OPEN INNOVATION MATURITY OF TURKISH A&D INDUSTRY

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ABSTRACT

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Increasing competition, global tensions, and rapid developments in disruptive technologies have made innovation a necessity for companies and economies, not just to be competitive but to survive. The paradigm of open innovation argues that companies can no longer survive in isolation and need external knowledge and effective collaborations for sustainable growth. Despite being known for security concerns, protectionist policies, and traditional in-house R&D activities, aerospace and defense (A&D) companies are also trying to open their innovation systems. However, academic studies examining the open innovation practices and maturity of the sector are still quite limited.

This thesis aims to develop a model to measure the open innovation maturity of A&D companies in Türkiye employing the dynamic capabilities theory and to design a sector-specific model by weighing the maturity dimensions via AHP method. The model consists 16 dimensions under 5 categories. Later, an empirical study is

conducted to measure Turkish A&D industry's open innovation maturity. In this context, the maturity model is converted into survey format and a field research was conducted with managers of a Turkish A&D OEM company and its innovation ecosystem. The survey results are verified through interviews and internal company data. In this research, data was collected both with quantitative and qualitative methods. The results indicate a planned (level 3, out of 5) maturity level both for the OEM and its ecosystem companies with some differences in dimensions. Finally, policy and strategy recommendations are developed, and policy tools are designed to enhance the industry's open innovation maturity.

Keywords: Open innovation, maturity model, Turkish aerospace and defense sector, dynamic capabilities, AHP method.

ÖZ

TÜRK HAVACILIK VE SAVUNMA SANAYİNİN AÇIK İNOVASYON OLGUNLUĞU

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Artan rekabet, küresel gerginlikler ve yıkıcı teknolojilerdeki hızlı gelişmeler, yeniliği şirketler ve ekonomiler için yalnızca rekabetçilik için değil, hayatta kalmak için bir zorunluluk haline getirmiştir. Açık inovasyon paradigması, şirketlerin artık izole bir şekilde hayatta kalamayacağını ve sürdürülebilir büyüme için dışsal bilgiye ve etkili iş birliklerine ihtiyaç duyduğunu savunmaktadır. Güvenlik endişeleri, korumacı politikalar ve geleneksel kapalı Ar-Ge faaliyetleri ile tanınmasına rağmen, havacılık ve savunma şirketleri de inovasyon sistemlerini açmaya çalışmaktadır. Bu gelişmelere rağmen, sektörün açık inovasyon uygulamalarını ve olgunluğunu inceleyen akademik çalışmalar hâlâ oldukça sınırlıdır.

Bu tez, Türkiye'deki havacılık ve savunma şirketlerinin açık inovasyon olgunluğunu dinamik yetenekler teorisini kullanarak ölçen bir model geliştirmeyi ve bu modeldeki boyutları AHP yöntemi ile ağırlıklandırarak sektör spesifik bir ölçüm modeli tasarlamayı amaçlamaktadır. Geliştirilen model 5 kategori altında yer alan 16 boyuttan

oluşmaktadır. Ardından ampirik bir çalışma ile, sektörün açık inovasyon olgunluğunu ölçmek amaçlanmıştır. Bu bağlamda, Türkiye'deki bir OEM şirketi ve onun inovasyon ekosisteminde yer alan firmaların yöneticileri ile bir anket gerçekleştirilmiştir. Anket sonuçları, mülakatlar ve iç şirket verileri ile doğrulanmıştır. Bu araştırmada, hem nicel hem de nitel yöntemlerle veri toplanmıştır. Ampirik araştırma sonuçları, hem OEM şirketinin ve hem de inovasyon ekosisteminin, boyutlar arasında bazı farklılıklar olmakla birlikte planlı bir açık inovasyon olgunluk seviyesine sahip olduğunu (5 seviyeden 3üncüsü) göstermektedir. Son olarak, sektörün açık inovasyon olgunluğunu artırmak için politika ve strateji önerileri geliştirilmiş ve politika araçları tasarlanmıştır.

Anahtar Kelimeler: Açık inovasyon, olgunluk modeli, Türk havacılık ve savunma sanayi, dinamik yetenekler, AHP yöntemi

To my beloved family

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I wish to extend my profound gratitude to Company A, the principal entity in the empirical section of this study, which is referenced anonymously due to confidentiality considerations. I also wish to acknowledge the priceless contributions of the managers of Company A who supported this thesis. Furthermore, I would like to thank to the respondent companies, which are esteemed members of the Turkish A&D ecosystem. They play a vital role in a sector of immense significance to Türkiye's economy and security, serving as subcontractors, system manufacturers, integrators, and component producers.

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The final gratitude is to me, to whom I have been and becoming, as Rilke says "I have been circling for thousands of years and I still don't know: am I a falcon, a storm, or a great song?"

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LIST OF ABBREVIATIONS

AAM	Advanced air mobility
A&D	Aerospace and defense
AHP	Analytic Hierarchy Process
AI	Artificial Intelligence
CAGR	Compound annual growth rate
CMM	Capability Maturity Model
DPs	Design principles
EASA	European Union Aviation Safety Agency
ERP	Enterprise Resource Planning
EU	European Union
eVTOL	Electric vertical take-off and landing
FAA	Federal Aviation Administration
GDP	Gross domestic product
ICMM	Innovation Capability Maturity Model
IMF	International Monetary Fund
InovaLİG	Innovation development program of TIM
ITAR	International Traffic in Arms Regulations
MM	Maturity model
NATO	North Atlantic Treaty Organization
NGOs	Non-governmental organizations
OECD	Organization for Economic Co-operation and Development
OEM	Original equipment manufacturer
OI	Open innovation
R&D	Research and development
SAF	Sustainable aviation fuel
SASAD	Defense and Aerospace Industry Manufacturers Association
SC	Supply chain

SIPRI	Stockholm International Peace Research Institute
SLR	Systematic literature review
SSB	Secretariat of Defense Industries
SSIK	Defense Industries Executive Committee
TIM	Türkiye Exporters Assembly
TSKGV	Turkish Armed Forces Foundation
TUIK	Turkish Statistical Institute
TUSAŞ	Turkish Aerospace Industries, Inc.
UAV	Unmanned air vehicle
USA	United States of America

CHAPTER 1

INTRODUCTION

Companies are increasingly searching effective innovative ideas not only for gaining competitive advantage, but also for a basic reason: survival (Cefis and Marsili, 2003). Scholars have discovered that as well as companies, regions and entire economies are depending on innovation and innovativeness for success. This phenomenon is grounded on a well-known fact: technology has historically been, and continues to be, the main catalyst for growth (Essman and du Preez, 2009). Innovation enters the stage at this point by encompassing everything from invention to commercialization, serving as the foundation of technological progress.

Businesses and markets may resemble natural ecosystems, highlighting the need for continuous evolution to achieve balance and occasional revolutions to gain a competitive edge. Innovation fuels both this evolution and revolution. Therefore, innovation is not just a contemporary concern; it is an ongoing necessity. As Moore (2005) states, “To innovate indefinitely is not merely a goal; it is a fundamental design specification. It is not a strategy; it is an essential requirement.”

Management scholars generally argue that the ability to innovate is crucial for a company's performance. While academic literature often emphasizes the need for organizations to enhance their innovation capabilities, it provides little direction on how to evaluate and improve these capabilities (Arends, 2018). This prompts a significant inquiry into the effective measurement and enhancement of the innovation capabilities of organizations. Both academic researchers and corporate entities are actively exploring methodologies to measure innovativeness. The existing literature has not reached a consensus on a universally accepted measure of innovative performance or a standardized set of indicators. However, according to experts several

key factors can be identified for assessing a company's innovation capability. such as R&D expenditures, market share of new products, income generated from new products, patent counts, patent citations and products that are novel to the global market (Wang and Ahmed, 2004). Moreover, literature indicates that innovation is not a singular, isolated, or individual endeavor; rather, it is the capacity to engage in continuous collaboration with others to foster innovation. (e.g. Blommerde and Lynch, 2016; Chesbrough, 2003a; Saunila, 2016). In fact, innovation is like a complex and changing mechanism, so that there is not a guaranteed formula for innovation, but you can improve the chances of having a breakthrough and enhance your ability by consolidating the appropriate elements. These components represent the necessary requirements and practices for organizational innovation capability (Essman and du Preez, 2009).

Teece tries to understand companies' capabilities attaining a competitive edge in a fluctuating environment by the theory of dynamic capabilities that is built upon the resource-based view (Teece et al., 1997; Teece, 2007). Based on the dynamic capabilities framework, merely possessing internal resources and competencies is not enough to secure a competitive edge; these elements only provide the innovative potential necessary for developing new solutions. While this potential enhances innovation capability, it is not the only factor influencing the innovative changes enacted within organizations. The ability to transform resources is essential for promoting innovation, as the rapid evolution of the environment necessitates that organizations adjust to changing circumstances, including market opportunities and technological progress (Inkow, 2019; Teece, 2007). At this point, open innovation concept appears to have a reflection in dynamic capabilities framework.

The fundamental principle of open innovation is that organizations can and should utilize both external and internal ideas to improve their innovations. The definition of this concept has developed over time and Chesbrough and Bogers (2014) have recently redefined open innovation as "a distributed innovation process based on purposively managed external and internal knowledge flows across organizational boundaries". Open innovation is in alignment with the dynamic capabilities framework at this point. Since their introduction, dynamic capabilities have included "the management ability

to efficiently coordinate and redeploy both internal and external competencies" (Teece et al., 1997, p.515). In addition, dynamic capabilities encourage organizational agility and entrepreneurial insight necessary for an open innovation strategy. The three categories of organizational processes—sensing, seizing, and transforming capabilities—represent clusters of dynamic capabilities that empower companies to fully leverage the benefits of open innovation (Teece, 2020).

Recognizing the significance of developing and enhancing organizational innovation capability, researchers and practitioners have created maturity models or frameworks over the past decade to assess and improve these organizational capabilities. While a substantial number of maturity models have been developed to assess and enhance an organization's innovation capability at the firm level, research and practice in this area are still emerging, characterized by a lack of empirical validation (Arends, 2018; Röglinger et al., 2012). Moreover, open innovation phenomenon is rarely handled as a maturity concept. This thesis aims to develop an open innovation maturity model and base it on dynamic capabilities theory, due to the above-mentioned complementary structures of the two concepts.

The current innovation maturity models typically overlook the unique characteristics of various industries and they usually lack an empirical validation. They are usually concentrated on generic formulations that may oversimply reality (Röglinger et al., 2012). In fact, the open innovation maturity may refer different meanings for different internal and external contexts such as industry and country. Enkel et al. (2020) state that literature needs more research studying the effects of open innovation on industry level. The open innovation concept is about knowledge flows and partnerships that are subject to direct effects of external environment as well as internal one. Thus, developing a maturity model focused on a specific sector may contribute to literature as an innovative approach. This research preferred to study open innovation maturity grounded on dynamic capability framework and empirically validate the model on Turkish A&D industry.

Turkish aerospace and defense (A&D) industry is chosen as the field of study due to various reasons. First of all, innovation has become riskier and costlier for all

companies but especially for A&D sector in today's highly competitive and global world (OECD, 2008). In fact, organizations are progressively endeavoring to expand their innovation processes by engaging in collaboration with external partners, including suppliers, customers, and academic institutions, among others (OECD, 2008). Who will be daring to stay isolated in today's business environment in which collaboration and knowledge sharing is more than normal? Firms progressively rely on external knowledge, besides their internal knowledge base to develop innovative ideas and technologies (Chesbrough, 2003a; Dahlander and Gann, 2010). It is not surprising that aerospace and defense companies, which are recognized for their concerns regarding confidentiality and their reliance on traditional in-house R&D efforts, are seeking to open their closed innovation systems in order to leverage external knowledge. (Armellini et al., 2016, Honorato and de Melo, 2022; Zuluaga et al., 2024), in spite of the risk of unintentional knowledge leakages. A&D companies must have observed that the intended attempts of companies to open their innovation systems are initiated by various motivations. Open innovation (OI) is found to develop companies' capability to generate knowledge spillovers (Dahlander and Gann, 2010) and to facilitate the creation of new products, both through internal efforts and in collaboration with external partners (Bogers et al., 2018). Moreover, OI increases the tendency of knowledge complementarities via nourishing deep and broad activities with innovation partners (Audretsch et al., 2021).

OI scholars are examining different company and country contexts to further analyze the phenomenon. Although researchers recognize that the sources of knowledge for innovation are broadly dispersed throughout the economy (Chesbrough and Bogers, 2014), open innovation in A&D sector may seem to be a paradoxical concept, due to the secrecy concerns and complexity of design issues. Although sector leaders like Boeing, Lockheed, Airbus are launching programs and organizing open innovation contests to participate in the open innovation framework and enhance their innovativeness (PwC, 2024), the literature searching for open innovation practices in A&D sector is scarce and mainly focusing on explaining the practices in Brazilian and Canadian aerospace clusters. Armellini et al.'s (2014, 2016) earlier studies define that the aerospace sector is open-within a box or just unfreezing and the sector is proposed to have great potential to adopt OI. A recent study conducted by Honorato and De

Melo in 2022 is also about Brazilian aerospace cluster and grounded on project management perspective. They found out relevant maturity for two companies (55% and 68% respectively). However, Zuluaga et al. (2024) found out that OI is not a common practice in Colombian A&D industry. Studies focusing on the context in other countries and covering the A&D industry as a whole, instead of aerospace solely, may possibly reveal open innovation paradigm in the sector, more obviously. The innovation process within the aerospace and defense (A&D) industry is characterized as product-oriented, exhibiting a low level of adoption of formal intellectual property (IP) protection mechanisms (such as patents) in comparison to strategic methods (like secrecy and design complexity). Armellini et al. (2014) assert that collaboration and co-creation efforts are limited to the confines of the aerospace industry, leading to the characterization of the sector as being open within a constrained environment. However, the rapid developments in technology is reshaping the innovation perception of the A&D sector like the other ones.

Another reason for choosing A&D sector as the focus of this study is that the technological advancements of the past decade have transformed the timing and methods by which organizations can leverage open innovation (Dodgson et al., 2006). Particularly, advancements in digital technologies, including machine learning, big data, cloud solutions, artificial intelligence, and advanced robotics, facilitate the innovative use of data to develop new products and services. While these technologies are seldom incorporated into innovation maturity models, they significantly influence how individuals and organizations collaborate in innovation. Furthermore, partnerships, innovation ecosystems, and knowledge management have taken on increased significance in the digital era. Consequently, companies can undergo rapid and transformative changes more often than was previously thought. (Yoo et al., 2012). The A&D sector is closely affected by these digital technologies, since it is a high-tech sector with complex products and manufacturing systems.

A&D companies have undergone important technological, organizational and institutional changes in recent years and unavoidably they have to find ways to open their boundaries (Ayerbe et al., 2014). It is not only the new technological advancements, but also the Covid-19 pandemic that revealed that the sector is

vulnerable to crisis. In fact, the pandemic has seriously hit the commercial side of the aerospace sector and revenues of aero structures market have declined by 50 percent in 2020 compared to 2019 (Counterpoint, 2021), while it is proposed to reach 2019 levels in 2025. The defense branch of the industry has always been more insulated from crisis than the commercial side. However, technology is changing fast. New technologies like unmanned military fighter aircraft, cyber and intelligence solutions, and hyper sonics require contractors that utilize innovation for developing advanced military capabilities (Deloitte, 2021). The sector must prioritize innovation to advance new technologies and solutions, establish new markets, and enhance growth opportunities (Deloitte, 2021). Furthermore, in Türkiye the sector is experiencing another problem: limited revenue growth with respect to increased R&D expenditures. For example, in 2019 and 2020, R&D expenditures per revenues were 15 and 14 per cent, respectively. The ratio is 4,1 per cent globally and yet the market is discussing how to decrease this rate down (PwC, 2018). PwC (2018) states that the overwhelming R&D expenditures are questioned by the sector and policy makers worldwide and these expenditures are even more important for emerging countries like Türkiye. At this point, innovation appears to be a significant tool that promises new products and services with less resources. In this vein, open innovation is increasingly gaining popularity among industry participants, because OI embraces knowledge inflows that may increase innovativeness of firms with less resources via partnerships, technology transfer or IP rights.

Despite Armellini et al.'s (2016) earlier studies define A&D sector to be open-within a box or just unfreezing (Armellini et al, 2016; Armellini et al., 2014), the sector is proposed to have great potential to adopt OI. The leader A&D companies in Türkiye, may have revealed this potential and has recently launched an open innovation program. Our case OEM company, named anonymously as company A, is locomotive of the sector in Türkiye and is linked to the majority of the sector players with global and national supply chains as a primary manufacturer and contractor. It had more than 2 billion dollars in sales and 700 million dollars exports in 2021, with more than 12 thousand employees. The company supplies aero structures to world's leader OEM manufacturers Boeing and Airbus and also producing unmanned air vehicles, fixed

wing and rotary wing platforms. Thus, this thesis proposes to study the open innovation efforts of the Turkish A&D sector deployed around Company A.

This study aims to reveal the open innovation maturity of A&D ecosystem in Türkiye and propose recommendations for improving the industry's innovativeness. A&D companies in Türkiye have undergone important institutional, technological and organizational changes in recent years (Ayerbe, 2014), and they inevitably have to find ways to open up their boundaries, like the rest of the market.

1.1. Research Problem

Throughout much of the 20th century, A&D industry was the clear frontrunner in technological innovation, with advancements made in R&D laboratories frequently making their way into civilian applications. However, in the 1990s, a significant reduction in defense budgets and a shift in funding towards commercial uses driven by startups and internet leaders led to a reversal in the flow of innovation. As a result, the leader A&D companies got suspicious for their sustainable growth and has embraced "Open Innovation" strategy in the last decade to leverage new technologies emerging from the civilian sector. Likewise, in Türkiye, A&D industry is still the pioneer of technological advancement and innovation on the manufacturing side (Turkishtime, 2024). Open innovation has entered the glossary of Turkish A&D ecosystem, recently. Türkiye's leader and one of the few OEM companies in A&D industry, Company A, has recognized the OI potential in the sector and implemented an open innovation policy in 2022. Company A promises to enhance the sector in its vision and aims to grow and become more innovative throughout this OI process. In fact, open innovation is a long journey and has to be cultivated by partnerships with shareholders like customers, researchers, employees and, of course, suppliers to be successful.

To succeed in open innovation, a company must cultivate a collaborative business ecosystem that facilitates knowledge sharing, fosters individual development, and nurtures trust among participants (Chesbrough et al., 2014). Moreover, advancement in digital technologies plays a significant role in companies' innovation performance.

The emergence of the digital era has introduced powerful new capabilities that transform how organizations handle their data ecosystem and adapt to new market conditions. These dynamic capabilities fundamentally reshape the ways companies can generate, distribute, access, and preserve various forms of information and knowledge. Open innovation and dynamic capabilities framework intersect at various issues. Digital technologies enhance an organization's dynamic capabilities by providing tools that allow for quicker adaptation to changes in the market (Konlechner et al., 2018). This technological shift has profound implications for how organizations define and manage their operational boundaries and interfaces with stakeholders. Therefore, it is important to consider the digital maturity of a company while measuring its openness. This thesis is aiming to develop a model, grounded on dynamic capabilities theory, that enlarges the narrow open innovation maturity literature by adding different aspects of digital technologies and focusing on aerospace and defense sector in an emerging economy, Türkiye.

After the maturity model is constructed, the openness of Turkish aerospace and defense innovation ecosystem is assessed via examining Company A and its suppliers to briefly understand the open innovation maturity level of the sector in Türkiye. The Turkish A&D sector reached 15,1 billion dollars revenue and nearly 90 thousand employees in 2023 (SASAD, 2024). Company A is chosen as the focus of the empirical study due to its high representation capability of the sector. It is by far one of the pioneers in Türkiye with over 2 billion dollars revenues and over 14 thousand employees on its own. Moreover, it has over 200 supplier and partner companies some of which are system and sub-system manufacturers that are among top 5 of the sector in Türkiye. In this thesis, Turkish A&D innovation ecosystem is monitored via application of the pre-developed model on Company A and its ecosystem to sense its open innovation maturity.

The primary focus of this research is to develop an open innovation maturity index for companies in Turkish aerospace and defense sector for determining their current state of openness. The proposed maturity index is grounded on dynamic capabilities view and based on five main categories that are detailed in the next section: strategy and governance, innovation culture, partnership capacity, knowledge chain and finally

digital maturity. The five categories are detailed in 16 dimensions. These 16 factors are determined by a systematic literature review followed by expert reviews and sector professionals' assessments. Afterwards, AHP method is adopted by academic and sector experts to customize the model for A&D sector and to determine their comparative significance. The last chapter of this thesis will be a policy section to understand the research respondents' recommendations for improving the companies and ecosystem's open innovation maturity. The policy section will cover recommendations for innovation strategy and culture, partnerships, knowledge chain, and digital maturity.

Research Questions

There are three main research questions to be investigated throughout this research:

1. What are the parameters of OI maturity for Turkish aerospace sector?
2. What is the open innovation maturity level of A&D companies in Türkiye?
3. What are the policy areas for enhancing OI maturity of Turkish A&D industry?

1.2. Novelty of the Study and Contributions to Literature

This novel study proposes significant methodological, theoretical and empirical contributions to the literature about open innovation, maturity models and Turkish A&D industry.

This research is the first academic attempt to measure the open innovation maturity of the Turkish Aerospace and Defense Industry. Until very recently, the suitability of the concept of open innovation for the sector was being debated, but global and sectoral developments have now transformed this innovation phenomenon into a concept implemented by global giants in the sector. Likewise, there are recent formations to practice OI in Turkish A&D companies, to support the industry on its path to achieve challenging goals. In this context, understanding OI in Turkish A&D ecosystem is a significant contribution to the literature.

This thesis has provided a theoretical gain to better understand the connection between the theory of dynamic capabilities and open innovation concept. There are limited number of maturity models that are grounded on dynamic capabilities model in terms of open innovation. This thesis contributes to understanding how openness can be integrated in the theory as a way of improving innovation capability. Moreover, dynamic capabilities for sustaining digital transformation is an interesting subject for scholars studying dynamic capabilities theory. This thesis may serve as a guide for companies towards development of specific processes and resources aimed at achieving digital maturity, thereby fostering an organization's capacity for continuous adaptation within the perpetually evolving digital landscape.

There are a few studies that evaluate digital technologies and their maturity as part of innovation maturity. This research encompasses digital maturity in knowledge production and sharing, operations and manufacturing, and the supply chain as an open innovation capability. In this regard, the research may be one of the unique sources to attain a more comprehensive understanding of the relationship between digital transformation and open innovation.

Innovation maturity models in literature have rarely examined the comparative significance of maturity dimensions with each other. There are a rare number of models that use AHP to do this. The proposed model weighed the OI dimensions in line with the expert opinions with the AHP method, thus revealing both the priority of capabilities and areas for the A&D sector and ensuring that the model has a sector-specific and more quantitative structure. This method is thought to have several benefits. First, it can serve as an example in the work of maturity model studies in other sectors. In addition, it is thought that this model allows the creation of a model suitable for practical use in future comparison between companies and annual maturity follow-up studies.

Current innovation maturity models usually lack empirical validation and the ones that have practical measures are generally dealing with a company or set of companies, instead of an industry or ecosystem. This research proposes to monitor Turkish A&D industry through an innovation ecosystem approach. This attempt is an original input

to literature. Although this research may contain issues that can be improved in further studies, it is a novel approach to take an OEM company to the center and look at the ecosystem shaped around it to understand OI maturity.

1.3. Outline of the Thesis

After this introduction as the first chapter, academic literature regarding this research is presented in the second chapter. In the third chapter, all details of qualitative and quantitative research are described respectively. The methodologies employed during the model development and empirical validation stages are explained in detail. The fourth chapter presents the proposed open innovation maturity model. The fifth chapter outlines the results obtained from the gathered data, followed by a detailed discussion of the findings. Finally, the sixth chapter concludes the thesis by presenting the insights drawn from the conducted survey and offering policy recommendations related to the development of open innovation maturity in the Turkish aerospace and defense industry.

CHAPTER 2

LITERATURE REVIEW

This chapter aims to provide a review of literature in the areas related to the research subject: open innovation, open innovation in A&D industry and open innovation maturity and dynamic capabilities. First, open innovation is explained and the current understanding of open innovation after twenty years of its first discussion is presented. Second, Teece's dynamic capabilities theory which is the ground of our model and its relationship with OI is examined. Thirdly, the global and Turkish A&D sector's view on open innovation and OI practices in the sector is reviewed. Afterwards, the future vision of Turkish A&D sector and how its challenging goals requires access to external knowledge and partnerships is stated. Lastly, we conduct a systematic literature review and examine the models developed in the last 15 years to assess OI maturity. This last part is planned to form the theoretical framework for the maturity model to be built in this thesis.

2.1. Open Innovation

Open innovation (OI) was first defined by Chesbrough as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" in 2003 (Chesbrough, 2006a). Later, innovation scholars discussed the initial definitions and stressed the intentionality of knowledge inflows and outflows. In 2014, Chesbrough and Bogers extended the term and stated that OI is "a distributed innovation process based on purposefully managed knowledge flows across organizational boundaries" (Chesbrough and Bogers, 2014, p. 17). However, publications that carry the antecedents of OI were found much earlier. Scholars such as Freeman, Allen and Rothwell have admitted that innovative ideas sometimes emerge from external sources, in 1970s (Bigliardi et al., 2021). Later in

1990s, other scholars found out that a company's R&D capability not only enables generation of novel knowledge but also improves its capacity to absorb external knowledge (Cohen and Levinthal, 1990). Therefore, OI can be accepted as an early new millennium model that has roots in the late 20th century.

Since the invention of the term, OI has attracted increasing attention both from practitioners and academicians, because adopting open innovation activities can reduce innovation cycles, lower industrial research and development costs, and alleviate the challenges associated with limited resources (Gassman and Enkel, 2004). A considerable amount of external knowledge exists beyond firms, awaiting recognition and conversion into profitable innovative products and services (Chesbrough, 2003a, 2003b; Christensen et al., 2005). OI paradigm offers companies utilizing external knowledge as well as internally created ones to advance their technology (Chesbrough, 2003a). A more open firm is more likely to identify valuable opportunities and technologies, as well as to integrate valuable insights into groundbreaking products and innovations (Felin and Zenger, 2020). In fact, a linear or closed innovation model is no longer sustainable in today's technological and commercial conjuncture.

In a world that is becoming more interconnected and networked, the National Aeronautics and Space Administration (NASA) acknowledges the importance of open innovation in tackling significant challenges. As the variety of problems and the number of solutions increase, the design of these challenges is also becoming more complex, driven by the growth and development of expertise and resources, including personnel, platforms, and partnerships (Gustetic et al., 2015). Today, external knowledge may be less expensive, more accessible and less risky to sustain innovation activities. It may take a shorter time to access the outer knowledge for companies than to generate it in closed innovation systems. Moreover, flow of internal knowledge to the outside may contribute to the construction of an innovative ecosystem around the company, that may nourish the firm itself. Due to these promising outcomes, A&D sector has begun considering OI as a welcomed model despite the petulant traits of the sector that will be examined in the later chapters. However, the literature written on OI in A&D sector is still scarce. This thesis aims to narrow that scarcity and contribute

to academic and practical understanding of the relationship between open innovation and the aerospace and defense sector.

Although it is debated that open innovation practices can address many problems of companies, the founder of the Open Innovation (OI) concept suggests that the current business landscape is characterized not by a purely open innovation approach, but rather by companies that engage in both open and closed innovation activities concurrently (Enkel et al., 2009). This perspective moves away from the simplistic notion of a rapid expansion of open innovation. Proponents of the OI concept are increasingly recognizing the complexity involved in developing innovation strategies, which often bring together the factors of both open and closed innovation systems. These combinations are influenced by various internal and external components. Husingh (2011) further emphasizes this trend, stating that open innovation should be viewed as a continuum rather than a strict dichotomy between open and closed approaches.

As a natural result of the possible promises of OI for companies, OI has become one of the most popular topics in innovation management, recently. Google Scholar shows 222,000 results for the keyword “open innovation”, and the same search on Scopus in the article title, abstract and keywords results in around 9,438 documents (data retrieved in December 2024) in a broad range of academic fields. Since literature is growing fast, scholars recognize the need for filtering, reviewing and synthesizing the literature due to the diverse and disorganized knowledge production. At this point, our model, that integrates existing literature with the review of experts as discussed in chapters, is useful in dealing with this challenge.

Open innovation has two types: inbound and outbound open innovation (Gassman and Enkel, 2004). The inbound (outside-in) open innovation enriches the company’s own knowledge base through the integration of stakeholders like customer or suppliers and external knowledge sourcing may increase a company’s innovativeness. The outbound (inside-out) process is about earning profits by bringing ideas to market, selling IP and multiplying technology by transferring ideas to the outside environment. Any type of OI process does not emerge smoothly or spontaneously through the boundaries of the

firms. Most of the time, a conscious attempt to recognize valuable knowledge is required; and then firms have to look for mechanisms to assimilate and transform this knowledge (Spithoven et al, 2010). Moreover, a balance of inbound and outbound activities is significant. Firms who prioritize inbound processes but also have expertise in managing external sources, may become successful at OI attempts (Bigliardi et al.., 2021).

OI is gaining popularity especially in the last decade and scholars are developing different frameworks to identify types of OI. Lazzarotti and Manzini (2009) propose two variables representing the degree of openness: partner variety and innovation funnel openness. Their framework indicates that, sometimes, openness in innovation activities is not always the only and most suitable option. In fact, some scholars mention that moderate openness optimizes innovation; but excessive collaboration reduces returns (Bigliardi et al., 2021). Moreover, open innovation has been studied at firm-level to a certain extent, but research that studied OI at clusters or ecosystems still needs more attention. Bigliardi and his friends (2021) propose that future OI studies should address globalization and digitalization. This thesis recognizes these gaps and tries to offer a model that considers the concerns and characteristics of Turkish A&D sector.

In nearly every company today, the most innovative ideas and talented individuals can be found outside the organization. This trend is influenced by the globalization of business, advancements in education, and technological progress. Organizations can now quickly connect with extensive global technical communities, leading to more efficient solutions for complex problems. An increasing number of work activities are digitally interconnected, fostering new patterns of cross-functional collaboration. Timely access to expertise in specific domains and technologies is essential for maintaining competitiveness at the firm level. There is a need to develop tools for scouting and sensing, while skills in seizing, orchestrating, and integrating are now crucial. These changes are so significant that today's open innovation landscape is fundamentally different, both qualitatively and quantitatively, from the pre-Internet era. Consistent with the dynamic capabilities perspective, it has become necessary for

almost all companies to actively engage in sensing and outsourcing technology (Bogers et al, 2019).

A comprehensive global survey of chief executives across diverse industries revealed that approximately 80% of surveyed organizations actively implement Open Innovation (OI) practices (Brunswicker & Chesbrough, 2018). However, despite this widespread adoption and increasing attention to OI, significant knowledge gaps persist both in theoretical understanding and practical implementation. These gaps indicate that while OI has gained considerable traction in the business world, our understanding of its full implications, best practices, and implementation challenges remains incomplete. This thesis aims to contribute to understanding OI regarding the maturity and implications in A&D sector.

2.2. Dynamic Capabilities

In the context of open innovation, companies must be agile in integrating and reconfiguring not only internal resources but also external ones to leverage new ideas and technologies. This adaptability is crucial as firms increasingly rely on external knowledge sources, necessitating a proactive approach for identifying and evaluating potential innovations beyond their organizational boundaries. In other words, companies need capabilities that are agile and open to development. Therefore, resource-based perspective, which emphasizes firm-specific capabilities and assets rigid processes and isolated mechanisms as the fundamental determinants of firm performance (Rumelt, 1984; Teece, 1984) has become obsolete for companies that are pursuing external knowledge and partnerships to gain a competitive edge in today's rapidly changing global environment.

Resource-based views evolve from Nelson and Winter's research (1982) built upon Schumpeterian competition by presenting an evolutionary perspective on a firm's capabilities and actions. They invented the term "routine" to refer to consistent and predictable behavioral patterns that function as valuable resources. After them, the "routine" concept has achieved acceptance with broader interpretations (Eisenhardt and Martin, 2000; Winter, 2003), asserting that resources and products are

interdependent (Wernerfelt, 1984). He claimed that companies can attain above-average returns by recognizing and acquiring essential resources for the market. Researchers have emphasized that intangible assets are resources that can provide a sustainable competitive advantage. They stressed the importance of not only these resources but also the knowledge, skills, and technologies required to effectively leverage them. Their central argument was that new products should align with a firm's strategic resources, particularly its capabilities (Breznik and Hisrich 2014).

Teece and many other scholars have discovered that the leaders in the global marketplace are the ones that can respond to the changes on time via rapid and flexible product innovation and management skills of organization and reallocation of internal and external skills (Teece et al., 1997; Teece, 2007, 2014). Teece called this ability as “dynamic capabilities”. The term "dynamic" signifies the ability to refresh skills and competencies to align with the evolving business landscape. Innovative approaches are necessary when factors like time-to-market and timing are crucial, technological advancements occur swiftly, and future competition and market conditions are uncertain. Meanwhile, "capabilities" underscores the critical importance of strategic management in effectively adapting, integrating, and transforming both internal and external organizational skills, resources, and functional competencies to address the challenges of a dynamic environment.

Breznik and Hisrich (2014) searched for the connection between dynamic capabilities and innovation capability and suggest that innovation capability could be a dynamic capability. Teece’s theory is grounded on the critical capabilities of sensing, seizing, and transforming. Sensing involves recognizing valuable external opportunities, which is essential in open innovation where firms scout innovative ideas from various sources. Once these opportunities are identified, firms must seize them by effectively applying their existing resources and capabilities to integrate external innovations into their operations. This process often requires significant transformation of organizational structures to facilitate collaboration with external partners, highlighting the importance of flexibility in adapting to new collaborative frameworks (Bogers et al., 2019). These capabilities evoke Zahra and George’s (2002) absorptive capability

which is defined as a key element of both innovation capability and dynamic capabilities by scholars.

Moreover, dynamic capabilities theory addresses the complexity of modern innovation ecosystems, where firms must manage relationships with multiple external partners. This complexity necessitates a balanced approach for utilizing both internal resources, such as R&D, and external collaborations. Firms that excel in developing dynamic capabilities are better positioned to sustain long-term innovation, aligning their open innovation strategies with their overall strategic goals. Thus, the theory provides a comprehensive framework for understanding the mechanisms behind successful open innovation initiatives.

There are issues that have to be addressed carefully while dynamic capabilities theory may face challenges for open innovation concept, due to conflicts in resource allocation and cultural differences within organizations. Although dynamic capabilities focus on leveraging internal resources, open innovation emphasizes external collaboration, leading to potential tensions. Additionally, integrating internal and external knowledge can be complex, and companies may hesitate to commit open innovation due to risks and intellectual property concerns. Strategic misalignment and difficulties in measuring success further complicate the integration process, necessitating a cohesive approach that balances internal strengths with external opportunities for innovation. Especially for A&D industry, internal capabilities have been the main factor for competitive advantage since history. Thus, purposively balancing openness with internal R&D activities is supposed to be a right approach for A&D industry.

Dynamic capabilities theory is particularly suited for understanding open innovation because it emphasizes a firm's ability to fit in and respond to rapidly changing environments (Teece, 2019). We aim to develop an OI maturity model grounded on dynamic capabilities theory, because the emphasis on balancing internal and external resources is crucial for A&D industry. In particular, we accept Chesbrough and Bogers's OI definition in this study (2014) which is explained as "a distributed innovation process based on purposively managed knowledge flows across

organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model".

2.3. OI in A&D sector

The aerospace and defense (A&D) sector is a traditional high-tech industry that mainly depends on its in-house R&D for innovation and lacks strong links outside of its main production pipeline (Armellini, 2016). This industry is mainly composed of three segments: commercial, industrial and military applications. Regardless of the segment, products of A&D industry are characterized by continuous technological development and high cost intensity, which classifies them as complex products (Acha et al, 2004). Parida et al. (2010) declare that the industry has bare minimum tolerance to risk and failure compared to other industrial settings, and there is a long, 10 to 20 years, product development process from kick off to final delivery of the product. Furthermore, the product life cycle of a product usually exceeds 40 years, with life-long complete product support.

To comprehend the relationship between open innovation and the A&D sector, it is essential to conduct a detailed examination of the sector's characteristics. One of the key features of the sector is high-risk high-investment environment. A&D projects involve significant risks due to potential impacts on human lives and material losses. The Boeing 737 crisis is one of the primary cases to be analyzed. Origins of the crisis were rooted in the beginning of 2010s. By 2011, Boeing's 737 was losing ground to Airbus's A320neo and corporate leaders prioritized cost-cutting over innovation. Instead of developing an entirely new aircraft to replace the 737, the company implemented a five-year plan to create the upgraded 737 MAX. This approach required redesigning the aircraft to comply with the Federal Aviation Administration (FAA)'s original type certification while maintaining the same flight characteristics. Additionally, Boeing convinced customers that pilot retraining and updates to training manuals would not be necessary. Furthermore, rather than making additional design modifications that could jeopardize the 737's original type certification, Boeing also preferred to introduce a significant software update, which was neither reported to the FAA nor included in the pilot's manual. These choices prioritized reducing immediate

costs to boost short-term profits. Those significant risks were taken to reduce the required additional investment, but unfortunately, they resulted in the two 737 MAX crashes in 2018 and 2019, leading to the deaths of 346 people. Paradoxically, decisions aimed at prioritizing shareholder value over the past 20 years have ended up costing investors $87 billion since 2018. The long-term damage to Boeing's reputation and competitive position is considerably more severe, as Airbus has consistently surpassed Boeing in new aircraft sales each year for the past five years (George, 2024).

The high development costs in the sector also appear to be challenging in the military section. The lifetime cost of the Lockheed's F-35 Joint Strike Fighter program is anticipated to surpass $2 trillion, driven by the U.S. military's plans to extend its service life, increasing inflation, and the Pentagon's struggles to effectively control spending. The updated estimate includes approximately $1.6 trillion in sustainment costs, marking a 44% rise from the $1.1 trillion projected in 2018, along with around $442 billion in acquisition costs, which cover the development and procurement of the Lockheed Martin-produced jet (Losey, 2024).

The stringent applications of regulatory authorities are another characteristic that shapes the A&D sector (Zuluaga et al. ,2024). First of all, geopolitical fragmentation is rising in the world and A&D sector is directly prone to results of geopolitical tensions and trade restrictions (e.g., U.S.-China trade wars). Suppliers comply with sanctions that threaten supply chain resilience. Strict international regulations like the International Traffic in Arms Regulations (ITAR) and export restrictions govern technology transfers, requiring rigorous documentation and compliance frameworks to prevent unauthorized access to sensitive defense technologies. Agencies like the FAA (U.S.) and EASA (EU) enforce evolving airworthiness requirements, demanding continuous updates to design, manufacturing, and maintenance processes, to sustain safety with standards. Increasing threats to critical infrastructure (e.g., satellite systems, military networks) also necessitate compliance with frameworks like NIST SP 800-171 and NATO standards. Lastly, emerging sustainability challenges create pressure for adoption of green technologies (e.g., SAF mandates) and reducing carbon footprints under initiatives like the EU's Green Deal.

The Aerospace & Defense (A&D) sector is widely considered an oligopoly, dominated by a small number of OEM firms (Senaubar et al., 2024). These firms have significant control over pricing and supply, often leading to limited competition. They might compete on factors other than price, like innovation or branding. The aerospace and defense industry requires massive capital investment, advanced technology, and adherence to strict regulatory standards. The fact that the industry is heavily regulated, and contracts are often large and long-term (like government defense contracts) means that existing firms have stable positions, further entrenching the oligopoly.

Although these features seem to support R&D based closed innovation efforts in the sector, aerospace companies started to consider opening their innovation systems, owing to strong competition caused by global openness (Armellini, 2014). Open innovation attempts may mitigate risk and costs, leverage external knowledge, accelerate technological development, improve dual use, align markets in terms of regulations, strengthen supply chains and foster rapid responses to emerging challenges such as cybersecurity threats and geopolitical shifts, in the sector (Zuluaga et al. ,2024).

Despite its promising benefits, there exist scarce literature that study OI in A&D sector and it proposes that companies are living a profound transformation of the innovation landscape that leads to the adoption of collaborative and open approaches to innovation (Armellini, 2014; Hsieh et al., 2020). Scholars witness a transfer from the traditional innovation model, which is mainly based on internal research and development (R&D) to open innovation (Parida et al., 2010) and their efforts recently accelerated due to the global pandemic that brought out a substantial drop in the sector's revenues and profit (Deloitte, 2021).

