raise voice for system alignment in EU level by contributing to industry roadmaps and foresight activities
10	An undeveloped network and ecosystem dynamics with policymakers	Expand innovation ecosystem by including policymakers in the ecosystem
11	Lack of knowledge sharing between actors (OEMs, MROs & Airlines)	Encourage knowledge sharing by exchanging knowledge within networks and associations

Table 6.5: List of barriers identified at KLM Royal Dutch Airlines that can be prevented structurally and the corresponding recommendations.

6.2.2. Recommendations on improving the innovation ecosystem

In Section 3.3 four basic elements that structure an ecosystem proposed by Adner (2017) were presented. Building on these four elements, first, the current state of KLM innovation ecosystem was analysed based on the case study results presented in Chapter 5. Subsequently, by synthesizing the theoretical [14] and the practical knowledge [15], the desired future state of the innovation ecosystem was identified. The results are presented in Table 6.6

Elements	Current State	Desired Future State
Activities	High in value proposition to arise, low in value proposition to materialize	High in value proposition to arise and materialize
Actors	Not aligned, includes research institutes, business collaborators, and suppliers	Aligned around the common purpose, includes research institutes, business collaborators, suppliers, customers, and policymakers
Positions	Not defined	Defined, systemic view of innovation processes
Links	Sequential and weak, poor information and knowledge flow between ecosystem actors outside the business unit	Dynamic and strong, new links between existing partners can be created over if necessary (resembles value constellation see 3.2.4), free flow of knowledge between the ecosystem actors

Table 6.6: Current state of the innovation ecosystem vs the desired future state of the innovation ecosystem of KLM Royal Dutch Airlines based on the theoretical and empirical research.

Based on the results, this study proposes that the innovation ecosystems and innovation ecosystem strategies can be used by firms to overcome barriers to innovation, which consequently also improves the state of the firm's innovation ecosystem and increases its maturity level. All these changes and actions affect innovation processes of the firm positively. This positive correlation is visualized in Figure 6.5. In this Systems Map, the innovation processes of KLM demonstrate the system and the elements demonstrate the factors that can affect this system (innovation process) positively or negatively. The rectangles represent the factors that are beyond control of KLM. A "+" sign represents a "direct" relation, and a "-" sign an inverse relationship. Reinforcing loops exemplify and visualize the conclusions of this research that could trigger a change in the innovation processes of KLM (system).

Innovation ecosystem strategies can be used to overcome an internal barrier.

'Silo thinking' (included under the barrier lateral communication problems) is an identified factor that affects innovation processes of KLM negatively. 'Introduction of a digital knowledge sharing platform' is an innovation ecosystem strategy that aims to align actors in the exploitative layer. The use of this platform can prevent silo thinking among employees and encourage knowledge sharing between ecosystem actors that will raise the innovation ecosystem awareness and further stimulate the use of this digital platform. This reinforcing loop will eventually influence the innovation processes of KLM positively. Figure 6.6 visualizes this statement.

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[14]discussed in Section 3.3 and Subsection 3.2.4
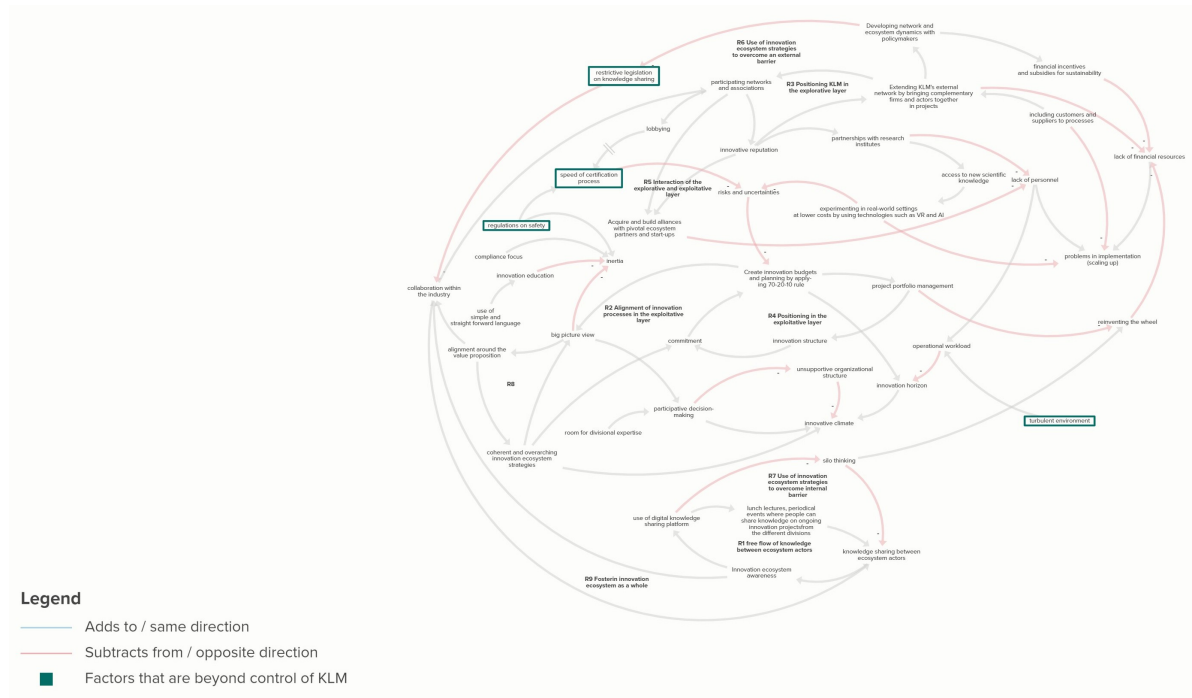[15]gathered by direct observations and the case study interviews

Figure 6.5: System map of the barriers and innovation ecosystem strategies for the innovation processes of KLM Royal Dutch Airlines (see Appendix F)
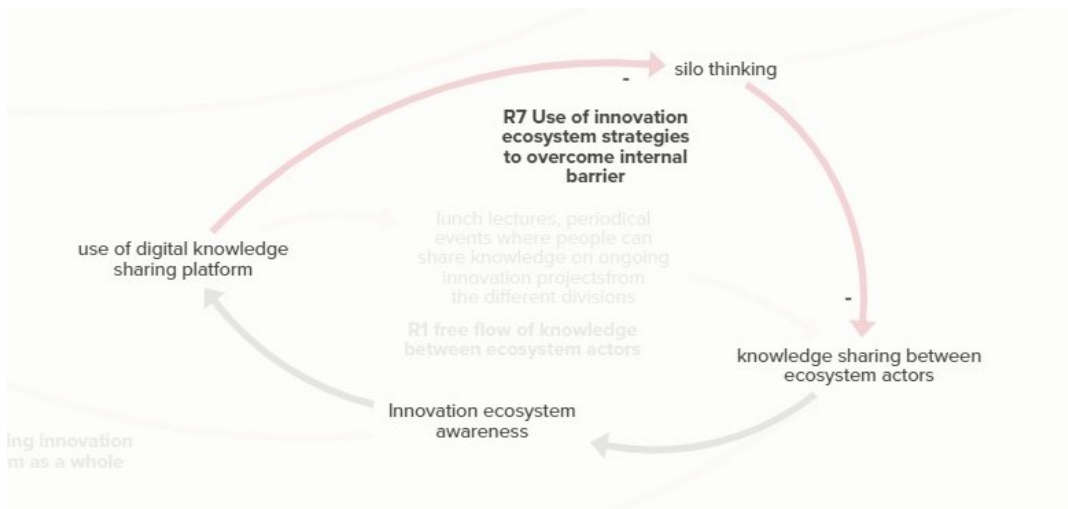

Figure 6.6: Use of innovation ecosystem strategies

Innovation ecosystem strategies can be used to overcome an external barrier.