While A&D companies are opening their innovation systems, the main challenge for A&D companies, like all others, is how to initiate a collaborative knowledge environment where companies feel confident and secure in their capacity to share ideas and collaborate on the development of new products. Companies need to find a balance between their open innovation programs and knowledge protection policies. A recent study by Barbaroux and Mistry (2024) searched open innovation (OI) practices

deployed by 115 aerospace and defense (A&D) companies in European regions and investigates their impact on their innovation capacity. They find out that some OI practices leverage innovation capacity whereas others may hamper it. Specific OI practices like M&A, spin-offs, customer collaboration, and R&D services provision are effective. Collaborating with suppliers has a negative effect on innovation, while IP-related practices and collaborations with R&D institutions do not have significant effects. Science-based collaborations with universities and research centers are found to create challenges like trust gaps and mismatched R&D priorities. Moreover, IP management in A&D is discussed to prioritize secrecy over commercialization, limiting its innovation impact. On the other hand, Alexy et al. (2009) proposes that IP may be used as a tool for developing an ecosystem rather than a wall against all outsiders. Educating employees about how IP strategy can act as a value capturing tool.

Another study compared the two rival OEMs, Boeing and Airbus in A&D sector in terms of their open innovation and risk-taking practices. Boeing's future hinges on reconciling its risk-taking culture with safety, while Airbus must adapt to shifting industry demands. The Boeing-Airbus rivalry highlights how competitive dynamics drive innovation but also introduce systemic risks. (Woo et al., 2021).

In fact, Boeing's open innovation model emerged as a strategic response to Airbus's competitive pressure, particularly after the launch of the A380. It involved decentralizing R&D and production by collaborating with external partners, suppliers, and global talent. For the 787 Dreamliner, Boeing crowdsourced design ideas and outsourced ~70% of manufacturing to suppliers worldwide (e.g., wings to Mitsubishi Heavy Industries, software to HCL Technologies). This approach aimed to reduce costs, accelerate development, and integrate cutting-edge technologies. However, over-reliance on external partners led to fragmented oversight, with critical components like composite materials and software systems suffering from mismanagement and delays. While intended to foster innovation, the model struggled to balance collaboration with core competency retention. The model's emphasis on cost-cutting over technical oversight also contributed to the 737 MAX crisis, where rushed decisions and external dependency compromised safety. Insights gained from

these failures emphasize the necessity of adopting a hybrid strategy: outsourcing non-core tasks while maintaining control over core technologies and enhancing collaboration with suppliers. Boeing's experience underscores the risks of prioritizing speed and profit over systemic resilience in open innovation (Woo et al., 2021; Boeing websites).

Airbus's open innovation model also emphasizes collaboration with external partners, academia, and startups to drive technological advancements and maintain competitiveness. But, unlike Boeing's decentralized approach, Airbus focuses on strategic alliances and joint ventures, such as partnerships with Safran (engines) and Siemens (electric flight systems). The company leverages innovation hubs like Airbus BizLab to incubate startups working on AI, sustainability, and digital twins. For projects like the A350 XWB, Airbus retained tighter control over core design while outsourcing non-critical components, ensuring quality and integration. This model balances external input with in-house expertise, enabling Airbus to pioneer advancements in fuel efficiency and composite materials without compromising oversight. Airbus also prioritizes sustainability-driven innovation, collaborating with institutions like the European Space Agency and Clean Sky Initiative to develop hydrogen-powered aircraft (e.g., ZEROe) and reduce carbon emissions. Open innovation extends to digital tools, such as the "Skywise" platform, which shares flight data with airlines and suppliers to optimize maintenance. By fostering ecosystems where external ideas complement internal R&D, Airbus mitigates risks of over-reliance on suppliers—a pitfall Boeing faced. This approach has solidified Airbus's market leadership, particularly post 737 MAX crisis, by aligning innovation with safety and long-term strategic goals. (Woo et al., 2021; Airbus websites).

This study by Woo et al. (2021) is crucial to be one of the scarce academic articles that integrates real sector-practices with innovation theory. The authors suggest that a balanced approach is needed. They recommend outsourcing non-core components while retaining control over critical technologies. Strengthening communication and quality checks in global supply chains is critical for successful OI applications in the sector. A company should also conduct feasibility studies before large-scale open innovation projects.

This thesis will take the issue further and search for the maturity of OI in A&D sector. In the upcoming chapters, a model defining a balanced and intended openness in terms of knowledge and collaboration is aimed to be developed to measure OI maturity in the sector.

2.4. Global A&D Industry

The global aerospace and defense industry demonstrates significant growth in recent years driven by rising demand for air travel technological advancements, and heightened defense spending due to geopolitical tensions. Deloitte (2024) highlights a significant recovery in the aerospace sector, with a projected 11.6% increase in global air passenger traffic in 2024, fully rebounding from the pandemic's impact. The defense sector is also witnessing heightened spending, driven by ongoing geopolitical tensions.

According to the research of SIPRI (Stockholm International Peace Research Institute Military), global military expenditures have been increasing worldwide marking the ninth consecutive year of growth and the steepest year-on-year increase since 2009. It reached an unprecedented 2.443 billion dollars in 2023, marking a 6.8% increase, and projected to grow by 4% annually between 2023 and 2029 due to rising military tensions worldwide. Military spending has increased in all five regions for the first time since 2009. In 2023, the five countries with the highest spending were the USA, China, India, Russia and Saudi Arabia, accounting for 61% of global military expenditure. This current increase and future projections imply an opportunity for Turkish A&D industry.

This growth was primarily driven by Russia's invasion of Ukraine and heightened geopolitical tensions worldwide. Russia's military spending increased by 24% in 2023, reaching an estimated 109 billion dollars. This equates to 5.5% of Russia's GDP. The United States remained the dominant spender at 916 billion dollars, followed by China at 296 billion dollars, together accounting for nearly half of global military spending. Notable developments included Ukraine becoming the eighth-largest spender with a 51% increase to 64,8 billion dollars, and Russia's 24% spending growth to 109 billion

dollars. The global military burden rose to 2.3% of GDP, with NATO members' combined spending reaching 1.341 billion dollars (55% of world spending). These trends reflect escalating international tensions, particularly in Europe and Asia, driving countries to enhance their military capabilities and modernize their armed forces (SIPRI, 2024). As an EU candidate and NATO member, Türkiye may get higher shares from the market, considering the recent revenue and exports drawing attention worldwide.

The estimate of Statista shows that the revenues of the A&D market have reached from 745 billion dollars in 2022 and up to 829 billion dollars in 2023, with a steady annual increase after the pandemic Figure 1).

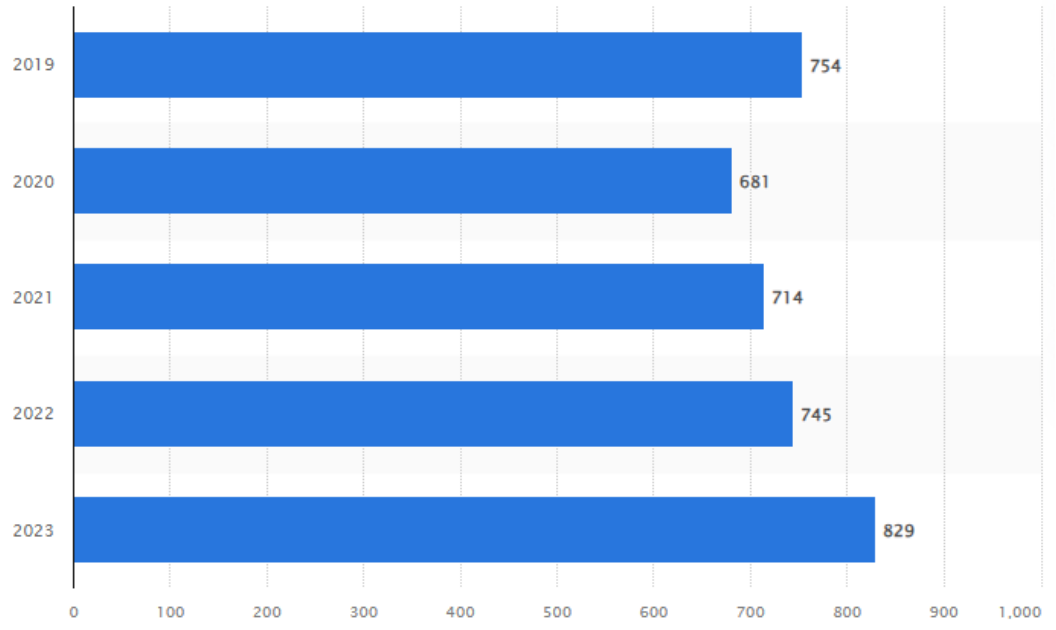

Figure 1. Global A&D Industry Revenue in billion dollars
(Source: Statista)

Another research predicts the market size as 750 billion dollars (approximate to Statista) in 2022 (Zion Market Research, 2024). The growth is estimated to continue, and the revenues are projected to reach 1,388 billion dollars in 2030. This growth is expected to be driven by a compound annual growth rate (CAGR) of roughly 8.2% between 2023 and 2030. It appears that not only the military side, but also the

commercial side of the industry is projected to expand. The recovery in the commercial aerospace sector, which significantly shrinked due to the pandemic and the Boeing crisis, is expected to grow more than the defense sub-sector in global forecasts (Zion Market Research, 2024).

According to the same report, the aerospace and defense market is currently facing significant challenges related to environmental impact and regulatory compliance. The sector faces challenges regarding emissions oversight, as aviation represented 2% of global energy-related CO2 emissions in 2022, with a notable recovery in emissions post-COVID-19. To align with the Net Zero Emissions by 2050 scenario, the industry must adopt low-emission technologies and operational optimizations. However, the growing defense budgets in countries like the US, China, and India present lucrative opportunities for market expansion, with the US alone increasing its military spending to approximately 801 billion dollars in 2023, focusing on technological innovations and capability enhancements.

Market segmentation reveals a clear distinction between the aerospace and defense sectors, with the defense segment expected to dominate due to rising global military expenditures, which increased by 3.7% in 2022. The autonomous operation segment is projected to grow rapidly, driven by advancements in technology that enable vehicles and drones to operate independently. Innovations in UAV systems exemplify the shift towards autonomous systems. Thus, open innovation which may ease collaboration, knowledge transfer and cost reduction, is expected to become more attention-grabbing for the industry.

Deloitte (2024) outlines key trends and strategic priorities for 2025 and ahead, shaping the industry. The industry is expected to operate various technologies, including artificial intelligence (AI) and advanced air mobility (AAM), to enhance efficiency and meet growing demands. Technological advancements are supposed to revolutionize the industry. Companies are increasingly adopting AI for predictive maintenance and inventory optimization, which will improve operational efficiency and customer satisfaction. The focus on AAM, particularly electric vertical takeoff and landing (eVTOL) aircraft, is achieving progress, with significant investments and

interest from professional investors, indicating a shift towards sustainable urban air mobility solutions.

However, the industry faces challenges related to workforce attraction and retention. Companies are expected to implement strategies that leverage both traditional and modern approaches to build a skilled workforce, including partnerships with educational institutions. Additionally, supply chain resilience remains a priority, as the industry seeks to enhance visibility and integrity amid ongoing parts shortages and delivery delays (Deloitte, 2024). Overall, the aerospace and defense sector is expected to undergo significant transformation driven by strategic investments and technological integration, signaling the need for successful innovative products and services to remain competitive in the global market.

2.5. Turkish A&D Industry

The 1974 Cyprus Peace Operation was a turning point for the Turkish aerospace and defense industry. After the Cyprus Peace Operation, embargo on the arms imposed on the country, a new initiative has been launched to develop an independent defense industry. The establishment of the Presidency of Defense Industries (SSB) in 1985 accelerated efforts in domestic production and advanced technology development. The production, supply, and procurement of all kinds of materials to be used in the construction, maintenance, and repair of ammunition, war weapons, equipment, machines, devices, systems that the Turkish Armed Forces needed, with local resources, has begun to be established with public support. The necessary bureaucratic mechanisms, institutional infrastructure and support mechanisms in line with strategic goals were established. The industry became capable of producing under license and then designing products to a certain extent. While Türkiye was still recognized as net importer during 80s and 90s, the co-production projects have created know-how for a large number of companies to conduct indigenous projects later on. It is the period when the question "can" is replaced by the question "how much can be done?" (Ziylan, 2001; Ermiş, 2023).

In the early 2000s, the Turkish A&D industry gained significant momentum with genuine projects focused on domestic production and advanced technology development. In 2004, the Defense Industry Execution Committee (SSIK), which is the decision mechanism of SSB, declared a new strategy to support R&D expenditures, utilize foreign collaboration in the defense industry, encourage private sector initiatives, increase export potential, and create a defense industry capable of competing with global rivals. SSB cancelled all external procurement projects in which national industry was subcontractor of a foreign company and started a new procurement system in which national companies would be main contractors and the foreign companies may be subcontractors of them by supplying subsystems of main products. Under the leadership of the SSB, domestic design and production projects were conducted, and significant advancements were made through strategic partnerships and collaborations. The regulatory framework of the sector was also strengthened, allowing the defense industry to operate more flexibly and quickly. The industry started focusing on indigenous design and production instead of partial designs. In addition, development and design of advanced technologies have been supported as well as supply chain networks and cluster structures in specific areas in the ecosystem (İstikbal, 2022).

The industry remains largely controlled by the companies owned by Turkish Armed Forces Foundation (TSKGV) and SSB and continuing to follow an import substitution policy aimed at self-sufficiency. However, this approach has led to a dependency on foreign technologies for critical subsystems. There are other challenges that hinder effective policy making such as lack of coordination between civilian and military bureaucracies, outdated Cold War-era procurement processes, and insufficient interdisciplinary feedback. The industry is dealing with delays in projects, and unrealistic budget allocations that further complicate the procurement process. Moreover, the industry heavily reliant on local demand (primarily from the Turkish Armed Forces) which limits competitiveness and innovation in global markets. Dependency on foreign components exposes the sector to geopolitical risks and export license restrictions. Scholars stated that limited workforce and a lack of vertical expertise constrain innovation and technological advancement of the Turkish A&D industry (Mevlütoğlu, 2017).

The projects that were pursued in the last 20 years promoted collaboration and operation in a more flexible manner. Development and design of advanced technologies have been supported as well as supply chain networks and cluster structures in specific areas in the ecosystem (İstikbal, 2022). These projects can be recognized as the first open innovation attempts of the sector, considering the definition of OI by Chesbrough (2003) as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively". In fact, there is a partial openness, which is mostly restricted to inflow of knowledge, with limited number of partners, and without a broad strategy. It is apparent that the previous orthodox closed innovation approach has begun to change, so that this phase can be evaluated as the beginning of open innovation in the sector. We can notice the projects conducted during this period include co-operation, collaboration and co-innovation activities, which are defined as types of OI in the Oslo Manual (2018). However, scholars have not studied how far this openness has become, yet. This thesis aims to contribute the literature by examining the industry in terms of OI maturity, in a systematic way.

It is found that strategic plans and goals of the SSB have emphasized the significance of innovation (particularly R&D) regularly, since 2007. There has been a shift in the strategy that aims to enable collaboration, increase knowledge flows and ease adoption of new technologies. Meanwhile, the revenue, profit, project number and labor force of Turkish A&D sector has shown tremendous developments. Although this shift in the performance results of the industry can be attributed to many reasons, innovation may inevitably be one of the major ones.

Aerospace and defense companies have generated billions of dollars in revenue and exports in recent years. Figure 2 below illustrate the continuous growth in revenues of the Turkish aerospace and defense industry since 2002, highlighting the sector's growth potential and global competitiveness. As of 2023, the sector has become a significant actor, globally.

According to the 2023 data compared to 2022, revenue increased from 12,2 billion dollars to 15,1 billion dollars (rise 23.57%). The R&D expenditure increased from 2,1

billion dollars to 2,6 billion dollars (27.22%), and industrial labor force rose from 81 thousand to 91 thousand (12.12%) (SASAD, 2024).

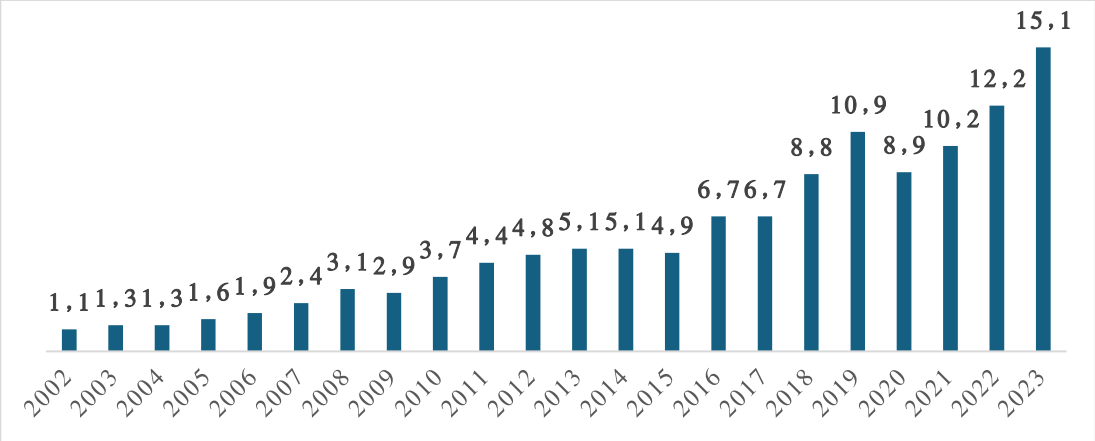

Figure 2. Turkish A&D Industry Total Revenues
(Source: SASAD Performance Reports)

Export revenues increased from 4,4 billion dollars to 5,5 billion dollars (rise 26.15%). This significant growth in defense exports reflects the global acceptance and competitiveness of Turkish A&D industry.

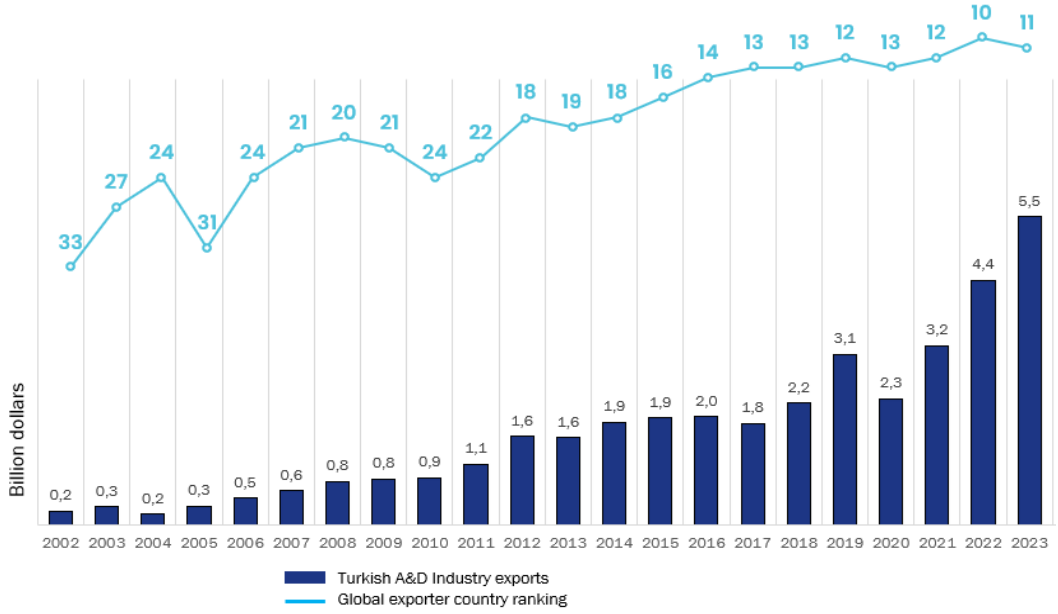

Figure 3. Turkish A&D Industry Exports and Worldwide Ranking
(Source: TİM, SİPRİ)

This growth was driven by increased exports of aerostructures, armored vehicles, unmanned aerial vehicles (UAVs), naval platforms, ammunition, and weapon systems. Over the years, Türkiye became one of the top 10 exporter in the world (Figure 3).

These successes are a testament to Türkiye's determination in the industry, supported by strategic partnerships, technological innovations, and a robust regulatory framework. A study conducted in 2007 stated that while the sector shows steady growth, however true self-sufficiency and global competitiveness requires a more holistic, forward-looking strategy (Mevlütoğlu, 2017). The scholar states that the industry must develop long-term industrial policies focused on R&D and innovation, address dependency on foreign subsystems, foster better coordination between civilian and military stakeholders, enhance export readiness by completing and maturing key platforms and prioritize interdisciplinary approaches in defense planning to adapt to modern threats.

When we have a look to the domestic market, Türkiye's military expenditures are rising in a similar manner to the global conjuncture (Figure 4).

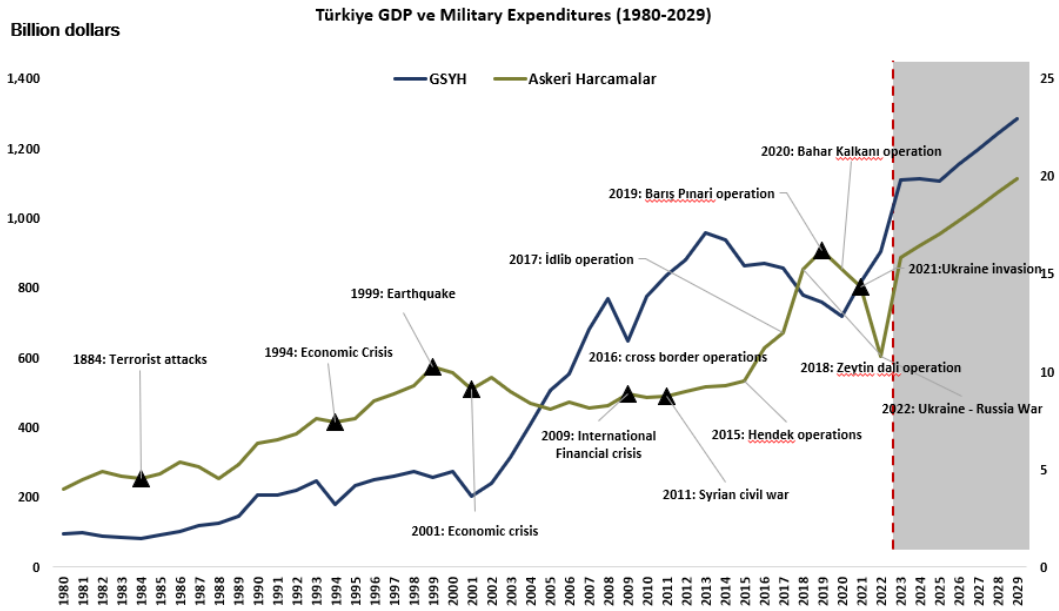

Figure 4. Türkiye's military expenditures
(Source: SIPRI, IMF)

The depreciation of the Turkish lira against the dollar and high inflation, resulted in a decrease in 2020-2022 period in military expenditures, however the expenditures showed an upward trend after 2022 and are projected to increase in the coming years. In 2023, Türkiye's increased military spending was influenced by regional security threats, defense industry investments and modernization efforts, NATO commitments and international relations, support for defense exports, and strategic independence goals, all stemming from its geopolitical position (SIPRI, 2024; IMF, 2024).

Not only the revenues and expenditures but also R&D spending is increasing in Türkiye A&D sector. A&D companies constitute the main element of the total growth in R&D. In this sense, defense industry companies made up 65.5% of the total R&D investments of the top 50 companies in 2023. This rate was 67.3% in 2022 (Turkishtime, 2023). According to "Türkiye 2024 R&D and Innovation" report, currently, 31% of R&D expenditures in the manufacturing sector are made by this sector (10 years ago this rate was 10%) in Türkiye. TUSAŞ alone became the company with the highest R&D expenditure in Turkey with an R&D expenditure of 28 billion TL (SER, 2024).

The Turkishtime's 2023 Türkiye R&D 250 research reveals that 5 out of top 10 companies are operating in A&D industry. According to the report, TUSAŞ (Turkish Aerospace Industries Inc.) has made the highest R&D expenditure in 2023, amounting to 28,2 billion TL. This figure indicates that TUSAŞ has doubled its R&D investments compared to the previous year. ASELSAN has made an R&D expenditure of 9.9 billion TL in 2023, placing it in second position on the list. Another significant defense firm, Roketsan, ranks third with its R&D expenditure of 2,2 billion TL. Together, these three companies have made significant R&D investments in the aerospace and defense sector, greatly contributing to the country's technological development efforts. The A&D industry is the main contributor of R&D activities in the country along with the automotive industry. According to information released by TUIK on November 16, 2023, R&D expenditures in Türkiye have steadily increased from 1,2 billion dollars in 2002 to dollars 12 billion in 2022. Similarly, the share of R&D expenditures in GDP rose from 0.51% in 2002 to 1.32% in 2022. This upward trend is a positive development. However, considering that the share of R&D expenditures in GDP is

around 3% in developed economies and the OECD average, Türkiye still has progress to make in this area. According to OECD data, Türkiye needs to increase its R&D intensity to enhance its global competitiveness.

According to the 2023 Türkiye R&D 250 research, upon industry-specific evaluation of the companies that have obtained national patent protection in 2023 in Türkiye, it is apparent that A&D industry has outstanding results. 7 A&D companies have taken place among the top 50 companies in terms of most national patent applications (Turkishtime, 2023).

2.6. Future Goals of Turkish A&D Industry

SSB (2024) recently announced 2024-2028 Strategic Plan and put forward its vision and targets for the upcoming period. The Turkish Aerospace and Defense Sector is planning to become a global brand that promises peace with its innovative and competitive technologies. By having a share in directly or indirectly nearly 90 defense industry companies, SSB has the right and duty to structure Turkish defense industry with more than 2500 companies and an ecosystem including sector organizations, research facilities and universities, not only officially and but also practically. Sustainability, competitiveness in the globe, localization and nationalization of products and talents and being a pioneer in technology are focus topics in the next five years. (SSB, 2024a).

The industry is going to reach its vision in accordance with its basic values which are sustainable change, value-based competency, innovative leadership, national product and technology development, accountable and trustworthy communication and overarching and participatory partnerships. The strategic plan's objectives are grounded upon these values. The first objective of the sector is to enable competitive and sustainable industrial development. In accordance, one of the main goals of Turkish policy makers will be to sustain and enhance collaboration mechanisms to increase export volume of the industry. Especially, mechanisms with multi-partners will be supported to develop industry export volume. The second objective of the industry is to develop technologies and competencies that will guide the future of the

sector, with national resources. In fact, government support and investments that will provide an overarching and stable development is expected to continue in the upcoming years to achieve that aim. Also, the industrial ecosystem will be enforced to build a resilient supply chain. The third objective is to develop institutional and industrial capacity of the industry. Hence, planning and coordination activities with friendly and allied nations is planned to be improved.

Those strategic objectives are expected to promote Turkish aerospace and defense sector so that Türkiye will become one of the top 5 exporters in the world in 2028. Türkiye's 12th Development Plan (2024-2028) categorizes A&D industry as a prioritized development area and it is aimed to meet the country's defense and security needs by maximizing the use of national technologies and capabilities, to enhance the competitiveness of the aerospace and defense industry on a global scale, and to elevate it to a level that produces significant economic value for our country by also ensuring the dissemination of skills acquired in the defense industry to the civilian sector. SSB's strategies are designed to align with that plan. Industrial goals are written down as increasing the technological depth and domestic production rate of the defense industry, keeping foreign dependency at the lowest possible level, ensuring the sustainability of the defense industry ecosystem, and focusing on groundbreaking technologies (SSB, 2024a). To ensure this breakthrough, assessing and increasing the maturity of open innovation of the sector may be quite important, considering the promised benefits outlined in the literature.

Moreover, SSB emphasizes the widespread adoption of dual-use applications especially in the field of artificial intelligence as a sectoral strategic goal in its sectoral strategy document published in 2024 (SSB, 2024b). Dual use is critically important for the defense industry because the use of the same technologies for both military and civilian applications reduce costs and ensures the efficient use of resources. This approach fosters innovation, allowing for the rapid integration of developments in the civilian sector into the military domain. Additionally, it provides strategic flexibility to meet security and defense needs. Dual use offers an international competitive advantage and is supported by legal regulations, making it one of the cornerstones of modern defense industry. As Mowery (2012) argues, defense R&D investment has

impacted innovation in the civilian sectors of several OECD countries. The increasing significance of dual-use and civilian-origin technologies, combined with evolving national security needs and decreasing GDP growth rates, global economic instability has altered the dynamics of defense technological innovation (James 2009).Thus, purposively leveraging open innovation activities is more than an intention for Turkish A&D industry for achieving ambitious goals of SSB.

To understand the emerging open innovation practices in the Turkish A&D sector, it has been necessary to turn to open sources instead of academic ones, as researchers have almost not ventured into this field. According to the results of open-source website monitoring, a few companies in Türkiye have declared open innovation policies and programs. TUSAŞ, ASELSAN, Havelsan are mentioning about their open innovation activities and contests on their websites. However, there has not been any article published focusing on the sector's OI understanding yet. This research as a pioneer in this field, is expected to contribute to unfold the relationship between Turkish A&D industry and OI maturity.

2.7. OI Maturity

In recent years, innovation and innovative products and services have become fundamental to the success of not only individual businesses but also entire regions and economies. Scholars increasingly argue that the survival of organizations today hinges on their ability to innovate continuously, rather than relying on isolated innovations. This shift in perspective emphasizes the importance of an organization's innovation capability, which is the capacity to transform resources effectively to foster innovation. Lawson and Samson (2001, p. 384) define innovation capability as the "ability to continuously transform knowledge and ideas into new products, processes and systems for the benefit of the firm and its stakeholders". Drucker (1997) argues that for a firm to foster continuous innovation, it must effectively apply knowledge to enhance its own knowledge base. More generally, innovation involves departing from, altering, and improving established practices, which is crucial for firms to maintain flexibility and ensure their survival (Mintzberg et al., 2003, p. 406). Birchall and

Tovstiga (2005, p. 4) assert that innovation capability is likely the most critical capability a firm can possess.

Innovation capability is closely related to the concept of innovation maturity, which assesses how well organizations utilize their resources, including their innovative potential. Innovation capability plays a critical role in shaping an organization's innovative outcomes and its competitive edge; however, this relationship is driven by the evolution of dynamic capabilities (Wang, Ahmed, 2007; Zhang, Garrett-Jones, and Szeto, 2013). As discussed in the previous section, this thesis supposes that measuring innovation maturity under a capability-based view is appropriate since a company needs certain capabilities to transform resources effectively to innovative outputs.

The maturity concept originates from psychologist Argyris (1968), emphasizing that individuals achieve maturity through gradual skill acquisition, requiring planning and action. In a business context, maturity involves defining, managing, measuring, and controlling processes effectively. This contrasts with readiness, which is assessed before the maturation process begins, while maturity captures the current state during maturation. Enhanced maturity leads to more consistent and repeatable processes, minimizing discrepancies between planned and actual outcomes, thus enhancing performance. Maturity is characterized by the development of systems and processes that ensure high success rates, where management practices become institutionalized, reducing reliance on individual professionals. Companies utilize maturity models to evaluate their current status, prioritize improvement actions, and monitor the implementation of these actions (Honarato and Melo, 2022).

Research on corporate performance measurement indicates that it enables managers to effectively plan and manage their organizations and is crucial for attaining company objectives (Chiesa et al., 2008; Hauser, 1998). Performance measurement plays a vital role in decision-making, motivating employees, fostering learning, and enhancing effective communication and coordination (Loch and Staffan Tapper, 2002). Deciding the objective of measurement, what to measure, the method, data collection and resolving conflicts within the measurement system are the most important factors in a

measurement system (Neely et al., 1996). Thus, designing appropriate metrics is essential for performance measurement models.

Measuring performance through maturity of a concept is a relatively new approach. The literature argues that there is a positive correlation between process improvements and organizational performance. Paulk et al. (1993) argue that maturity involves the institutionalization of processes through policies, standards, and organizational structures. The establishment of additional components within the process correlates with increased maturity and enhanced capabilities of the process. In order to assess the level of maturity and identify areas for improvement, they introduce a Capability Maturity Model (CMM) in 1993, which is still respected as the cornerstone of capability maturity models. This model distinguishes five levels of maturity: initial, repeatable, defined, managed and optimizing.

Later in 2009, a maturity model for measuring innovation capability was developed by Essman and du Preez. They discussed the elements that enhance innovation capabilities of companies. These include the rising standards of innovation, continuously increasing rates of diffusion, and growing complexity that necessitates greater multidisciplinary collaboration. Additionally, they claimed that there was an urgent need for improved cooperation and communication among scientists, employees, and between inventors and consumers. The need for greater creativity from both creators and consumers, coupled with an expanding range of innovation to meet expectations from centers of excellence and consumers, highlights the importance for organizations to attain consistent innovation. This consistency is crucial as it serves as the main determinant of competitive advantage and a means to sustain that advantage.

Essmann and du Preez (2009) recognized the significance of developing and enhancing organizational innovation capabilities, and their research was initiated to identify the essential components that contribute to innovation capability. These components were then integrated into what is termed the Innovation Capability Maturity Model (ICMM), which is based on the original Capability Maturity Model developed by Paulk et al. (1993). They talk about three dimensions: innovation capability construct, organizational construct and capability maturity. They label five

levels of innovation maturity which basically focus on internal R&D. Considering the potential advantages of maturity models, there has been a growing interest in assessing how effectively a firm's capabilities can consistently generate innovation, particularly following the introduction of the ICMM in 2009. This thesis focuses on that time period of 15 years, 2010-2024 and systematically review the existing models in order to understand the current innovation maturity concept and contribute to the literature by developing less worked on phenomena, open innovation.

Enkel et al. (2011) is the first who tried to measure open innovation processes within organizations in a maturity framework. They propose that maturity measurement may help continuous improvement and development in quality and effectiveness of open innovation. They have reviewed the previous performance measurement and innovation measurement literature and proposed that the effectiveness of open innovation activities is positively related with partnership capacity, innovation climate and having internal systems and tools like IP protection. They have labeled five maturity levels after testing and optimizing the maturity framework.

The previous framework developed for open innovation maturity has been reviewed after 9 years by Enkel, Bogers and Chesbrough in 2020, due to the rapid developments in digitalization. The authors are discussing that there is a tendency in the market from being a traditionalist to a modernist and finally to a visionary state of open innovation. Digitalization has a severe effect on this framework because digital technologies and transformation are directly connected with companies' ability, desire and strategy to utilize external sources via open innovation activities (Enkel et al., 2020). Enkel et al. (2020) propose that there are important research areas which will attract open innovation scholars interested in digitalization. For example, the nature of collaboration, partnerships, methodology of OI in digital age and technologies are open study areas. In fact, global aerospace industry is intensely passing through the digital transformation process (PwC, 2018; Deloitte, 2024). Turkish A&D sector has to experience this paradigm shift inevitably. Thus, there is a need in the sector to realize how their openness will be affected by this transformation, whether they are willing to be more or less open in a digital world and how their collaborations, partnerships, OI tools and activities will be affected.

As Wendler (2012) notes, a well-designed maturity model comprises a series of clearly defined stages or levels that outline the development of the assessed enterprise in a clear manner. The specified stages should follow a sequential order and demonstrate hierarchical progression. Furthermore, these stages should be closely associated with the structures, activities, stages, or levels utilized to evaluate the completeness of the analyzed entities through various multidimensional criteria. The areas most frequently cited in the literature as influencing the development of innovation capabilities in enterprises include: organizational culture (Saunila and Ukko, 2014; Lambrou, 2016), knowledge management (Nieves, 2016; Blommerde and Lynch, 2016; Ullah et al., 2017), strategy (Saunila and Ukko, 2014; Blommerde and Lynch, 2016; Lambrou, 2016), the scope of innovation activities (Wang and Ahmed, 2004; Lambrou, 2016) and customer involvement (Rapaccini et al., 2013; Blommerde and Lynch, 2016). In this thesis, all and further areas are examined and maturity dimensions were carefully selected after a systematic literature review and expert review, to create an maturity model based on dynamic capabilities view. In addition, digital technologies are given a special emphasis while developing our maturity model.

2.8. Systematic Literature Review (SLR): Open Innovation Maturity Models

To recognize and comprehend the scopes and aspects of the current firm-level innovation maturity models, we have conducted a systematic literature review. This is a method for assessing all available research relevant to a particular research question, issue, or phenomenon of interest. We also aimed to determine the gaps in the innovation maturity literature and draw a scheme in order to propose a new maturity model for Aerospace and Defense industry in Türkiye. The report of Kitchenham and Charters (2007) guided this thesis for this literature review (Figure 5).

2.8.1. Digital libraries and keywords

Four digital libraries (Google Scholar, IEEE Xplore, Science Direct and Scopus) were selected for this literature review. The studies written on “innovation maturity models” conducted between the years 2010 and 2024 and published in one of these four academic digital libraries in the form of book chapters, conference papers and journal

articles are considered. Although this research proposes to develop an “open innovation maturity model”, the literature search was conducted on a broader perspective and a general review for all “innovation maturity models” were considered.

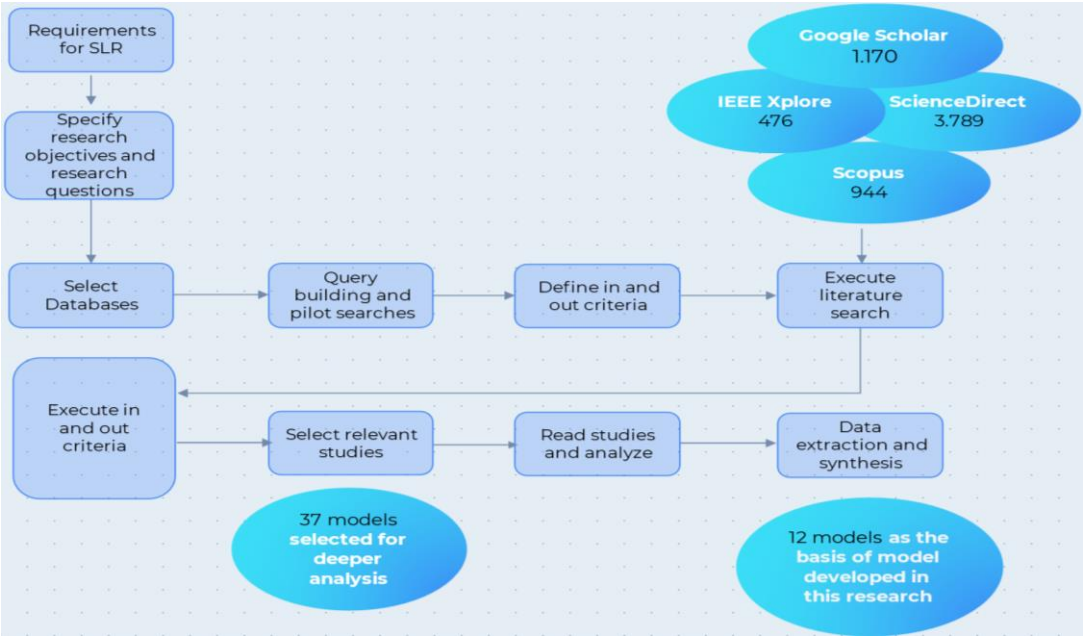

Figure 5. SLR Procedure

(Source: Author’s own figure)

Various keywords were tried to ensure that pertinent studies would be incorporated into the search results. Exploring the concept of "innovation" in digital libraries is quite complex due to a variety of factors. First of all, ‘‘innovation’’ is defined in several different ways in different scientific fields. For instance, while research and development (R&D) and "innovation" are commonly used interchangeably, they are not the same thing. Also, the term "innovation" refers to both an idea and a process that varies depending on its use. Sometimes "innovation" refers to the entire product life cycle process, while other times it only refers to the innovation process's final commercialization phase. Thus, we preferred to look up for “innovation maturity” as the concept instead of searching for “innovation” and “maturity” as two categories. The other concepts we used interchangeably during the literature search were model, capability, readiness, assessment and index, as the second search category. Table 1 includes the keywords used to construct the queries used in digital libraries.

Table 1. Initial set of keywords comprising the main terms

Concept	Keywords
(Open) Innovation Maturity	Innovation maturity, open innovation maturity, innovation capability, open innovation capability
Model	Model, assessment, index

(Source: Author's own construction)

2.8.2. Query building

Different search queries were constructed for different libraries, once the search terms were determined. Each digital library has certain limitations; thus, the search strings are designed accordingly. Due to the multifaceted nature of innovation, the strings are built again and again to narrow the search results adequately, since broader queries produced an unmanageable number of results (i.e., more than 60 K). After some pilot searches the queries were decided as given in Table 2.

Table 2. Queries Used in Search Engines

Google Scholar	"innovation capability model" OR "innovation capability index" OR "innovation maturity model" OR "innovation maturity index" OR "innovation maturity assessment" OR "innovation capability assessment"
IEEEX	(("Abstract":"innovation capability model") OR ("Abstract":"innovation maturity model") OR ("Abstract":"innovation maturity assessment") OR ("All Metadata":"innovation capability assessment"))
Scopus	TITLE-ABS-KEY ((innovation OR "open AND innovation") AND (maturity OR capability) AND (model OR index OR assessment)) AND PUBYEAR > 2009 AND PUBYEAR < 2025 AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "ch"))
Science Direct	Title, abstract or author-specified (innovation OR open innovation) AND (capability or maturity) and (assessment or index or model) 2010-2024

(Source: Author's own construction)

2.8.3. Inclusion criteria and the first pool of research

The inclusion criteria used for selecting the first pool of research used in this study are listed in Table 3. There are three inclusion criteria considered to determine the pool for this research.

The publication year (I1), document type (I3) and language (I3) in which the research is published are the three inclusion criteria. These inclusion criteria are supposed to assure that the studies chosen are written in English and published in the last 15 years and in reputable journals, conferences, or books. The academic popularity of open innovation has increased rapidly within this period. Due to the multifaceted structure of innovation, different fields of study were reviewed. A large scope of academic fields was reviewed to have a comprehensive research pool. In fact, innovation is an area of business management by nature and finds large application areas in engineering and social sciences. These four digital libraries revealed a total of 6.379 studies after employing the three inclusion criteria**:**

- **Scopus** 944 results, 593 article 269 conference paper 82 book chapter
- **Science Direct** 3.789 results, 3.244 research articles, 402 book chapters, 143 conference abstracts.
- **IEEEX** 476 results, 79 journals, conferences 374, books 23
- **Google Scholar** 1.170 journal articles

Table 3. Inclusion Criteria

ID	Criterion	Explanation
I1	Publication year	Studies published between 2010 and 2024.
I2	Document type	Book chapters, conference papers, journal articles
I3	Language	English

(Source: Author's own construction)

2.8.4. Exclusion criteria and fundamental research

Three exclusion criteria were designed to determine the fundamental studies for this thesis (Table 4). Duplicated studies (E1) and the ones not assuring academic quality

(E2) were excluded while determining the research scope of this thesis. Scopus was determined as the core library and duplicates are extracted from the other libraries. The last exclusion was done via expert review by reading the title and abstract of articles. Innovation is an immense concept, so studies practicing innovation in order to complete tasks, improve specific modules or processes, such as e-commerce, medicine, and human resources were eliminated. The ones that only aim to empirically test a pre-developed model were omitted (E3).

Table 4. Exclusion Criteria

ID	Criterion	Explanation
E1	Duplication	Studies that are duplicated in different libraries were excluded.
E2	Academic relevance	To sustain quality, documents with no citations were eliminated
E3	Scope relevance	Relevant studies were selected by experts via review of title, abstract, industry, aim and methodology.

(Source: Author's own construction)

The remaining 37 studies out of 6.379 are selected to be examined further to come across dimensions of maturity, a framework or model, theoretical basis and/or methods, that may leverage proposal of an (open) innovation maturity model (Appendix B).

2.8.5. Core models chosen after SLR execution

The 37 studies were analyzed and their purpose, methodology and empirical aspects were examined deeply. These studies were employed to prepare a pool of open innovation factors mentioned in the literature. Some of them are review articles, some are not for company level, and others are applicable for service industries. We used these studies not to miss a single factor that may be significant for A&D industry. The dimensions and sub dimensions of innovation, especially open innovation, were examined and Table 5 has been constructed accordingly.

There has been an increasing effort to develop an innovation maturity index, since 2010. However, studies about open innovation maturity are rare in literature. Besides, digital technologies and their effect on innovation maturity is a relatively new concept. In fact, digital tools and their effect on collaboration, knowledge management and the value chain as a whole are related with external and internal flows of knowledge. This thesis seeks to contribute to the existing literature by developing a new maturity model that focuses on open innovation and covers one of the catalysts of OI, digital technologies.

Table 5. Dimensions and sub-dimensions of innovation

Dimensions and Sub-dimensions	**Academic Reference**
Digitization	1, 4, 13, 20, 22, 30
Digital tools	1, 4, 13, 20, 22
Digital transformation	1, 13, 20, 30
Innovation culture	3, 5, 6, 8, 10, 11, 12, 13, 16, 17, 23, 25, 26, 27, 29, 32, 34, 35
Collaboration	3, 10, 11, 20, 22, 27, 32
Incentives	21, 22, 27, 32, 36
Innovation ecosystem	5, 6, 7, 12, 13, 15, 16, 18, 23, 24, 32, 35, 36
Organizational context	6, 14, 13
Motivation and empowerment	9, 10, 21, 32
Risk taking	3, 10, 19
Tolerance of failure	3, 10, 32, 36
Innovation Strategy	2, 3, 4, 5, 6, 7, 9, 10, 15, 16, 18, 19, 20, 21, 25, 26, 27, 28, 32, 33, 36
Communication of Innovation Strategy	3, 5, 9, 10, 15, 19, 26
Market analysis	3, 4, 10, 15, 16, 19, 24, 26, 32, 37
Leadership	3, 9, 12, 13, 20, 22, 35
Knowledge Management	11, 14, 19, 21, 22, 32, 23
External knowledge acquisition	3, 13, 14, 27, 28
Knowledge sharing	3, 11, 14, 20, 21, 26
External networks	3, 5, 6, 7, 12, 13, 15, 16, 18, 25, 24, 26, 35, 36
Organizational Learning	5, 10, 15, 21, 22, 23, 25, 26, 33, 36
Absorptive capacity	14, 15, 31

Table 5 continued	
Fact-based criteria system or KPI	3, 11, 15, 19, 25, 37
Learning ability	5, 21, 22, 26
Sharing innovative achievements	3, 20
Process & Governance	2, 5, 6, 7, 10, 11, 12, 13, 14, 15, 16, 18, 19, 21, 22, 21, 24, 25, 27, 31, 32, 33, 34, 35, 36, 37
Existence of formal innovation process	1, 3, 4, 5, 9, 11, 14, 16, 19, 20, 21, 33, 34
Project Management	16, 19, 26, 34, 37
Portfolio Management	3, 5, 10, 18, 19, 37
Management techniques and practices	4, 20, 36, 32, 34, 37
User Involvement within the process	3, 10, 21, 27
IP Management	22, 26, 27, 37
Organizational Structure	9, 17, 26, 27, 34
Resource allocation	3, 19, 22, 23
Technology	2, 16, 19, 23, 24, 25, 29, 32, 37
Technological Capability & Management	2, 13, 16, 19, 25, 26, 31, 32, 37

Source: Author's own construction

Another contribution of this thesis to the literature is the sectoral ground: Aerospace and Defense Industry. A&D sector is known for its security concerns as well as long project life cycles and R&D expenditures. Studying open innovation maturity in A&D sector may seem paradoxical but offers valuable benefits to the sector as mentioned in previous sections.

Based on the work of Tranfield et al. (2003), the findings of this systematic literature review (SLR) were separated into two sections. The first section presents a descriptive analysis of the field, whereas the second section provides a thematic analysis that highlights the main emerging themes and the degree of consensus concerning these themes.

This thesis has selected 12 out of those 37 models, as an anchor to develop a new maturity model to measure Turkish aerospace and defense industry's open innovation maturity. In addition to the findings of SLR executed here, Essman et al.'s model

(published in 2009) which has influenced a large audience, was added to the essential studies chosen. These 12 fundamental models were deeply studied and presented in Methodology Chapter. After the pool of OI dimensions were constructed according to the preliminary set of 37 studies, we picked only 12 of them to build a model on due to reasons like theoretical background, empirical capacity and appropriateness for A&D industry and methodological accountability.

The models presented in Caird et al. (2015), Enkel et al. (2011 and 2020) and Kebure et al. (2023) are focused on open innovation. Only 4 out of 37 reviewed models (4, 14, 15, 24) have looked at the innovation concept with the lens of openness. Furthermore, digital technologies have not been paid enough attention regarding their effect and presence in innovative activities. 7 studies searched for IT support tools as a dimension of innovation maturity and only 4 of them (1, 15, 22, 24) assessed digital technologies and digital transformation as an innovation factor, particularly.

2.8.6. Dimensions of Innovation Maturity

The dimensions (capabilities) identified as effective in open innovation maturity have been systematically categorized in this literature review, as illustrated in Table 5. However, decision regarding which of these dimensions will be incorporated into the proposed model is attained following the steps outlined in the methodology section of the research. Consequently, the positioning of these dimensions within the existing literature will be elaborated in the next Chapter "Final Maturity Index." Section.

2.9. Concluding Remarks

This thesis emphasizes the pivotal role of open innovation (OI) in transforming the aerospace and defense (A&D) sector. As the industry grapples with escalating development costs, stringent regulatory requirements, and the urgent need for both to develop and to adopt rapid technological advancements, leveraging OI practices becomes essential for driving innovation and sustaining competitive advantage. By leveraging external knowledge and fostering collaborative relationships, organizations

can enhance their innovation capabilities and respond more effectively to the complexities of the changing market landscape.

The global A&D industry has experienced rapid growth in recent years, mainly due to technological advancements, increased demand for air travel, and rise in defense spending due to geopolitical tensions. The Turkish A&D sector is poised to benefit from these trends. Despite the growth, the industry faces challenges related to environmental impact and regulatory compliance, particularly concerning emissions and sustainability. Companies are increasingly adopting low-emission technologies to align with global initiatives such as the Net Zero Emissions by 2050 scenario. Key trends for the future include the integration of artificial intelligence (AI) and advanced air mobility (AAM) technologies, which are expected to enhance operational efficiency and meet growing demands. Overall, the A&D sector is undergoing a transformation driven by strategic investments and technological integration, highlighting the need for innovative solutions to remain competitive in the global market.

Literature highlights the necessity for organizations to develop dynamic capabilities that enable them to sense, seize, and transform opportunities effectively. These capabilities are crucial for navigating the complexity of contemporary innovation ecosystems, where external collaborations and knowledge flows play an increasingly significant role. This is a reality for A&D sector, too. By cultivating a more open approach to integrating both internal resources and external insights, A&D industry can enhance their capabilities, ultimately leading to more successful innovation outcomes.

The introduction of an OI maturity model specifically designed for the Turkish A&D sector represents an innovative attempt in understanding how organizations can evaluate and improve their innovation capabilities. This model offers a structured framework for assessing the current state of OI practices and identifying areas for enhancement. By focusing on a balanced approach that marries internal strengths with external partnerships, the model aims to foster a culture of innovation that is not only sustainable but also aligned with the evolving demands of industry.

As the global A&D landscape continues to evolve, it is imperative for stakeholders within the Turkish sector to adopt a proactive stance toward open innovation. This involves not only forming strategic partnerships and collaborations but also investing in digital technologies that facilitate knowledge sharing and innovation. The insights gained from this research provide a foundation for future studies and practical applications, encouraging organizations to engage in continuous improvement and adaptation in their innovation strategies.

Ultimately, the successful implementation of open innovation strategies can empower the Turkish A&D industry to emerge as a significant global player. By addressing both current and future challenges, the sector can contribute to technological advancements, and economic growth, reinforcing its position in the international market. The findings of this thesis not only advance academic understanding but also offer practical guidance for A&D industry practitioners seeking to enhance their innovation capabilities and drive sustainable growth.

CHAPTER 3

METHODOLOGY

The lack of a clear theory of open innovation, its interdisciplinary nature, and the characteristic features of the A&D sector were taken into consideration, while designing the methodology of this research. First, an academic definition of what is meant by open innovation was adopted, ensuring that this definition aligned with the realities of the A&D sector. This is because the concept, which falls within the scope of many different disciplines, involves a fragmented literature as well as a practical dimension, and efforts were made to place it within a specific framework. On the other hand, the understanding of information security concerns in the A&D sector, the impact of disruptive technologies, and the long-term and high-cost projects required careful selection of the dimensions of open innovation maturity model.

The theoretical basis of this research is constructed on a capability-based view which is the most scholarly accepted ground for understanding innovation maturity in academic literature. In fact, the findings of the SLR conducted for this research state that 23 models out of the 37 selected models depend on a capability-based view, while 4 of them use resource-based view and the others work with other theories. We employ capability-based view not only because the most influential models in literature trust upon it (Dervitsiotis, 2010; Enkel et al., 2011; Enkel et al., 2020; Essmann and Preez, 2009; Paulk et al., 1993; Saunila and Ukko, 2012) but also, organizational capabilities leverage the firm's evolutionary ability to continuously redefine its technological and organizational boundaries and seize new market opportunities (Teece, 2007). We clarify capabilities in this thesis as Richardson's (1972) "knowledge, experience, and skills," and as Teece's (2007) dynamic capabilities which imply "integrating, developing, and reconfiguring internal and external resources and competencies to respond to and influence rapidly evolving business environments".

One of the most influential studies in OI innovation maturity, Enkel et al.'s (2020) research, defines a "visionary maturity" level in OI, that employs Teece's (2007) dynamic capabilities framework. We propose a dynamic structure rather than a static resource based one in this this research, because a company that aims to pursue open innovation requires dynamic capabilities, which involve the ability to perceive and respond effectively to environmental changes, mobilize partners within a network, and coordinate these partners in adapting cooperative and competitive activities (Bogers et al., 2019). Moreover, empirical research indicates that the level of openness required varies among companies, influenced by factors such as industry, the speed of innovation, corporate strategy, market positioning, and technological requirements (Enkel et al., 2009). A&D industry is a living example of this paradox. The industry requires the ability adapt to environmental changes, exploit knowledge networks, and collaboration to stay competitive. On the other hand, the industry is suspicious about the optimum degree of openness due to regulatory barriers, security concerns and long project development cycles. Here, "dynamic capability perspective" becomes appropriate for A&D industry, because it entails that organizations should not only focus on external knowledge per se but also realize that open innovation is as much about 'leveraging and enhancing internal capabilities as well' (Bogers et al., 2019, p. 84).

We highlight that dynamic capabilities are needed to turn internal and external novelty efforts into innovation. Saunila and Ukko (2012) explain that relationship and emphasize that higher levels of innovation maturity often led to enhanced dynamic capabilities. Organizations that have developed robust innovation processes are better equipped to respond to changes in their environment. Conversely, strong dynamic capabilities can foster innovation maturity by enabling organizations to adapt their innovation strategies and processes in response to market demands.

Our thesis employs Lawson and Samson's (2001) definition of innovation capability for this thesis: the capacity to consistently convert knowledge and ideas into new products, processes, and systems that benefit the firm and its stakeholders, to seek a model to measure innovation maturity. Therefore, innovation capability encompasses the ability to utilize limited resources effectively to manage and implement innovation.

(Stawasz, 2014; Inków, 2019 and 2024). Innovation maturity is pursued through innovation capabilities in this thesis. Scholars have studied what is meant by innovation maturity and defined it as the ability to effectively leverage the resources of an enterprise, including its innovation capability (Corsic and Neau, 2015; Zalesna, 2013). Innovation maturity occurs when a company recognizes the critical role of innovation in achieving market success. Thus, innovation is seen as an integral part of both the company's operations and its growth (Spoz, 2019). The innovation maturity of an organization can be assessed through its dynamic innovation capabilities; a greater innovation capability leads to more innovative solutions, which subsequently enhances the organization's overall level of innovation maturity

Innovation maturity is not a new issue, yet it remains a "hot" topic. Measuring innovation maturity through models can act as effective tools for self-assessing a company’s level of innovation maturity and pinpointing areas where improvements are needed within the organization. Addressing deficiencies can help to elevate the organization to a higher level of innovation maturity. This research proposes a maturity model for open innovation which was under-studied previously. The SLR of this research indicates that only 4 models were developed in the last 15 years for measuring OI maturity. Furthermore, the 2 models which studied innovation maturity at A&D sector lacked open innovation perspective. Moreover, only 6 models talk about digital technologies and/or their effects on innovation, despite the fact that digital technologies have direct and indirect effects on innovation maturity of a company (Enkel et al., 2020; Bogers et al., 2017; Bereznoy et al., 2021). Maturity models can provide a company with the opportunity to see its development in a particular area over the years and allow for comparisons between different units and with other companies. In this sense, models with weighted parameters can help to make greater use of these benefits. However, only one model utilized a weighted approach. This thesis aims to develop a weighted model, so that more quantified and traceable results can be obtained.

The systematic literature review detailed in the previous section constitutes the first step of the methodology developed in this thesis. Systematic literature review (SLR) assesses the current understanding in a particular field and enables a methodical, multi-

step process for analyzing a substantial volume of literature over long durations (Tranfield et al., 2003; Denyer and Neeley, 2004). The reason for starting the methodology with a systematic literature review (SLR) was to examine the models related to innovation maturity over the past 15 years and to use the findings obtained as a foundation for designing my own model. Moreover, SLRs are becoming more common in the social sciences to provide a reliable and comprehensive process that reduces subjective bias and the chances of overlooking important literature (Mangas-Vega et al., 2018). For scholars, a SLR enhances methodological rigor and reveals new avenues for research (Briner and Denyer, 2012). Conducting SLR for this research has revealed the fact that OI maturity was scarcely studied in literature and A&D industry has stayed out of this scope, despite the increasing prevalence of OI (Open Innovation) practices in the sector, in recent years.

3.1. Research Design

The methodology of this thesis is designed in two sections. In the first part, a maturity model (MM) employing a capability-based view has been developed. This model is intended to measure the open innovation maturity of companies operating in Turkish A&D sector. The model consists of 16 dimensions which are assumed to affect open innovation maturity and 5 maturity levels. The dimensions of the model have been weighed using the AHP method and prepared in a questionnaire format. In the second part of the research, the developed model has been applied in an OEM sector company and its leading subcontractors to gain insights into the open innovation maturity of the sector. The summary of methodology is presented in Figure 6.

3.1.1. Model Development

The two essential goals of a capability maturity model are (Essmann, 2009, p. 36) to determine the capability maturity of an enterprise in terms of a specific domain of practice and consequently to facilitate enhancements that are most suitable for the organization. These two goals attracted attention and dragged along scholars and practitioners from different theoretical and empirical areas.

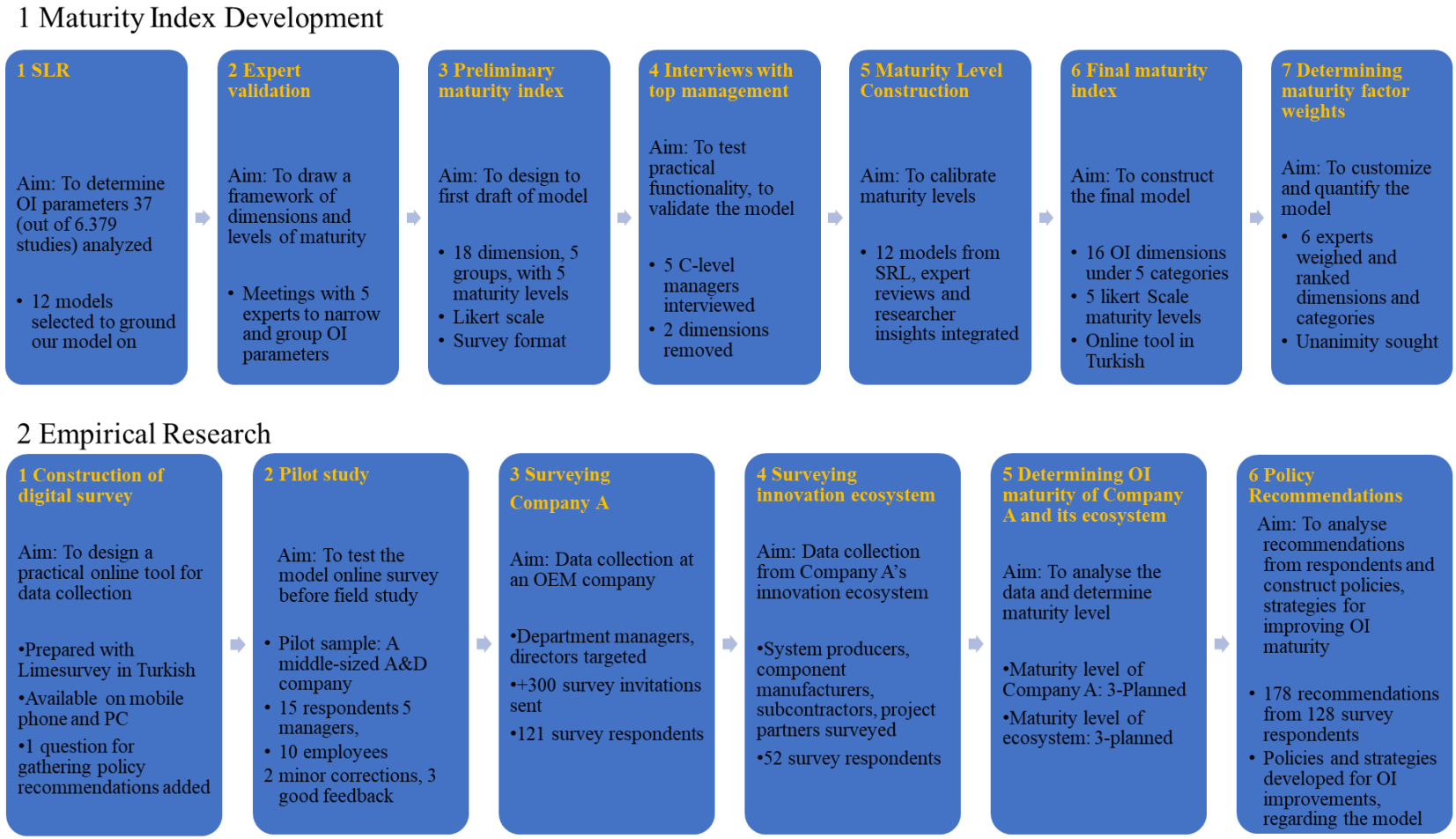

Figure 6. Methodology of the Research
(Source: Author's own construction)

Numerous maturity models have been developed in various application fields since the Software Engineering Institute introduced the Capability Maturity Model (Paulk et al., 1993), nearly three decades ago. However, maturity models face criticism regarding their design and application processes.

The major criticisms stated are lack of empirical foundation, neglect of multiple paths, inadequate documentation and proliferation of similar models (Röglinger and Pöppelbuß). The SLR conducted for this thesis finds out that most of the innovation maturity models lack practical foundation and have inadequate documentation. Moreover, the majority of models (solely depend on inferences from previous models without any theoretical framework). Scholars have addressed these shortcomings and offered methodologies for designing maturity models (Becker et al., 2009; Mettler, 2011; Röglinger and Pöppelbuß, 2011).

This research utilized the framework proposed by Röglinger and Pöppelbuß (2011) which argue for a comprehensive understanding of design principles that can enhance design and effectiveness of MM and guide researchers for systematically developing one. The framework was chosen from a range of articles based on literature research that incorporates practical and pragmatic support for capability maturity model development, as well as citation counts as criteria for selection. They proposed general design principles (DPs) categorized into three groups. Basic principles emphasize the importance of clear documentation, central constructions related to maturity, and target audience considerations.

Descriptive principles focus on establishing verifiable assessment criteria and structured methodologies for conducting evaluations. In contrast, prescriptive principles provide specific improvement measures and decision-making guidance tailored to organizational needs (Table 6). This research employs and adopts the basic (1) and descriptive (2) design principles in order to develop a descriptive OI maturity model for Turkish A&D industry.

Table 6. General Design Principles for MM building

(1) BASIC
1.1 Basic information
a) Application domain and prerequisites for applicability
b) Purpose of use
c) Target group
d) Class of entities under investigation
e) Differentiation from related maturity models
f) Design process and extent of empirical validation
1.2 Definition of central constructions related to maturity and maturation
a) Maturity and dimensions of maturity
b) Maturity levels and maturation paths
c) Available levels of granularity of maturation
d) Underpinning theoretical foundations with respect to evolution and change
1.3 Definition of central constructs related to the application domain
1.4 Target group-oriented documentation
(2) DESCRIPTIVE
2.1 Intersubjectively verifiable criteria for each maturity level and level of granularity
2.2 Target group-oriented assessment methodology
a) Procedure model
b) Advice on the assessment of criteria
c) Advice on the adaptation and configuration of criteria
d) Expert knowledge from previous application
(3) PRESCRIPTIVE
3.1 Improvement measures for each maturity level and level of granularity
3.2 Decision calculus for selecting improvement measures
a) Explication of relevant objectives
b) Explication of relevant factors of influence
c) Distinction between external reporting and an internal improvement perspective
3.3 Target group-oriented decision methodology
a) Procedure model
b) Advice on the assessment of variables
c) Advice on the concretization and adaption of the improvement measures
d) Advice on the adaptation and configuration of the decision calculus
e) Expert knowledge from previous application

(Source: Röglinger and Pöppelbuß, 2011)

3.1.2. Basic Design Principles

This maturity model has been designed to measure the open innovation maturity level of firms operating in the Turkish aerospace and defense industry. The aerospace and defense sector has been considered as an ecosystem by the European Commission (2025) and consists of the aerospace, defense, and space segments. Experts from all three sub-segments were consulted while designing this model. However, it should be noted that companies operating solely in-service sub-segments such as air transportation and aircraft maintenance did not contribute to the model. The model mentioned primarily focuses on manufacturing companies included in the sub-segments of this ecosystem. This study focuses on the manufacturer firms in Turkish A&D ecosystem as the application domain. The model's appropriateness for those service firms may be studied later and this issue is out of scope for this thesis.

This model is built in a questionnaire format that can be participated by the target company's managers. The model targets managers for determining innovation maturity, as the audience, because they are the ones who guide and direct workforce, lead culture, implement top management's goals, allocate resources and make decisions (Adams et al., 2006). Dougherty and Cohen (1995) identified that the awareness and behavior of senior managers significantly impacts innovation. Chief executives who are most effective at driving innovation tend to have a clear vision for the future direction of organizational change and creativity (Shin and McClomb, 1998). Also, senior management plays a crucial role in formulating and communicating innovation vision, fostering support, maintaining a positive attitude towards change, and promoting the concept of innovation within the organization (Adams et al., 2006).

It is implied in the literature that the impact of managers on innovation management increases with higher hierarchical levels, so that first-level managers at the case company have not been invited to participate in the survey. The case company is highly hierarchical (Figure 7) and has approximately 15,000 employees, about 1,000 of whom hold the title of "chief" as first-level unit managers. Due to their very narrow scope of authority and responsibility, participation to the survey was limited to department

managers, directors and vice presidents and executive vice presidents. More information about the case company is mentioned in the empirical chapters.

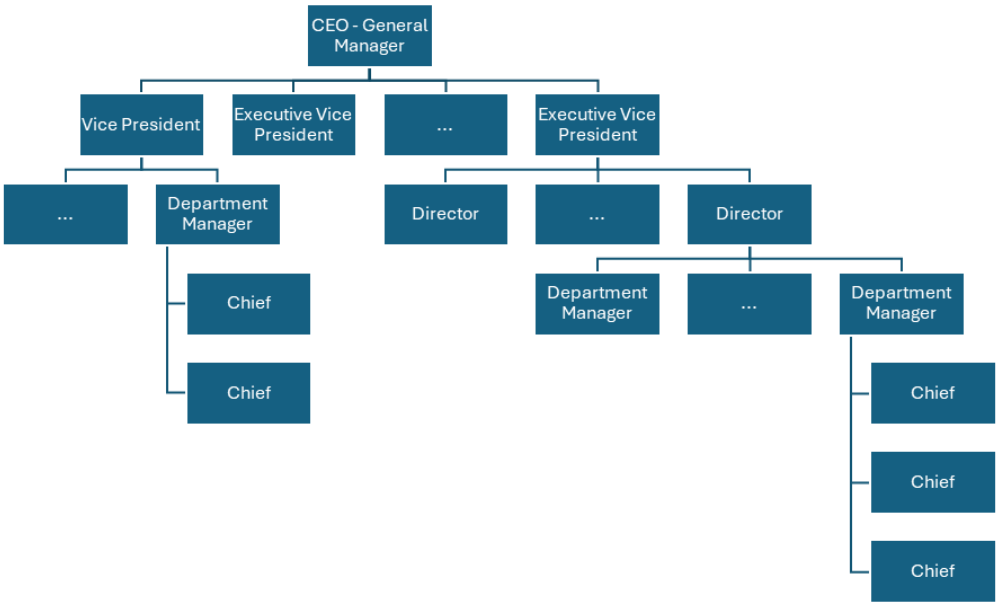

Figure 7. Hierarchical Structure of Case Company
(Source: Author's own construction)

Organizations engaged in OI are not limited to internal ideas; they also utilize those that emerge outside the organization for product, service, and technological development. OI has been described as a system that combines both internal and external ideas, allowing organizations to introduce new internal technologies to the market through external channels. (Chesbrough, 2003). This system enables organizations to open their boundaries for collaboration with external partners (such as suppliers, research institutes, or competitors) and contributes to the development of internal technologies while creating new opportunities for profitable business. Apart from other shareholders, this thesis focuses on suppliers, partners and subcontractors from an ecosystem perspective. In fact, A&D industry is characterized by vertical integration, leading to significant interdependence among firms for performance. The industry is generally defined as an ecosystem because of this interdependence (European Commission, 2025). Aslan (2018) explains that the tenders in A&D ecosystem primarily consist of large projects that only major defense industry companies can participate in and secure. As a result, subcontractors in the defense

sector heavily rely on collaboration with these key companies. However, the degree of this interdependence and the precise impact of major defense firms on other companies within the supply chain has not been thoroughly investigated. Aslan (2018) mentioned in his thesis that main defense industry firms contribute to the capabilities of their suppliers, but it could be made better. Our research will have a look at the case company and its suppliers in terms of OI maturity and may help us to understand that relationship. When applying the survey to the companies in the ecosystem of the case company, the organizational structure and number of employees of these companies were taken into account. In large companies the respondents were chosen from senior level managers while first-level managers were selected from other small and medium-sized enterprises, due to the lack of a layered managerial structure.

The differences of this model from its predecessors are mentioned at the beginning of this chapter. Becker et al. (2009) states the importance of explaining the differences of a proposed model from the existing ones. First of all, in today's innovation theory, where a closed system is seen as a dead end, there are very few models developed that measure open innovation maturity (4 out of 37). Among them, only one of these models has considered digital technologies as a significant dimension of OI maturity (Kebure and Zedtwitz, 2023). However, this model is still a re-version of CMM adopted for OI and tested on a single household (sector) company with a limited number of respondents. Another model developed by Honorato and Melo (2023) studied innovation maturity of projects at a sub-segment of A&D ecosystem, aerospace sector, pursuing a project management perspective. This study talks about open innovation and digital technologies for two Brazilian aerospace companies. However, this model is more about projects and does not have a holistic organizational perspective.

Another research by Zuluaga et al. (2024) employed TRL perspective to measure technological innovation maturity via gathering data from Columbian A&D sector, lacking an empirical foundation. Open innovation and significance of digital technologies are not mentioned clearly in that model. In fact, these two models are the most intimate ones to this thesis. However, there is still a gap in the literature for understanding how to measure the open innovation maturity of A&D companies, how

digital technologies play a role in that maturity and what can be implied about Turkish A&D ecosystem in terms of OI, apparently.

The construction of our model begins with a systematic literature review. In the literature chapter, the steps of our SLR are explained in detail, providing the basis for this model design. In this section we will explain the following development phases. The design stages of the model proposed within this thesis are shown below (Figure 8).

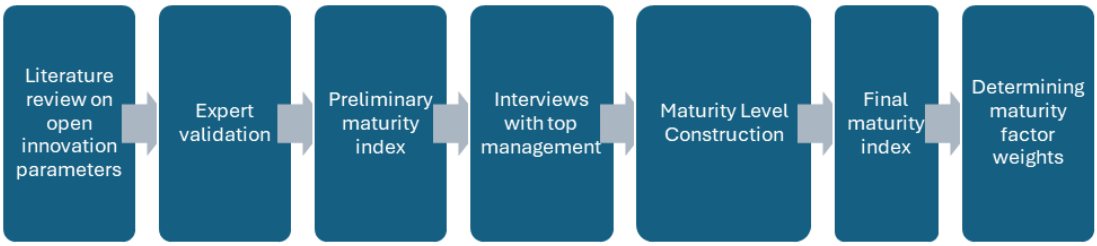

Figure 8. Model Development Stages
(Source: Author's own figure)

First, a systematic literature review was employed to monitor studies conducted between 2010 to 2024 about innovation maturity. Out of these studies, 37 models were closely examined based on academic relevance, scientific theory, originality, and content. They were evaluated in terms of theoretical approaches in the literature, dimensions of innovation, model integrity, applicability to A&D sector, and research questions. These 37 models were analyzed to determine the most mentioned and relevant dimensions and a pool of OI dimensions were developed as the first iteration. This first iteration brought out 33 dimensions that were grouped under five main categories as presented in Table 7.

Afterwards, expert validation was conducted and the second iteration was completed. This stage is explained in the following section.

Table 7. Iterations for OI Dimensions

1. Iteration Pool of categories and dimensions gathered from SLR	**2. Iteration** Categories and dimensions after expert views	**3. Final Iteration** Final categories and dimensions developed after interviews with executive managers
Strategy	**Strategy & Governance**	**Strategy & Governance**
1 New technology adoption	1 Innovation Strategy and vision	1 Innovation Strategy and vision
2 Management Support	2 Adoption of New Technologies, technology diffusion	2 Management Support
3 Innovation Strategy	3 Management Support	3 Innovation governance
4 IP Strategy	4 Innovation governance	**Innovation Culture**
5 Process management	**Innovation Culture**	4 Process development
6 IP protection	5 Process development	5 Risk tolerance
7 Openness and experimentation	6 Risk tolerance	6 Incentives for innovation
8 Knowledge transfer and integration	7 Incentives for innovation	7 Time and budget
Innovation Culture	8 Time and budget	**Partnership Capacity**
9 Communication of a vision	**Partnership Capacity**	8 Partner selection
10 Written and spoken support	9 Partnership process	9 Partnership intensity and effectiveness
11 Safe environments for employees	10 Partner selection	10 In house collaboration
12 Incentives	11 Partnership intensity and effectiveness	**Knowledge Chain**
13 Visionary leadership	12 In house collaboration	11 Absorptive capacity
14 Entrepreneurial spirit	**Knowledge Chain**	12 Adoption of new technologies, technology diffusion
15 System perspective	13 Absorptive capacity	13 Knowledge Diffusion
16 Risk Tolerance	14 Knowledge Diffusion	**Digital Maturity**
17 Tolerance for Ambiguity	**Digital Maturity**	14 Knowledge generation, sharing
18 New idea welcoming	15 Knowledge generation, sharing	15 Horizontal Integration
Partnership Capacity	16 Digital strategy	16 Vertical Integration
19 Partner Selection Process	17 Supply chain	
20 Partner diversity	18 Operations, from design to end product	
21 Partner features		
22 Need for commitment and trust		
23 Partnership tools		
Absorptive Capacity		
24 Recognition		
25 Assimilation		

Table 7. continued		
26 Transforming 27 Exploitative vs Explorative learning **Digital Maturity** 28 Knowledge generation 29 Knowledge sharing 30 Knowledge Storage 31 Supply Chain 32 Operations 33 Production		

(Source: Author's own construction)

3.1.3. Expert Validation

Although maturity models represent assessment tools, they are also subject to evaluation and improvement activities. Hence, validation from experts carries significance for developing a more comprehensive, accurate and objective maturity evaluation. The expert validation's focus is to understand and improve the maturity model itself, while maturity model assessment focuses on comprehending and enhancing the process under investigation (in this case, OI maturity) (Helgesson et al., 2012).

In this research, expert validation was utilized to select from pre-determined dimensions, eliminate irrelevant ones and develop the pre-defined maturity definitions. Between December 2023 and June 2024, expert opinions of the researcher, the academic advisor of the thesis, and experts with professional and academic experience in the field were gathered. As the output of expert view, the preliminary version (2. Iteration) of OI maturity dimensions and their sub-dimensions were constructed. The personal information of the experts who participated in the research and their areas of expertise are listed below (Table 8).

In this research, expert validation was utilized to select from pre-determined dimensions, eliminate irrelevant ones and develop the pre-defined maturity definitions. Between December 2023 and June 2024, opinions of the researcher and the academic advisor of the thesis, and experts with professional and academic experience in the field were utilized (total 5 experts). As the output of expert view, the

preliminary version (2. Iteration) of OI maturity dimensions and their sub-dimensions were constructed. The personal information of the experts who participated in the research and their areas of expertise are listed below (Table 8).

Table 8. Experts Participating the Research for Validation of the OI Model

Name	Area of expertise	Title	Field	Experience	Type of Meeting	Meeting Date
A	Economics, Economic Policy, Technology Policies	Professor	Academic	+25 years	Face-to-face	December 2023-June 2024
B	New Product Development, Innovation, Aerospace Industry	Associate Professor	Academic and Industrial	+20 years	E-mail and online meeting	January 2024
C	Innovation Management	Innovation Manager, PhD	Industrial	+15 years	Face-to-face and email	December 2023
D	Technology Management	Supplier Management, PhD Candidate at METU	Industrial and Academic	+20 years	Face-to-face and e-mail	February 2024
E	Innovation and Technology Management	Innovation Manager, PhD	Industrial and Academic	+15 years	Online meeting and e-mail	March 2024

(Source: Author's own construction)

Due to the scarcity of an academic "open innovation maturity model" that focuses on A&D industry, a model that is developed solely based on literature review is assumed to be stillborn because the previous academic and industrial literature ground does not provide adequate trustworthiness, credibility and methodological soundness to develop a model for measuring OI maturity of Turkish ecosystem, on its own. Hence, expert validation is a significant step for the validation of this model. The participants of the expert validation phase have sufficient expertise and experience both in academic and sectoral ground to provide meaningful feedback and evaluation.

Expert validation has some challenges by nature. The possible bias and conflict of interests is eliminated by following a certain order during interviews with experts. At first, the supervisor of the thesis (A) reviewed the model. He has long term research experience in Turkish innovation and A&D ecosystem. Afterwards, to be more specific on A&D sector, an online discussion is organized by expert B. He has remarkable professional career in Turkish aerospace and defense industry, besides his academic experience. Afterwards, experts C and D were met to frame the maturity model according to an industrial view that catches practical realities of the sector. Lastly, expert E, who has completed his PhD thesis on innovation and is still working in a different industry, gave his feedback on the model. The validation mechanism is designed to begin with the closer research circle and go on with further ones.

The evolution of the maturity model by the experts resulted in a number of subsequent model versions. After all expert meetings were completed, the main maturity dimensions remained same (5) in number but changed in name. Besides, the above-mentioned 33 sub-dimensions were eliminated to 18. Not only the dimensions, but also the pre-determined maturity levels of this research, which were adopted from previous academic studies, before the expert validation phase started, were reviewed by the experts mentioned above. Also, the questions that were pre-constructed for questioning OI maturity dimensions were monitored and revisions were made to align questions with dimensions.

3.1.4. Semi-Structured Interviews

As the next process, semi-structured interviews with 3 C-level managers (executive vice presidents) and 2 technology and innovation managers of the case company were conducted. There are two main purposes for conducting these interviews. The first is to understand whether the 18 dimensions, prepared as a draft, work in practice. This means examining whether the theoretically constructed maturity dimensions and their level descriptions, developed through a systematic literature review and expert opinions, are effective when applied in the field. The second purpose is to serve as a validation tool for the results obtained from the field study. In the second phase of this research, the output from field study will be collected through a survey. To validate

the results of this survey, internal observations, documents, and systems were examined, and the interviews with senior management also provide data.

The expert reviewed version of the model is converted into an interview format. 18 structured questions and 1 open-ended question have been prepared for the interview participants. The structured questions relate to the dimensions affecting OI maturity, while the open-ended question addresses what policies are needed to enhance the ecosystem's innovation maturity.

Interviews with 3 C-level managers and 2 technology managers (EVP1, EVP2, EVP3, TM1, TM2) have been completed between June and August 2024. The organizational roles of the interviewees are exhibited below (Figure 9).