'Restrictive legislation on knowledge sharing' is an identified factor that affects innovation processes of KLM negatively. 'Participating networks and associations' is an innovation ecosystem strategy that aims to align actors in the explorative layer, by joining these networks KLM will increase their reputation as an innovative partner in the aviation industry, which will result in the increase of companies and organizations that wants to partner up with KLM and extend their external network. In the long term, extending KLM's external network and including policymakers in the innovation ecosystems can result

in less restrictive legislation on knowledge sharing between actors to achieve sustainability goals. All in all, this might stimulate the collaboration in the industry rather than restricting it. Figure 6.6 visualizes this statement.
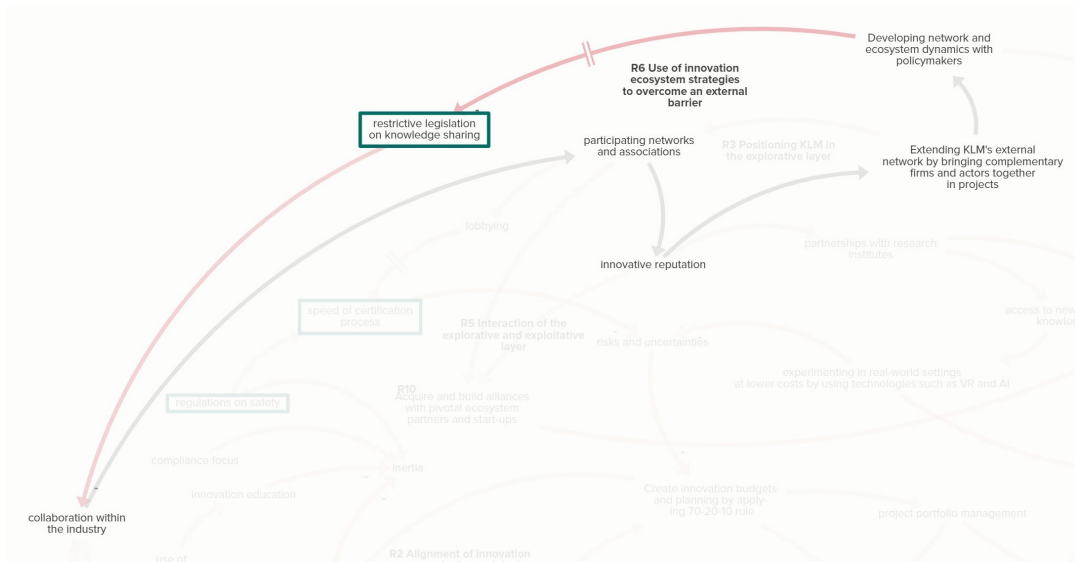

Figure 6.7: Use of innovation ecosystem strategies

Two layers (explorative & exploitative) are in constant interaction and the outcomes of each feeding one other.

As we discussed previously, 'participating networks and associations' will increase the reputation of KLM as an innovative partner in the aviation industry and extend their external network. Research institutes are one of these actors that KLM can partner up with to access new scientific knowledge on technologies like AI and VR. By using these technologies, KLM can experiment in real life settings at lower costs, which will decrease the risks and uncertainties that come with radical innovations. Lower risks can stimulate the company to create more room for materializing horizon 3 innovations that will encourage employees to see the big picture view and to align around the common purpose to achieve long-term goals such as sustainable aviation. All in all, this will stimulate the collaboration in the explorative layer. Figure 6.8 visualizes this statement.

Functioning of the innovation ecosystem should be fostered as a whole.

Currently, the innovation ecosystem of KLM is fragmented. Each BU has their own ecosystem, however, increasing the innovation ecosystem awareness can stimulate the knowledge sharing not only between the internal ecosystem actors but also with the external ones. Figure 6.9 visualizes this statement.
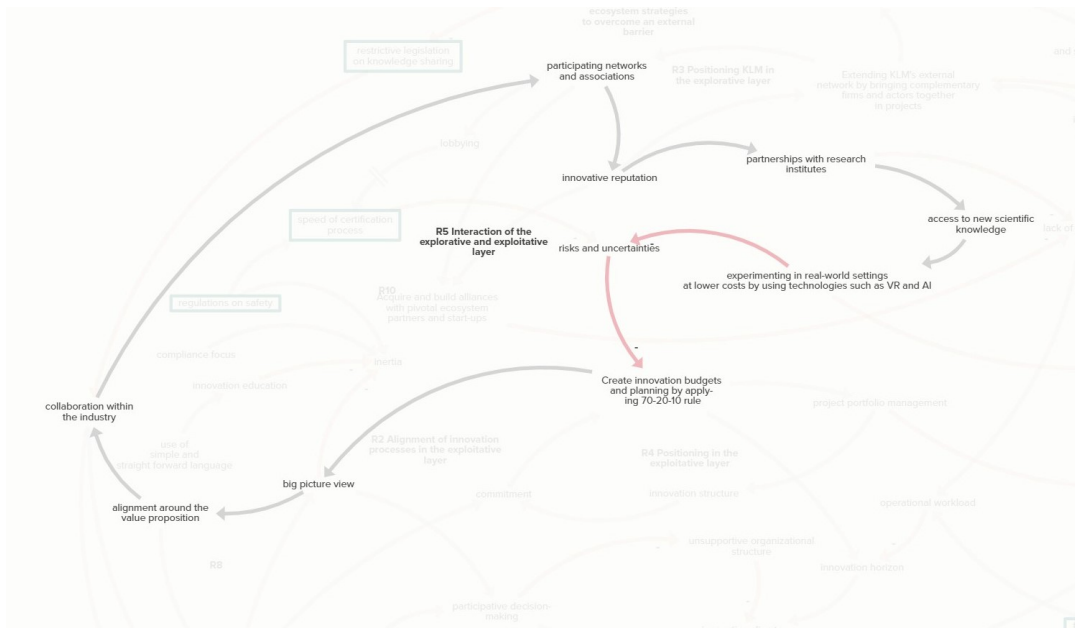
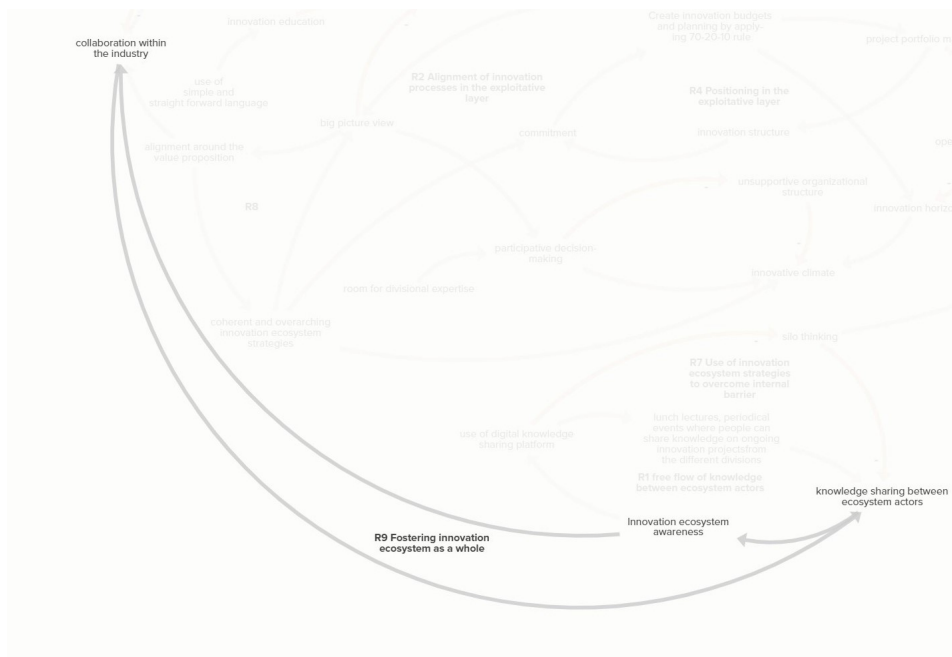Figure 6.8: Interaction between the explorative and exploitative layer