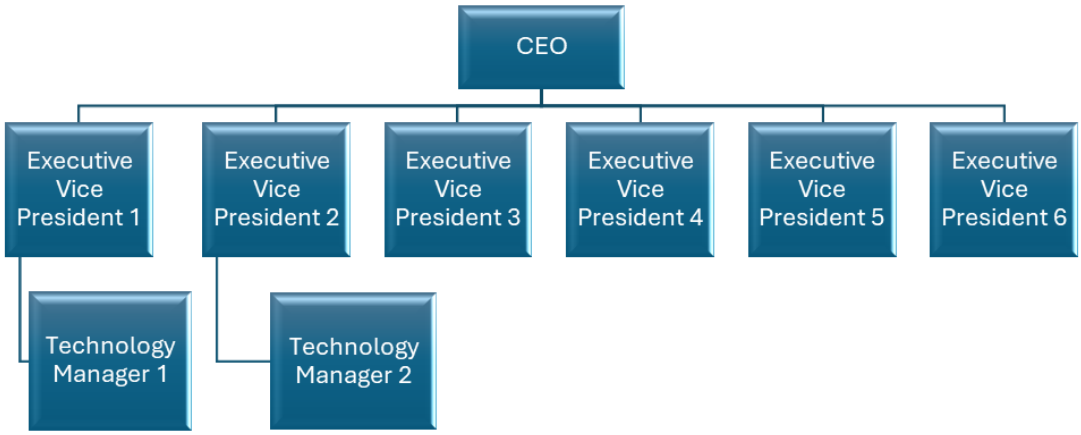

Figure 9. Role of Interviewees in organizational structure
(Source: Author's own construction)

There are six C-level managers on duty that directly report to the CEO. 3 of them were interviewed in this phase and the others were surveyed during the field study of the research. One of the interviewees is responsible for technology management and technology transfer projects for the most influential platform of the company. The other technology manager is responsible for open innovation and entrepreneurship activities of the company.

Interviews with the EVPs were preferred because the awareness and behavior of executive managers impact innovation management directly (Dougherty and Cohen, 1995). They are the ones who establish the strategic vision and direction for innovation and align it with the organization's overall goals and objectives. They control the allocation of resources, determining which innovation projects receive funding, have the duty to ensure that teams possess the required skills and expertise. Moreover, they can promote an environment that encourages creativity, risk taking and open communication. They have the authority to make critical decisions that can affect the direction and outcomes of innovative projects. Top executives engage with external stakeholders to gather insights and support for innovation initiatives. Lastly, they monitor the performance of organizations. Senior managers have strong influence in cultivating innovation in an organization. (Adams et al., 2006; Hidalgo and Albors, 2008; Chapman and Hewitt-Dundas, 2018).

The dimensions and sub-dimensions were asked in question format to understand which questions work in field study. During the interviews 2 sub-dimensions, partnership process and digital strategy, appeared to be ineffective. Partnership process is perceived as a sub-segment of process development, partner selection and effectiveness of partnerships. Digital strategy is assessed as a part of innovation strategy. Digital maturity dimensions are re-worded and modified. Lastly, adopting new technologies is re-categorized under knowledge chain category. The final coverage of the model appears as the third column of Table 7.

The interviews with the top management have constraints. First of all, planning the interview time and duration was challenging. Also, we have confronted inquiries about the coverage and data utilization of the interviews. Due to the security concerns and industry's traditional business model, diving deep and gathering detailed data took patience and effort.

3.2. Final Maturity Index

As the output of this chapter, the general construction of proposed model is depicted below (Table 9). Studies focusing on maturity models must establish key concepts

associated with maturity and the maturation levels (Becker et al., 2009). Innovation maturity models are structured hierarchically and sequentially, delineating various levels that reflect an organization's innovation maturity. These models provide a multi-criteria assessment, highlighting specific areas where improvements are needed to achieve higher innovation maturity. While most models categorize innovation maturity into five levels, some propose three levels (Mattei et al., 2019), and others, such as Demir (2018), offer six levels. Regardless of the number of levels defined, all models share a common characteristic: the lowest level indicates insufficient innovation maturity, while the highest level signifies full innovation maturity, marking the organization as an innovation leader. This framework helps organizations understand their current capabilities and the steps required to enhance their innovation processes.

Table 9. General Structure of Proposed OI Maturity Model

		1 Freeze	**2 Melting**	**3 Planned**	**4 Mature**	**5 Inspiring**
Strategy & Governance	Innovation Strategy					
	Management Support					
	Innovation Governance					
Innovation Culture	Process Development					
	Risk Tolerance					
	Incentives					
	Time and Budget					
Partnership Capacity	Partner selection					
	Partnership Intensity and Effectiveness					
	In-house Collaboration					
Knowledge Chain	Absorptive Capacity					
	Adoption of New Techs, Tech. Diffusion					
	Knowledge Diffusion					
Digital Maturity	Knowledge Generation and Sharing					
	Digital Manufacturing and Operations					
	Digital Supply Chain					

(Source: Author's own construction)

According to scholars, simply specifying constructs related to maturity and maturation is inadequate. Maturity models must also encompass definitions of key constructs pertinent to the application domain. This is in accordance with the principles of "understandability" and "language adequacy" (Röglinger and Pöppelbuß, 2011). This research employs 12 models that are determined out of our SLR, as the basis of our study for dimension and level development (Table 10).

This methodology construction enabled us to develop a unique open innovation maturity model that is to be explained in the next chapter as the first output of this thesis.

3.3. Concluding Remarks

The methodology of this thesis is designed to confront the complexities of measuring open innovation maturity in the Aerospace and Defense (A&D) sector. It begins with a comprehensive systematic literature review (SLR), which serves as the foundation for understanding existing models of innovation maturity. The SLR examines studies conducted over the past 15 years, focusing on identifying gaps in the literature, especially regarding open innovation practices within the A&D industry. This initial step is crucial for establishing a theoretical basis and ensuring that the proposed model is grounded in relevant academic research.

Building on the insights gained from the SLR, the thesis adopts a capability-based view to frame the research. This perspective emphasizes the importance of dynamic capabilities, which enable organizations to adapt to environmental changes and leverage both internal and external resources effectively. The methodology recognizes that the level of openness required for innovation varies among companies, influenced by factors such as corporate strategy and market positioning. By focusing on dynamic capabilities, the research aligns with contemporary theories of innovation maturity, ensuring that the model developed is relevant and applicable to current industry challenges.

Table 10. Fundamental Models

	Academic Writing	Source	Type	Methods	Model / Framework	Empirical application	Citation
1	Achi, A., Salinesi, C., & Viscusi, G. (2016). Innovation capacity and the role of information systems: a qualitative study. Journal of Management Analytics, 3 (4), 333–360.	Google Scholar	Journal Article	Qualitative interview	Framework	Yes	34
2	Arends S.C. (2018). Development of a Firm-level Innovation Capability Maturity Model and Identification of Innovation Archetypes. Master's thesis	Google scholar	Journal Article	Mixed, literature review, survey, delphi.	Model	Yes	12
3	Björkdahl, J., & Börjesson, S. (2012). Assessing firm capabilities for innovation. International Journal of Knowledge Management Studies, 5 (1/2), 171.	Google Scholar	Journal Article	Literature review, empirical	Model	Yes	78
4	Dervitsiotis, K. N. (2010). A framework for the assessment of an organisation's innovation excellence. Total Quality Management & Business Excellence, 21(9), 903–918.	Google Scholar	Journal Article	Literature review, BCG measurements.	Framework	No	184
5	Enkel, E., Bell, J., & Hogenkamp, H. (2011). Open Innovation Maturity Framework. International Journal of Innovation Management, 15(6), 1161–1189.	Google Scholar	Journal Article	Exploratory research, literature review	Model	Yes	239
6	Enkel, E., Bogers, M., & Chesbrough, H. (2020). Exploring open innovation in the digital age: A maturity model and future research directions. R&D Management, 50(1)	Google Scholar	Journal Article	Literature review	Framework	No	145
7	Essmann, H., & Preez, N. (2009). An Innovation Capability Maturity Model – Development and initial application. International Journal of Human and Social Sciences, 5(1), 44–55	Google Scholar	Journal Article	Literature review, case study	Model	Yes	145

	Table 10 continued **Academic Writing**	**Source**	**Type**	**Methods**	**Model / Framework**	**Empirical**	**Citation**
8	Honorato, C. (2023). Maturity model for innovation project management in industrial enterprises: A case study of the aerospace sector in Brazil. Journal of industrial integration and management: innovation & entrepreneurship, 8(2), 201-227.	Scopus	Journal Article	Quantitative and qualitative research literature review, bibliometrics	Model	Yes	4
9	Kebure, K., & von Zedtwitz, M. (2023). Open innovation capability maturity model: the case of a multinational organization. 2023 IEEE International Conference on Technology and Entrepreneurship (ICTE), 110-115.	ieeex	Conference paper	Exploratory, case study, literature review and interview	Model	Yes	1
10	Nada, N., Ghanem, M., Msebah, S., & Turkyilmaz, A. (2012). Innovation and Knowledge Management Practice in Turkish SMEs. Journal of Knowledge Management, Economics and Information Technology, II (1), 248–265.	Google Scholar	Journal Article	Implementation of 3 innovation auditing models	-	Yes	26
11	Niewöhner N, Lang N, Asmar L, Röltgen D, Kühn A, Dumitrescu R (2021) Towards an ambidextrous innovation management maturity model. Procedia CIRP 100:289–294.	Scopus	Conference paper	Systematic literature review	Model	No	6
12	Zuluaga, J. A. F., Escobar, J. F., Martínez, G. A. G., D'Aleman, J. C., & Vallejo, A. O. (2024). Model for measuring technological maturity for critical sector industries. *Journal of Open Innovation: Technology, Market, and Complexity*, 10(1), 100194.	Science Direct	Journal Article	Bibliometric review of readiness level (TRL, IRL, RRL, MRL) models	Model	No	8

(Source: Author's own construction)

To enhance the model's validity and applicability, an expert validation process is conducted. This involves soliciting feedback from industry professionals and academics with extensive experience in innovation management and in the A&D sector. The insights gained from these experts lead to the refinement of the model, resulting in the identification of 18 key dimensions that effectively encapsulate the essence of open innovation maturity. This iterative process ensures that the model is not only theoretically sound but also practically relevant to the organizations it aims to serve. Following the expert validation, the methodology includes a series of semi-structured interviews with top management and technology managers from selected case companies. These interviews aim to assess the practical applicability of the identified dimensions and validate the findings from the field study. By engaging with senior leaders, the research captures insights into how these dimensions manifest in real-world settings and their impact on organizational innovation practices. This qualitative data enhances the quantitative results obtained from the questionnaire, providing a holistic view of open innovation maturity.

Finally, the methodology culminates in the creation of a final maturity index, which synthesizes the research findings into a coherent framework. This index outlines the key constructs related to maturity and maturation levels, enabling organizations to understand their current capabilities and the steps needed to enhance their innovation processes. By implementing a systematic method for assessing open innovation maturity, this thesis contributes significantly to both academic literature and practical applications in the A&D sector, offering valuable insights for organizations seeking to thrive in a rapidly changing environment.

The proposed model that is introduced in the next chapter in detail is structured around 5 categories and 16 dimensions that are determined to affect open innovation maturity of Turkish A&D industry. The dimensions are organized into a questionnaire format, allowing for empirical testing within companies. The model categorizes maturity into five levels, providing a clear framework for assessing where a company stands in its innovation journey. The use of the Analytic Hierarchy Process (AHP) for weighting these dimensions ensures that the model is both systematic and quantifiable.

CHAPTER 4

THE PROPOSED OPEN INNOVATION MATURITY MODEL

This chapter explicates our proposed model which aims to measure open innovation maturity of A&D companies in Turkish ecosystem. The 5 categories and 16 dimensions that are compromised after various stages are detailed below regarding their meaning and relationship with open innovation.

In the following paragraphs, the five levels of open innovation maturity are explained, along with the definitions of maturity dimensions and their level descriptions. In the section related to each dimension, firstly, the reflection of this dimension in the SLR conducted within the context of this research and in the general innovation literature is mentioned. Later, a table presenting the category, dimension name, general definition and the capability descriptions corresponding to each level is given. The reference model is added to the table if the descriptions have been adapted from one of the 12 core models. The definitions and levels of maturity are upgraded with insights coming from expert views and/or interviews with top management.

4.1. Open Innovation Maturity levels

We propose 5 levels of OI maturity for Turkish A&D industry, grounding our design on dynamic capabilities framework (Table 11). We have to state that this model is designed for company level via measuring organizational open innovation capabilities. Individual researchers, academicians, consultants, customers (Turkish Armed Forces etc.), sectoral institutions (SASAD, TSKGV etc.) or policy makers (SSB, Ministry of Defense etc.) are out of the scope of this model.

Table 11. Explanation of OI Maturity Levels

LEVEL	DEFINITION
1 FREEZE	The main focus is operations on a day-to-day basis. Any form of innovation output is inconsistent and unpredictable.
2 MELTING	Organization recognizes importance of OI. However, the strategy and culture are not prepared to take advantage of it. Partnerships and digital tools may enable OI. Innovation output is inconsistent.
3 PLANNED	Appropriate OI practices, processes and (digital) tools are in place for internal and external partnerships and knowledge management. OI is planned and encouraged by the organization. Strategy and innovative outputs are consistent. Employees and managers are aware of OI practices.
4 MATURE	OI practices, processes, partnerships and (digital) tools are intentionally mature to integrate the company with external environment in terms of partnerships and knowledge. A deep understanding of OI exists in company. Innovation strategy and outputs are measurable, consistent, diverse and a source of competitive advantage. Employees and managers are aware and supported via organization's culture to initiate OI practices.
5 INSPIRING	The firm is capable of intentionally navigating its external and internal boundaries regarding culture, knowledge management and partnerships. Strategy and digital technologies allow company to fully leverage its potential in innovation efforts. The results of innovation activities are traceable and utilized to enhance OI capability on a continuous basis. Output provides inspiring competitive advantage in existing and new markets. Employees and managers are empowered via company culture to pursue OI activities.

(Source: Essman & Du Preez, 2009; Arends, 2018; Enkel et al., 2020)

Five main categories and the dimensions beneath them have been evaluated as a whole in order to develop the general maturity levels implied by the model. While building these definitions, Innovation Capability Maturity Model (ICMM) developed by Essman and du Preez (2009), Arends' thesis study (2018), and the work conducted by Enkel and colleagues (2011) which represents the most comprehensive open innovation model to date, have been employed as a basis. Furthermore, the core of Teece's dynamic capabilities theory (2007) focuses on the abilities required to maintain exceptional enterprise performance in an open economy characterized by rapid innovation and globally distributed sources of invention, innovation, and manufacturing capabilities, are taken into consideration while defining what is meant

to be mature in OI. Lastly, maturity levels are developed regarding features of the A&D sector, seeking sustainable growth and competitive advantages via balancing the development of internal resources and exploitation of external ones.

In the following sections the dimensional breakdown of our model is explained. The empirical validation of this model is the next chapter's subject. The empirical results are aimed to give us an understanding of Turkish A&D innovation ecosystem. To perceive what those empirical results mean, first we must comprehend what each dimension stands for.

4.2. Strategy and Governance Category

The first category of our model has three dimensions: innovation strategy, management support and innovation governance.

4.2.1. Innovation Strategy

Tidd and Bessant (2014) discussed how a well-defined strategy can improve an organization's innovation capabilities and maturity in their book. They declare that embedding innovation in strategic management process as a value for competitive advantage is crucial. Teece (2007) agrees with them and state that aligning strategic objectives with innovation helps companies to deal with the complexities of the current business landscape and enables sustainable growth. Setting clear objectives and building autonomy with internal and external agents are crucial for innovation management. They explain that the impact of external factors, such as market trends and technological advancements, are impacting innovation strategies. Indeed, a lack of clarity in the defined strategies for innovation hinders the participation of all employees.

Therefore, it is essential to implement and promote innovation strategies that make innovation a collective responsibility among all employees, aligned with a comprehensive vision encompassing all business functions. Furthermore, formalizing the innovation vision with highly skilled personnel in the R&D department is crucial

for large companies, where the R&D department possesses the necessary resources and support to develop innovations in a strategically organized and planned manner (Enkel et al, 2011). Business strategy and level of openness should be connected to the corporate culture. Empirical research indicates that not all companies or industries require the same level of openness, as this can vary based on factors such as innovation speed, corporate strategy, market positioning or technological requirements. (Enkel et al., 2009). In fact, until recently the A&D sector has always approached open innovation at a distance. Due to their traditional way of doing business and the principle of confidentiality, it took time for them to open up to external information networks. Nowadays, while there is a more moderate approach to this issue as opposed to the past, it is observed that the sector is selectively permeable in external information exchange. This thesis will contribute to understanding A&D managers' willingness to be open as an innovation strategy.

The existence of an innovation strategy is important at this point, as it indicates the sector's awareness of what the quantity and direction of this permeability should be. Thus, developing a clear and long-term strategy for innovation which is aligned with sector realities and company objectives, is an important driver of innovation maturity (Arends, 2018). Innovation strategy is one of the most mentioned dimensions in innovation maturity models according to the literature. The SLR conducted for this thesis finds out that innovation strategy and its sub elements (communication, leadership and market analysis) are mentioned in 21 out of 37 models that are selected for this research (Table 5). Table 12 presents the innovation strategy dimension developed in this thesis, in detail.

4.2.2. Managerial Support

There are clear academic conclusions regarding the importance of managers' positive attitude toward change in motivating their employees to reach specific innovation goals (Delgado-Verde et al., 2011). Managers' commitment to organizational learning practices may enhance firms' innovation performance (Fleming and Waguespack, 2007).

Table 12. Proposed Model: Innovation Strategy Dimension

MAIN DIMENSION	SUB-DIMENSION	DEFINITION	SURVEY/ INTERVIEW QUESTION	ADOPTED FROM
STRATEGY & GOVERNANCE	**1 Innovation Strategy and vision**	The presence of an innovation vision and strategy, the organization's capacity to identify and assess trends, and the manner in which the innovation strategy is communicated and integrated into the daily activities of employees.	Do you have an innovation strategy and vision?	Arends, 2018 Rao & Weintraub, 2013 Björkdahl & Börjesson (2012)

LEVEL	Definition
1 FREEZE	There is no well-defined innovation vision or strategy established.
2 MELTING	An innovation plan exists, but it is largely limited and/or primarily oriented toward short-term objectives.
3 PLANNED	A long-term innovation vision, mission, and strategy are established and thoroughly documented, with clearly defined strategic focus areas.
4 MATURE	A strategic plan for innovation exists, is well-documented, emphasizes long-term objectives, and is integrated into the organizational strategy. It is converted into actionable goals and key performance indicators (KPIs).
5 INSPIRING	There is a clear and actionable long-term innovation strategy in place, which is continually evolving based on the latest trend insights and adaptations to the organizational strategy.

(Source: Author's own construction)

Especially, when managers understand the importance of innovative HR practices like intrapreneurship and incentives for risk taking, firms' innovation performance enhances (Shin and Konrad, 2017). Another study by Periz-Ortis et al. (2018) states that the support of top managers is necessary for radical innovations to emerge.

There are specific management practices that encourage innovative behavior determining the appropriate right employee, strategic vision, incentives and recognition, employee deployment, promotion of idea generation, and multifunctional teaming are supportive practices for OI management's strategic vision that prioritizes innovation, aligning organizational goals with innovative initiatives supports innovation performance (McGourty et al. 1996). Managers should not only focus on the internal environment but also remain open to the external environment to obtain resources, technology, and knowledge for innovation. Adopting an open innovation strategy is more likely to enhance competitiveness in a rapidly evolving market (Lichtenthaler, 2011).

The SLR conducted for this research states that managerial support appears often under different titles: management, leadership, governance. We explained what we mean by management support in this model, in Table 13.

4.2.3. Innovation Governance

Governance encompasses the frameworks, policies, and practices that guide an organization's decision-making and accountability. Gregory and Simms (1999) define corporate governance as the interactions among corporate managers, directors, and shareholders. It also encompasses the corporation's connections with stakeholders and the broader society. More generally, corporate governance involves the combination of laws, regulations, listing requirements, and voluntary practices that enable a corporation to attract capital, function efficiently, generate profits, and meet legal obligations as well as societal expectations (Table 14).

Table 13. Proposed Model: Management Support Dimension

MAIN DIMENSION	SUB-DIMENSION	DEFINITION	SURVEY/ INTERVIEW QUESTION	ADOPTED FROM
STRATEGY & GOVERNANCE	**2 Management Support**	The degree to which managers engage in innovation activities and motivate employees to pursue innovative ideas.	How do you coach, inspire /support your employees to try new ideas? Do you have a feedback mechanism?	Rao & Weintraub, 2013 Enkel et al., 2011

LEVEL	Definition
1 FREEZE	Leadership discourages innovation activities. There is a management resistance towards innovation activities.
2 MELTING	Leadership supports innovation initiatives, and occasionally, the organization presents innovation success to employees.
3 PLANNED	Managers are trained to encourage employees to innovate. The organization frequently identifies key innovation success stories and disseminates them among employees.
4 MATURE	Organized inspiration programs are put in place to foster innovation. Leaders and team members actively encourage innovation initiatives across all levels.
5 INSPIRING	The results of inspiration programs are measured, assessed, and continuously enhanced. Employees at all levels consistently motivate and encourage one another to innovate in a systematic manner. Flagship projects are disseminated throughout the organization.

(Source: Author's own construction)

The symbiotic relationship between innovation maturity and governance is a significant study field for organizational behavior and management. Effective governance can enhance innovation maturity, while a mature innovation framework can lead to improved governance practices. Namely, to generate value in an open innovation environment, companies must enhance the flexibility of their organizational boundaries to facilitate knowledge sharing with a diverse range of shareholders. However, to effectively capture that value, firms must also focus on how to govern their collaborative initiatives and safeguard against unintentional knowledge loss (Zobel and Hagedoorn, 2020). This need makes innovation governance a crucial factor for innovation capability and scholars have started to study the concept of innovation governance especially for the last 15 years.

Arends (2018) states that an innovation governance framework must encompass both functional and financial responsibilities, ensuring it is integrated and aligned with the organization's structure and processes while being subject to ongoing development. Additionally, the decentralized autonomy of project teams in decision-making, or employee empowerment, is crucial for effective innovation management (Storey et al., 2016).

The 37 fundamental models chosen for this research emphasize the significance of governance under different sub-dimensions like project management, empowerment and motivation, leadership and resource allocation. Both scholars and industry leaders recognize that governance and innovation are essential for maintaining a competitive advantage in today's rapidly changing business landscape.

4.3. Innovation Culture

The second category of our model is innovation culture which includes, process development, risk and failure tolerance, incentives and time and budget dimensions.

Table 14. Proposed Model: Innovation Governance Dimension

MAIN DIMENSION	SUB-DIMENSION	DEFINITION	SURVEY/INTERVIEW QUESTION	ADOPTED FROM
STRATEGY & GOVERNANCE	**3 Innovation governance**	The degree to which authorities and responsibilities for innovation are clearly defined and implemented.	How innovation is managed/governed in your company?	Arends, 2018 Achi et al., 2016

LEVEL	Definition
1 FREEZE	Responsibilities for innovation are not formally defined. Employees assume (if any) responsibility for innovation activities on an ad-hoc basis.
2 MELTING	Innovation results are measured and assessed when a project team or employee takes the initiative to do so.
3 PLANNED	It is clear how innovation activities are organized and who is functionally responsible for each innovation activity. This is reflected in the organizational structure and processes.
4 MATURE	A clear structure for innovation exists, in which centralized and decentralized autonomy in decision-making is defined. The innovation structure encompasses functional and financial responsibilities and authorities and is integrated and aligned with the overall organizational structure and primary processes.
5 INSPIRING	A clear structure (and agile in case) of authorities and responsibilities and for innovation activities have been defined. This governance system is integrated and aligned with the organizational structure and processes and is continuously being developed. Project teams are empowered to make decisions autonomously.

(Source: Author's own construction

4.3.1. Process Development

A company's innovation culture necessitates a unified process that includes the integration of enterprise design, product design, and the design and implementation of new technologies. This integrated design approach requires effective collaboration and management of the different designs, backed by efficient knowledge management, strategies and tools. For innovation to effectively contribute to business growth and enhance competitiveness, careful planning of the innovation process is imperative (Preez and Louw, 2008).

A common denominator among successful innovators is a rigorous process for managing innovation that entails a systematic, stage-by-stage approval framework, accompanied by regular evaluations of all critical factors, including time and financial investments, as well as the market performance of new products (Jaruzelski et al., 2006).A vast body of literature emphasizes significance of innovation processes, outlining the management aspects and the different stages involved, from the initial concept to the commercialization of a product. Essman and du Preez (2009) mentions the innovation process as the practices, procedures and activities throughout all innovation stages; A comprehensive and focused process covering various types of innovation and ensuring alignment with other organizational procedures is crucial.

The criteria for every stage and decision moment are expected to be clearly defined. The organization should be skilled at executing these processes both effectively and efficiently. The design, effectiveness, and implementation of these innovation processes must be regularly evaluated and improved with the participation of employees and in alignment with other corporate processes (Arends, 2018). Developing an innovation process is a commonly accepted phenomena for innovation maturity, as more than one third of the maturity models analyzed for this research mentioned process development as a sub-dimension of innovation maturity. We have constructed process development capability as depicted in Table 15.

Table 15. Proposed Model: Process Development Dimension

MAIN DIMENSION	SUB-DIMENSION	DEFINITION	SURVEY/ INTERVIEW QUESTION	ADOPTED FROM
INNOVATION CULTURE	**4 Process development**	The degree to which an innovation process is established and effectively executed, with clearly defined criteria for each stage and decision point.	How do you develop procedures, processes, or unwritten rules for supporting innovative attempts?	Enkel et al. (2011) Honorato and de Melo, 2023 Kebure and von Zedtwitz, 2023

LEVEL	Definition
1 FREEZE	There is no clearly defined innovation process established.
2 MELTING	Innovation is primarily regarded as a component of the R&D process. An explicit innovation process may be partially outlined and documented; however, the stages of decision-making and criteria are not clearly defined.
3 PLANNED	The innovation process is clearly defined and documented, featuring well-established decision points and criteria for each stage of the process.
4 MATURE	Different but aligned processes for different types of innovation are defined, including stages and criteria, is clearly established, documented, and applied in practice. These innovation processes are carried out effectively and are smoothly integrated with other organizational processes.
5 INSPIRING	Processes are created for various types of innovation, ensuring agility and alignment with other organizational processes. Proficient execution of these processes both proficiently and efficiently. An after-launch process is established to redesign organizational processes, facilitating the integration of the innovation into the organization. The design, efficiency, and execution of these innovation processes are continually assessed and enhanced.

(Source: Author's own construction)

4.3.2. Risk and Failure Tolerance

In literature higher risk and failure tolerance often correlates with increased innovation output. According to Cooper et al. (2004), a key best practice for product innovation is no punishment for failure. Additionally, being risk-averse is seen as a constraint on the performance of product innovation. Hutchison- Krupat and Chao (2014) explains that an organization can improve its capacity for innovation by managing risk-taking behavior and fostering a culture that accepts failure. They explained that innovation capability deepens when risk-taking is embraced and both successful and unsuccessful innovations are recognized. They also found that greater tolerance for failure encourages individuals to accept greater risks.

Openness of communication regarding mistakes among employees enables organizational learning and that can be an important catalyst in organizational performance (Weinzimmer and Esken, 2017). Innovation culture is cultivated when employees can talk openly about failure and their learning experiences.

However, risk and failure are bete noirs for A&D sector. The sector is generally risk-averse due to several unique characteristics and factors inherent to the industry. First of all, A&D projects require massive upfront investments. Financial stakes are high and any failure can lead to significant losses. These projects often take long years to develop, making it difficult to recover from mistakes or miscalculations. Another reason is the regulatory issues, that bring strict safety, environmental, and quality standards. Non-compliance can lead to costly penalties, loss of contracts, or reputational damage. Especially, failure at implications for human safety can result in catastrophic consequences, including loss of lives, lawsuits, and damage to public trust. In fact, Boeing, which is one of the two OEM's in the sector, has been experiencing a long and dramatic crisis since 2019. Boeing's push to rapidly develop the 737 MAX to compete with Airbus resulted in potential design compromises. Besides, inadequate training for pilots on the new systems posed risks in emergency situations where quick decision-making was essential. Also, the fast-tracking of the certification process may have led to insufficient testing of critical systems. These

risks, stemming from both technical and organizational decisions, ultimately contributed to the crises surrounding the 737 MAX and highlighted the importance of balancing innovation with safety and compliance. The first indicator of the Boeing 737 crisis was a crash that happened in 2018, raising significant concerns about the aircraft's safety and the effectiveness of its Maneuvering Characteristics Augmentation System (MCAS). However, Boeing could not address the problem quickly and correctly after that crash and the second accident came only three months later. Another crash involving a 737 MAX occurred, leading to 157 fatalities, in 2019. This incident further intensified scrutiny and led to the grounding of the entire 737 MAX fleet worldwide. The main problem here was not “risk taking” but “taking incomputable risk”, ignoring key indicators signaling something was wrong and failing managing the crisis.

On the other hand, The A&D sector relies on cutting-edge technologies, thus embracing risk allows companies to explore new ideas and innovations that can lead to significant advancements in aircraft design, materials, and systems. In a highly competitive market, taking calculated risks can help organizations develop unique products and services that differentiate them from competitors. Moreover, testing new systems and components involves taking risks in controlled environments to identify potential issues before full-scale production. Hence, instead of risk aversion, it is better to approach risk as a calculable equation by weighing the opportunities it presents against the potential downsides. When engaging with a risk, it is essential to assess the potential benefits of success in relation to the probability and impact of failure. Strategically accounting for the advantages of risk can enable traditionally cautious approaches to explore a broader spectrum of possibilities (Terrile, 2010).

There are scarce academic studies that searches the tolerance for risk and failure in the A&D sector. What kind of risks and how much risk should be endured in an open innovation system is a difficult question. This thesis may contribute to answering these questions by assuming that a mature company is expected to manage and compute risks and record failures and as well as successes via organizational tools and they are communicated with employees regularly, via meetings, documents etc. (Table 16).

Table 16. Proposed Model: Risk and Failure Tolerance Dimension

MAIN DIMENSION	SUB-DIMENSION	DEFINITION	SURVEY/INTERVIEW QUESTION	ADOPTED FROM
INNOVATION CULTURE	**6 Risk and failure tolerance**	The degree risk-taking embraced, and are both successful and unsuccessful innovations recognized and appreciated	How risk tasking is assessed, are both successes and failures of innovation celebrated and/or acknowledged at your company?	Arends, 2018 Dervitsiotis, 2010

LEVEL	Definition
1 FREEZE	Failure in innovation activities is met with strict penalties, including employee layoffs, which discourages others from pursuing innovation efforts.
2 MELTING	Failure in an innovation project results in a loss of reputation for the employees involved in that project.
3 PLANNED	Employees involved in innovation failures are not penalized or blamed for those failures. There is an awareness of lessons learned. Risk taking is neither welcomed nor punished.
4 MATURE	Employees who have the courage to innovate are consistently recognized and respected, regardless of the results. They openly discuss failures and share their learning experiences.
5 INSPIRING	Both failures and successes are documented at the company level using organizational tools and are regularly communicated to employees through meetings, documents, and other channels.

(Source: Author's own construction)

4.3.3. Incentives for innovation

Schumpeter's Theory of Innovation (1942) emphasized that economic incentives, such as profits and market monopolies, are crucial for fostering innovation. The primary role of an entrepreneur is to bring about innovation, with profit serving as the reward for their innovative efforts. That economic finding can be applied to organizational behavior. Self-determination theory emphasizes that intrinsic motivation, fostered by incentives, enhances creativity and innovation. When employees feel motivated, they are more likely to engage in innovative activities (Ryan and Deci, 2000):

Ederer and Manso (2013). mentioned that prioritizing the stimulation of innovation, creativity, and entrepreneurship is considered the foremost challenge in human resource management, according to CEO surveys. This includes a range of situations, from creating compensation packages for top executives and middle managers in large corporations to establishing incentives for entrepreneurs in startups. Notably, many firms that thrive on innovation and creativity have implemented reward systems that not only accept but also reward employee failures. Regarding executive compensation, cultivating a culture that accepts initial failures can be encouraged through practices such as option repricing. These practices are frequently criticized for potentially hindering or even rewarding managers after poor performance. However, research shows that well-defined and regulated rewards can effectively promote innovation.

Other than financial incentives, intrinsic motivators, such as recognition, autonomy, and opportunities for career development, were found to be equally important for fostering innovation in employees (Sauermann and Cohen, 2010). Enkel et al. (2011) mentioned that employees should be inspired by incentives to become creative. Both monetary and non-monetary incentives are essential for fostering an environment that ensures employees are dedicated to the organization's innovative vision. In open innovation activities, the emphasis is placed not only on internal creativity but also on leveraging external avenues to reach the market. Thus, this thesis claims that incentives have to lead employees to identify external knowledge paths for their ideas. Clearly defined and company focused monetary but also, promotional and entrepreneurial incentives for everyone are needed for innovation maturity (Table 17).

Table 17. Proposed Model: Incentives Dimension

MAIN DIMENSION	SUB-DIMENSION	DEFINITION	SURVEY/ INTERVIEW QUESTION	ADOPTED FROM
INNOVATION CULTURE	**6 Incentives for innovation**	The degree of incentives given to employees and other parties for engaging in innovation activities.	Do you have an incentive mechanism for innovation? Who are given incentives: employees, your suppliers, other partners?	Enkel et al., 2011 Nada et al., 2012

LEVEL	Definition
1 FREEZE	There are no incentives for innovative activities.
2 MELTING	Innovations are encouraged via monetary incentives on an irregular basis and without pre-defined criteria.
3 PLANNED	Employees are given incentives periodically according to a procedure based on a monetary basis. Assessments are made by specialists from or outside the company.
4 MATURE	The incentives are not only monetary but also promotional, working benefits etc. For employees. Targets are set for incentives. Competitions or idea markets are present for outsiders to engage in company innovation activities.
5 INSPIRING	Incentives are not only monetary but also, promotional and entrepreneurial such as, permission and capital for establishing a spin-off company. Targets are clear for everyone and screened and modified according to company needs.

(Source: Author's own construction)

4.3.4. Time and Budget

Time and budget are critical resources for innovation because they directly influence the ability of individuals, teams, and organizations to explore, develop, and implement new ideas. Without adequate time and financial resources, innovation efforts can be limited, rushed, or fail to materialize.

The father of open innovation, Chesbrough (2006a, 2006b) reveals that firms that allocate sufficient resources (both time and budget) to innovation activities tend to perform better in terms of innovative output and market success. Employees should be motivated to determine how to allocate their time flexibly between exploitative and explorative tasks in their daily responsibilities (Niewöhner et al., 2021).

Arends (2018) discovered that a specific percentage of time is necessary for innovation-related activities for all employees within the organization. She stresses the importance of providing employees with full-time opportunities to participate in innovation efforts.

The interdependent availability of budget is named to be a “game changing” factor for innovation according to Schwabe et al. (2020). Perkmann and Walsh (2007) highlight the importance of allocation of a budget in enabling open innovation activities. When companies commit sufficient financial resources to innovation, they enable several critical success factors. First, they can maintain dedicated research and development teams, allowing for continuous exploration of new ideas and technologies. Second, they can invest in cutting-edge equipment and technologies necessary for experimental work and prototype development. Third, adequate funding enables organizations to attract and retain top talent, who bring fresh perspectives and specialized expertise to innovation initiatives.

According to Enkel et al. (2011), some companies create new key performance indicators within their R&D processes that emphasize budgets allocated for collaboration with external partners as a means to enhance their innovative performance. This model proposes time and budget dimension as in Table 18.

Table 18. Proposed Model: Time and Budget Dimension

MAIN DIMENSION	SUB-DIMENSION	DEFINITION	SURVEY/INTERVIEW QUESTION	ADOPTED FROM
INNOVATION CULTURE	**7 Time and budget**	The degree to which an organization allocates time and budget for investing in innovation activities.	Do you allocate time and budget for innovation activities?	Arends, 2018 Honorato, 2023 Enkel et al., 2011

LEVEL	Definition
1 FREEZE	No budget or time is designated for innovation activities, compelling employees to rely on their own resources to innovate.
2 MELTING	Innovation activities receive time and budget on an irregular basis, provided that operational activities remain the priority. Employees conduct innovation activities mostly within their daily tasks.
3 PLANNED	Employees are motivated to innovate by having a procedure in place that allows them to access time and budget for their initiatives.
4 MATURE	The proportion of the innovation budget relative to the overall organizational budget is well-defined. Employees are actively encouraged to utilize the procedure for accessing time and budget allocations.
5 INSPIRING	Employees have access to separate time apart from their daily tasks (e.g., a specified number of hours per week to work on their own projects) and budget for innovation. A clear and flexible budget balanced with the overall organizational budget, is allocated for each type of innovation.

(Source: Author's own construction)

4.4. Partnership Capacity

Partnership capability is determined as one of the main indicators of open innovation and we have proposed three dimensions to measure that: partner selection, partnership intensity and effectiveness and in-house collaboration.

4.4.1. Partner Selection

To determine the important aspects of partnership capacity for OI various research has been done. Cullen et al. (2002) and Kauser and Shaw (2002) highlight the requirement for trust and commitment between partners. Moreover, coordination, interdependence and communication are found to be good for partnerships. In literature, the importance of selecting the right partner and forming the right partnership type are frequently emphasized (Ireland et al., 2002).

Any partnership begins with deciding the partner, thus working with an appropriate partner is crucial for the success of innovation projects. In fact, open innovation literature serves as a demonstration of how companies decide to either develop innovations internally or engage with external partners (Dahlander and Gann, 2010). A good partner should possess the expertise and specialized skills relevant to the project's unique challenges. Performing comprehensive research to evaluate their qualifications and verifying that they have a successful history with similar projects can help reduce potential risks. It's also essential to evaluate the partner's cultural fit, ensuring that values and work styles align, which fosters better collaboration and reduces misunderstandings. Establishing mutual accountability and transparency helps maintain trust and ensures that each party fulfills their responsibilities. Additionally, effective communication channels should be established to facilitate clear and consistent information exchange, enabling both parties to stay informed and make timely decisions (Enkel et al., 2011).

A shared vision and strategic alignment are foundational to a successful partnership. Both partners should be committed to the project's goals and agree on the desired outcomes, ensuring that efforts are harmonized toward a common objective. Also,

working with a partner that has the required know-how for the partnership is important (Enkel et al., 2011). Finally, formalizing the partnership through a clear and comprehensive agreement can help manage expectations, clarify roles, and provide a framework to resolve any issues that may arise during the project, ultimately contributing to its success (Yoon and Song 2014). Partner selection is determined as the beginning phase of developing a capacity for collaboration. Although selecting a partner initiates the whole story of collaboration, literature has not dived into the partner selection part as required. Regarding the features of a well selected partner above, any innovative company has to design a comprehensive partner selection process that has a partner database, assesses partners with certain criteria. Inter-network linkages are also needed to find new potential partners in and out of the ecosystem. It is mostly Enkel et al. (2011)'s model that examined the partnership capacity in detail and mentioned that a company must be capable of choosing the appropriate partner at the right moment. In this thesis we explain partner selection capability in Table 19.

4.4.2. Partnership intensity and effectiveness

Several scholars studied and agreed on the importance of partnership capacity for open innovation, since the invention of the concept (Cullen et al., 2000; Kauser and Shaw, 2002; Lichtenthaler and Lichtenthaler, 2009; Cohen and Levinthal, 1990) as collaboration is a major way of experiencing external environment. Partnership intensity is an indicator of partnership capability. Intensity means diverse and effective partnerships that expand over the value chain. An organization must collaborate with a diverse array of partners, including suppliers, customers, universities, research centers, and even competitors, rather than innovating in isolation, to stay competitive (Bigliardi et al., 2020).

Companies in which partnerships are enduring, various along value chain and viewed as a routine type of innovative activity tend to have more capacity to innovate (Enkel et al., 2011). It is not only customers or suppliers, but all shareholders may take place in an innovative partnership.

Table 19. Proposed Model: Partner Selection Dimension

MAIN DIMENSION	SUB-DIMENSION	DEFINITION	SURVEY/ INTERVIEW QUESTION	ADOPTED FROM
PARTNERSHIP CAPACITY	**8 Partner Selection**	The extent in the company is able to select the right partner at the right time.	What do you consider when choosing a partner (Culture, capabilities, proximity, previous experience etc.)?	Enkel et al., 2011 Kebure and von Zedtwitz, 2023 Achi et al. 2016

LEVEL	Definition
1 FREEZE	The partners are not selected with a pre-decided process. Mostly consequences or acquaintances cause partnerships.
2 MELTING	Partners are chosen based on affection, familiarity, and past collaborations.
3 PLANNED	Partner selection is based on existing knowledge of partners or experience within the network. Potential innovation partners are continuously evaluated and intentionally chosen for collaboration.
4 MATURE	Partners can be selected from new ones as well as previous ones, based on vision and strategy of the partnership process.
5 INSPIRING	There is a partner database for partnership activities, these partners are assessed with certain criteria. Also, inter-network linkages are established and employed to find new potential partners from in and out of the ecosystem.