Figure 6.9: Functioning of the innovation ecosystem should be fostered as a whole.

Ecosystem-as-structure perspective where actors are aligned around the value proposition is highly relevant for KLM to align its innovation processes in the exploitative layer.

As we previously discussed in the subsection, aligning actors around a value proposition or common goal is very important for KLM's innovation processes to achieve concrete results. Therefore, innovation-as-structure perspective is highly relevant for KLM and its innovation processes in the exploitative layer. Figure 6.10 visualizes this statement.
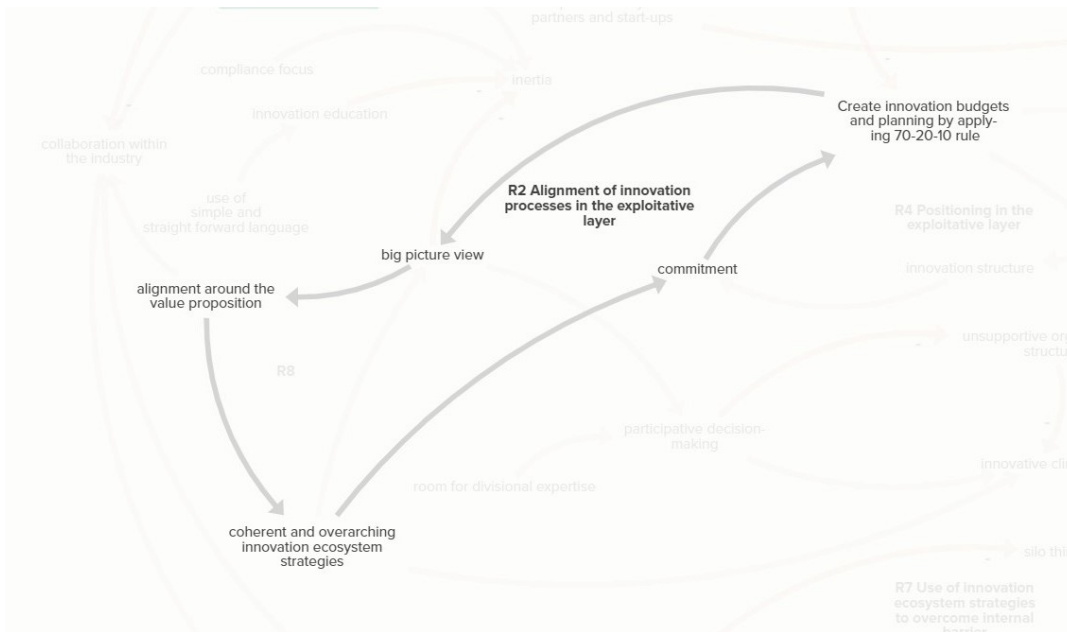
Figure 6.10: Ecosystem-as-structure perspective

Defining the position of KLM in the ecosystem is important.

By defining the position of KLM in the ecosystem, KLM can make strategic choices on which networks and associations to participate and which technologies to include and prioritize in their project portfolio. This can help committing to provide the necessary budget and time on the projects that will use these technologies. Figure 6.11 and 6.12 visualize this statement.
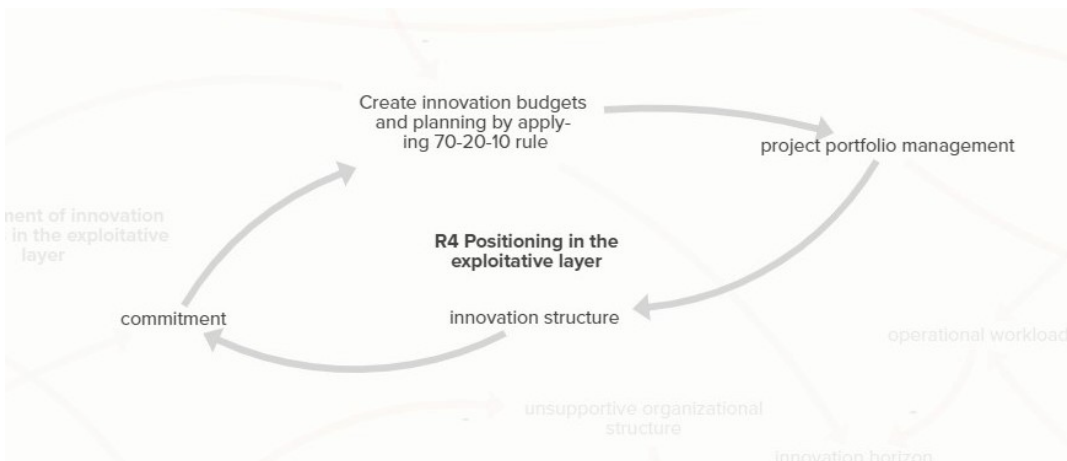
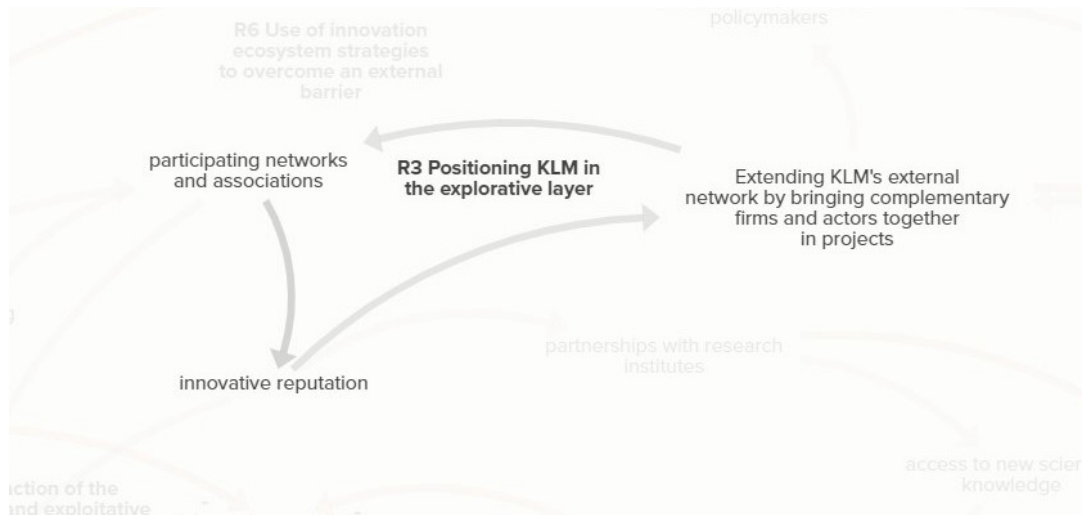Figure 6.11: Positioning in the exploitative layer