(Source: Author's own construction)

In particular, Van Beers and Zand (2014). finds that partner diversity plays distinct roles in driving innovation performance. Functional diversity significantly enhances radical innovation by providing complementary knowledge and skills from diverse partner groups, while geographical diversity improves incremental innovation by enabling product adaptation to local markets, regulations, and standards. Organizational factors such as prior collaboration experience, patenting, IT infrastructure, and public subsidies positively influence partner diversity. Additionally, internal R&D, continuous investment, employee training, and process/organizational innovations strengthen absorptive capacity, enabling firms to better leverage external partnerships. Overall, partner diversity is particularly impactful in cutting-edge and knowledge-intensive industries, such as aerospace and defense, where innovation projects face higher complexity and uncertainty.

Partnership diversity leverages its effectiveness. Organizations that engage in diverse collaborative relationships and work long time with various partner categories build valuable expertise that serves them well in future alliances. This accumulated experience enables them to navigate potential partnership challenges more effectively, establish efficient collaboration protocols, and expand beyond their usual operational boundaries. Developing standardized practices for successful joint ventures and exposure to multiple partnership scenarios enhances companies' ability to identify and prevent common collaboration issues (Rosenkopf and Nerkar, 2001) and thus improves the overall innovation performance (Lhuillery and Pfister, 2009). Not all partnerships seem to help gather innovative outputs. Besides diversity, companies look for effectiveness. Previous know-how and experience increase the effectiveness of partnerships (Van Beers and Zand, 2014). Besides, satisfied partners regarding the process and outputs of the innovation partnership is an important indicator of a company that has the capability to build up partnerships. Thus, assessing the partners and taking action to develop satisfying collaborations for all parties improve partnership capability. Enkel et al. (2011) states that monitoring the satisfaction of partners and taking corrective actions accordingly, and training the partners are important for effective partnerships. This paper proposes that partnership diversity and effectiveness is a significant determinant of open innovation maturity (Table 20).

Table 20. Proposed Model: Partnership Intensity and Effectiveness Dimension

MAIN DIMENSION	SUB-DIMENSION	DEFINITION	SURVEY/ INTERVIEW QUESTION	ADOPTED FROM
PARTNERSHIP CAPACITY	**9 Partnership intensity and effectiveness**	the extent in the company is collaborating in effective and intense partnerships	How diverse and effective are your partnership activities?	Enkel et al., 2011 Arends, 2011

LEVEL	Definition
1 FREEZE	The organization does not participate in any formal collaboration with external partners for innovation. Partner relationships are established and maintained only for operational reasons.
2 MELTING	Current operational partnerships are infrequently utilized for innovation activities. There are only a few partnerships, and their scope is limited. The effectiveness of these partnerships is not evaluated.
3 PLANNED	Current innovation partnerships are formal, low intense, short. Effectiveness is monitored in some partnerships.
4 MATURE	A wide variety of external partner relationships for innovation purposes is established and utilized. There is intensity, focus, and evaluation in innovation partnerships. These partnerships occur at various stages of the product life cycle (from design to final product) with clearly defined expectations.
5 INSPIRING	Partnerships are viewed as a routine type of innovative activity. There are partnerships among all value chain. Effectiveness is evaluated default by management and/or innovation professionals in terms of expected outputs. Satisfaction of partners monitored and actions taken to improve the effectiveness of partnership.

(Source: Author's own construction)

4.4.3. In-house collaboration

In-house collaboration is another factor that plays a crucial role in cultivating open innovation within organizations. By facilitating communication, knowledge sharing, and skill integration, in-house collaboration enables the development of innovative solutions. Companies like Google and Amazon exemplify this through their cross-functional collaboration and innovative project initiatives, such as '20% Time,' which have led to significant breakthroughs like Google Maps and Alexa. However, in-house collaboration is not without challenges; communication barriers, resistance to change, and trust issues can impede the collaborative process. Nevertheless, by addressing these challenges, organizations can enhance their capacity for innovation, gain competitive advantages and promote sustained growth.

Training the workforce is expected to increase readiness of employees to engage in alliances (Enkel et al. 2011). Literature indicates that employees who are capable at collaborating with colleagues from diverse backgrounds are essential for achieving innovation performance (Enkel et al., 2011). Employees who know how to locate the right information or connect with the appropriate individuals when seeking to innovate possess a crucial skill for effective internal collaboration. Training programs designed to develop employees' cross-functional collaboration skills and their willingness to engage with all types of colleagues, beyond formal roles and tasks, foster in-house collaboration capabilities (Arends, 2018). Table 21 explains what in-house collaboration means for this thesis.

4.5. Knowledge Chain

Measurement of knowledge creation and diffusion capabilities are significant for open innovation maturity, hence the phenomena is often defined as purposive inflows and outflows of knowledge. We have 3 dimensions listed under this category: absorptive capacity, adoption of new technologies and technology diffusion and knowledge diffusion in networks.

Table 21. Proposed Model: In-House Collaboration Dimension

MAIN DIMENSION	SUB-DIMENSION	DEFINITION	SURVEY/INTERVIEW QUESTION	ADOPTED FROM
PARTNERSHIP CAPACITY	**10 In house collaboration**	The degree to which employees engage in cross-functional collaboration with one another within their team and across the entire organization.	How often do your employees engage in collaborative projects with other departments?	Dervitsiotis, 2010 Enkel et al., 2011 Björkdahl & Börjesson (2012)

LEVEL	Definition
1 FREEZE	Cross functional collaboration is weak or absent. Knowledge sharing between cross functional teams is weak and met with resistance.
2 MELTING	Innovation is sometimes carried out in cross-functional teams; however, the majority of innovation activities are conducted based on the shared values and norms of the current team or business unit.
3 PLANNED	The organization promotes cross-functional collaboration by forming innovation teams with diverse backgrounds.
4 MATURE	There is a willingness to engage with all types of colleagues beyond formal roles and task descriptions. Training programs are established to equip employees with cross-functional, agile collaboration skills.
5 INSPIRING	Decision-making in collaborative innovation projects is guided by the organization's strategies, common values and norms. Employees are agile and skilled at collaborating with colleagues from diverse backgrounds, and collaboration is actively pursued and utilized.

(Source: Author's own construction)

4.5.1. Absorptive Capacity

Absorptive capacity is a crucial dynamic capability that allows companies to capture, assimilate, transform, and utilize external information, thereby maintaining a competitive edge in rapidly changing markets (Zahra and George, 2002). It bridges the external linkages with the internal innovation ecosystem. Cohen and Levinthal (1990), showed that organizations with high absorptive capacity are more capable of transforming external knowledge into innovative practices. This argument is supported by Hitt et al.'s (2007) empirical research which provides evidence of a confidential positive correlation between absorptive capacity and innovation performance.

In an environment where self-sufficiency in knowledge creation is increasingly difficult, absorptive capacity enables firms to utilize external knowledge effectively via complementing their internal resources. It ensures that knowledge is not just acquired but also transformed into actionable insights that improve processes, routines, and strategies. It supports both short-term adaptability and long-term growth (Camison and Fores, 2010).

The defense industry's relationship with absorptive capacity represents a critical nexus in technological innovation and knowledge management, particularly given the sector's unique characteristics of high technological intensity and strict security requirements. Absorptive capacity, defined as an organization's ability to recognize, assimilate, and apply valuable external knowledge (Zahra and George, 2002) plays a paramount role in aerospace and defense firms' capability to integrate complex technological systems and adapt to rapidly evolving military requirements. The intricate nature of defense technologies, combined with the necessity to maintain technological superiority, demands that defense organizations maintain exceptional levels of absorptive capacity, which enables them to effectively leverage both explicit and tacit knowledge from various sources, including research institutions, commercial sectors, and international defense partners.

Furthermore, the defense industry's absorptive capacity is distinctively characterized by its dual-use nature, where technologies and capabilities developed for military

applications often find civilian applications and vice versa. This bilateral knowledge flow necessitates sophisticated absorptive capacity mechanisms within defense organizations to effectively identify, evaluate, and integrate knowledge from diverse sources while maintaining security protocols. The industry's high barriers to entry, substantial R&D investments, and long development cycles make absorptive capacity a crucial determinant of competitive advantage, as it enables defense firms to reduce technological gaps, accelerate innovation cycles, and enhance their skills to respond to emerging threats and requirements. This relationship is further strengthened by the industry's increasing reliance on cross-sector collaboration and the growing complexity of defense systems, which require organizations to continuously enhance their absorptive capacity to remain competitive and technologically relevant. These interconnections underscore the critical necessity of incorporating absorptive capacity as a fundamental dimension within open innovation maturity framework in A&D sector (Table 22).

4.5.2. Adoption of New Technologies, Technology Diffusion

Scholars (Chesbrough and Bogers, 2014) defined OI as “a distributed innovation process based on purposively managed knowledge flows across organizational boundaries”. Thus, knowledge transfer, both inbound and outbound, can be strategically leveraged to facilitate innovation development and advancement. In fact, adopting recent technologies and diffusing them throughout the company may close the discrepancy between existing core competencies and the emerging technologies of competitive advantage, especially for technology intensive firms, to embrace innovation performance.

Adopting new technologies and diffusing them within an organization necessitates comprehensive transformations across multiple dimensions. These include modifications to organizational architecture, operational mechanisms, and technology management practices at both strategic and operational levels. Furthermore, it requires the recalibration of organizational learning processes to effectively support the development, maturation, and continuous enhancement of organizational innovation capabilities (Chesbrough and Brunswicker 2013).

Table 22. Proposed Model: Absorptive Capacity Dimension

MAIN DIMENSION	SUB-DIMENSION	DEFINITION	SURVEY/INTERVIEW QUESTION	ADOPTED FROM
KNOWLEDGE CHAIN	**11 Absorptive capacity**	The absorptive capacity of the firm to acquire, assimilate, transform, and exploit external knowledge and incorporate knowledge into firms' routines, processes and operations systems.	To what extent can your company take in external knowledge and combine it with internal knowledge base?	Enkel et al., 2011 Arends, 2018
LEVEL	**Definition**			
1 FREEZE	The employees / managers cannot recognize or are not interested in valuable external knowledge.			
2 MELTING	Employees/ managers are aware of the valuable external knowledge. They engage in sectoral meetings, monitor scientific studies and track patents licenses etc. to determine external knowledge.			
3 PLANNED	Managers & employees can and willing to learn and assimilate external knowledge by training, observation & practices.			
4 MATURE	External knowledge can be transformed for the sake of company via R&D activities. The firm is capable of transferring knowledge by enhancing and refining its internal routines that enable the integration and combination of prior knowledge with newly acquired or assimilated information. Transformation can be achieved by either adding or removing knowledge, or by reinterpreting and amalgamating existing knowledge in a novel and innovative way.			
5 INSPIRING	The company possesses the capacity to integrate acquired, assimilated, and transformed knowledge into its operations and routines. This capability not only allows for the refinement, enhancement, and expansion of existing processes, competencies, and knowledge but also facilitates the creation of new operations, competencies, routines, organizational structures, as well as innovative products and services.			

(Source: Author's own construction)

Scholars say that engaging in OI activities without adequately evaluating an organization's OI capabilities can lead to limited success in producing global competitive innovations. This oversight not only creates challenges in managing the external environment but also hinders the development of organizational competencies essential for effectively participating in and navigating OI networks. (Kebure and Zedtwitz, 2023). Adoption of new technologies and diffusing them in the organization is that kind of a capability for firms operating in A&D sector. However, OI literature rarely talks about the significance of technology adoption and diffusion.

When the A&D sector's unique characteristics, including long development cycles, high technological complexity, and stringent security requirements are considered, making the effective adoption and diffusion of new technologies particularly challenging, yet essential. Organizations within this sector must continuously evaluate, integrate, and deploy advanced technologies across their operations to maintain technological superiority, enhance operational effectiveness, and ensure competitiveness. This process requires not only substantial investment in research and development but also sophisticated mechanisms for knowledge transfer. The process of technology adoption may drive innovation across multiple tiers of suppliers, generate valuable spillover effects into civilian applications, and contributes to the development of high-skilled workforce capabilities. The sector's ability to effectively adopt and diffuse new technologies also plays a crucial role in fostering international cooperation, enabling interoperability among allied forces, and maintaining industrial base capabilities. This technological diffusion process must be carefully managed to balance the need for rapid innovation with security considerations, cost effectiveness, and the maintenance of critical industrial capabilities (Table 23).

4.5.3. Knowledge Diffusion in Networks

The development of scientific and technological expertise is fundamentally shaped by the intricate network of relationships among diverse stakeholders. These collaborative interactions and knowledge exchanges enable organizations to establish robust knowledge foundations and enhance their technological competencies.

Table 23. Proposed Model: Adoption of New Techs. / Tech. Diffusion Dimension

MAIN DIMENSION	SUB-DIMENSION	DEFINITION	SURVEY/INTERVIEW QUESTION	ADOPTED FROM
KNOWLEDGE CHAIN	**12 Adoption of new techs, technology diffusion**	Bridging the gap between existing core tech. competencies and the emerging techs of competitive advantage	How do you adopt new technologies and diffuse them throughout the company? What about obscure techs?	Honorato & de Melo, 2023, Zuluaga et al., 2024

LEVEL	Definition
1 FREEZE	Adoption of new technologies (via patents, tech. transfer, reverse engineering etc.) are not on the scope of interest. There may be opposition to the adoption of advanced technologies and digitalization, a lack of employee training, insufficient processe failure to adhere to technological standards and protect intellectual property rights, and a lack of digital and personalized tools.
2 MELTING	Adoption is done via irregular practices; the responsibility and process are not clear.
3 PLANNED	Adoption of new technologies is pursued by departments via pre-defined processes. Or processes are designed during adoption. Besides, the old, replaced tech. (if any) is assessed and decided to be left or stayed. Employees are trained.
4 MATURE	Adoption of new technologies is pursued via departments and through a central companywide tool like strategic plan or technology road map etc. There are performance metrics measuring the completion of adoption. There is a written IPRs strategy.
5 INSPIRING	The new technologies are screened periodically and effects on the company are monitored. Besides, the old replaced tech. (if any) is assessed and decided to be left or stayed based on a plan. Employees are trained regularly in new techs. The supplier are aware of the new techs and their effects on them.

(Source: Author's own construction)

Through this interconnected ecosystem, companies can build and strengthen their technological capabilities while leveraging the collective expertise of various actors in their innovation network.

Scholars highlight that the spread of complex knowledge between segments is improved when there are numerous connections, or "wide bridges," linking them. They also note that innovation spreads more quickly and extensively when concentrated connections link the segments of a network (Phelps et al., 2012).

In open innovation networks, the complexity of knowledge exchange plays a vital role, where despite the environment's openness, there is a critical need to regulate and monitor which participants contribute or extract specific knowledge components in the innovation process. This complexity becomes particularly significant in heterogeneous networks, especially those involving collaborations between established corporations and emerging startups. In such partnerships, both parties face increased risks of uncontrolled knowledge spillovers (Alberti and Pizzurno, 2017). These inadvertent knowledge transfers - referred to as knowledge "leaks" occurring within open innovation networks can hamper OI efforts in the A&D sector. The asymmetric nature of these relationships creates unique challenges in managing knowledge flows and protecting intellectual assets while maintaining the benefits of transferring knowledge in networks. Therefore, open innovation requires networking activities designed in a strategic framework in order to cultivate innovation performance but not to lose competitive advantage. This thesis suggests that a company needs a plan and routine to enable inflows and outflows of knowledge throughout the company and employees need resources to access and learn from these knowledge flows, up to a pre-determined level (Table 24).

Table 24. Proposed Model: Knowledge Diffusion in Networks Dimension

MAIN DIMENSION	SUB-DIMENSION	DEFINITION	SURVEY/INTERVIEW QUESTION	ADOPTED FROM
KNOWLEDGE CHAIN	**13 Knowledge diffusion in networks**	The openness of the company to diffuse knowledge in and out of the company.	To what extent can your products or innovations penetrate new regions and networks?	Enkel et al., 2020 Casanueva et al., 2013 Ucler, 2019

LEVEL	Definition
1 FREEZE	There are no local knowledge flows around the company in which the company can penetrate. The A&D ecosystem in which the knowledge (product or innovation) can penetrate is immature.
2 MELTING	Employees and/or organization are a part of intraregional and/or intrasectoral knowledge networks. There is no apparent connection with other regions and sectors. Interpersonal knowledge networks are weak.
3 PLANNED	Employees and the company are engaged in knowledge networks in other sectors and regions as well as intrasectoral and intraregional networks. The knowledge/product diffusion is not controlled or under assessment. Interpersonal networks of knowledge exist.
4 MATURE	The knowledge networks are regularly engaged in and knowledge inflow is enabled through tools (reports, patents, conferences, meetings, research). The company has a plan and routine to enable inflows of knowledge throughout the company. Employees have resources to access and learn from these inflows.
5 INSPIRING	The knowledge flow is two sided: inflows and outflows of knowledge. The company has a plan for the degree of openness of knowledge on how and to what extent to release knowledge out of the company.

(Source: Author's own construction)

4.6. Digital Maturity

The last maturity category is digital maturity, which affects partnerships, knowledge sharing and generation, production and the way of doing business as a whole. This category covers knowledge generation and sharing, digital manufacturing and operations and digital supply chain.

4.6.1. Knowledge Generation and Sharing

The digital age for open innovation presents numerous opportunities for knowledge to flow across organizational boundaries, facilitating the innovation process (Enkel et al., 2020). Innovation literature highlights that the digital age created opportunities for generating new ideas, problem-solving, and absorption of knowledge.

Scholars suggest that the capacity for digital-based innovation is a valuable area of research, as digital tools and systems allow businesses to leverage network externalities effectively. The optimal scenario of interest is when information systems serve as the core foundation for open innovation, complementing traditional research and development (R&D). This setup enables companies to collaborate with both internal and external stakeholders to generate new ideas and expertise (Chesbrough, 2003; Chesbrough and Bogers, 2014).

Digital technologies increased opportunities for collaboration and innovation across organizational boundaries. The emergence of digital platforms has significantly reduced communication costs and geographical barriers and enabled massive numbers of participants to engage in knowledge sharing activities regardless of their location (Bogers et al. 2017). These platforms provide a sophisticated technological architecture that supports not only basic information exchange but also complex collaborative development, integration of diverse knowledge sources, and real-time interaction among participants (Peng, 2009).

The effectiveness of digital technology-enabled knowledge sharing is enhanced through multiple mechanisms, including interconnected digital systems, modular

design architectures, standardized interfaces, and comprehensive knowledge management systems. These systems facilitate both the storage and distribution of knowledge while supporting dynamic interaction between those who generate knowledge and those who share it (Bereznoy et al., 2021). This study admits that development of efficient and inclusive digital knowledge-sharing environments support both individual and organizational learning while fostering continuous innovation. As explained above, a digital knowledge exchange ecosystem with a good governance has proven to be powerful for enhancing open innovation maturity in literature, especially in knowledge intensive industries. Thus, knowledge generation and sharing through digital tools is considered to be a significant facilitator of open innovation maturity in A&D sector (Table 25).

4.6.2. Digital Production and Operations (Vertical Integration)

The importance of digital technologies in manufacturing represents a fundamental shift in how production systems operate, moving from traditional automation to smart, connected, and adaptive manufacturing systems that can respond dynamically to changing market demands while optimizing efficiency and quality. Scholars imply that organizations investing in digital manufacturing capabilities are likely to see corresponding improvements in their innovation performance across multiple dimensions. Digital manufacturing and operations enable faster production cycles, provides better data for decision making, supports continuous improvement, facilitates cross-functional collaboration, and thus creates opportunities for new innovations (Sjödin et al., 2018). The link between digital manufacturing and innovation performance is characterized by a symbiotic relationship where digital technologies enable better innovation capabilities, while successful innovation implementation requires proper digital infrastructure and competencies. This creates a positive feedback loop that continuously improves both manufacturing capabilities and innovation performance (Enkel et al., 2020). Despite the scholar and practical evidences of this positive relationship, only very few papers study the methodological and empirical opportunities of open innovation in the digital age. This paper aims to contribute to the literature by examining what it takes to be an innovative company in terms of manufacturing and operating in a digital way (Table 26).

Table 25. Proposed Model: Knowledge Generation and Sharing Dimension

MAIN DIMENSION	SUB-DIMENSION	DEFINITION	SURVEY/INTERVIEW QUESTION	ADOPTED FROM
DIGITAL MATURITY	**14 Knowledge generation and sharing**	The degree to which digital tools are available to facilitate idea generation, communication, knowledge sharing, collaboration, and project and portfolio tracking.	Which digital tools are present to support idea generation and knowledge sharing?	Enkel et al., 2020 Niewöhner et al., 2021

LEVEL	Definition
1 FREEZE	There are no digital tools used for idea generation or sharing knowledge.
2 MELTING	There are digital tools that enable idea generation and sharing knowledge on a departmental basis. Collaborations and projects are not tracked digitally.
3 PLANNED	Digital tools are available to all employees during idea generation, sharing and internal collaboration on departmental basis. Knowledge generation, sharing and collaborations with external partners are partially digital.
4 MATURE	Digital tools are available across the organization; these tools are compatible with each other. They can be integrated when necessary and available for all related parties from idea generation and while tracking knowledge and to the end of projects.
5 INSPIRING	Digital tools for knowledge generation, sharing and collaborations are connected to other digital systems so that they provide inputs for improvements and changes in organization, processes, or products.

(Source: Author's own construction)

Table 26. Proposed Model: Digital Production and Operations Dimension

MAIN DIMENSION	SUB-DIMENSION	DEFINITION	SURVEY/INTERVIEW QUESTION	ADOPTED FROM
DIGITAL MATURITY	**16 Vertical integration**	The extent of production operations and enterprise operations are digital.	To what extent are your production and enterprise operations digital?	Kebure & Zedtwitz, 2023 Sjodin et al., 2018 Lasi et al., 2014

LEVEL	Definition
1 FREEZE	Systems are not integrated and some systems are not automated.
2 MELTING	Some OT and IT systems that are used in production operations as well as services are integrated.
3 PLANNED	All OT and IT systems at the production and enterprise levels are integrated into automated networks. While data exchange is feasible, data analysis and decision-making are not. Communication has improved, but resource planning and operational demands are not managed digitally.
4 MATURE	OT and IT systems at both the production and enterprise levels are integrated into automated, interoperable, and flexible networks that facilitate seamless data exchange, analysis, and decision-making. This integration enhances communication, flexibility, and operational efficiency, while also enabling quicker and more coordinated responses to changes in resource availability, operational requirements, or product types.
5 INSPIRING	OT and IT systems at both production and enterprise levels are unified into automated, interoperable, and flexible networks that allow for seamless data exchange, analysis, and decision-making. This integration will improve communication, flexibility, and operational efficiency, thereby enabling faster and more coordinated responses to fluctuations in resource availability, operational demands, or product types.

(Source: Author's own construction)

4.6.3. Digital Supply Chain (Horizontal Integration)

Organizations already face turbulent market conditions due to globalization and business complexity. Besides, customers with rapidly changing needs have been forcing A&D sector to shorten their product lifecycles. Also, raw materials shortages and global crisis like Covid19 uncovered vulnerable supply chain issues, in the recent decade. At this point, digital technologies may strengthen the supply chains via enhanced visibility and control, data driven decision making, and process automation. In fact, Sjödin et al. (2018) finds out that digital maturity brings agility, resilience, and reliability to supply chains.

Open innovation performance depends on the organization's ability to create an environment that supports continuous improvement and learning via enabling inflows and outflows of knowledge. Supply chains are the primary environments in which a company may build such knowledge flows. Digital technologies enable knowledge bridges in supply chains by facilitating cross-enterprise collaboration and information sharing. Digital supply chains promote continuous improvement through data-driven decision making, predictive capabilities, and dynamic network reconfiguration. Since A&D sector are impressed and yet restricted by their suppliers' capabilities, digitally mature suppliers may embrace the innovation capabilities of the mother companies, and the ecosystem as a whole.

Digital supply chains create an integrated ecosystem where Industry 4.0 technologies like big data analytics, IoT and cloud computing enable real-time information exchange and advanced analytical capabilities. This technological foundation transforms traditional operations by enabling new operational models. In traditional A&D sector, these technologies may create new opportunities for innovation and competitive advantage via decreasing development costs, enhancing collaboration, improving quality, cost efficiency, and reducing risk. However, these benefits have scarcely been researched in the open innovation literature. This thesis considers examining this issue by assessing the digital maturity of supply chain a dimension of OI maturity (Table 27).

Table 27. Proposed Model: Horizontal Integration Dimension

MAIN DIMENSION	SUB-DIMENSION	DEFINITION	SURVEY/ INTERVIEW QUESTION	ADOPTED FROM
DIGITAL MATURITY	**15 Horizontal Integration**	The extent, digital techs. are used in supply chain for decision making, product and process innovations.	To what extent are digital techs integrated into supply chain?	Obal & Lancioni, 2013 Enkel et al., 2020 Dervitsiotis, 2010

LEVEL	Definition
1 FREEZE	Knowledge about and application of I4.0 technologies in supply chain (SC) operations is inadequate. There may be some isolated attempts to adopt I4.0 concepts. Resistance to incorporating new technologies into supply chain operations.
2 MELTING	Some I4.0 technologies are integrated into process improvements aimed at aligning with SC trends. The organization recognizes the importance of adopting I4.0 technologies and supply chain trends. Systems remain mostly isolated.
3 PLANNED	Industry 4.0 technologies are consistently incorporated into improvement projects alongside the supply chain. Processes are being modified to address unpredictable supplier behavior. Initial integrations of systems and Industry 4.0 technologies are currently taking place and are subject to comprehensive analysis.
4 MATURE	A comprehensive vision of SC 4.0 is formulated and disseminated among all stakeholders within the supply chain. Industry 4.0 technologies, which enable decision-making based on real-time information and support ongoing improvement efforts, are integrated into the supply chain framework. Additionally, best practices pertaining to Industry 4.0 and prevailing supply chain trends are identified and adapted to align with the organizational culture.
5 INSPIRING	A culture of SC learning and improvement, driven by digital trends, has been established within the enterprise. It sets a benchmark, with its employees tasked with enhancing the processes of suppliers. The organization contributes valuable insights to the development of I4.0 concepts and plays an active role in the evolution of this initiative.

(Source: Author's own construction)

4.7. AHP Method

The proposed model aims to analyze OI maturity of an A&D company through 16 dimensions organized into 5 categories, as outlined in previous chapters (Figure 10). A digital questionnaire that addresses these dimensions using a 5-point Likert scale will be sent to managers to conduct the field research. Before conducting the empirical part of the study, we need to analyze the pair-wise significance of each dimension.

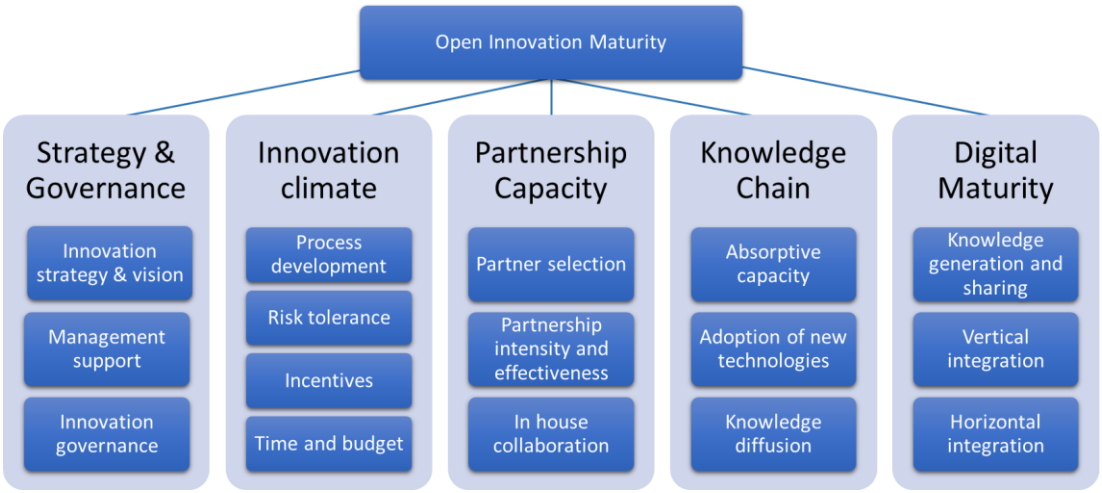

Figure 10. AHP Hierarchy of The Proposed Model
(Source: Author's own construction)

While this model is tailored for the A&D sector, each sector or ecosystem may have unique competitive factors, meaning that certain capabilities or processes may hold differing significance in different contexts. Consequently, two companies from different industries completing the questionnaire with same answers may exhibit varying levels of OI maturity due to their distinct contexts. Additionally, the dimensions within the model may have different levels of priority for a company. For instance, in our model, innovation governance and management support may have different weights for defining maturity of the strategy category. To deal with that challenge, it is crucial to initiate the assessment of a target company with a "pondering phase" via utilizing Saaty's (1980) Analytic Hierarchy Process (AHP) technique. This technique is utilized to rank and assign appropriate weights to the various sub-dimensions based on the specific requirements and needs of the A&D industry.

The ability to manage and prioritize different levels of importance for these sub-dimensions is a key advantage of the proposed model. Among the 37 innovation maturity studies examined during the SLR phase, only 3 of them try to weigh the innovation dimensions/capabilities and 1 among them used the AHP technique. The proposed model is contributing to OI maturity literature as being the only OI model employing AHP. Saaty's AHP is selected because this approach is expected to tailor the model according to the specific needs of an A&D company and its environment and facilitate a more quantified evaluation and assessment.

Additionally, AHP provides a valuable "consistency check" to evaluate whether the importance assigned to various dimensions is logically consistent. If inconsistencies arise, it may indicate that the respondent struggles to differentiate between dimensions, suggesting a need to adjust the data collection process or the analysis framework. The consistency ratio (CR) used in the AHP methodology facilitates this assessment. The maximum threshold of 10.00% is assumed to be acceptable by Saaty, indicating that the respondents were consistent in their evaluations. In this model, we prefer the acceptable threshold to be 5 % at most to increase consistency among dimensions.

AHP effectively integrates both qualitative judgments and quantitative data, allowing for a comprehensive evaluation of alternatives based on multiple criteria (Saaty, 2004). This thesis aims to build a model considering the creative inputs of qualitative judgments combined with quantitative data. Therefore, a focus group discussion is conducted to determine the weighted importance of the dimensions in the sector's open innovation maturity. In this context, an online 2-hour session was held with 6 academics and industry professionals listed in Table 28 to decide the weights of the 5 categories and 16 sub-dimensions within the maturity model.

The participants of the focus group are chosen according to industrial expertise, innovation awareness and academic background. The researcher works in the A&D sector, thus her professional network along with her adviser's academic network enabled the accessibility of appropriate participants.

Table 28. Participants of AHP Session

	TITLE	FIELD OF EXPERTISE	TENOR
A	University Instructor, Prof. Dr.	Academic and A&D Sector	+20 years
B	Open Innovation & Entrepreneurship Manager, PhD	A&D sector	+15 years
C	Innovation Director, PhD	Turkish innovation ecosystem	+15 years
D	Leader Engineer, PhD	A&D sector	+20 years
E	Innovation Manager	A&D sector	+15 years
F	Supplier Management VP, PhD	A&D sector	+20 years

(Source: Author's Own Construction)

Before the AHP session, participants received an e-mail and attached documents containing the dimensions that make up the model, definitions of these dimensions, and explanations of the maturity levels, as well as tables for pairwise comparisons of each category and the dimensions under those categories to facilitate quicker and more efficient responses during the session. The e-mail message conveyed the purpose of the study, the aim of the AHP session, the planned flow of the session, and what was expected of them during the AHP session. It was also noted that reviewing the model and getting prepared for choices based on the comparison matrices in advance would be beneficial for an effective session. Subsequently, a survey was conducted to determine an appropriate date and time for all participants to schedule the online session.

The focus group discussion was held in February 2025. At the beginning of the online session, the researcher stated the aim of the research and the session. Then, the academic advisor and the session participants briefly introduced themselves. Following that, they moved on to the pairwise comparison tables (Table 29). Each participant first indicated their choice depicting the relative importance level of the dimensions on a scale of 1 to 9. A number chosen on the left side states that the dimension on the left has more significance compared to the dimension on the right and vice versa. The degree of significance increases as the number increases.

Table 29. Example of pairwise comparison tables used during AHP session

	Strategy & Governance									
Which dimension is considered more important and how much more?										
	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Innovation Strategy										Management Support
Innovation Strategy										Innovation Governance
Management Support										Innovation Governance

(Source: Author's own construction)

The researcher noted these responses in the tables in a way that all participants could see them at that moment, and then the participants were given a brief opportunity to speak in order to reach a common consensus. During the discussions the researcher and the advisor did not intervene in the determination of the weights; they only provided information aimed at description and purpose. A consensus was reached for each pairwise comparison before moving on to the next comparison.

AHP technique provided a systematic method for aggregating individual preferences, helping to achieve consensus in group decision-making contexts (Saaty, 1980). This process continued until the comparisons of the 5 categories and the internal comparisons of the dimensions belonging to those categories were completed. The pairwise comparisons and CRs are presented in the following tables (Table 30-35).

Table 30. Main Categories of the Model - Matrix of Pairwise Comparisons

Matrix	Strategy and Governance	Innovation Culture	Partnership Capacity	Knowledge Chain	Digital Maturity
Strategy and Governance	1	1/2	3	2	5
Innovation Culture	2	1	2	1	5
Partnership Capacity	1/3	1/2	1	1/3	3
Knowledge Chain	1/2	1	3	1	5
Digital Maturity	1/5	1/5	1/3	1/5	1

CR: 5%

(Source: Author's own construction)

Table 31. Strategy and Governance Category- Matrix of Pairwise Comparisons

Matrix	Innovation Strategy	Management Support	Innovation Governance
Innovation Strategy	1	1	3
Management Support	1	1	3
Innovation Governance	1/3	1/3	1

CR: **0%**

(Source: Author's own construction)

Table 32. Innovation Culture Category- Matrix of Pairwise Comparisons

Matrix	Process Development	Risk Tolerance	Incentives	Time and Budget
Process Development	1	1/3	1/2	1/5
Risk Tolerance	3	1	3	1
Incentives	2	1/3	1	1/3
Time and Budget	5	1	3	1

CR: **2%**

(Source: Author's Own Construction)

Table 33. Partnership Capacity Category - Matrix of Pairwise Comparisons

Matrix	Partner Selection	Partnership Intensity and Effectiveness	In-house Collaboration
Partner Selection	1	1	¼
Partnership Intensity and Effectiveness	1	1	1/3
In-house Collaboration	4	3	1

CR: **1%**

(Source: Author's own construction)

Table 34. Knowledge Chain Category – Matrix of Pairwise Comparisons

Matrix	Absorptive Capacity	Adoption of New Technologies	Knowledge Diffusion in Networks
Absorptive Capacity	1	1	2
Adoption of New Technologies	1	1	2
Knowledge Diffusion in Networks	½	½	1

CR: **0%**

(Source: Author's own construction)

Table 35. Digital Maturity Category- Matrix of Pairwise Comparisons

Matrix	Digital Knowledge Sharing	Digital Manufacturing and Operations	Digital Supply Chain
Digital Knowledge Sharing	1	3	4
Digital Manufacturing and Operations	1/3	1	2
Digital Supply Chain	1/4	1/2	1
CR:		**2%**	

(Source: Author's own construction)

The results of the AHP session shows that "Innovation culture" is the most influential category for OI maturity in A&D sector (Table 36). "Strategy and governance" follows as the second most weighted category. Knowledge chain has the third place in the model. These three categories nearly weigh 84% of the open innovation model. Partnership capacity and digital maturity explain only 16 % of the maturity. This can be due to the fact that the industry has met the advantages of partnerships just recently. Also, the security concerns and oligopolistic structure of the industry may hamper intensity and effectiveness of partnerships. Moreover, although digital technologies are recognized to be crucial for knowledge management, their presence in vertical and horizontal chains remains restricted. The Turkish A&D ecosystem has been dominated by large OEMs and this fact may create less digitally mature suppliers in the value chain. These issues imply an apparent need for further research. It was also found that all CR values are below 10%, confirming that all pairwise comparisons are consistent and valid.

Out of 16 dimensions 6 of them appear to have a weigh equal to and more 10 %. Innovation strategy (12%), management support (12%), risk tolerance (11%), time and budget (12%), absorptive capacity (10%) and adoption of new technologies (10%) are found to be the most influential dimensions in OI maturity of A&D sector Table 37. In the previous chapters we have explained that almost all innovation models mention the significance of a clear strategy and support of management for successful innovation outcomes.

Table 36. Weighted Impact of Category and Dimensions in the Model

Category	Category's Weight in Model	Dimension	Weight in Category	Dimension's Weight in Model
Strategy and Governance	29%	Innovation Strategy	43%	12%
		Management Support	43%	12%
		Innovation Governance	14%	4%
Innovation Culture	31%	Process Development	9%	3%
		Risk Tolerance	36%	11%
		Incentives	14%	4%
		Time and Budget	41%	12%
Partnership Capacity	11%	Partner Selection	17%	2%
		Partnership Intensity	19%	2%
		In-house Collaboration	63%	7%
Knowledge Chain	24%	Absorptive Capacity	40%	10%
		Adoption of New Technologies	40%	10%
		Knowledge Diffusion in Networks	20%	5%
Digital Maturity	5%	Digital Knowledge Sharing	63%	3%
		Digital Manufacturing and Operations	24%	1%
		Digital Supply Chain	14%	1%

(Source: Author's own construction)

The need for fair resource allocation (time and budget) is also a primary expectation of previous models for innovative outcomes. Moreover, in the interviews with C-level executives, it has been repeatedly mentioned that Türkiye is trying to catch up with pioneers of the industry. Thus, it's not surprising that capabilities that enhance catching up competencies, absorptive capacity and adoption of new technologies criteria, stand

out among others. Our findings are in correspondence with the literature and our qualitative findings.

Table 37. Ranking of dimensions according to AHP results

Dimension	Weight in Model
Innovation Strategy	12%
Management Support	12%
Time and Budget	12%
Risk Tolerance	11%
Absorptive Capacity	10%
Adoption of New Technologies	10%
In-house Collaboration	7%
Knowledge Diffusion in Networks	5%
Innovation Governance	4%
Incentives	4%
Process Development	3%
Digital Knowledge Sharing	3%
Partner Selection	2%
Partnership Intensity	2%
Digital Manufacturing and Operations	1%
Digital Supply Chain	1%

(Source: Author's own construction)

Turkish A&D industry has showed remarkable development in the last 15 years. As mentioned earlier, this rapid catch-up includes a strategy change, managerial support and enhanced awareness for innovation activities which may mean risk tolerance and allocation of time and budget. Moreover, the industry owes a lot to its absorptive capacity and technology adaptability (SSB, 2024a and 2024b).

CHAPTER 5

THE EMPIRICAL RESEARCH - MEASURING OI MATURITY

We aim to validate the designed model by conducting a survey at an OEM company and its ecosystem and by doing so, imply about the open innovation maturity of the Turkish A&D industry. To understand the basics of this empirical phase, first of all it is significant to understand ecosystem approach in innovation literature, because A&D industry is accepted to be an innovation ecosystem. Moreover, the approach of conducting empirical research aligns with the suggestions of De Bruin et al. (2005), who recommend employing quantitative methods for evaluating maturity models. According to them, after a model is developed, it needs to be assessed for its relevance and robustness. It's essential to assess both the model's construct and its instruments for validity, reliability, and generalizability.

The concept of ecosystems has emerged as a valuable framework in the fields of strategy, innovation, and entrepreneurship (Gomes et al., 2018). Jackson (2011) defines an innovation ecosystem as “the complex relationships that are formed between actors or entities whose functional goal is to enable technology development and innovation.” In an environment where organizations are becoming increasingly specialized, a single entity often lacks the internal resources necessary for developing and implementing innovations (Adner, 2006; Adner and Kapoor, 2010; Talmar et al., 2020). Thus, open innovation is not an option but the new era in innovation literature. Therefore, organizations must depend on the contributions of various stakeholders, both within and outside the institution, to create a value proposition across the ecosystem (Talmar et al., 2020). In particular, A&D industry is referred to be an ecosystem in this research due to its intricate network of interconnected stakeholders, including manufacturers, suppliers, partners, research institutions, and regulatory bodies, all of whom collaborate to drive technology development and innovation. This

sector features complex supply chains that require specialized contributions from various entities, fostering collaborative innovation and resource sharing. Additionally, the industry's oligopolistic nature leads to strategic partnerships, while stringent regulatory requirements necessitate cooperation among participants to ensure compliance and safety. These elements combined highlight the interdependence and collaborative dynamics that characterize the A&D industry as an ecosystem.