Figure 6.12: Positioning in the explorative layer

7

Conclusion

This chapter will provide the conclusion of the thesis, whereby the main research question will be answered and main findings of will be restated in Section 7.2. Section 7.3 will discuss the scientific contribution of this thesis to the existing literature. The limitations of the study will be discussed in Section 7.4 by reflecting on the theory and outcomes. Finally, in Section 7.5 the recommendations for future research and will be given.

7.1. Introduction

The airline industry is going through a big transformation. The institutional environment as well as the industry itself has changed. Competition with the entry of the low-cost carriers in a market that used to be dominated by flagship carriers. Furthermore, societal pressure regarding sustainability on airlines with COVID-19 state aids increased, while the shortage in the labour market limited the pace of recovery. The technologies that airlines use to operate have outdated to cope with today's massive challenges. All of these changes forced airlines to innovate to maintain their services. However, as both the innovations and the relationships necessary to produce them to cope with these massive challenges become much more varied and complex (Normann and Ramírez, 1993). The aviation industry needs to encourage both internal and external collaboration, an open-minded approach and knowledge sharing between different actors to successfully innovate. Innovation ecosystems where different actors are aligned around a value proposition can facilitate this need and encourage different actors to combine their individual products or ideas into coherent solutions that are necessary to disrupt the industry (Adner, 2006). Despite its potential, the implementation of the innovation ecosystems in the aviation industry and how it can support an airline to implement their innovation strategy has not been investigated. Therefore, the main research question of this thesis was formulated:

"How can innovation ecosystems support airlines to implement their innovation strategy?"

Several sub-questions were formulated to answer the main research question. Below these sub-questions are answered and the main findings of this study are presented.

7.2. Main findings

SQ1: *How do companies formulate their innovation strategy and manage their innovation processes?*

According to literature, one can conclude that *innovation strategy is a set of coherent and internally consistent resource allocation decisions that are aimed at achieving an organization's specific goals* and formulation of innovation strategy requires the right balance between *exploration and exploitation* and alignment with the firm's business strategy. Based on the answers from several employees, company documents and the quote from a strategy consultant presented in Subsection 5.2.1, exploration and exploitation is currently off balance at KLM. The majority of the resources (financial, human capital and time) are put on "supporting current processes and markets" (also called as horizon 1 innovations) although achieving company's specific goals require consistent resource allocation decisions in horizon 2 and horizon 3 innovations. Regarding the innovation management of companies, nowadays, companies use contextual approaches and techniques that fits and aligns with their innovation strategy. At KLM, innovation processes are managed locally based on the contextual factors and specific needs and visions of the business unit so, innovating in silos is very common within the organization.

SQ2: *What are the barriers to radical innovation in large organizations?*

The barriers to radical innovation in large firms that were identified in the literature are shown in Table 2.2 (see page 16). Internal barriers to radical innovation included: a restrictive mindset, a lack of discovery competences, an unsupportive organizational structure and, the external barriers included: customer resistance, undeveloped network and ecosystem, technological turbulence. According to literature study, it can be concluded that type of barriers to innovation is related to contextual factors mentioned in the contextual innovation management approach (e.g. type of industry, type of innovation, type of country/culture, type of organization).

SQ3: *How to drive innovation in an organization, and what are innovation ecosystem strategies implemented by the organizations to drive innovation?*

According to literature review (see Chapter 3), it can be concluded that organizations can drive innovation *culturally and structurally*. While cultural approach includes a set of attitudes and values that are favourable for innovation to create an innovative climate, structural approach includes mechanisms and means that enable innovation which innovation ecosystems also fall under. Innovation ecosystems are described as *the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize*. Organizations use innovation ecosystem strategies in order to implement this concept, these innovation ecosystem strategies are described as *deliberate and coherent ways in which firms approach the alignment of their innovation activities within the different layers (explorative and exploitative) of an ecosystem and the ways in which they secure their position in relation to other actors and to the ecosystem as a whole*. Organizations use different strategies in each layer for aligning and positioning, an overview of these strategies identified in the literature is presented in Table 3.6.

SQ4: *What are the barriers to radical innovation at KLM?*

In Chapter 5 a set of barriers to radical innovation at KLM was identified. A comparison of these barriers to those identified during the literature review (see Table 6.1) showed that the contextual factors that

have the most influence in innovation management at KLM included: type of organization and type of industry. The internal barriers to radical innovation at KLM mostly has to do with the size of the organization, while the rigidity and restrictiveness of the aviation industry due to safety regulations leads to external barriers to radical innovation. Moreover, highly competitive and operation driven nature of the industry limits the knowledge sharing between the actors and allocating resources in radical innovations.

SQ5: *What are innovation ecosystem strategies implemented by KLM to drive innovation?*

From the results of the case study presented in Chapter 5, it can be concluded that KLM is aware of the relevance of ecosystems for its innovation processes and puts effort into building its reputation as an innovative airline in the aviation ecosystem. In order to facilitate this, KLM collaborates with others within and beyond the value chain including a variety of other companies and knowledge institutes, and uses different innovation ecosystem strategies. However, KLM did not define its position in the ecosystem, lacks an overarching innovation ecosystem strategy and alignment between the ecosystem actors. An overview of identified innovation ecosystem strategies used by KLM is shown in Table 5.3. One of the more significant findings to emerge from this study is that the benefit of using innovation ecosystem strategies is twofold. First, they can be used to overcome barriers to innovation and therefore positively contribute to innovation processes of the firm. Second, the use of innovation ecosystem strategies can improve the innovation ecosystem and increase its maturity level. It is important to mention that while previous studies (Visscher *et al.*, 2021) did not investigate whether the companies with higher maturity levels exceed companies with lower levels, in innovativeness or effectiveness. In the case of KLM, aiming for higher maturity levels is beneficial to the company's innovation processes as this will require KLM to define its position in the ecosystem and formulate an overarching innovation ecosystem strategy which might help the management to make strategic choices on innovation such as resource allocation, selection of the potential partners and innovation projects.