There are two reasons that differ an innovation ecosystem approach from previous science and technology parks approach, regional innovation systems, science cities, or innovation clusters. First of all, digitalization plays a central role, with information and communication technologies (ICT) connecting innovation actors and facilitating the development of new products and services. Our proposed model accepts that contribution of digital techs to open innovation maturity. Second is the ecosystem approach's emphasis on open innovation practices, including borrowing, licensing, and crowdsourcing, enable the integration of diverse ideas (Oh et al.,2016). Validating our model in an ecosystem approach is aligned both with open innovation theory and structure of A&D industry.

As mentioned in previous chapters, A&D companies that were once pursuing closed innovation systems cannot be innovative on their own in today's competitive and intertwined economies. Companies need partners, external knowledge and digital maturity to innovate. Although ecosystem approach suggests a broader partner portfolio, such as NGOs, universities, research centers and government, in this research we planned to look at an OEM and its suppliers, in particular. The main reason is that suppliers are often considered the most significant partners for A&D companies (Aslan, 2018), due to their critical role in providing specialized components and technologies essential for production. The industry relies on complex supply chains where various suppliers contribute vital parts, thus making collaboration with them is crucial for innovation, product quality, and cost efficiency. Additionally, suppliers must comply with stringent regulatory standards, ensuring reliability throughout the supply chain. Effective management of supplier relationships not only helps A&D companies control costs but also optimizes resource allocation, further emphasizing the interdependence that drives success in the industry. The proposed model is

designed based on company level organizational capabilities and requires the responses of company managers instead of university officials, customers, NGOs or other parties. Future studies may have the opportunity to focus on other partners to examine A&D ecosystem.

The oligopolistic structure of Turkish A&D ecosystem reinforces the interdependency between OEMs and their suppliers (Aslan, 2018). Thus, surveying an OEM along with the suppliers (subcontractors, system producers, project partners) may have a reliable implication for the Turkish A&D industry's OI maturity. In the following sections, the design of the empirical study will be explained, and the introduction of the OEM company and suppliers are presented. Lastly, the results of the survey are presented.

5.1. Case Company Profile

The company A has global presence and is based in Türkiye, Ankara. Company A has been operating for 40 years and has become among the top hundred global players in A&D industry in the last decade. Company A is organized under 6 different business segments of aerospace with more than 14.000 employees. There are around 1.000 first level managers, titled as "chief", and more than 300 department managers and directors. Each aerospace business segment is directed by an executive vice president that report to the CEO.

Company A is one of the largest in the Turkish A&D sector with an annual revenue of over 2.5 billion dollars and exports exceeding 700 million dollars in 2024. The company is an OEM and has adopted a vision not only to be a global player but also to develop the Turkish ecosystem. In parallel with the development of the Turkish aerospace and defense sector especially in the last 15 years, Company A has launched novel air platforms to the market and is continuously developing strategies to improve its global position.

The company's sustainable revenue and export growth and increasing number of market new products entering the market in recent years coincide with the innovation (particularly R&D) activities of the company during this period. We cannot share

company information due to confidentiality agreements. However, it is possible to confirm the increase in R&D expenditures and R&D employee number situation through national publications and sectoral programs. In fact, "Ar-Ge 250" Research, which monitors the pulse of R&D expenditures in the Turkish business world, has been conducted by the Economy and Business World Portal, Turkishtime, since 2013. This research shows that company A has been among the top five R&D companies since the research has been launched. Moreover, there is a steady increase in Company A's R&D employees and R&D expenditures (Figure 11).

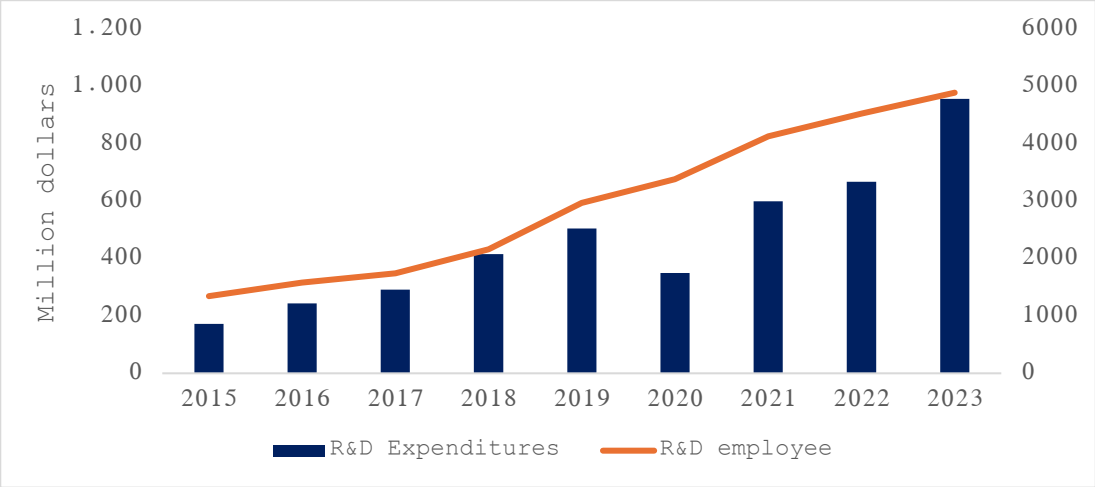

Figure 11. Company A's R&D Data
(Source: Turkishtime Ar-Ge 250 Research website)

On the other hand, we have reviewed Turkish Exporters Assembly's (TİM) first Innovation Development Program (InovaLIG). In 2014, TİM launched Türkiye's InovaLIG to support the increase in innovation-based exports, develop innovation awareness in companies, enhance the innovation cultures of companies on an interactive platform, and reward efforts to acquire innovation competencies. Turkish A&D companies, as well as company A, have been taking degrees in the program's Innovation Culture, Innovation Strategy, Innovation Product Life Cycle or Innovation Resources categories since 2018. Company A has been the champion two times in different categories. Furthermore, Company A launched an open innovation program in 2023 and still manages OI and intrapreneurship programs with a separate unit under technology management department. The mission and value statements of Company

A mentions about being innovative and enhancing technological capabilities of Turkish A&D ecosystem.

5.2. The Ecosystem Profile

In the Aerospace and Defense (A&D) industry, suppliers are a part of the value chain, providing essential components, materials, and services that support the design, manufacturing, and maintenance of various products. The general organization of Turkish A&D ecosystem is in compliance with the global one. These suppliers can be categorized into several types. Raw material suppliers deliver specialized metals and alloys, such as titanium and aluminum, along with advanced composites and plastics that are vital for aircraft and defense systems. Component manufacturers produce critical electronic systems, mechanical parts, and subassemblies, including avionics, engines, and cockpit controls. Systems integrators play a crucial role by combining various components into cohesive units, ensuring functionality and compatibility across complex systems like missile guidance and integrated avionics. Specialized contractors may provide services such as testing, certification, and quality assurance, while research and development partners, including universities and research institutions, collaborate on innovative technologies and advanced materials. Additionally, service providers offer engineering services, maintenance, repair, and overhaul (MRO) support, while technology providers supply software solutions, including simulation tools and cybersecurity measures. Logistics and supply chain management companies facilitate the transportation and storage of materials, ensuring timely delivery and regulatory compliance. Overall, the supplier network in the A&D sector is complex and multifaceted, requiring stringent regulatory compliance and high-quality standards to ensure the reliability and security of aerospace and defense products.

Within this thesis, raw material suppliers which are almost foreign companies and service companies like specialized contractors and logistics companies are kept out of scope. Companies that are subcontractors (component manufacturers), system manufacturer and integrators and R&D partners are the basis of our ecosystem research. Company A is not only working closely with Turkish A&D ecosystem but

also shaping it by collaborating with more than 200 national suppliers that are either subcontractors, partners and/or system producers. Some companies have multiple roles in Company A's ecosystem. For example, one of the leader OEM's in Turkish A&D industry is acting both as a R&D partner and crucial system integrator of Company A.

Company A outsources production and assembly of certain components to its sub-contractors. The top 15 sub-contractors cover 60%, and top 30 explain nearly 80 % percent of outsourced work in dollars. In 2024, the outsourced work volume is predicted to exceed 200 million dollars. On the other hand, the company is executing over 100 R&D and innovation projects, more than half including a partnership with national partners. There is also an ongoing attempt to supply products, critical systems and technologies from national companies instead of foreigner ones. Company A has been working on the localization of hundreds of aircraft components in total, collaborating with around 200 local and national companies. It is expected to prevent approximately 500 million dollars foreign procurement in the coming years. This policy is led by SSB and named as "yerlileştirme", localization, and employed by Turkish A&D companies as a priority. Company A announced their endenization rate as nearly 80 % in 2024. This policy has implications for the significance of Turkish A&D ecosystem. Not only the OEM companies but also their suppliers and partners are dependent on innovation efforts to reach challenging goals set by policy makers and OEM's strategies.

The profile of Company A, the ecosystem and their engagement with OI approach makes it appropriate to employ this empirical research. The interviews conducted with the top management, the internal observations and documents and the data gathered through national R&D and innovation projects enable valuable data to validate our proposed model developed for measuring OI maturity.

5.3. The Survey

The development and implementation stages of this empirical study are explained in this section (**Figure 12**).

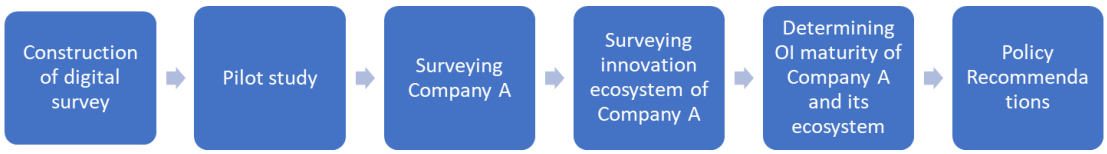

Figure 12. Phases of Empirical Study
(Source: Author's Own Construction)

First of all, the proposed maturity model was transformed into a survey format. The survey questions and answers were developed based on the model. Each dimension is converted into a question format and the corresponding maturity levels were inserted into the survey as answer options (in a Likert 5-scale format). An introduction part is added to the survey, that defines open innovation concept and explains the goals of survey. The communication details of the researcher and approval of the METU Human Subjects Ethics Committee (Appendix A) were given. The introduction part reminds the respondents that personal information and the company's name will be kept confidential throughout the research. After the introduction, one open-ended question asking the managerial title of the respondent is asked. At this point, the survey delivered to the suppliers includes one additional question about the company name, but this question is not mandatory, in case respondents who do not want to mention their company name may become discouraged to answer the survey. The main section of the survey has 16 compulsory questions with a 5-scale Likert format (1-lowest maturity level, 5-highest maturity level) that aims to measure the maturity dimensions of Company A. Finally, one open-ended question is added as the last question to gather the participants' opinions about policy recommendations. Appendix C includes all Turkish and English components of the survey delivered.

The model is translated to Turkish and embedded into a digital survey format to sustain ease of participation. The digital format is planned to be digitally secure, user-friendly and accessible through a link or QR code. The following figure is a representation of that survey tool.

The created survey was made digitally accessible via a digital survey website (limesurvey.com). Due to the internet security policies of Company A, there were limited website alternatives for the survey that can be accessed through company internet protocols. An example of the e-mail and survey screenshot is given below (Figure 13). The survey was prepared in Turkish and sent to the sample via e-mail.

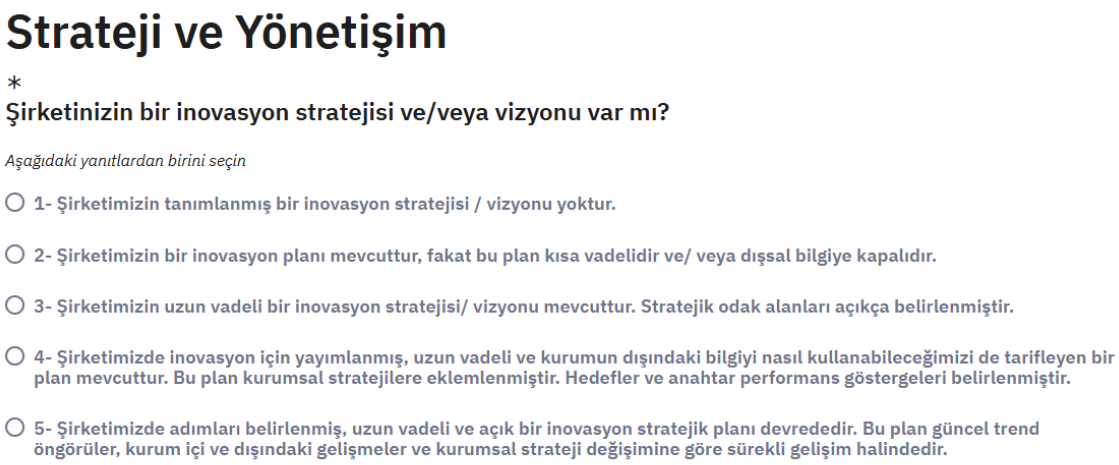

Figure 13. Digital Survey Screenshot
(Source: Author's own construction)

Before data collection stage, pilot implementation was conducted at one of Company A's main subcontractors. The invitation to the survey was sent via e-mail to the pilot company. The e-mail mentioned that this was a pilot study and feedback was requested from the respondents about the coverage of questions, answer options, language, flow of the survey, design problems and user-friendliness. 15 employees (5 were managers) answered the survey. Two correction notices were received about the language of a question and necessary adjustments were made. Moreover, 3 respondents gave positive feedback about the structure and content of the survey.

As the next phase, the survey invitation was sent via email to the middle and upper management of Company A. The invitation has reached more than 300 managers. Following the e-mail invitation, the managers were also called via phone or met face

to face to increase the response rates. The researcher is an employee of Company A thus she had advantage in accessing the e-mails and phone numbers of the managers. Collecting data as an outsider is difficult by nature, and at an A&D company it is even more challenging due to the security concerns and intensity of managers' agenda. Survey data was collected from the company within 1 month and the number of respondents reached 121 from Company A.

Subsequently, as part of the approach to evaluate open innovation maturity within an ecosystem, the survey was sent to the main subcontractors of the company, critical system and subsystem manufacturers, and partners with whom they collaborate on R&D and innovation projects that are located in Türkiye. One non-compulsory question was added to the survey at this point, to determine which companies answered the survey. To increase participation rates, besides e-mail, the survey invitation was announced on the supplier portal of Company A. Moreover, the researcher got in contact with SASAD, the strongest NGO in the sector, and the survey invitation was resent to member companies and SASAD's technology and innovation working group. On the other hand, Saha Istanbul and Ostim Aviation clusters were called, but no positive response was received from them. Two critical system and sub-system manufacturers were visited to ask for participation. As a result of the continuous efforts that took place over two months, responses from the ecosystem of company A have reached 52. The data collection stage from Company A innovation ecosystem was more challenging than the data collection phase of Company A. There are possible reasons. First of all, most of the companies are small enterprises that may lack managerial awareness about innovation. Personal data or phone numbers of suppliers were not accessible thus e-mail invitations were the primary means of contact. Also, suppliers may have a resistance to answering the survey due to their work pace, concerns about being recorded, or simply their indifference.

5.4. Results and Discussion

In this section the results of the survey conducted at Company A are explained. The survey was sent to more than 300 middle and senior level managers. 192 has opened

the survey and 121 of them have completed it. The title distribution of respondents is given below (Figure 14).

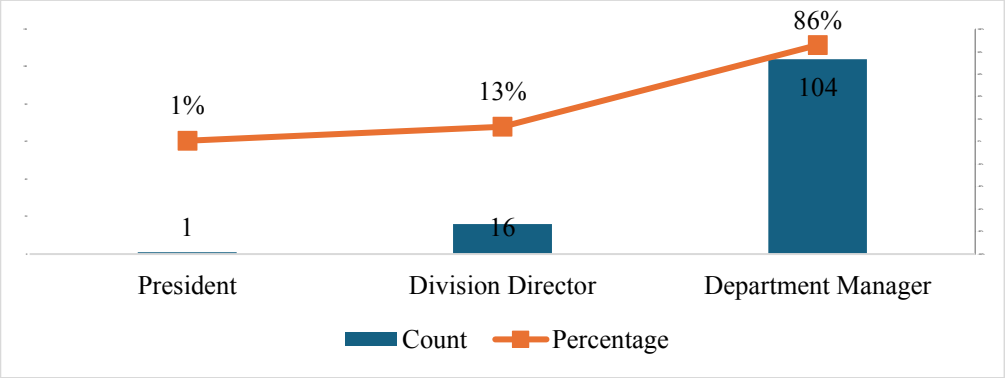

Figure 14. Title Distribution of Survey Respondents
(Source: Author's Own Construction)

In the following sections, first of all, the results for maturity categories, Strategy and Governance, Innovation Culture, Partnership Capacity, Knowledge Chain and Digital Maturity are explained. After that, the general OI maturity level of Company A is examined. The findings obtained through the survey are validated through interviews conducted with top management (C-level executives) and results obtained from observations, policies, publications, and Company A's achievements gathered in national and international innovation programs.

5.4.1. Strategy and Governance

This section shares the survey results related to the strategy and governance category (Table 38).

The innovation strategy has the highest average among the dimensions within this category. When taking the arithmetic average of the responses given by the survey participants, a figure of 3.3 is reached. Looking at the maturity levels proposed by our model for the innovation strategy in the survey, level 3 is "A long-term innovation vision, mission and strategy are present and well-documented, strategic focus areas are clearly defined".

Table 38. Strategy and Governance Category Maturity Findings

Category	Category Weight in Model	Dimension	Dimension Weight in Category	Dimension Weight in Model	Dimension Maturity	Category Maturity
Strategy and Governance	29%	**Innovation Strategy**	43%	12%	3.3	**3.1**
		Management Support	43%	12%	3.0	
		Innovation Governance	14%	4%	2.9	

(Source: Author's own construction)

Level 4 represents "A strategic plan for innovation is present, well-documented, focuses on the long-term and is incorporated in the organizational strategy. It is translated into actionable goals and KPIs". In this context, the overall assessment is closer to level 3. The interviews with the top management give a similar result. They talk about a clear strategy; short and long time focus areas but measurable goals are not clear in all areas. Only one- C-level manager stated that increasing the profits is a major goal. Also, there appears some differences in how each product group deals with the innovation strategy. One C-level manager said that "they have a clear roadmap for innovation, the other stated that they wait until the emergence of a need to start and allocate resources for an innovative project. To validate the survey result for first dimension, the documents and strategic plan of the company were reviewed. It has been found that there is a documented innovation strategy that clearly defines the vision and strategies for short term and long-term innovation. However, KPIs for innovation is partial and mostly in binary format, such as publishing a roadmap or conducting a workshop for determining innovation focus areas. Thus, the average maturity scores 3,3 seems to be valid for Company A.

Management support with an average score of 3 means that "Managers encourage employees to innovate and receive training to ensure this. The institution selects significant innovation stories and shares them with employees". This dimension has the same weight as innovation strategy in the model (one of the highest) and constitutes most of the category together. When we check the interviews to validate the support

of management, C-level manager of technology development stated that “Our company has launched an intrapreneurship program this year. We trained the intrapreneurs to incubate their ideas and we presented the successful projects to the top management. This was a pilot project and we aim to repeat this regularly”. Top manager of another product group is more conservative and states that they have limited resources to train and encourage employees for innovation, due to challenging production schedules. When the internal processes of the company are examined an ERP application is present for recording best practices and failures to enterprise memory with which an employee can also offer innovative ideas. Also, there is a structured training program for all levels of employees covering creative thinking methods, business model canvas, innovation management titles. As a whole it is apparent there is management support to cultivate innovative ideas however the inspiration efforts are not regularly or structurally executed throughout the company. Thus, the result of the survey for this dimension is reliable.

Innovation governance is the third dimension under this category with a weight of 14%. Governance may be a pre-mature term for managers. Thus, while asking the question about the maturity of innovation governance first of all the definition of the term is given. Innovation governance refers to the framework of policies, procedures, decision-making authority, and accountability mechanisms established to ensure that innovation initiatives are aligned with the company's overarching business strategy. The respondents answered that maturity level as 2,9 on average. This score is pretty close to 3. Thus, we assumed that the explanation of level 3: “It is clear how innovation activities are set up and who is functionally responsible for each innovation activity. This is reflected in the organizational structure and processes” would be appropriate for that dimension. The interviews are reviewed to understand how governance is understood and implemented by managers. An interviewee stated that “the company brings together top-level managers for governance to identify innovation focus areas, discuss how to create awareness and start projects, and subsequently evaluate results of intrapreneurship projects, pilot applications, and external ideas (open innovation) specifically from start-ups and universities. If there is success, progress, or problem, it is discussed at executive board meetings. This is gradually breaking the ice towards innovation. Our company should be involved more in open innovation and

intrapreneurship". Another interviewee said that "innovative ideas mature to a certain extent and afterwards they are presented to a higher management board, which determines priorities and decides to invest in certain technologies and initiate specific projects, also prioritizing based on budget conditions. As I mentioned, this board, made up of top management, does not meet regularly; there are no routine meetings. As I said, as projects mature...". These explanations highlight the absence of a clear framework for innovation governance, where centralized and decentralized decision-making autonomy is established. Additionally, functional and financial responsibilities are not clearly defined in advance. Therefore, maturity level 3 is enough to explain the innovation governance of Company A.

5.4.2. Innovation Culture

Innovation culture category is considered to be the most significant category in the model (2 percent more in weight than strategy and governance) and has four dimensions (Table 39).

Table 39. Innovation Culture Category Maturity Findings

Category	Category Weight in Model	Dimension	Dimension Weight in Category	Dimension Weight in Model	Dimension Maturity	Category Maturity
Innovation Culture	31%	**Process Development**	9%	3%	2.9	**2.9**
		Risk Tolerance	36%	11%	3.4	
		Incentives	14%	4%	3.1	
		Time and Budget	41%	12%	2.5	

(Source: Author's Own Construction)

Process development dimension seeks for procedures, processes, or unwritten rules for supporting innovative attempts. This dimension has the lowest weight in the category and one of the lowest in the proposed model. The average score for this dimension is 2,9. This score almost means a level 3 maturity, that the company has a well-defined innovation process that is documented, outlining clear decision points and criteria for

each stage of the process. The interviews with the top management support the same opinion. One of the respondents declared that “the company has studies related to procedures and processes. A team works autonomously with our employees. Currently, we have not reached all employees. The team reviews the literature and tries best practices at our company. The process is updated every year with a working group composed of different backgrounds”. However, two other interviewees did not know the details of the innovation process. This may be due to the fact that the process is published in 2024 and not diffused to the whole company. In fact, the innovation process is published in the enterprise process system and accessible by all employees. The process proposes a general way for innovation. There are not a bunch of processes that are dedicated to certain types of innovation. Moreover, we could not find proof of concept that this process is pursued in innovation activities. Therefore, we concluded that the maturity level 2,9 is explorative for the company.

Risk tolerance is a significant dimension for the category and for the whole proposed model. The average score for risk tolerance has been 3,4. This maturity level equates somewhere between maturity levels 3 and 4. This means that “employees engaged in innovation failures are not punished or, without reflection, blamed for the innovation failure in any way”, but more is encouraged. Level 4 at risk tolerance means that “employees who take the courage to innovate are continuously acknowledged and respected, regardless of the innovation outcome. Employees talk openly about failure and their learning experiences”. The company must stay in between provided the maturity score 3,4 is meaningful. To assess this situation the responses of the top management are reviewed. One of them states that “from the beginning, we accepted risk. We do not have an expectation that there will definitely be a success or a product resulting from innovation. We are aware that there can be side benefits to failure. So, even if a product does not emerge at the end of the day, we know that different ancillary benefits can arise from that research or technology development. Therefore, we do not have such an expectation. We are not on the mindset that every R&D effort or every technology development project will necessarily lead to a product.” However, another top manager thought in a different way: “Now, as a culture, we do not come from a background that tolerates a lot of risk. Because, as I said, we are trying to catch up. We

need to quickly go through processes that others have taken 20 years to accomplish in 5 years. What does this require? We do not have a culture where we say, I'll try one, and if it fails, I'll try another, and if that one fails, I'll try again. What we are trying to do is to succeed on the first attempt. But of course, we do not penalize our colleagues." The top manager who is responsible from innovation management states that "So far, we do not have an application or initiative for risk management in innovation activities. However, we have an enterprise risk system for projects that may be a ground for innovation risk system." The survey result, 3,4, is reliable at this point. The company is tolerating risk to a bearable point.

Incentives is the third dimension in innovation culture category. This dimension is aiming to understand the company's incentive approach for innovation activities. The average score of respondents participating the survey is 3,1. This score iterates to level 3 of maturity meaning "employees are given incentives periodically according to a procedure based on a monetary basis. Assessments are done by specialists from or outside the company". The top management stated that "Giving incentives is in the procedure. We implemented how we would support intrapreneurs last year. Instead of a specific monetary reward, we give awards that will enhance and support that person's creativity and intrapreneurship. There are training sessions that can qualify as awards. We need to develop it based on the needs." Another top manager said that "so, in a sense, it exists. We prepare a certificate of appreciation, sign it, and present it to the colleague. We have a mechanism for this. Our company has already defined an award mechanism, which could be half a salary, a full salary, etc. We have such a corporate award mechanism in place. We use it. We also work to ensure that its use is not arbitrary or random. We are working to institutionalize it a bit more." The corporate policies support the existence of an incentive system. The awards are appreciation or a percentage of salary. However, this system may not be applied throughout the company and does not include non-monetary incentives, yet. As a result, the average score 3,1 seems quite reasonable for this dimension.

Time and budget are the most influential dimension in the proposed model along with innovation strategy and management support and yet got one of the lowest scores in

the model, 2,5. This means that there is more than "an irregular time and budget, provided that operational activities remain the priority. Employees conduct innovation activities mostly within their daily tasks. But also, the company has not reached the level of "employees are encouraged to innovate by the presence of a procedure to receive time and budget". Time and budget are the prior problem of the company. One top manager declared that "now, there are both innovation activities and R&D activities. We are in a slightly better position on the R&D side. We allocate a budget for this and operate within that budget. We need to have a separate budget for R&D and innovation. This will be in place by 2025. That's the next step." Another top manager said that "we did not need excessive budgets for innovation up to this point. Right now, we are actually using the research resources of the university. There are cheap labor available, especially doctoral students. In fact, we use a doctoral student's most valuable time at the lowest cost. For now, I can say that we are not using a regular excessively large budget or time." The innovation process implies ways to get a budget, however, the time allocated for R&D and innovation activities is not clear. The company has very strict schedules regarding projects and their product life cycles, thus allocating time for innovation (including R&D) is perceived usually as luxury by the managers.

5.4.3. Partnership Capacity

Partnership capacity is the third category to be investigated. The details of this category are presented in Table 40.

Partner selection is the first dimension of this category and the findings show a maturity score of 3,2. This means that partner selection is based on existing knowledge of partners or experience within the network. Potential innovation partners are continuously evaluated and intentionally chosen for collaboration (level 3). But we cannot talk about a database for potential and current partners that can be utilized before any partnership occurs (level 4).

Table 40. Partnership Capacity Maturity Findings

Category	Category Weight in Model	Dimension	Dimension Weight in Category	Dimension Weight in Model	Dimension Maturity	Category Maturity
Partnership Capacity	11%	**Partner Selection**	17%	2%	3.2	**2.8**
		Partnership Intensity	19%	2%	3.1	
		In- house Collaboration	63%	7%	2.7	

(Source: Author's own construction)

The interviewees also supported this maturity level by mentioning that "There isn't a very crowded or highly competent ecosystem. Only a few companies are emerging. We are trying to work with the most competent company. Of course, being competent is not enough. Ultimately, having a common work culture is an important factor. We might not work with a company we don't know just because they are competent. I believe that work culture is always important, but in that sense, we don't eliminate companies just because we don't know them. We are directly trying to get to know them. While trying to understand their competencies, we also look at their work cultures, the structure of the company, and the human resources within it. Therefore, as I said we don't have many options anyway." Another top manager said that "as part of R&D activities, there is already a study for partners on measuring technology readiness levels, such as competency mapping. However, innovation partnerships do not have a database, yet". In fact, the open innovation and intrapreneurship unit has begun to form a database for determining possible partners in the ecosystem, start-ups, researchers and entrepreneurs. However, this system is not actively used during starting partnerships, yet. Therefore, the maturity level 3,2 determined during the survey appears to be valid.

Partnership intensity and effectiveness is the second dimension in this category. The survey findings reveal a maturity score of 3,1. This dimension has pretty low weight in the category and in the proposed model. The maturity level 3 for this dimension is stated as "Current innovation partnerships are formal, low intense, short. The effectiveness is monitored in some partnerships". One interviewee state that

“unfortunately, we do not have such a mechanism to monitor effectiveness of partnerships. There is also no culture like this in our universities. When I first came here (Türkiye), I wanted to do many things together with universities, but unfortunately, I couldn't achieve that. The reason for this, as I mentioned, is that our industry does not have the luxury, so to speak, to wait for innovation and implement new ideas. We need to quickly produce products in a way that does not lead to any failure. In other words, we need to bring an idea to fruition. However, as I said, since there are no mechanisms to institutionalize this (conduct effective partnerships) in our country and no mechanisms to guide universities, we cannot establish that connection. I believe that this is our biggest problem as a country. There is an effort to measure the success of projects but these efforts are not scaled throughout the company. As a consequence, 3,1 level of maturity seems to be fair for company A.

In-house collaboration is the most critical dimension in this category and one of the least mature ones in the proposed model with a score 2,7. This score implies a maturity close to “Cross-functional collaboration is stimulated by the organization by the composition of innovation teams with different backgrounds”. Company A has a long history of R&D projects, but due to the huge structure of the company the product groups have an introverted tendency in terms of working together. The top management interviews have similar implications. One interviewee indicated that “we should have a general setup where product teams come together, meet at the engineering level, discuss what we're doing in innovation, and who is doing what. But currently, there isn't really a well-established system for that. We are working only with the central technology management department. I think others (other product divisions) are working with them, too. Another example, endenization efforts are not being managed in a collaborative way. Everyone (each product group) is trying to manage their own activities. But sometimes, collaborative efforts can take place, but they are somewhat driven by personal relationships. It would be beneficial to make it more institutionalized within the company”. The technology management department of the company is aware of the weakness in in-house collaboration and trying to align all product groups by communicating and establishing training programs that may trigger collaborations. Hence, the survey result, 2,7 seems to be fair for demonstrating the company’s actual situation.

5.4.4. Knowledge Chain

Knowledge chain is the fourth category of the proposed model with 24% weight in the entire model (Table 41).

Table 41. Knowledge Chain Maturity Findings

Category	Category Weight in Model	Dimension	Dimension Weight in Category	Dimension Weight in Model	Dimension Maturity	Category Maturity
Knowledge Chain	24%	**Absorptive Capacity**	40%	10%	3.1	**3.1**
		Adoption of New Techs	40%	10%	3.1	
		Knowledge Diffusion in Networks	20%	5%	3.2	

(Source: Author's Own Construction)

All of the dimensions in this category have a maturity score just above 3. The first is the absorptive capacity dimension. This dimension is determined to have 3,1 level of maturity meaning that "Managers and employees can and willing to learn and assimilate external knowledge by trainings, observation and practices." This dimension has 10% weight in the whole category. One manager declared this issue as "We are forced to look at how things are done externally. We need external information to be fast. Our young workforce can bring new ideas, keep up with the world, and learn quickly. Therefore, we can view the absorption of external information as both a collaboration and learning project. We have also brought in experienced foreign people who have worked on the projects we are trying to capture and we employed them in the projects. These individuals retired from their jobs years ago, are in their 50s, 60s, or 70s. Some may have come here and worked part-time, some worked full-time, some came and went, and some worked remotely. We have created such a mechanism". Another respondent stated that "we can recognize and learn external information, but I don't know if we can integrate it. Develop a technology, start an innovation, and then move on to a product… I don't think this process exists yet. As I mentioned, we are currently in the phase of creating an innovation ecosystem. Afterwards, as those projects mature, we need to establish the paths that lead to transforming knowledge into new products". In fact, the company does not have a process or unwritten rule for

absorbing external knowledge and integrating it into products or services. They monitor competitors and their products and try to catch up in a short time. For example, the company has long been a subcontractor of a combat aircraft project for decades and now they utilize these know-hows in indigenous projects. But we did not meet any written process or procedure that defined this absorptive capacity. Thus, level 3,1 seems valid for this dimension.

The company has a similar attitude towards adopting new technologies. The maturity level of this dimension stays at 3,1. This maturity level means "adoption of new technologies is pursued by departments via pre-defined processes or processes are designed during adoption. Besides, the old, replaced tech. (if any) is assessed and decided to be left or stayed. Employees are trained about the new tech". The interviews validate the situation. One interviewed manager mentioned that "we identify the required technologies, initiate technology development projects suitable for them, and create a framework to manage those technology development projects and integrate their outputs into products. We should admit that we are in that initial phase, but this process will become a routine." The top manager of technology management explained that "We have a technology roadmap. We update this work every six months. We do this with the support of our product groups, meaning the departments that directly use the technology. This is the technology acquisition roadmap. There are ambassadors in our units related to the management of this document, responsible for each product group. Projects are shaped according to the roadmap. Almost all of them are renewed projects closely aligned with the roadmap." However, the survey does not indicate maturity level 4. This may be due to the fact this technology roadmap is not product specific, scaled, but a general one. We analyzed that technology roadmap and found some inconsistencies and lapses in technologic capabilities that are required and written down. Moreover, the performance metrics do not measure the completion of adoption systematically. Also, due to the resistance of employees to adopt new techs and financial constraints, company A does not have a current plan to leave obsolete techs. Thus, maturity level 3 sounds reliable for this dimension.

Knowledge Diffusion in Networks is the last dimension of this category. The maturity

level is found to be 3,2 which is just better than “Employees and the company is engaged in knowledge networks in other sectors and regions as well as intrasectoral and intraregional networks. The knowledge/product diffusion is not controlled or under assessment. Interpersonal networks of knowledge exist”. The interviews hold corresponding answers. One manager said that “we have significantly expanded our culture here, and we have relationships with institutions within Türkiye and abroad. I personally visited the European Union presidency in Türkiye. We received their support. The same goes for the Ministry of Industry and Technology. We are already working very closely with the Defense Industries Presidency and NATO.” Another interviewee mentions that “there are worldwide organizations for our industry. They hold conferences and symposiums. I believe we are not participating enough in those.”. When we review the company-wide projects, there is ongoing participation in conferences, meeting and invitations for international organizations more than it was a decade ago. However, there is a lack of a routine or process to take advantage of these activities for inflow of knowledge. Also, how the outflow of knowledge should be managed is not decided on a managerial level. Thus, the maturity level 3,2 seems validated.

5.4.5. Digital Maturity

The last category in our proposed model is digital maturity and this category has three dimensions (Table 42).

The first dimension, digital knowledge sharing, is the most influential one in the whole category. The maturity score of this dimension is found to be 3. This level of maturity implies a planned state meaning “digital tools are available to all employees during idea generation, sharing and internal collaboration on departmental basis. Knowledge generation, sharing and collaborations with external partners are partially digital.”

Table 42. Digital Maturity Findings

Category	Category's Weight in Model	Dimension	Weight in Category	Weight in Model	Dimension's Maturity	Category's Maturity
Digital Maturity	5%	**Digital Knowledge Sharing**	63%	3%	3.0	**2.9**
		Digital Manufacturing and Operations	24%	1%	3.2	
		Digital Supply Chain	14%	1%	2.2	

(Source: Author's Own Construction)

This level lacks a full integration of systems and links with external environment. The replies of top managers during the interviews are screened to validate this maturity score. One respondent stated that "this is one of our advantages. As I mentioned earlier, since we don't have old processes and are just starting in this area, we are using new technologies. Since new technologies are generally digital-based, I can say that we are perhaps ahead of many companies from the countries we are trying to catch up to. The sector is still not so digitized. While they are trying to emerge, we are already adapted. Maybe it's harder for them because they need to let go of the old techs. We, on the other hand, remain a natural part of the new culture we are creating." Another manager said that "The digital infrastructure we have opened the way for those types of idea proposals as I mentioned earlier, we use digital environments for sharing, reporting, and making knowledge visible. When we consider all our products, processes, and corporate applications, we have a digital transformation strategy." The top managers seem to have awareness for the significance of digital technologies for innovation. They also mention the improvement areas. One top manager mentioned that "while digitalization has been considered in parts, we are not in a position where all systems can communicate with each other or where we can see the entire structure from a single location". Therefore, maturity score 3 is meaningful for Company A.

The second dimension in digital maturity category is digital manufacturing and operations. The results indicate an average of 3,2 maturity score. The explanation for this level of maturity is just above "all OT and IT systems across the production and enterprise levels are integrated into automated networks. Data exchange is possible but

data analysis and decision making is not. Communication is better but resource planning and operational demands are not managed digitally". Again, this maturity level refers to planned digital maturity but the systems lack integration and are not a part of organizational culture yet. The top management thought that "In terms of engineering, we are digital, but as I mentioned, we are trying to establish the entire product life cycle from customer requirements to flight testing and production, digitally. Gradually, this aspect is bringing PLM (a digital software for product life cycle) to a certain level of maturity. I think we are not in a bad position compared to equivalent companies. In fact, there isn't a very advanced PLM system in the world; it shapes itself according to everyone's specific needs. Digital product life cycle culture is gradually settling in the company". Another top manager mentioned that "Managing, designing, and maintaining our products with digital processes that cover the entire picture is possible in the near future. A lot of progress has been made. We are developing software for digital production and digital enterprise". Company A has a plan but there is a way to complete digital maturity ahead. Thus, the score determined by the survey, 3,2 is reliable.

The last dimension of digital maturity is digital supply chain (SC). This dimension is assessed as the least influential dimension and scored the lowest maturity with 2,2. This level means "The organization is aware of the relevance of adopting I4.0 technologies and supply chain trends. Several I4.0 technologies are incorporated into process improvement aimed at adopting a SC trend. However, these technologies and the surrounding systems are still isolated or partially integrated along with the SC." This explanation is validated by interview findings. One top manager said that "Unfortunately, the connection with the external partners often has to operate manually, or there are issues with data being provided and transferred in a specific format. When transforming data into a new format for subcontractors, we unfortunately face problems. However, these are not issues that can be resolved quickly. We work with hundreds of companies, subsystem suppliers, and direct material suppliers including small firms and SMEs with poor digital awareness. The problem will be resolved when they reach the same level of digital maturity. Therefore, I believe we have not yet fully achieved a transformation with external parties,

including subcontractors. There is a very young ecosystem there. I think there are still many things we need to do even within our own internal system. For example, we don't have a specific process for subcontractor management. We go out to tender, conduct a special procurement committee, and evaluate different bid proposals. At the end of the day, we make a decision. After making a decision, it may go to the board of directors depending on the level, a contract is signed, and contract management is carried out. This is actually a procurement process. Unfortunately, there is currently no tool that allows us to manage this procurement process digitally with us". Another opinion is "we have not yet fully achieved a transformation with external parties, including subcontractors. There is a very young ecosystem there. We don't have a digital process for subcontractor management. Unfortunately, there is currently no tool that allows us to manage this procurement process digitally". Moreover, there is not a plan to improve supply chain operations in terms of digital maturity. Therefore, the maturity score 2,2 seems fair for Company A.

5.4.6. General OI Maturity Findings

The open innovation maturity of Company A is calculated to be 3,0. The maturity of categories and dimensions are exhibited below in radar charts a generally accepted presentation method for maturity findings (Figure 15, Figure ***16***).

Company A struggles with digital supply chain (2,2), time and budget (2,5) and in-house collaboration (2,7) at most. Among these three dimensions time and budget and in-house collaboration have significant weights (12% and 7%, respectively) in the overall maturity. Thus, focusing on these dimensions will contribute to a more balanced maturity for Company A.

When we have a look at the more mature and significant capabilities of Company A, innovation strategy (3,3), management support (3,0) and risk tolerance (3,4) differ from the others as they contribute to the maturity score at most.