Answering the main research question: *"How can innovation ecosystems support airlines to implement their innovation strategy?"*

This study has shown that innovation ecosystems can support airlines to implement their innovation strategy in two ways. Firstly, being part of innovation ecosystems allows the focal firm (in this study KLM) to closely observe and track other actors in the ecosystem. By doing so, the firm can align its innovation strategy and positioning its organization based on the most recent developments in areas such as technology (e.g. introduction of a new (disruptive) relevant technology or new methods and techniques to overcome an identified technological limitation, etc.), science (e.g. new scientific knowledge that can provide improvements in current products and processes), policymaking (e.g. introduction of a new legislation and regulations or financial incentives), industry (e.g. increasing trend of collaboration or competition, differences in services offered etc.) and societal environment (e.g. pressure of citizens and NGOs on carbon reduction goals, noise or shortage in labour market). This will allow the firm to be up-to-date when the innovation strategy must be formulated and the strategic choices on innovation must be made, mitigate the risks associated with radical innovations and eventually will increase the likelihood of the firm to manage its innovation processes successfully.

Secondly, innovation ecosystems are multilayered structures where a heterogeneous set of actors can align their multilateral interactions to arise (exploration) and materialize (exploitation) the novel value propositions. The results of this study show that although KLM is considered to be a major player

in the Dutch commercial aviation ecosystem, its impact on the global aviation ecosystem is rather limited. KLM and other airlines need other actors to truly disrupt the aviation industry and achieve their objectives on topics like sustainable aviation and automation. Innovation ecosystems and the corresponding innovation ecosystem strategies can promote the interparty collaboration that is needed in the industry for exploration of future opportunities and bring the critical mass and knowledge that is necessary for the exploitation to drive successful innovations. Furthermore, innovation ecosystems can be used to overcome barriers to radical innovation, which will support the execution of innovation strategy and therefore reaching the objectives of the company.

So, this research concludes that in order to achieve company objectives and implement its innovation strategy, KLM should use innovation ecosystems and innovation ecosystem strategies to align its innovation processes, overcome the barriers to innovation that hampers its innovation processes and finally to collaborate within and beyond the value chain to develop radical innovations that are required to cope with today's complex challenges.

7.3. Scientific Contribution of This Thesis

Up-to-date, there are no studies in the literature focusing on the innovation ecosystem implementation or innovation ecosystem strategies of airlines. Therefore, this study is the first to specifically focus on the innovation ecosystem strategies of airlines. The outcomes of this study might not only be interesting for conducting further research on innovation ecosystem implementation in airlines, but also for the different modes of transportation like railways, as it also requires alignment of different actors. Moreover, in their paper, Visscher et al. (2021), recommended further research with other kinds of firms (in particular service firms) and studies at the firm level to gain in-depth understanding of innovation ecosystem strategies. This thesis contributed to gain in-depth understanding of innovation ecosystem strategies by conducting research that focused on innovation ecosystem strategies of a commoditized service firm (an airline), at the firm level. Another contribution of this study has been to confirm the relevance of innovation ecosystem concept for airlines and emerging trends on collaboration within the aviation industry (Pickard and Pasqualino, 2022). Although the study from Pickard and Pasqualino (2022) was published during the during the finalization of this thesis, similar to outcomes of this thesis on collaboration, their outcomes concluded that collaboration is an emerging theme in aviation industry and collaboration between actors is necessary to achieve the objectives of the industry on decarbonization. This study also contributed to the relevance of contextual factors in barriers to innovation (Sandberg and Aarikka-Stenroos, 2014) and firm's innovation management (Ortt and van der Duin, 2008). Lastly, this study proposed that a link between barriers to innovation ecosystem strategies can be established and innovation ecosystem strategies can be used to overcome barriers to innovation.

7.4. Limitations

This section reflects on the limitations of the research based on four aspects; theory, methodology, collected data and empirical outcomes.

Regarding *theoretical limitations*, in this research the identified theoretical barriers were limited to barriers to radical innovation. So, inclusion of more barriers to other types of innovations can result in different outcomes. Furthermore, this paper focused on the technological innovations, a study that focuses on the social innovations might require a different perspective and lead to different results.

Regarding *the limitations on the outcomes*, the sample (respondents) chosen for the case study might be biased because the interviews were conducted with usual suspects of innovation at KLM such as project managers and innovation leads. The barriers to innovation experienced by employees from other positions, such as the junior level engineers and operational personnel, might be different. Furthermore, this study focused on the actors around the topic 'autonomous vehicles', however if this study focused on another strategic innovation topic of KLM, we could have had different results. In an organization at this scale and with many subsidiaries (e.g. Transavia, KLM Equipment Services, Cygnific etc.) it is possible that the innovation ecosystem strategies identified in this research represent a part of the total innovation ecosystem strategies used within the organization. Lastly, this case study was conducted in very turbulent times for the world and the aviation industry (post COVID-19 crisis, start of the war, and shortage in labour market), conducting this study in less turbulent times (e.g. 2019) could lead to different outcomes.

Regarding *the limitations on the recommendations*, the empirical evidence collected in this thesis focuses on a single organization (a flag carrier airline based in the EU). This makes it hardly possible to state recommendations on the innovation ecosystem implementation generally applicable to all types of airlines in different geographical locations. After all, both internal and external factors for those airlines can be very different (e.g. regulations on the noise and sustainability, culture of the country, available workforce, wages of employees, state aids etc.). Therefore, different airlines might require different recommendations. Moreover, it is important to bear in mind that changing the culture of an organization requires time and the effect of these recommendations will be seen in the long term.

7.5. Recommendations For Future Research

Conducting more case studies with other airlines is necessary to draw industry-wide conclusions on barriers to radical innovation and innovation ecosystem strategies of airlines. Moreover, making a comparison between airlines from other countries and business models (low cost vs flag carrier) can be interesting to investigate the relevance of the contextual factors on barriers and chosen strategies. It is possible that new barriers, strategies and contextual factors will be identified in these studies.

The current literature on ecosystems is mostly focused on large enterprises in manufacturing industry. However, the perspective of public bodies, start-ups and research institutes are still missing. So, another interesting research direction would be investigating the innovation ecosystem strategies of other actors in the commercial aviation ecosystem. These actors might include governmental bodies, research institutes, MROs, suppliers, start-ups and OEMs.

As far as known, there are no studies in the literature focusing on the innovation ecosystem implementation or innovation ecosystem strategies of companies operating in the transportation sector such as railways and airlines. It might be interesting to conduct similar study with a railway, since air and rail transportation systems requires alignment of many actors and, they are considered as highly complex systems in the literature.

This study was constructed on ecosystem-as-structure perspective, which is suitable for individual commercial entities, so it might be interesting to investigate the ecosystems-as-affiliation perspective

in airline industry. Strategic alliances such as SkyTeam, Star Alliance and One Sky could serve as a suitable environment to investigate this perspective.

A

Interview - Strategy team

Strategy

1. How much do you emphasise each of the following in your innovation strategy? With what relative effort?

   - supporting current processes and markets
   - developing next generation products and processes
   - establishing new businesses (in new value domains)

2. What is your firm's time horizon for innovation processes (time to market)? Have these changed in the past 5-10 years?