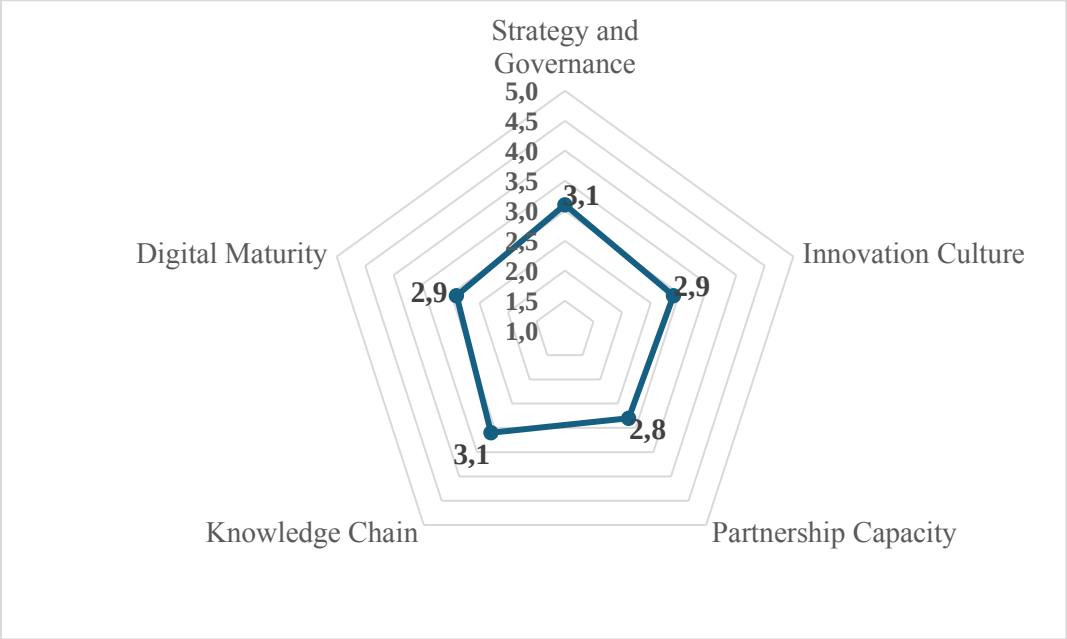

Figure 15. Category Based OI Maturity of Company A

(Source: Author's Own Construction)

Figure 16. Dimension Based OI Maturity of Company A

(Source: Author's Own Construction)

Assessing the problems in these dimensions and taking corrective actions may improve the overall maturity level of the company more easily because they have reached a planned state and may require fewer resources and investments than others, digital maturity for example.

5.4.7. Survey Results of Innovation Ecosystem

An innovation ecosystem refers to the complex relationships established among actors or entities whose primary objective is to facilitate technology development and innovation. A&D industry is recognized as an ecosystem instead of a bunch of companies working in the same industry. There is a reciprocal relationship between the parties of the system and each party is dependent on the other for sustainable innovation and thus growth. Thus, we acknowledged the necessity of examining the ecosystem to understand the open innovation maturity of company A and the ecosystem as a whole. Of course, the innovation ecosystem includes more than just subcontractors, system producers, and project partners, but also the university professors and students, research institutions, policymakers, local government authorities, and customers are part of this ecosystem. However, the proposed maturity model developed within the framework of this thesis focuses on the dynamic capabilities of companies. It is necessary to modify the model and/or use other methods to measure the open innovation maturity of other parties. Therefore, we measured the open innovation maturity of companies defined as supplier, subcontractor and project partner included in the ecosystem of Company A. Companies that provide standard products (computers, cutting tool etc.), materials (aluminum, chemicals etc.) and services (catering, insurance etc.) and those are established abroad have been excluded from the scope. The survey was sent more than 200 companies located in Türkiye, via e-mail. The survey invitation was also announced at Company A's supplier portal. Moreover, an e-mail was sent to the companies by the ecosystem's reputable sectoral association SASAD to increase the return rate. The e-mail gave a brief explanation about the goal of the study and indicated that the survey is prepared to be answered by one of the following: technology manager, R&D manager, engineering manager or at least a manager in charge of production. In order to decide whether the responses gathered represent the

sample, the company name is asked as the first question in the survey sent to the ecosystem. The rest of the survey is the same as the survey sent to managers of Company A, previously.

It took more than two months for 52 companies to complete the survey. As the name of our main company is kept anonymous in this thesis, so do the companies surveyed in the innovation ecosystem. However, this thesis assures that the companies completing the survey represent more than %20 in terms of the number of companies and %80 in terms of monetary volume which Company A allocates for partnership, outsourcing and procuring sub-systems.

The analyses conducted about the supply chain profile of company A show that top 20 subcontractors constitute 60% of the manufacturing work outsourced in monetary terms. The variety of manufacturing processes and the monetary volume of work among the rest is so dispersed that each subcontractor weighs less than 1% of works done. The respondents that recorded their company name are tracked and it is seen that 11 out of 20 top subcontractors completed the survey. This rate ensures that the survey has reached at least 45 % of the work outsourced. It is estimated that when subcontractors who did not specify their company names in the survey and the others included (total 19 companies), the total percentage of the subcontractors responding to the survey may exceed 60% of the total work outsourced by Company A.

In addition to the subcontractors, the companies that provide critical systems and subsystems to Company A have also been invited to the survey. 5 out of the 10 largest A&D companies in Türkiye, which are also critical system providers of Company A, have completed the survey. Considering the revenue, it is seen that these 5 of the responding companies account for approximately 40% of the Turkish A&D sector's 2024 turnover. In total, 7 system/subsystem producers responded to the survey. These companies operate in the electrical/electronics, avionics, rockets and missile, software, machinery, and hardware sectors. 6 of these system producers are also serving as project partners in R&D and/or endenization projects.
During the meeting with the company's technology management executives, it was

learned that there are approximately 100 ongoing R&D projects and around 300 endenization projects. Analysis of the partners involved in these projects shows that some partners have are multiple roles in multiple areas. For example, there are over 70 ongoing endenization projects with one of the significant players (OEM) in the sector, and this company is also part of the ecosystem as a system manufacturer. The number of firms involved in some projects is more than 2. Also, some projects are being conducted in collaboration with universities and research centers, but the maturity levels of these parties have not been examined in this thesis. Although there is a central technology management department, the projects are executed by many different independent units, and since there is no central reporting obligation, it has not been possible to list the collaborations under a single umbrella. However, with the guidance of the technology management department, it is estimated that the number of active project partners is around 300. Looking at the R&D projects, it was observed that there are 33 firms that responded to our survey among 104 projects. In the localization projects, it was noted that there are 10 firms among 100 projects, of which 7 have returned the survey. The large number of projects in localization compared to R&D projects is partly due to simpler operations (such as basic turning) being considered as projects. In light of all this data, technology management officials estimated that the number of active firms in the collaboration ecosystem is 100 and stated that the number of firms reached through the survey corresponds to at least 30% of the ecosystem.

There are areas for improvement at this point. First of all, only one respondent from each company participated in the survey. This may raise questions about the adequacy of that 1 respondent for determining the current maturity status of the participating company. However, anyone has to consider that the respondents were selected from senior level managers and are proficient in technology management, R&D management or production management. Also, this methodology is a general way for quantitatively collecting data from a pool of companies, especially when we try to access a cluster or ecosystem. On the other hand, the researcher may declare that the survey data could not be validated by qualitative interviews, as was the case with Company A. But the validation process in Company A showed that the survey results were consistent with the interview results and thus the OI maturity model is assumed

to sustain reliable results as a measurement tool.

Despite the concerns, the profile analysis of respondent companies indicates that our sample is able to represent an outlook for the OI maturity of Company A's innovation ecosystem. The results of the survey conducted with 52 ecosystem member companies are presented in Figure 17and Figure 18.

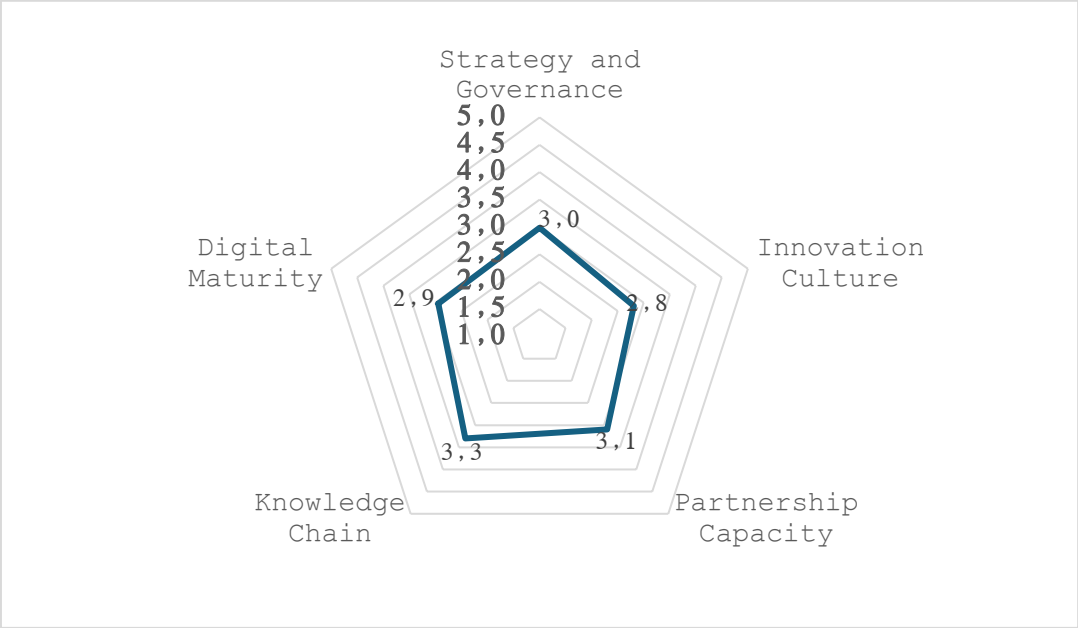

Figure 17. Category Maturity of Innovation Ecosystem
(Source: Author's Own Construction)

The average maturity score for the innovation ecosystem is found to be 3. Although the general maturity score level is the same as company A, the maturity composition showed differences in some dimensions. It is important to state that same computation process applies for determining the maturity scores of the innovation ecosystem and Company A. The arithmetic average of 52 respondents are taken to determine an average score for each dimension and weights of the dimensions are kept same while determining the general maturity level. The comparative table showing the maturity levels of Company A and its innovation ecosystem is presented below (Table 43). The bold colored scores indicate the areas in which Company A and innovation ecosystem differ more than 10 % in maturity level.

In category level, innovation ecosystem is more mature in partnership capacity, thanks to the companies' capability of in-house collaboration. The other categories have similar maturities on both sides, although there are noteworthy differences in the dimension level. The first category "strategy and governance" has a maturity level of 3 for the innovation ecosystem.

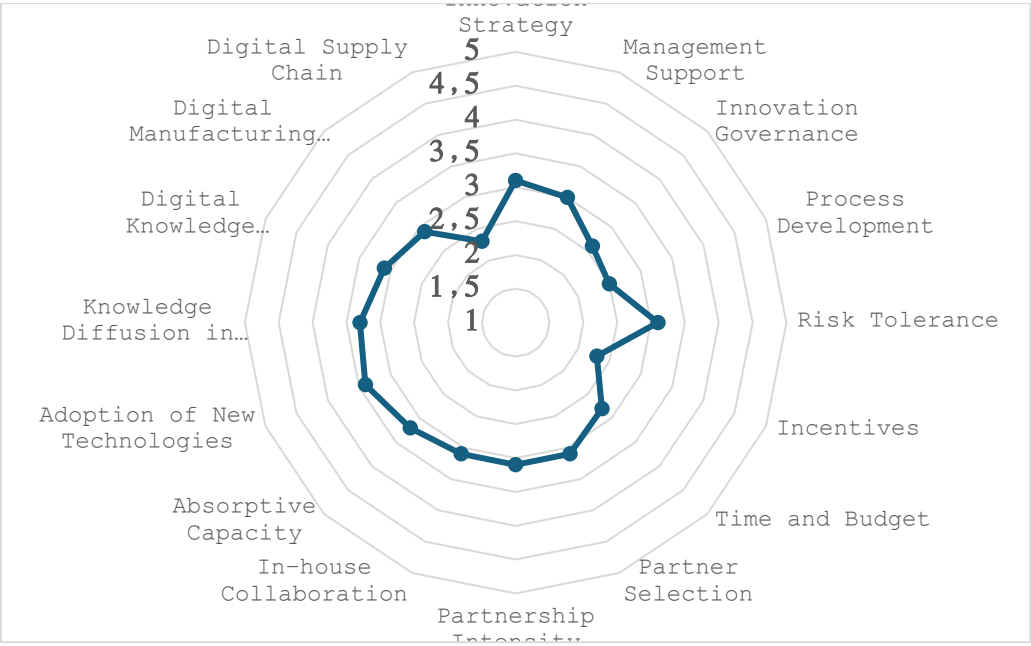

Figure 18. Dimension Maturity of Innovation Ecosystem
(Source: Author's Own Construction)

In this category, innovation strategy is slightly behind the maturity level of Company A with maturity level of 3,1. "Management support" score is the same in both sides and has maturity score of 3. The only remarkable difference is in the innovation governance dimension. The "innovation governance" scores 2,6 in maturity but the overall effect of this dimension is relatively low to decrease the category maturity, thus the overall category maturity stand at level 3, just behind the Company A (3,1).

The second category "innovation culture" has a maturity score of 2,8 in the innovation ecosystem. In this category all dimensions, except for "time and budget" are found out

to be less mature than Company A. “Process development” is 2,5 and this is one of the least mature dimensions. “Risk tolerance” is also less mature in the ecosystem with score 3,1. “Incentives” category is the least mature category with 2,3 maturity level in the innovation ecosystem. This score is near to maturity level 2 that means “innovations are encouraged via monetary incentives on an irregular basis and without pre-defined criteria”. This dimension is the only one that is defined with a different maturity level in between Company A and the innovation ecosystem.

Table 43. Comparing Maturity Levels of Company A and Innovation Ecosystem

Category	Company A Category Maturity	Innovation Ecosystem Category Maturity	Dimension	Company A Dimension Maturity	Innovation Ecosystem Dimension Maturity
Strategy and Governance	3.1	3.0	Innovation Strategy	3.3	3.1
			Management Support	3.0	3
			Innovation Governance	**2.9**	**2.6**
Innovation Culture	2.9	2.8	Process Development	**2.9**	**2.5**
			Risk Tolerance	**3.4**	**3.1**
			Incentives	**3.1**	**2.3**
			Time and Budget	**2.5**	**2.8**
Partnership Capacity	**2.8**	**3.1**	Partner Selection	3.2	3.1
			Partnership Intensity	3.1	3.1
			In-house Collaboration	**2.7**	**3.1**
Knowledge Chain	**3.1**	**3.3**	Absorptive Capacity	3.1	3.2
			Adoption of New Technologies	**3.1**	**3.4**
			Knowledge Diffusion in Networks	3.2	3.3
Digital Maturity	2.9	2.9	Digital Knowledge Sharing	3.0	3.1
			Digital Manufacturing and Operations	**3.2**	**2.9**
			Digital Supply Chain	2.2	2.3
OI Maturity of Company A				**3.0**	
OI Maturity of Innovation Ecosystem				**3.0**	

(Source: Author’s Own Construction)

The innovation ecosystem is less willing to take risks and reward employees for their

innovative efforts. However, the “time and budget” allocated for innovation activities is more in the innovation ecosystem than Company A with a score of 2,8. Partner selection dimension is just under the Company A’s.

The third category in our proposed model is “partnership capacity”. This category is more mature in the innovation ecosystem compared to Company A with a score of 3,1. It is the in-house collaboration dimension that carried the partnership capacity to a higher level for the ecosystem. The score 3,1 for “partner selection” is just below the maturity level of Company A and partnership intensity has the same 3,1 maturity score.

The fourth category “knowledge chain” is the second category in which the innovation ecosystem performs better than Company A in terms of OI maturity with a score of 3,3. In all dimensions, the ecosystem performs better than company A. In fact, absorptive capacity and knowledge diffusion in networks has similar maturities with scores of 3,2 and 3,3 respectively. The highest score (3,4) belongs to adoption of new technologies dimension. However, this maturity score is not enough to carry the ecosystem to level 4 and still nearer to level 3.

The fifth and the last category “digital maturity has the same maturity score 2,9 in both sides. “Digital knowledge sharing” and “digital supply chain” dimensions show just better performance in the ecosystem. However, the “digital operations and manufacturing” is less mature at the innovation ecosystem performing a score of 2,9.

In general, all categories and dimensions stay on the same level of maturity except for incentives dimension. Thus, the maturity level explanations proposed in the model are not written repeatedly in this section for the other 15 dimensions. The OI maturity of both Company A and the innovation ecosystem is found to be at level 3. According to the proposed model, level 3 indicates that a “planned stage” is occurring in open innovation. As proposed in the model, this level is explained as “Appropriate OI strategy, practices, processes and (digital) tools are in place for internal and external partnerships and knowledge management. OI is planned and encouraged by the

organization. Strategy and innovative outputs are consistent." The detailed explanations for maturity of each dimension is given in Table 44.

Table 44. Open Innovation Maturity Explanations of Model

Strategy and Governance	
Innovation Strategy	A long-term innovation vision, mission, and strategy are established and thoroughly documented, with clearly defined strategic focus areas.
Management Support	Managers are trained to encourage employees to innovate. The organization frequently identifies key innovation success stories and disseminates them among employees.
Innovation governance	It is clear how innovation activities are organized and who is functionally responsible for each innovation activity. This is reflected in the organizational structure and processes.
Innovation Culture	
Process development	The innovation process is clearly defined and documented, featuring well-established decision points and criteria for each stage of the process
Risk tolerance	Employees involved in innovation failures are not penalized or blamed for those failures. There is an awareness of lessons learned. Risk taking is neither welcomed nor punished.
Incentives for innovation	Employees are given incentives periodically according to a procedure based on a monetary basis. Assessments are done by specialists from or outside the company.
Partnership Capacity	
Partner selection	Partner selection is based on existing knowledge of partners or experience within the network. Potential innovation partners are continuously evaluated and intentionally chosen for collaborations
Partnership intensity and effectiveness	Current innovation partnerships are formal, low intense, short. Effectiveness is monitored in some partnerships.
In-house collaboration	The organization promotes cross-functional collaboration by forming innovation teams with diverse backgrounds.
Knowledge Chain	
Absorptive capacity	Managers and employees can and willing to learn and assimilate external knowledge by trainings, observation and practices.
Adoption of New Techs	Adoption of new technologies is pursued by departments via pre-defined processes. Or processes are designed during adoption. Besides, the old, replaced tech. (if any) is assessed and decided to be left or stayed. Employees are trained.
Knowledge Diffusion	Employees and the company are engaged in knowledge networks in other sectors and regions as well as intrasectoral and intraregional networks. The knowledge/product diffusion is not controlled or under assessment. Interpersonal networks of knowledge exist.

Table 44 continued	
Digital Maturity	
Knowledge generation, sharing	Digital tools are available to all employees during idea generation, sharing and internal collaboration on departmental basis. Knowledge generation, sharing and collaborations with external partners are partially digital.
Operations, manufacturing	All OT and IT systems at the production and enterprise levels are integrated into automated networks. While data exchange is feasible, data analysis and decision-making are not. Communication has improved, but resource planning and operational demands are not managed digitally.
Supply Chain	Industry 4.0 technologies are consistently incorporated into improvement projects alongside the supply chain. Processes are being modified to address unpredictable supplier behavior. Initial integrations of systems and Industry 4.0 technologies are currently taking place and are subject to comprehensive analysis.

(Source: Author's Own Construction)

The partnership capacity and digital maturity categories are the least two important categories of the model, despite their critical role in knowledge flows and dynamic capabilities. We assume this may be due to the underestimation of partnerships and digital maturity for the industry. Turkish A&D industry is not experienced long enough in terms of conducting partnerships and monitoring the results. On the other hand, digital transformation is yet the last decade's priority. Thus, the readiness of the sector managers and experts to value these categories in terms of their effect on openness is found to be different from the other sectors. Thus, developing a sector specific model has emerged to be reliable to gather and conclude sector specific results.

We aimed to define a path in this study for development of open innovation maturity of Turkish A&D industry. We started by gathering recommendations from company managers during the survey phase. There is a last open-ended question in the survey asking respondents their policy recommendations for improving the OI maturity in the company or the Turkish A&D sector. The next section discusses the survey findings and its policy implications. Later in the next chapter, we will discuss and develop strategies and policies for more mature companies, ecosystem and industry, in terms of OI.

5.4.8. Recommendations of Survey Respondents

In this chapter, the key recommendation findings of the survey results are interpreted. Based on these findings and the overall conclusions, policy recommendations are outlined to enhance open innovation maturity in Turkish A&D industry. The list of 178 recommendations gathered through the survey is listed in Appendix D.

One of the main reasons for measuring any maturity is to realize the actual situation of the maturity phenomenon by determining the strengths and improvement areas. Maturity models have a gradual structure, so they generally contain the steps that need to be followed for maturity improvement. In our research we aim to measure the OI maturity of Turkish A&D industry. Our proposed model managed to determine the strengths and weaknesses of Company A and its innovation ecosystem. At this point, we aim to go further and compile policy and strategies to enhance the OI maturity. This chapter begins with the analysis of the respondents' answers about company and sector level policy recommendations. Afterwards, we will discuss these recommendations in terms of our proposed maturity categories regarding the results of the survey.

5.4.8.1. Analysis of Recommendations

As mentioned in previous sections, one open-ended last question was asked in the survey sent to both Company A and the ecosystem to gather respondents' policy suggestions for enhancing open innovation maturity. The question was as follows:

Open innovation is an innovation model that suggests combining internal and external ideas, as well as internal and external pathways to market, for the development of new technologies, thereby allowing the firm's boundaries to become permeable to information in a controlled manner. If you had the authority to make policies, what would you do to increase the open innovation maturity of A&D industry in Türkiye?

97 out of 121 Company A respondents (80%) mentioned their ideas and 29 out of 52 ecosystem respondents (56%) answered the question (Figure 19).

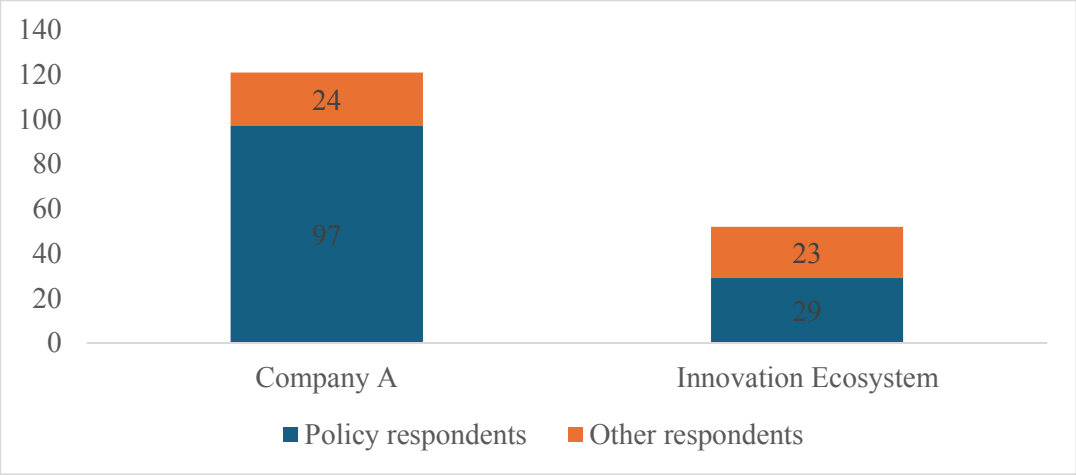

Figure 19. Policy recommending respondents
(Source: Author's Own Construction)

Some of the respondents mentioned their recommendations at company level while the others talked about the Turkish A&D sector as a whole, and some of them recorded ideas in both categories (Figure 20).

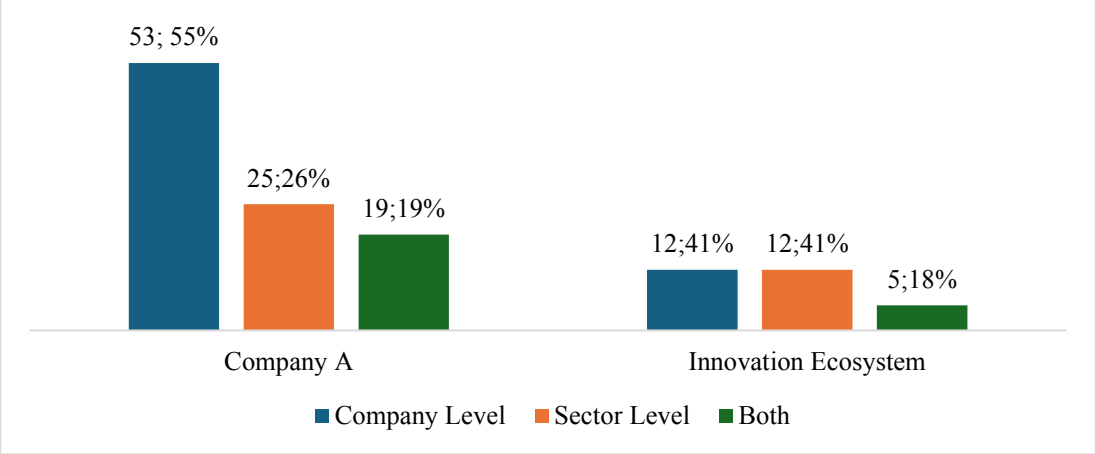

Figure 20. Distribution of Recommendations: Company Level or Sector Level
(Source: Author's Own Construction)

Evaluating policy recommendations has been challenging because ideas and suggestions often overlap in multiple areas. For instance, recommendation on in-house collaboration can also find itself place under the innovation strategy and managerial support. Therefore, while organizing the categories below, an effort has been made to

anticipate the primary aim of the proposer and to consider which policy area would be more beneficial within the company. Furthermore, some participants have made multiple suggestions. The ideas and suggestions of respondents are scanned and arranged carefully and as a result, although a total of 126 managers participated in the survey, the number of proposals was counted as 178.

The analysis of those 178 proposals were consolidated under 20 areas and 5 maturity categories. Partnership, digital knowledge sharing and knowledge diffusion in networks take the top three places in ranking (Figure 21 andFigure ***22***). In the following sections the proposals were analyzed and assessed as the last part of our research.

Figure 21. Distribution of Recommendations Based on Development Areas
(Source: Author's Own Construction)

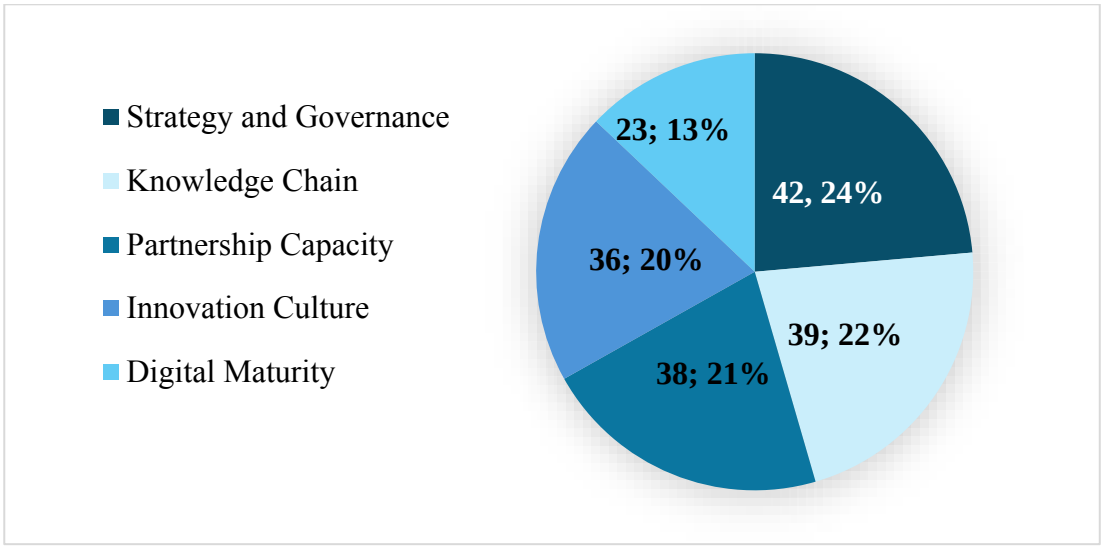

Figure 22. Distribution of recommendations Based on Maturity Category

(Source: Author's Own Construction)

5.4.8.2.Recommendations on Strategy and Governance

The proposals categorized under the heading of strategy and governance total 42. The following paragraphs analyze feedback related to strategy and roadmap, governance, management support, innovation organization, and the elimination of duplicate projects.

Recommendations for strategy include measuring our readiness for open innovation at both sectoral and corporate levels, outlining a vision for the future, considering Türkiye's and companies' resources, determining the steps necessary to achieve this vision, and creating actionable plans. After establishing the strategy or roadmap, it is recommended to follow up the outputs and update the actions according to evolving needs and agendas. Also, the strategy is supposed to integrate all ecosystem members— customers, universities, suppliers and partners—into this process. The proposals at this category align with the requirements of our proposed model for reaching the 5th maturity level in the context of innovation strategy dimension and indicates a strategic approach to develop open innovation within Turkish aerospace and defense industry.

A notable need for a higher institutional framework emerges from the proposals

gathered under the governance heading. The suggestion to establish a regulatory, supervisory, and/or managerial central institution is prominent. While some participants emphasized that the clustering and techno park structures could fulfill this role, others suggested that the SSB or another governmental entity could be empowered with this authority. In this context, governance proposals complement strategy proposals. If a central strategy is to be defined for the sector, it should originate from a central source to mitigate resource losses and communication issues that lead to inefficiencies.

Other proposals in this category relate to the necessity of linking innovation with clear objectives and performance metrics. It has been indicated that for the development of open innovation within the company, it should be established as an individual goal, tracked with measurable targets, and aligned with the company's main strategic plan. Proposals concerning organization of innovation function have also been evaluated under this heading. Some managers have reported that operational duties or daily responsibilities hinder the allocation of budget and time for innovation; therefore, innovation projects and activities could be conducted by a separate unit that does not carry operational burdens. Others have suggested that it would be beneficial to designate a leader/responsible person/coordinator for innovation in each unit.

5.4.8.3. Recommendations on Innovation Culture

The breakdown of the 36 proposals listed under the innovation culture category is quite diverse. Aspects such as culture, incentives, time and budget, communication, competitions, and entrepreneurship are evaluated within this category.

Initially, we can examine the proposals related to the culture dimension, which serves as the overarching title of this category. It has been emphasized that an innovation culture represents a state of awareness and internalization, necessitating activities to disseminate this understanding throughout the organization. Additionally, it has been stated that cultural change requires time and patience, thus a sustained effort is deemed appropriate. The importance of reducing procedural barriers as a motivating factor has

been highlighted. Communication is another critical aspect; it has been suggested that an environment to express ideas with ease both internally and externally will enhance the organizational culture. An intriguing piece of feedback regarding culture is that, despite the widespread practice of innovation, individuals often do not recognize these efforts as innovation, as the concept is frequently understood primarily in the context of R&D. This feedback has surfaced at various stages of this research, indicating that a fundamental understanding of what innovation encompasses is essential for fostering an innovation culture.

Managers discuss the importance of motivating open innovation activities as a concept and creating space for these initiatives, highlighting that this support is crucial for cultivating an innovation culture. It is suggested that a systematic and rule-based process should be established corporately to encourage employees in this regard.

The category with the highest number of proposals pertains to incentives, which should encompass both monetary and non-monetary methods. Proposals related to time and budget can also be assessed within this category. Upon reviewing the proposals, participants have not elaborated on the specifics of what incentives should be provided or how support will be extended. Items that could serve as policy proposals tend to manifest more prominently in the dimensions of budget and time.

Proposals concerning time and budget are generally meant to allocate resources for innovation activities. These resources should encompass both financial and labor-related aspects. Among the proposals, suggestions include distributing and monitoring the corporate budget through a centralized structure and advocating for government funding for companies struggling to secure funds for innovation within the sector. Time has also been recognized as a critical resource, with recommendations that employees require dedicated time for innovation beyond their daily responsibilities.
Suggestions for organizing idea competitions and encouraging entrepreneurship both internally and externally have also been evaluated within the innovation culture category. The significance of idea competitions in generating new ideas has been emphasized, along with the recommendations to promote the establishment of spin-

off and spin-out companies.

5.4.8.4.Recommendations on Partnership Capacity

The proposals classified under the category of collaboration capacity total 38. Proposals regarding partnerships and collaborations are evaluated together. Suggestions about startup ecosystem are also included in this category.

In examining company-based proposals, there is a consensus that establishing cooperation and partnerships between internal and external stakeholders is essential for fostering open innovation. Proposals emphasizing value creation through collaborations and the effective utilization of resources are particularly noteworthy. Some managers have highlighted issues related to redundant projects and the resultant inefficiencies at both corporate and sectoral levels. Others have underscored the necessity for partnership projects to be planned with a focus on time, funding, and capabilities, as well as being product oriented.

Regarding the proposed types of collaborations, suggestions include joint efforts between large corporations and SMEs, the establishment of international consortia with sector-leading companies, fostering partnerships with universities, creating structures such as sectoral techno parks and clusters, promoting collaboration within these frameworks, and developing systems that facilitate matching firms with similar capabilities, as well as forming project partnerships with research centers.

Additionally, participants have emphasized the need to enhance internal collaborations and teamwork. When reviewing responses related to the implementation of these proposals, there is a strong emphasis on increasing awareness activities to integrate collaboration and partnership into corporate culture. It is also important to structure and monitor technical capabilities, project needs, and resource planning through a central entity within the company and the sector.

5.4.8.5. Recommendations on Knowledge Chain

The proposals categorized under the knowledge chain focus on the Knowledge diffusion through networks, training and workforce competency, benchmarking and best practices, and the development and adaptation of new technologies. A total of 39 proposals are included in this category. Among these, the most significant feedback pertains to the Knowledge diffusion through networks. Managers have emphasized the importance of learning, disseminating, and integrating sectoral and technological developments within the organization. Participation in conferences, seminars, congresses, and trade fairs is regarded as essential. The prevailing understanding in this area considers participation in these activities as a loss of workforce, leading to a lack of engagement in national and particularly international knowledge networks. It is strongly recommended to engage in events that facilitate periodic information flow and to disseminate these through regular workshops and conferences with other stakeholders in our country and organizations. Monitoring external information is deemed important not only at the sector level but also in a broader context. One manager noted that an engineer with an innovative idea requires international knowledge networks to understand the value of her idea and to develop it further. This feedback underscores the significance of knowledge networks in establishing the knowledge chain.

Proposals aimed at improving education and workforce competence appear to start at the university education level. It has been suggested that courses on innovation and technology management could be offered at the undergraduate level. Additionally, there are proposals indicating that the company should systematically provide trainings and raise awareness about the importance of innovation and encourage employees to engage in such activities, resulting in developed absorptive capacity.

It is reasonable to assert that some managers view Türkiye as a country still striving to catch up in the aerospace and defense industry. Indeed, 10 proposals suggest leveraging best practices from other countries and companies worldwide and benchmarking against them. Some managers have characterized the pursuit of

different paths as seeking adventure, asserting that there is no need to rediscover established concepts. Technological advancements often begin with an understanding of prior accumulated knowledge. At this juncture, partnerships with sector-leading companies and countries, as well as the formation of consortia, are recommended. Furthermore, sharing best practices within the organization and conducting benchmarking between units is also advocated.

Moreover, regarding the adoption and development of new technologies, which constitute a step in the knowledge chain, it has been proposed to work on identifying which technologies to adopt. There are also suggestions emphasizing the importance of determining which new technologies will be utilized within the organization. However, proposals in this category have been evaluated as more general and less detailed compared to those in other dimensions.

5.4.8.6. Recommendations on Digital Maturity

In the digital maturity category, 23 recommendations have been classified, with 17 related to knowledge sharing and 6 directly pertaining to digital maturity. The rationale for evaluating knowledge sharing in this context rather than within the knowledge chain category stems from the fact that nearly all proposals are linked to digital technologies. Participants largely agree that knowledge should be made accessible and shared within and between organizations via platforms, portals, or databases. In addition to sharing knowledge, a model is proposed that allows for recording technological competencies of companies, sharing technological needs, and access to real-time knowledge. It has been noted that intellectual property rights should be secured and that information permeability should be managed selectively and with oversight.

One of the most significant constraints faced by the A&D industry is the inability to implement cloud technologies due to concerns surrounding information security. Proposals have been made in this area advocating for the development of sector-specific cloud technology. Respondents indicate that even mandatory information

transfers are currently limited and slow. In this context, there is a noted need for sector-specific information storage and sharing technology.

Other proposals related to digital maturity generally focus on improving digital infrastructure, prioritizing digital transformation projects that create value, and establishing an end-to-end system that includes the customer, particularly in the supply chain, from design to after-sales services. The importance of having systems that can communicate with each other has been underscored.

These proposals generally put a light on the requirements of Turkish A&D innovation ecosystem. The findings are aligned with the maturity levels of our proposed model and covers insights to develop the maturity level of Company A and the innovation ecosystem as a whole.

In the next chapter, the conclusions and recommendations for Company A and its innovation ecosystem as well as the industry is discussed.

CHAPTER 6

CONCLUSIONS and POLICY RECOMMENDATIONS

In this chapter first of all, we examine the findings of the survey and discuss their implications for Turkish A&D industry. Afterwards policy recommendations are offered at micro, meso and macro level to improve the maturity of open innovation in Turkish context. Lastly, in the last section of the thesis, ideas for further research are discussed.

6.1. Conclusions for Research Findings

The survey findings indicate that the maturity of open innovation in both the company and its ecosystem are at the planned phase, which we refer to as level 3. Planned open innovation implies that there are sufficient practices, processes, and tools in place to facilitate external collaborations and intentional knowledge flow, open innovation is planned and encouraged at the organizational level, strategies and innovative outputs are consistent with each other, and employees and managers are aware of open innovation and its implications.

This finding, the maturity at planned stage of OI, can be considered a significant advancement in open innovation for the sector. For many years, concerns about information security and the sector's traditional perspective had fostered a belief that a closed innovation system based on R&D was dominant and required in the industry. This can be observed also from interviews conducted with managers and previous limited academic studies. In one of the rare studies on OI maturity in A&D sector, Armellini et. Al (2014) described the open innovation maturity of the aerospace sector a decade ago as "unfreezing in a box." They observed elements of open innovation within the companies, but there is no accompanying open business strategy.

Challenges related to funding, R&D maturity, and intellectual property protection prevent the cluster from fully embracing open innovation. However, the culture of the companies in the sample is very open to the concept. As a result, they concluded that open innovation in the Brazilian cluster is still in the process of "unfreezing" yet holds significant potential to develop once these issues are addressed. It seems the situation has evolved in recent years. In fact, a study by Honorato and de Melo (2022) on two Brazilian aerospace companies classified openness as a factor of innovation environment in their project management maturity model and found out that the two case companies in their research showed a relevant maturity for innovation environment. However, that research does not specify the maturity of open innovation as a separate finding. Thus, our study contributes to the literature to be first research that develops a model and empirically investigates the open innovation maturity of the industry as a unique research topic.

Our research is also aiming to contribute to the literature that seeks the relationship between open innovation and digital technologies. Enkel et. al (2020) suggested to study the open innovation concept under the light of digital transformation due to their interdependent nature. Some maturity models examined throughout this research revealed certain links between the intensity and availability of digital techs and the open innovation practices and outputs. However, none of them positioned digital maturity of vertical integration, horizontal integration and digital knowledge sharing as a separate category while measuring open innovation at companies. Our research aims to leverage understanding in this field and take attention to the significance of digital technologies for providing openness in A&D industry.

A&D industry is generally recognized as an innovation ecosystem. Companies need to rely on the contributions of various stakeholders, both within and outside the institution, to develop a value proposition throughout the ecosystem (Talmar et al., 2020). In an increasingly specialized world, a single organization frequently lacks the internal resources necessary for the development and implementation of innovation (Adner and Kapoor, 2010; Talmar et al., 2020). In this research we aimed to develop an innovation ecosystem approach for measuring innovation maturity and investigate

not only the OEM company but also surrounding companies that are sub-contractors, suppliers, system producers and innovation or R&D partners of the company. However, other ecosystem parties such as the customers, researchers, governmental or sectoral organizations are kept out of scope, because the proposed model is grounded on company level dynamic capabilities and focused on company level OI maturity. This is an innovative and yet reliable attempt to measure the maturity of a company and its ecosystem, since open innovation is about building up partnerships and creating intentional knowledge flows with other companies. Particularly, Aslan (2018) states that the A&D ecosystem primarily consists of large projects that only major companies can participate in and secure. Consequently, subcontractors in the sector heavily depend on collaboration with these OEM companies.