3. What would you describe as your firm's key innovations in the past five years?

4. By what mechanisms is innovation integrated in your overall strategy?

5. Who are the main actors involved in making decisions about innovation within the company? (organizational and individual e.g. business units, corporate or business unit R&D)

6. Is open innovation a part of this strategy? How is it used? What are the experiences?

   - To what extent do you rely on outside organizations to provide/augment core technological knowledge?
   - Apart from your core technologies what innovation-related knowledge would you seek to source from outside the company?
   - Do you have start-up or entrepreneurship activities within your company? If so, how are these integrated in the innovation strategy?
   - Does your firm engage in mergers and acquisitions explicitly to enhance innovation or innovation assets?
   - What is the role of IPR (intellectual property rights) and how do you manage your IPR portfolio?

- Do you provide R&D and services for and share knowledge with other partners as part of your innovation strategy?

Ecosystems

This section seeks to establish what innovation ecosystem(s) the company perceives itself to be working in and how important this is for the firm's innovative activities.

1. Analysts today regularly refer to the concept of an 'innovation ecosystem' to describe the interdependencies firms have with collaborators, suppliers, customers, public research bodies, other infrastructure, finance and regulators. These typically involve flows of knowledge, people, finance and services. These may be international, national, sectoral or specific to a market. We have some questions about our interactions with this extended network:

   - How important for your innovative activities are: business collaborators (large firms/ SMEs/ startups), suppliers, customers, public research bodies (including universities), other infrastructure, finance, regulators, any other players?

   - Which of the above have the greatest influence on the form and direction of the ecosystem?

   - Has this changed in the past five years? If so what were the main drivers of that change? (competition, technological progress, regulation etc.?)

   - What is your firm's position/role within this ecosystem?

   - How do you maintain/strengthen your position within the ecosystem? (build coalitions)

   - How relevant is this concept for your firm's innovation activities?

   - Has the relevance/importance changed in the past five years?

   - Could you describe the most important elements of the innovation ecosystem(s) in which your firm operates?

2. Do you seek to influence the ecosystem as a part of your firm's strategy?

   - Do you seek to influence the ecosystem as a part of your firm's strategy?

Current Ecosystem

1. What are the characteristics of innovation challenges at KLM? Example: societal political pressure, technology, internal organizational problems, economic incentives

2. Did these challenges change (improve) after the introduction of the current ecosystem?

3. What are the main challenges/problems you see with the current ecosystem?

Macro level

Literature suggests that the relationship between airlines and their respective home country's market conditions is interdependent, much like the relationship between airlines and the economy as a whole.

1. Do you think an approach with a broader perspective at macro level (such as politics, economics etc.) would help overcome the factors hampering innovation at KLM?

2. Do you consider any of the following to be major barriers to successful innovation for your company at the macro level?

   - access to finance

- access to knowledge/talents
- access to markets
- lack of capabilities or skills
- regulation
- establishing partnerships
- establishing standards
- IP system
- Any other (please specify)

B

Interview - Radical Innovation team

Strategy

1. How much do you emphasise each of the following in your innovation strategy? With what relative effort?

   - supporting current processes and markets
   - developing next generation products and processes
   - establishing new businesses (in new value domains)

2. What is your firm's time horizon for innovation processes (time to market)? Have these changed in the past 5-10 years?

3. What would you describe as your firm's key innovations in the past five years?

4. By what mechanisms is innovation integrated in your overall strategy?

5. Who are the main actors involved in making decisions about innovation within the company? (organizational and individual e.g. business units, corporate or business unit R&D)

6. Is open innovation a part of this strategy? How is it used? What are the experiences?

   - To what extent do you rely on outside organizations to provide/augment core technological knowledge?
   - Apart from your core technologies what innovation-related knowledge would you seek to source from outside the company?
   - Do you have start-up or entrepreneurship activities within your company? If so, how are these integrated in the innovation strategy?
   - Does your firm engage in mergers and acquisitions explicitly to enhance innovation or innovation assets?
   - What is the role of IPR (intellectual property rights) and how do you manage your IPR portfolio?

- Do you provide R&D and services for and share knowledge with other partners as part of your innovation strategy?

Innovation Management and Practice

This section seeks to establish the processes and routines by which the firm manages innovations internally with a particular emphasis on what is new.

1. Please outline the main stages of an innovation project within your firm from idea to implementation?

   - What are the main factors involved in beginning an innovation project? What are the main points of handover between the main stages you have identified?
   - How do you manage the progression of a project (e.g. three innovation methods of KLM)?
   - Which parts/functions of the company are involved? If cross-functional teams are involved how are these coordinated?
   - Do you differentiate between incremental and radical innovations in your management structure or processes?

2. How do you report on and assess the overall innovation progress in your company?

   - What are the reporting lines?
   - What are the main performance criteria? Any formal processes?
   - Are stock market expectations taken into account when innovation strategy is formulated?

3. Has your firm's approach to innovation management (organisation, processes and tools) changed in the last 5 or 10 years?

   - If so how? - What has the effect of these changes been?
   - What were the drivers of these changes?

Ecosystems

This section seeks to establish what innovation ecosystem(s) the company perceives itself to be working in and how important this is for the firm's innovative activities.

1. Analysts today regularly refer to the concept of an 'innovation ecosystem' to describe the interdependencies firms have with collaborators, suppliers, customers, public research bodies, other infrastructure, finance and regulators. These typically involve flows of knowledge, people, finance and services. These may be international, national, sectoral or specific to a market. We have some questions about our interactions with this extended network:

   - How important for your innovative activities are: business collaborators (large firms/ SMEs/ startups), suppliers, customers, public research bodies (including universities), other infrastructure, finance, regulators, any other players?
   - Which of the above have the greatest influence on the form and direction of the ecosystem?
   - Has this changed in the past five years? If so what were the main drivers of that change? (competition, technological progress, regulation etc.?)
   - What is your firm's position/role within this ecosystem?
   - How do you maintain/strengthen your position within the ecosystem? (build coalitions)

- How relevant is this concept for your firm's innovation activities?

- Has the relevance/importance changed in the past five years?

- Could you describe the most important elements of the innovation ecosystem(s) in which your firm operates?

2. Do you seek to influence the ecosystem as a part of your firm's strategy?

- Do you seek to influence the ecosystem as a part of your firm's strategy?

Current Ecosystem

1. What are the characteristics of innovation challenges at KLM? Example: societal political pressure, technology, internal organizational problems, economic incentives

2. Did these challenges change (improve) after the introduction of the current ecosystem?

3. What are the main challenges/problems you see with the current ecosystem?

Literature suggests that ecosystems often focus on micro and meso level (companywide), however the relationship between airlines and their respective home country's market conditions is interdependent, much like the relationship between airlines and the economy as a whole. This question seeks to assess the relevance of policy interventions for innovation in the firm.

1. Do you think an approach with a broader perspective at macro level (such as politics, economics etc.) would help overcome the factors hampering innovation at KLM?

2. Do you consider any of the following to be major barriers to successful innovation for your company at the macro level? (EASA. IATA, het Rijk)

- access to finance

- access to knowledge

- access to markets

- lack of capabilities or skills

- regulation

- establishing partnerships

- establishing standards

- IP system

- Any other (please specify)

C
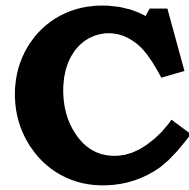
Interview - Business Units

1. What are the characteristics of innovation challenges at KLM?

Ecosystems Innovation Ecosystems
This section seeks to establish what innovation ecosystem(s) the company perceives itself to be working in and how important this is for the firm's innovative activities.

1. Analysts today regularly refer to the concept of an 'innovation ecosystem' to describe the inter-dependencies firms have with collaborators, suppliers, customers, public research bodies, other infrastructure, finance and regulators. These typically involve flows of knowledge, people, finance and services. These may be international, national, sectoral or specific to a market. We have some questions about our interactions with this extended network:

   • How important for your innovative activities are: business collaborators (large firms/ SMEs/ startups), suppliers, customers, public research bodies (including universities), other infrastructure, finance, regulators, any other players?

   • How relevant is this concept for your BU's innovation activities?

2. Is open innovation a part of KLM culture? How is it used? What are the experiences?

3. Which parts/functions of the company are involved in innovations within this topic? If cross-functional teams are involved how are these coordinated?

4. What is missing in the current practices?

5. If there is a collaboration on certain topic or innovation, what is the reason behind this collaboration?

6. If not, what is the reason behind this, what hampers collaborating with others (internally and externally)?

7. How can it be improved?

8. How to balance exploration and exploitation?

D

Interview coding

Category	Code	Description
Interviewee	**Interviewee specific information**	
Interviewee	Division	The business division interviewee belong to.
Interviewee	Business title	The current role of interviewee in the organization
Innovation strategy	**Information regarding innovation strategy formulation and execution**	
Innovation strategy	Importance	How important is innovation for the strategy
Innovation strategy	Horizon	Innovation horizon of the firm
Innovation strategy	Key innovation	Most important innovation of the firm in last 5 years
Innovation strategy	Integration	Mechanisms that integrate innovation in the business strategy
Innovation strategy	Decision-making	Important actors of the organization that are involved in decision-making on innovation
Innovation strategy	Open innovation	Organization's view on open innovation
Innovation strategy	External venturing	Outsourcing innovation via investment funds
Innovation strategy	Share knowledge	Occurrence of sharing knowledge with other stakeholders
Innovation Management	**Information regarding management of innovation processes of the organization**	
Innovation Management	Main stages	Description of innovation processes within the organization (airlines)
Innovation Management	Progress	Assessment of innovation progress within the organization (airlines)
Innovation Management	Change in approach	Changes in innovation management approach within the organizations
Innovation Management	Challenges	Barriers to radical innovation in airlines
Innovation Management	Improve	Drivers to eliminate barriers
Innovation Management	Problems	Problems with current ecosystem
Innovation Ecosystems	**Information regarding the view of interviewee on innovation ecosystems concept and implementation of the concept in airline industry**	
Innovation Ecosystems	Importance of actors	Important actors in the ecosystem for airlines
Innovation Ecosystems	Greatest influencer	Actor that has the most influence in the ecosystem for airlines
Innovation Ecosystems	Change	Change in the relevance of innovation ecosystems concept for airlines
Innovation Ecosystems	Position	Positioning of airlines in the innovation ecosystems
Innovation Ecosystems	Relevance of concept	Relevance of the concept for airlines
Innovation Ecosystems	Important element	Most important elements of the ecosystems for airlines
Innovation Ecosystems	Influence	Airlines' willingness to influence innovation ecosystems

Figure D.1: Interview coding
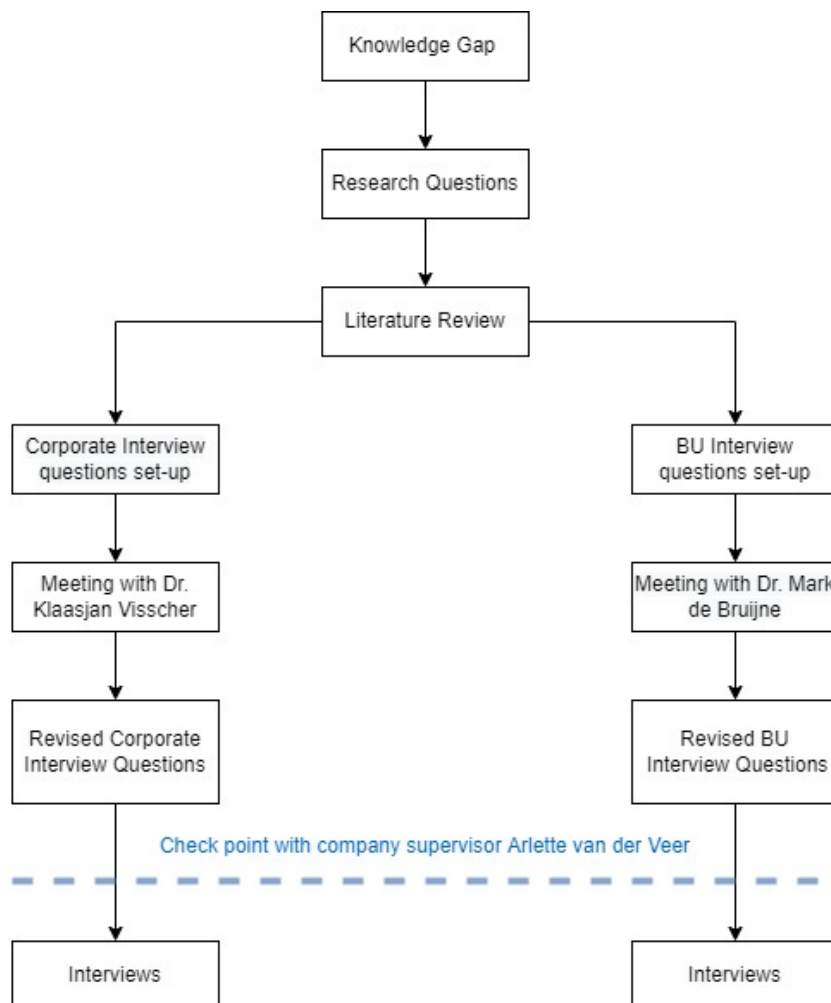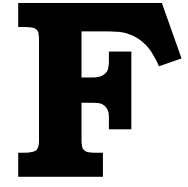
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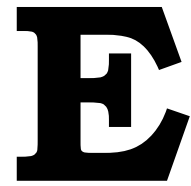
Process

Figure E.1: Process of setting up interview questions

F

Discussion Map

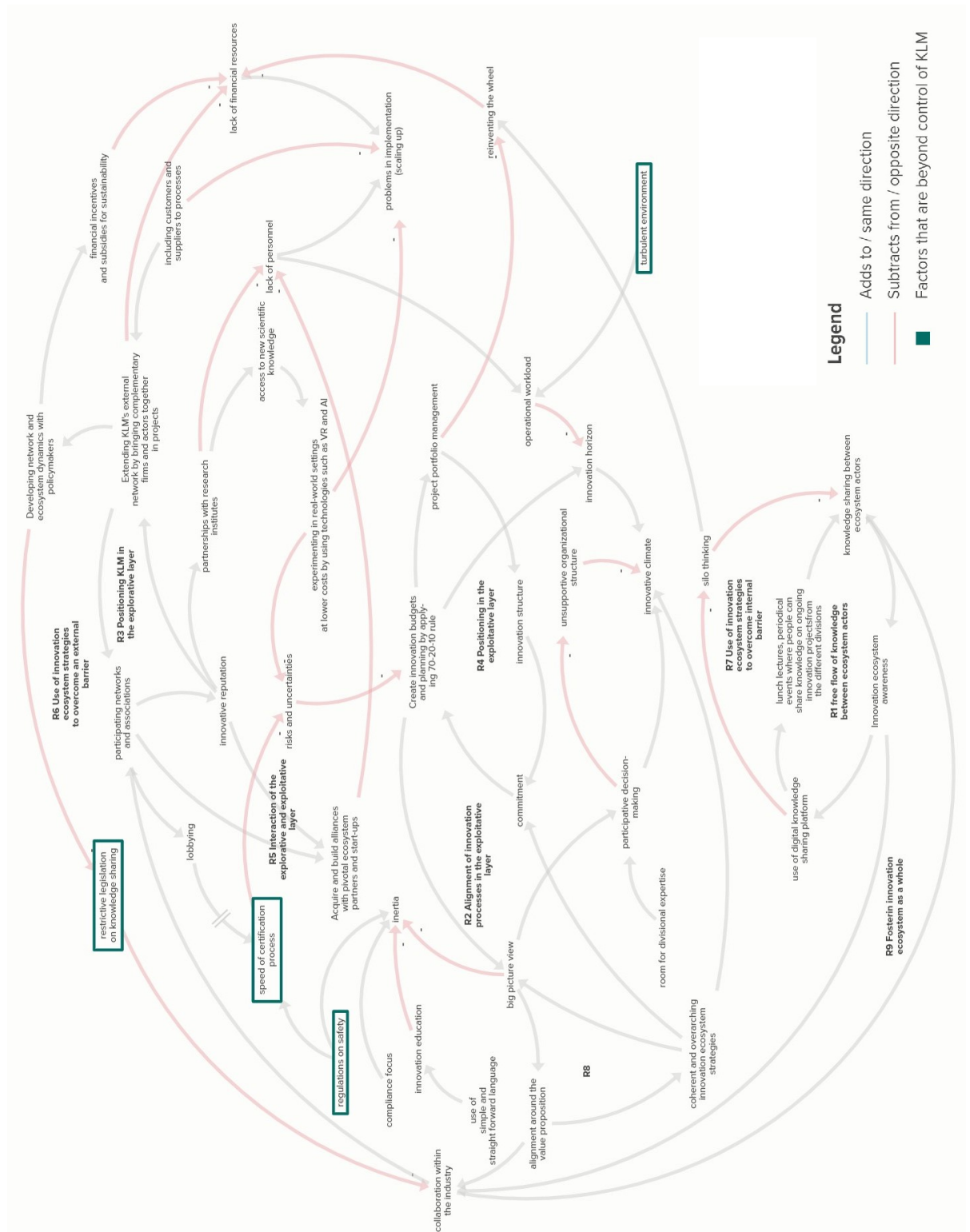Please see the next page for the figure.

Figure F.1: System map of the barriers and innovation ecosystem strategies for the innovation processes of KLM Royal Dutch Airlines.

G

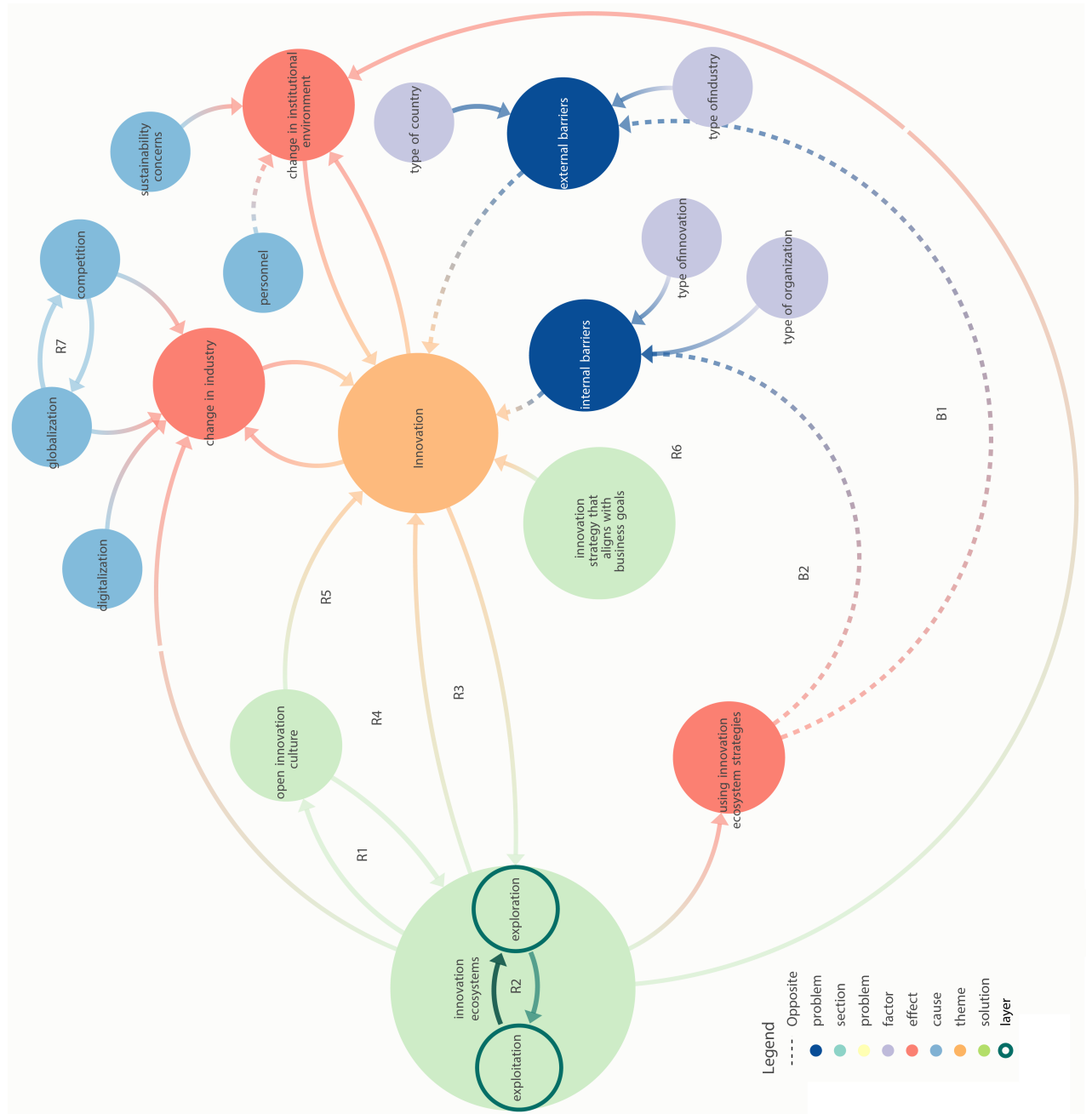## Analytical Framework

Please see the next page for the figure.

Figure G.1: Analytical Framework

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