Aslan (2018) noted in his thesis that main industry firms enhance the capabilities of their suppliers and vice versa. At this point we assume that suppliers, sub-contractors and system and technology partners have more influence than the other parties in the ecosystem in A&D industry. However, the extent of this interdependence and the specific impact of major defense firms on other companies within the supply chain has not been thoroughly examined. This study contributes to understanding this relationship. The open innovation maturity of Company A and its ecosystem is found to be at level 3. However, when we examine the details there are differences at dimension level. Company A is better at innovation governance, process development, risk tolerance, incentives and digital manufacturing and operations. On the other hand, the ecosystem companies are more mature in time and budget, in house collaboration and adoption of new techs. However, the differences in maturity are not huge enough to set the two sides on different levels of maturity. This finding needs further analysis but this similar positioning in maturity levels may be an indicator of this interdependence. In fact, OEMs are the drivers of the A&D industry with their oligopolistic structures and suppliers are generally directed by them in terms of technology investments, pursued strategies and trends, product development processes and future goals.

The results of the empirical study mainly address that Turkish A&D industry is

struggling with allocating appropriate time and budget for innovation activities and has limited capability of in-house collaboration. Besides, the ecosystem, particularly the supply chain operations, is not digitally mature yet. Among these three dimensions time and budget and in-house collaboration have significant effects on the overall maturity. Thus, focusing on time and budget allocation and enhancing collaboration both in and out of the companies will contribute to a more mature state for Company and the ecosystem.

On the other hand, this research found out that the more mature and effective capabilities of companies are innovation strategy, management support, and risk tolerance. Assessing the problems in these dimensions and designing strategies and actions that guide for better maturity may improve the overall maturity level of the company more easily because they are the strengths of the Turkish ecosystem and may require fewer resources and investments than others.

The survey in this study is conducted with managers of the A&D companies. Their recommendations for improving the OI maturity at company, ecosystem and industry levels carry valuable insights for policy makers. At the next section the above-mentioned conclusions are integrated with their recommendations and we are to close this study with policy recommendations for improving the OI maturity of Company A, its ecosystem and A&D industry as a whole.

6.2. Policy Recommendations and Strategies

This section groups the policy recommendations of this study in accordance with the proposed maturity model, under five categories: strategy and governance, partnership capacity, knowledge chain and digital maturity. The recommendations begin with micro level (for company A), continues with meso level (ecosystem) and finishes with macro level (Turkish A&D industry).

6.2.1. Policy Recommendations Strategies for Strategy and Governance

Company A has an innovation strategic plan and open innovation process, but the

findings indicate that this plan is not recognized by all departments of the company. The communication of the strategic innovation plan has to be reviewed and seminars, workshops and media studies can be organized to raise awareness of this plan. Also, the goals and aims of the innovation strategic plan have to be linked with the company's strategic plan and the vision, aims and goals should be updated according to the developments in the internal and external environment in case. This thesis offers Company A and its ecosystem to put down an agile structure for innovation management in which the financial and functional resources are clear, open to development and aligned with organizational structure and processes, and continuously in development. Also, corporate innovation goals and KPIs should be aligned with organizational and individual ones.

The innovation ecosystem may follow the same steps to arrange a more applicable and mature strategy for the ecosystem. Company A can influence its ecosystem to find out their innovation maturity, open their boundaries and put forward goals for them to prepare and publish strategic plans for open innovation. Company A and the ecosystem companies can spread goals and strategies to leverage open innovation at whole levels, so that they are encouraged to spare resources and take action to implement open innovation practices throughout the ecosystem.

At the macro level (A&D industry) there is an apparent need for a regulatory institution that guides, coordinates and monitors the (open) innovation attempts of the industry. Currently, the policies and promotions are grounded mainly on supporting R&D efforts. However, due to the cost and long duration of R&D projects, the industry should also benefit from the promises of OI. Thus, this study recommends establishment of an institution or empowering an existing one in order to govern and regulate the open innovation efforts of the industry, mitigate resource losses and duplicate projects, solve communication and coordination problems, ease collaboration between parties and thus sustain efficient and selective openness to cultivate the innovation outputs of the Turkish A&D industry.

6.2.2. Policy Recommendations and Strategies for Innovation Culture

Innovation culture category covers issues about innovation processes, incentives, risk tolerance, time and budget allocation, communication, contests and entrepreneurship. At company level, innovation culture encompasses the shared values, beliefs, and practices that nurture and encourage innovation. It is marked by an atmosphere that promotes creativity, experimentation, and the exploration of new ideas. Company A should establish systems and processes that reduce obstacles and resistances to creativity and encourage employee participation innovation. It has been found out that the practical meaning of innovation is not fully understood both at employee and manager level. The concept is usually mistaken for R&D. Furthermore, open innovation can be understood as unlimited and uncontrolled knowledge transfer and security vulnerabilities. To overcome these problems, the innovation process can be revised to become simpler and more reliable at all levels. The failures and successes of innovation efforts should be welcomed with curiosity and managers can open up space for taking computable risks. Incentives for innovation should be more diverse, predictable and not only in monetary terms. Innovative spirit should be enhanced via idea competitions and entrepreneurial practices. Finally allocating time and budget for OI activities seem to have significant effect on gathering innovative outputs, since our study discovered that both Company A and the ecosystem have limited time and budget allocation for innovation.

At meso level, similar policies can be expected to give positive results for spreading the innovation culture throughout the industry. Moreover, Company A should take responsibilities for developing the innovation culture of the ecosystem by organizing competitions, promoting incentives, training labor force and increasing its capacity for failures as well as successes in partnerships. Company A and the ecosystem can design campaigns to raise awareness of labor force about open innovation concept, its promises, ways to conduct it, understand its similarities and differences from the R&D projects and develop OI practices and processes that are applicable and in alignment with industrial strategies. As Drucker once said, "culture eats strategy for breakfast”. Thus, developing routines, beliefs, processes and events that encourage and convince employees and managers for intentional openness in innovation is crucial. There is a

need for a clear and flexible budget to mature. Employees should be given time (e.g. a certain number of hours per week to work on own projects) and budget for innovation on a continuous basis.

The research findings show us that the Turkish A&D industry is familiar with open innovation attempts, but the concept is not directly mentioned in sectoral and governmental documents and organizations, apparently. This study recommends policy makers and industrial institutions to address open innovation as a concept in strategic plans, sectoral processes, events, policy documents etc., conduct awareness and communication activities, and set requirements that encourage collaboration and knowledge sharing in product and service procurement tenders. As the last recommendation, time and budget for innovative projects should be promoted financially by the state. The current regulations mainly focus on R&D projects. In fact, these regulations can be revised to cover and define OI practices like contests, intrapreneurship programs and different types of innovation activities.

6.2.3. Policy Recommendations and Strategies for Partnership Capacity

The survey results show that respondents are paying attention to the improvement of partnership capacity, while this category has various suggestions. Partner selection, partnership intensity and effectiveness and in-house collaboration are examined together, to design policy recommendations for improving partnership capacity. At company level, there is a need for increasing effectiveness of partnerships. The effectiveness of each partnership process can be measured, a database for existing and current partners can be designed, satisfaction of partners and type of partnerships may be enhanced to build up a more mature partnership capacity. Also, in-house collaboration should be improved with removal of internal communication and managerial barriers. Performance goals of departments and individuals can be revised to encourage collaboration. Events and trainings can be implemented to motivate employees and managers to participate in collaborative projects.

The innovation ecosystem of Company A requires better partnership processes that are

less bureaucratic and more agile, since SMEs face challenges while dealing with the procedures of main companies. The recommendations for Company A can also be pursued by the ecosystem.

At sectoral level, the establishment of international consortia with sector-leading companies, fostering partnerships with universities, building sectoral techno parks and clusters, promoting partnerships financially and developing systems that facilitate matching firms with similar capabilities are beneficial policies for governmental and sectoral parties. At this point a need for a regulatory body to coordinate OI can be stated again. An organization that is in charge of structuring and monitoring technical capabilities, project needs, and resource planning is recommended in accordance with the findings of this research.

6.2.4. Policy Recommendations and Strategies for Knowledge Chain

Maturing at the knowledge chain requires capabilities of knowledge diffusion in networks, developing absorptive capacity and adopting new techs. Among them knowledge diffusion in networks is recognized as the most popular one. Company A should support employees to participate in conferences, seminars, congresses, and trade fairs. This research strongly recommends engaging in events that facilitate periodic knowledge flows with regular workshops and events with other stakeholders. Absorptive capacity is related with the capacity of employees to recognize, capture and transform valuable knowledge. Company A can conduct organizational training programs to sharpen the skills of labor force and prepare them for disruptive technologies.

Company A and the ecosystem can build partnerships with sector-leading companies and countries, while best practices and benchmarks are important sources for knowledge transfer. Financial need of SMEs can be supported by Company A and in fact, Company A can design trainings and organizations to foster knowledge flows and networking throughout the industry.

Knowledge accumulation in the industry should be pursued and supported by governmental and industrial institutions in terms of facilities, financials and trainers. Policy makers can set goals, incentives and establish programs for capability gain, adoption of new techs and participating in networks nationally and internationally.

6.2.5. Policy Recommendations and Strategies for Digital Maturity

Recommendations of the respondents about the digital maturity category generally gather around knowledge sharing and generation. Due to the dominance of digital technologies in this field we recommend that Company A has to develop digital systems that are seamless and interoperable to gain the benefits of knowledge transformation. Digital systems not only ease share but also enable generation of knowledge via techs. Such as AI and big data. Thus, both Company A and the ecosystem should invest in digital knowledge generation and sharing technologies to mature at OI. There is an urgent need for cloud technologies for the sector, because the A&D companies cannot store and share knowledge with external parties due to security restrictions of current cloud technologies. Policy makers should initiate a project for developing a clouds service for A&D industry and promote companies to invest in digital transformation.

Regarding production and corporate operations, (OT) and (IT) systems should be integrated into automated, interoperable, and flexible networks that enable seamless data exchange, analysis, and decision-making. These advancements in digital technologies are anticipated to enhance communication, flexibility, and operational efficiency at Company A and throughout its ecosystem.

Supply chain is another dimension to improve digital maturity. Incentives and regulations that enforce companies to work digitally are required. Digital transformation efforts along the value chain can be promoted financially. Suppliers, partners, procurement modules and even customers should be operating on digital systems that enable data updates, partnerships and procurement operations.

Digital maturity is not only a way to improve OI maturity but also a proven tool for efficiency and profitability, thus policy makers can allocate budget and experts that can transform the industry in digital terms and link it to the global A&D value chain. Regulations, trainings and obligations to pursue company activities via digital systems can enforce companies to take action to change their way of doing business.

Table 45 below summarizes this section and offers policy tools in order to improve the OI maturity of Company A, ecosystem and the Turkish A&D industry.

Table 45. Policy Recommendations and Policy Tools for OI Maturity

Category	Level	Policy Recommendation	Policy Tool
Strategy and Governance	Company	Communication of innovation strategic plan	Compulsory trainings, events, individual goals, department goals, media releases, portal announcements, periodic reminders
	Company	Linking innovation strategic plan with company strategic plan	Revision of both plans and meetings with managers to align them, reflecting innovation goals at strategic aims and goals
	Company	Revision of innovation strategic plan to sustain a more mature level	Clearly set financial and functional resources and responsibilities, conducting meetings and developing processes to create alignment, agile corporate innovation goals and KPIs, collaboration of technology management and strategic management departments to align focus areas and goals
	Ecosyste m	Measuring OI maturity periodically	Developing a process to measure OI maturity level via this proposed model or other methods regularly and determine improvement areas.
Innovation Culture	Company, ecosystem	Reduction of obstacles and resistances to creativity and encouraging employee participation for innovation.	Training programs, on the job trainings about OI and creativity, problem solving at all levels. Revision of innovation processes.
	Company, ecosystem	Raising awareness and recognition of OI, learning the intersections and differences of OI and R&D	Training programs, on the job trainings about OI and creativity, problem solving at all levels, media campaigns
	Company, ecosystem	Effective failure and success management	Developing a digital tool for recording results of innovative projects, partnerships that build a memory for companies
	Company, ecosystem	Motivating labor force for idea creation and developing entrepreneurial spirit	Idea contests, programs for spin offs and spin outs

	Table 45. continued		
	Company, ecosystem	Enhancing time and budget allocation	Pre-defined processes for innovation projects in terms of budget and working hours. Giving employees separate time within working hours (ex. four hours a week) for idea creation and development according to the development phase of their innovation project
	Company, ecosystem	Enhancing routines, events, culture at ecosystem	(OEM company) setting goals for innovation maturity and increasing collaboration, mandatory audits and training. Developing routines, beliefs, processes and events that encourage and convince employees and managers for intentional openness
	Company, ecosystem	Diverse incentives	Monetary rewards such as bonus, wage increase, non- monetary benefits like titles, fringes, financing establishment of spin outs
	Turkish A&D industry	Promoting and supporting innovation at industry	Laws and regulations that ensure financial credits, grants, tax incentives, tax exemptions, organized clusters and training expenses.
Partnership Capacity	Company, ecosystem	Increasing effectiveness of partnerships	Building a database for recording possible and existing partners, partner performance and project effectiveness.
	Company, ecosystem	Improving in-house collaboration	Setting goals for internal partnerships, revision of systems and processes to remove communication problems, initiating projects that require different backgrounds, building routine conferences, seminars in companies and ecosystem to bring employees together often.
	Turkish A&D industry	Promoting partnerships, best practices and benchmarks	Financially supporting benchmark studies with international leaders, establishing consortia, building a database that records competencies and project experiences of sector players and matching them accordingly. Making partnerships compulsory in projects for public procurements.
Knowledge Chain	Company, ecosystem	Increasing participation to knowledge networks	Budget and time allocation at company level for engaging in sectoral conferences, contests, academic studies, trainings, trade fairs, international organizations' events Raising awareness of managers about the significance of knowledge networks via trainings, briefings etc. to get their support
	Company, ecosystem	Improving the technical and collaborative working skills of employees	Developing trainings, compulsory rotations for some positions in and out of the organization. Public grants and incentives for participation in national and international knowledge networks.

	Table 45 continued		
	Turkish A&D industry	Supporting knowledge accumulation	Policy makers, industrial institutions, universities, research centers and international organizations establish events, conferences, meetings to bring industry shareholders together and knowledge accumulation
Digital Maturity	Company, ecosystem, Turkish A&D industry	Improving digital knowledge generation and sharing in companies, in ecosystem and among the Turkish industry	Investing in seamless digital tools to generate, share and store knowledge. Trainings at all levels to increase digital literacy Transforming manually kept and shared date in digital platforms. Initiating a partnership project for developing a cloud software that reduce the security concerns of companies for digitally sharing and storing knowledge.
	Company, ecosystem, Turkish A&D industry	Improving digital maturity of manufacturing and operations	Establishing automated and interoperable OT and IT systems, scaling up the digital applications in all departments, establishing a department that manages digital transformation and taking consultancy for digital maturity Tax incentives, financial credits and grants for digital investments.
	Company, ecosystem Turkish A&D industry	Increasing maturity of supply chain	Tax incentives, financial credits and grants for digital investments. Making certain digital applications mandatory for procurement and collaboration. Regulations and incentives for maturing in digital tenders, customer relations and partnerships
All	Turkish A&D industry	Coordination of innovation activities, developing culture, partnerships, openness and knowledge networks, mitigating duplicate projects, regulations and promotions for OI specialized on the sector	Establishment of an institution or empowering an existing one to regulate and promote (open) innovative works/innovation efforts of the industry

(Source: Author's own construction)

6.3. Concluding Remarks

Firstly, strategy and management support are the first two dimensions that need to be emphasized, since they are found to be highly significant (11% and 12% weights in model, respectively) due to the AHP results, for the maturity level and as they are relatively less costly and do not require significant investments in fixed assets

compared to other dimensions. These to dimensions have also been main topics of focus according to the survey participants. Revising Company A's innovation strategy, ensuring it is known and implemented throughout the organization, and aligning innovation strategic plan with the organization's strategic plan are among the primary recommendations of this study. It is suggested to monitor the innovation strategy, update it, and track it with smart KPIs. These recommendations at the company level are also applicable to the ecosystem. Ecosystem companies should develop their innovation strategies in alignment with the industry leaders. Of course, management support is essential for the success of the innovation plan. Awareness trainings should be provided starting from the general manager level down to team leaders, and the success points defined in the innovation strategy should be linked to unit and individual performance targets. This way, management support should be improved in companies, starting from the highest level.

Risk tolerance (11% weight in model) and time and budget (12% weight in model) are determined as the main improvement areas for developing innovation culture according to AHP results and suggestions of survey respondents. These two dimensions are evaluated to become game changers for open innovation maturity in A&D industry. Employees should be encouraged to take manageable and pre-calculated risks and risk management should become efficient by setting up criteria to stop-loss, in advance. This research proposes that allocating spare time and effective budget for open innovation activities is proposed to be a game changer for improving OI maturity of Turkish A&D sector. Engineers and managers are squeezed under a heavy workload schedule both in Company A and its ecosystem. Main focus is on catching up with the timelines of projects. However, innovation requires creativity and time to try ideas and develop projects. Working together in teams, attaining training programs and experience sharing are important to reduce time required to develop ideas and cultivate an innovation culture that is more tolerant to risk. This research finds out that the ecosystem companies are struggling financially to create an innovation culture. Allocating time and budget and allowing more risk to require financial stability and funds. Thus, Company A and policy makers should promote middle and small sized firms to create a more profound and competent ecosystem.

This research emphasizes absorptive capacity and adoption of new technologies as the last two significant dimensions to improve open innovation maturity of Turkish A&D industry. AHP results indicated 10 percent weight for both dimensions in the model. These two dimensions are supposed to leverage the inflow of external knowledge. Systematic creativity and on the job trainings, rotations, collaborations with universities to train current and future engineers will leverage the maturity level of Company A and its ecosystem. Diffusion of new technologies throughout the company with a pre-determined technology road map or plan is crucial. Company A has a road map but it is not scaled, thus the plan should be revised to cover all departments and be pursued with smart KPIs. Establishing international consortia and conducting benchmark practices are tools that can be employed to improve adoption of new technologies for Company a and its ecosystem.

As the last insight of this research, we have to mention the need for coordination, promotion and regulation of (open) innovation activities in Türkiye. We propose establishment of an institution or empowering an existing one to regulate and promote openness and innovative works/innovation efforts of the industry that may develop innovation culture, partnerships, openness and knowledge networks, mitigate duplicate projects, improve digital maturity for Turkish A&D industry.

6.4. Future Research

The study presents both limitations and opportunities that can pave the way for future research. In this section, we will briefly outline the key limitations and suggest potential directions for future research.

The survey questions that reflect the 16 pre-determined dimensions used in this research are aimed at measuring open innovation maturity. For Company A, interviews with C-level executives, along with internal written and unwritten evidence and observations were utilized to validate the empirical findings indicated by the responses. However, such confirmation was not possible for the ecosystem. Therefore, understanding the ecosystem maturity more deeply through qualitative studies and

thus validating the results of this research could provide new areas of study for future researchers that are interested in measuring OI maturity of Turkish A&D industry.

In this study, innovation ecosystem approach is employed to project the OI maturity of Turkish A&D sector. An aerospace OEM company is positioned as the main point of the study and the suppliers, research and production partners and subcontractors that are in the ecosystem of Company A were investigated. In the future, researchers can deliver the survey to have a larger sample or investigate other segments such as electronics, artillery systems and weaponry, missiles and naval systems. In fact, OI in A&D industry is scarcely studied despite the increasing attempts of sector companies to open their innovation system, and there exists opportunities for researchers to better understand the industry's relationship with openness.

This research is aimed at developing a company level capability model and measuring OI maturity mainly through this model (in a survey format) conducted by managers of A&D companies. Shareholders such as researchers, universities, customers and governmental and industrial organizations are kept out of scope. In the future, researchers may develop a methodology to measure OI maturity not only at company level but to cover a broader range of shareholders. Furthermore, researchers may focus on employees instead of managers as the unit of response and the differences in OI perception of these two different sides may be investigated.

The survey is conducted in Turkish, however the model is developed in English. This may create a minor limitation due to translation restrictions.

The AHP technique employed in this research has the opportunity to bring out tailored results for other industries. Each sector has its unique priorities, culture, relationship with technology, and sense and need of openness. Thus, determining and weighing the dimensions to design a sector specific OI maturity model may attract attention of researchers to conduct further studies in the future.

This research has implications and insights for future policy studies. Main goals of this

research are to propose a model and conduct an empirical study to implicate the OI maturity of Turkish A&D industry. However, policy implications are gathered to recommend policies and strategies to improve the maturity level of Company A, its ecosystem and the industry finally. The findings and data gathered in this research may open new discussions and questions for future policy studies regarding OI maturity of Turkish A&D sector.

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APPENDICES

A. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE

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MIDDLE EAST TECHNICAL UNIVERSITY

29 KASIM 2023

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Prof. Dr. Erkan Erdil

Danışmanlığını yürüttüğünüz Arzu ŞAHİN'in ***"Türk Havacılık Sanayi için Açık İnovasyon Olgunluğu Modeli Geliştirilmesi ve Ölçülmesi"*** başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek 0454-ODTUİAEK-2023 protokol numarası ile onaylanmıştır.

Bilgilerinize saygılarımla sunarım.

Prof. Dr.
Başkan

Prof.Dr. [illegible]
Üye

Doç. Dr.
Üye

Doç. Dr. Şerife SEVİNÇ
Üye

Doç.Dr.
Üye

Dr. Öğretim Üyesi [illegible]
Üye

Dr. Öğretim Üyesi
Üye

B. STUDIES SELECTED AFTER SLR AND EXAMINED IN DETAIL

	Academic Writing	Type	Framework Model / Empirical	Theoretical basis?	Application
1	Achi, A., Salinesi, C., & Viscusi, G. (2016). Innovation capacity and the role of information systems: a qualitative study. Journal of Management Analytics, 3(4), 333–360.	Journal Article	Framework	CBV	Qualitative interview
2	Alves, A. C., Barbieux, D., Reichert, F. M., Tello-Gamarra, J., & Zawislak, P. A. (2017). Innovation and Dynamic Capabilities of the Firm: Defining an Assessment Model. Revista de Administração de Empresas, 57(3), 232–244.	Journal Article	Model	CBV	Data from a survey of 1,107 Brazilian manufacturing firms
3	Arends S.C. (2018). Development of a Firm-level Innovation Capability Maturity Model and Identification of Innovation Archetypes [Master's thesis, Eindhoven University of Technology].	Master's thesis	Model and implementation	CBV	90 organizations
4	Bachmann, N., Jodlbauer, H. (2023). Iterative business model innovation: A conceptual process model and tools for incumbents. Journal of Business Research, 168, 114177.	Journal Article	model	RBV and CBV, process model	No application
5	Björkdahl, J., & Börjesson, S. (2012). Assessing firm capabilities for innovation. International Journal of Knowledge Management Studies, 5 (1/2), 171.	Journal Article	Model and framework	CBV	literature review, empirical study
6	Caird, S., Hallett, S., & Potter, S. (2013). The Open2-Innovation Tool - A software tool for rating	Journal Article	Model		No application

	organizational innovation performance. Technovation, 33(10–11), 381–385.				
7	Carroll, N., & Helfert, M. (2014). Service capabilities within open innovation: Revisiting the applicability of capability maturity models. Journal of Enterprise Information Management, 28(2), 275–303.	Google Scholar	Journal Article	Framework	CBV RBV
8	Cropley, D., & Cropley, A. (2012). A psychological taxonomy of organizational innovation: Resolving the paradoxes. Creativity Research Journal, 24(1), 29-40.	Google Scholar	Journal Article	Framework	Psychological framework
9	Demir, F. (2018). A Strategic Management Maturity Model for Innovation. Technology Innovation Management Review, 8(11), 13-21.	Google Scholar	Journal Article	Model	Strategy management
10	Dervitsiotis, K. N. (2010). A framework for the assessment of an organisation's innovation excellence. Total Quality Management & Business Excellence, 21(9), 903–918.	Google Scholar	Journal Article	Framework Model	
11	El Bassiti, L., & Ajhoun, R. (2017). Towards innovation excellence: Why and how to measure innovation performance? Proceedings of 6th International Conference on Information and Communication Technology for the Muslim World, ICT4M 2016, 99–104.	ieeex	Conference paper	Model	innovation performance theory
12	Enkel, E., Bell, J., & Hogenkamp, H. (2011). Open Innovation Maturity Framework. International Journal of Innovation Management, 15(6), 1161–1189.	Google Scholar	Journal Article	Model	new theory, capability-based view

13	Enkel, E., Bogers, M., & Chesbrough, H. (2020). Exploring open innovation in the digital age: A maturity model and future research directions. R&D Management, 50(1).	Google Scholar	Journal Article	Framework	dynamic capabilities
14	Esterhuizen, D., Schutte, C. S. L., & Du Toit, A. S. A. (2012). Knowledge creation processes as critical enablers for innovation. International Journal of Information Management, 32(4), 354–364.	ScienceDirect	Journal Article	Framework	Knowledge creation theory
15	Fernandes, C., Ferreira, J. J., & Marques, C. S. (2013). Innovation management capabilities in rural and urban knowledge intensive business services: empirical evidence. Service Business, 9(2), 233 256.	ScienceDirect	Journal Article	empirical	innovation capability theory
16	Freitag, M., & Ganz, W. (2011). InnoScore® Service: Evaluating innovation for product-related services. Proceedings for 2011 Annual SRII Global Conference, SRII 2011 (pp. 214–221).	ieeex	Conference paper	Model, tool	
17	Goldasteh, P., Nadali, A., & Khalilinezhad, M. (2011). Innovation Culture Assessment by a Fuzzy Expert System (Case Study: An Iranian IT Company). Proceedings of 2011 International Conference on Information Management, Innovation Management and Industrial Engineering (2005), 530–533.	ieeex	Conference paper	Model	Fuzzy expert system, innovation culture view
18	Halemane, M., Janszen, F., Go, F. (2017). Managing innovation process: A structured,	Google Scholar	Book Chapter	Model	Capability view based

	simulation-based approach. In: Little, S., Go, F., Poon, TC. (eds) Global Innovation and Entrepreneurship (pp. 21-42). Palgrave Macmillan				
19	Honorato, C., & de Melo, F. C. (2023). Maturity model for innovation project management in industrial enterprises: A case study of the aerospace sector in Brazil. Journal of Industrial Integration and Management, 8(02), 201-227.	Scopus	Journal Article	Model	Capability view based
20	Igartua, J. I., Retegi, J., & Ganzarain, J. (2018). IM2, a maturity model for innovation in SMEs. Dirección y Organización 64, 42-49.	Scopus	Journal Article	Model	(Pöppelbuß and Röglinger, 2011)
21	Inków, M. (2024). Methodological aspects of measuring the innovation maturity of enterprises : proposal of the author's own innovation maturity model. European Research Studies Journal, 27(3), 499-510.	Google Scholar	Journal Article	Model	capability based view
22	Kebure, K., & von Zedtwitz, M. (2023). Open innovation capability maturity model: the case of a multinational organization. Proceedings for 2023 IEEE International Conference on Technology and Entrepreneurship (ICTE), 110-115.	ieeex	Conference paper	Model	explaratory research
23	Kozioł, L., Kozioł, W., Wojtowicz, A., & Pyrek, R. (2015). Diagnosis of Innovation Enterprises – Study Theoretical and Empirical Results. Procedia - Social and	Sciencedirect	Journal Article	Model	organizational learning

	Behavioral Sciences, 175, 137–145.				
24	Lee, M.-C., Chang, T., & Chang Chien, W.-T. (2011). An Approach for Developing Concept of Innovation Readiness Levels. International Journal of Managing Information Technology, 3(2), 18 37.	Google Scholar	Journal Article	Model	previous models, TRL SLR etc.
25	Li, E. Y., Chen, L.-W., & Shen, C. C.-L. (2010). A framework for the service innovation capability maturity model. Proceedings for 4th International Conference on Operations and Supply Chain Management, 529-534.	Google Scholar	Conference paper	Model	capability based view
26	Mattei, G., Canetta,L., Sorlini, M. Alberton S. & Tito, F. (2019). Innovation maturity model for new product and services development: a proposal. In 2019 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC) (pp.1-9). IEEE	ieeex	Conference paper	Model	previous models capability based
27	Müller-Prothmann, T., & Stein, A. (2011, June). I²MM–Integrated innovation maturity model for lean assessment of innovation capability. In XXII ISPIM Conference (pp. 12-15).	Google Scholar	Conference paper	Model	previous model capability based
28	Nada, N., Ghanem, M., Msebah, S., & Turkyilmaz, A. (2012). Innovation and Knowledge Management Practice in Turkish SMEs. Journal of Knowledge Management, Economics and Information Technology, 2(1), 248–265.	Google Scholar	Journal Article	Model	capability previous models

29	Nair, H. A. P., Kumar, D., & Ramalu, S. S. (2014). Assessment framework for innovation capacity. Man in India, 94(4), 775–795.	Scopus	Journal Article	Model	capability
30	Niewöhner, N., Lang, N., Asmar, L., Röltgen, D., Kühn, A., & Dumitrescu, R. (2021). Towards an ambidextrous innovation management maturity model. Procedia CIRP, 100, 289-294.	Scopus	Journal Article	Model	ambidexterity concept, previous literature
31	Oliveira, A. C. De, & Kaminski, P. C. (2012). A reference model to determine the degree of maturity in the product development process of industrial SMEs. Technovation, 32(12), 671–680.	Scopus	Journal Article	Model	previous literature
32	Oliveira, R. S. De, Freitas de Carvalho Lima De, A. A. T., Ferreira, M. A., & Pereira, N. R. (2011). Analysis of Competences for Innovation in Technology-Based Enterprise Incubators. Latin American Business Review, 12(3), 187–207.	Google Scholar	Journal Article	Model	RBV
33	Peisl, T., & Schmied, J. (2012, June). Innovating innovation: A conceptual framework. In European Conference on Software Process Improvement (pp. 217-228). Berlin, Heidelberg: Springer Berlin Heidelberg.	Google Scholar	Conference paper	Framework	Capability
34	Rolik, Y. A. (2013). A Complex Approach to Evaluating the Innovation Strategy of a Company to Determine its Investment Attractiveness. Procedia - Social and Behavioral Sciences, 99, 562–571.	Google Scholar	Journal Article	Model	Resource based view
35	Saunila, M., & Ukko, J. (2012). A conceptual framework for the measurement of	Scopus	Journal Article	Framework	capability based view

	innovation capability and its effects. Baltic Journal of Management, 7(4), 355–375.				
36	Wang, K. J., Widagdo, J., Lin, Y. S., Yang, H. L., & Hsiao, S. L. (2016). A service innovation framework for start-up firms by integrating service experience engineering approach and capability maturity model. Service Business, 10(4), 867–916.	Scopus	Journal Article	Framework	Capability
37	Zuluaga, J. A. F., Escobar, J. F., Martínez, G. A. G., D'Aleman, J. C., & Vallejo, A. O. (2024). Model for measuring technological maturity for critical sector industries. Journal of Open Innovation: Technology, Market, and Complexity, 10(1), 100194.	Science Direct	Journal Article	Model	

C. OI MATURITY PROPOSED MODEL IN SURVEY FORMAT

Original Format published in Turkish

Sayın katılımcı,
Bu anket Orta Doğu Teknik Üniversitesi Bilim ve Teknoloji Politikası Çalışmaları bölümünde sürdürdüğüm doktora çalışmamın bir parçası olarak, "Türk Savunma ve Havacılık Sanayinin Açık İnovasyon Olgunluğu"nu ölçmek amacıyla hazırlanmıştır. Üniversitenin etik kurulundan aldığım araştırma iznime linkten ulaşabilirsiniz.
Bu tez çalışmasında şirket ismi ve anket katılımcılarının tüm şahsi ve kurumsal bilgileri gizli tutulacaktır.

Sorularınız ve görüşleriniz için e-posta adresinden ve ..... no.lu telefondan benimle iletişime geçebilirsiniz.

Bu ankette yer alan inovasyon terimi Ar-Ge, Ür-Ge ve diğer yenilikçilik faaliyetlerinin tümünü içermektedir.

Açık yenilikçilik (inovasyon), sadece kurum içi kaynaklarla Ar-Ge ve Ür-Ge yapmak yerine dışarıdaki gelişmelere de açık olan, firma sınırlarının kontrollü bir şekilde bilgiyi geçirdiği ve işbirliğine değer veren bir yenilikçilik modelidir.
Aşağıda 5 ana boyut ve 16 alt boyutta açık inovasyon parametrelerine yer verilmiştir. Her soruda, en düşük olgunluk seviyesi 1, en yüksek olgunluk seviyesi 5 olarak belirlenmiştir. Şirketimizi göz önüne alarak sizce en uygun olan seçeneği işaretlemeniz beklenmektedir. İşaretleme yaparken **şirketinizin mevcut durumu** üzerinden değerlendirme yapmanız önem arz etmektedir.

Anketin son bölümünde ise açık inovasyon olgunluğunu artırmak için politika önerilerinizi/görüşlerinizi belirtebileceğiniz açık uçlu bir soru bulunmaktadır. Bu alanı doldurmanız ekosistemimizin gelişimine katkı verebilecektir.
Anketin toplamda 10-15 dakikanızı alacağı tahmin edilmektedir.

Katılımcı Bilgileri
Şirketinizin ismi nedir? (Bu bilgi sadece katılan şirketlerin kaydını tutmak içindir, tez içeriğinde kullanılmayacaktır)
Pozisyonunuz: ……..
Genel Müdür, Genel Müdür Yardımcısı, Direktör, Başkan, Müdür, Şef, Baş Mühendis, Yönetici, Mühendis, Uzman, Diğer

Strateji ve Yönetişim

1. Şirketinizin bir inovasyon stratejisi ve/veya vizyonu var mı?

Lütfen aşağıdakilerden yalnızca birini seçin:

1- Şirketimizin tanımlanmış bir inovasyon stratejisi / vizyonu yoktur.
2- Şirketimizin bir inovasyon planı mevcuttur, fakat bu plan kısa vadelidir ve/ veya dışsal bilgiye kapalıdır.
3- Şirketimizin uzun vadeli bir inovasyon stratejisi/ vizyonu mevcuttur. Stratejik odak alanları açıkça belirlenmiştir.
4- Şirketimizde inovasyon için yayımlanmış, uzun vadeli ve kurumun dışındaki bilgiyi nasıl kullanabileceğimizi de tarifleyen bir plan mevcuttur. Bu plan kurumsal stratejilere eklemlenmiştir. Hedefler ve anahtar performans göstergeleri belirlenmiştir.
5- Şirketimizde adımları belirlenmiş, uzun vadeli ve açık bir inovasyon stratejik planı devrededir. Bu plan güncel trend öngörüler, kurum içi ve dışındaki gelişmeler ve kurumsal strateji değişimine göre sürekli gelişim halindedir.

2. Çalışanlarınızı yeni fikirler denemesi için nasıl teşvik ediyor/ destekliyor/ koçluk ediyorsunuz? Bu konuda onlara geri bildirim veriyor musunuz?

Lütfen aşağıdakilerden yalnızca birini seçin:

1- Yöneticiler inovasyon faaliyetlerini teşvik etmezler. İnovasyon faaliyetlerine karşı bir direnç mevcuttur.
2- Yöneticiler inovasyon girişimlerini hoşgörürler. Kurum ara sıra çalışanlarından inovasyonda başarı bekler.
3- Yöneticiler, çalışanları inovasyona teşvik eder ve bunun sağlanması için eğitim alırlar. Kurum, önemli inovasyon hikayelerini seçer ve çalışanlar ile paylaşır.
4- Her seviyede çalışan yapılandırılmış bir şekilde inovasyon için sürekli teşvik edilir ve desteklenir. Gösterge olabilecek projeler tüm kuruma yayılır. Teşvik programlarının sonuçları ölçülür, değerlendirilir ve sürekli iyileştirilir.
5- Sadece kurum içi değil, kurum dışı inovasyon fırsatları da her seviye çalışan tarafından takip edilir ve değerlendirilir. Yöneticiler inovasyonu sadece kurum içinde değil, kurum dışı paydaşlarda da teşvik eder ve gözlemler. Şirketin kurum dışında sürdürdüğü inovasyon faaliyetleri de takip edilir ve değerlendirilir.

3. Şirketinizde inovasyon yönetişimi* nasıl yapılıyor?

** İnovasyon yönetişimi, inovasyon çabalarının şirketin genel iş stratejisiyle uyumlu olmasını sağlamak için uygulamaya konulan politikalar, prosedürler, karar alma yetkisi ve hesap verebilirlik mekanizmalarının çerçevesidir.*

Lütfen aşağıdakilerden yalnızca birini seçin:

1- İnovasyon ile ilgili süreç ve sorumluluklar net olarak tanımlanmamıştır. Çalışanlar (eğer var ise) gelişigüzel sorumluluk alırlar.

2- İnovasyon faaliyetlerinin sonuçları ancak bir proje grubu veya çalışan inisiyatif alır ise ölçülür ve üzerine düşünülür.
3- İnovasyon faaliyetlerinin nasıl başladığı ve kimin sorumluluğunda olduğu açıktır. İnovasyon faaliyetlerinin sonuçları ölçülür. Bu durum kurumsal yapı ve süreçlere yansıtılmıştır.
4- İnovasyon için karar almada etkili olan merkezi ve merkezi olmayan otoritenin tanımlandığı açık bir yapı vardır. İnovasyon faaliyetlerinin amacı belirgindir. İnovasyon yapısı fonksiyonel ve finansal sorumluluğu kapsar, kurumsal yapı ve temel süreçler ile uyumlu ve bunlara entegredir.
5- Finansal ve fonksiyonel sorumlulukların net olduğu açık inovasyon yapısı, kurumsal yapı ve süreçlerle uyumlu olmakla beraber sürekli gelişim halindedir. Faaliyetlerin amacı, nasıl ölçüleceği, iletişiminin nasıl sağlanacağı ve paydaşların kim olacağına dair karar alma mekanizmaları açıktır. Proje takımları kendi kararlarını alma yetkisi ile donatılmıştır.

İnovasyon Kültürü

4. Şirketinizde inovatif faaliyetler için prosedür, süreç ve yazılı olmayan kurallar var mıdır, bunlar nasıl oluşturuluyor?
Lütfen aşağıdakilerden yalnızca birini seçin:
1- Şirketimizde tanımlanmış bir inovasyon süreci yoktur.
2- Bir inovasyon süreci tanımlanmış ve dokümante edilmiştir. Ancak bu sürecin adımları ve her adımın karar alma kriterleri açıkça tanımlanmamıştır.
3- İnovasyon süreci açıkça tanımlanmış, dokümante edilmiştir. Her adım için açık karar verme kriterleri mevcuttur. Süreç oluşturulurken çalışan görüşleri ve geçmiş deneyimler dikkate alınır.
4- Her tür inovasyon için süreç açıkça tanımlıdır, aşamalar ve kriterler tanımlanmış, dokümante ve pratik edilmiştir. Süreçler ve kurallar şirketin her aşamasının görüşü alınarak belirlenir. Bu süreçler ustalıkla icra edilir ve diğer kurumsal süreçlerle muntazam bir uyum içindedir.
5- Farklı inovasyon tipleri için kurumsal süreçlerle uyumlu ve katılımcı inovasyon süreçleri oluşturulmuştur. Kurum bu süreçleri ustalıkla ve etkili bir şekilde icra etmek için yetkindir. İnovasyonun devreye alınması için kurumsal süreçlerin yeniden tasarlanmasına yönelik uygulamalar tanımlanmıştır. İnovasyon süreçlerinin tasarımı, etkinliği ve icrası düzenli olarak değerlendirilir ve geliştirilir.

5. Şirketinizde risk almak kabul edilebilir mi, inovasyonun hem başarı ve hem de başarısızlıkları tanınıyor ve hoşgörülüyor mu?
Lütfen aşağıdakilerden yalnızca birini seçin:

1- İnovasyon süreçlerindeki başarısızlıklar işten çıkarma vb. yöntemlerle ciddi şekilde cezalandırılır, bu nedenle çalışanlar inovasyon faliyetlerine girişmekten kaçınırlar.
2- Bir inovasyon projesindeki başarısızlık, bu projeye dahil olan çalışanlar için itibar kaybına neden olur.
3- İnovasyon başarısızlıkları, herhangi bir biçimde cezalandırılmaz ve çalışan için olumsuz bir yansımaya neden olmaz.
4- Şirketimizde hesaplanmış riskler almak kabul edilebilir. Yenilik yapma cesaretini gösteren çalışanlar, yeniliğin sonucu ne olursa olsun sürekli olarak takdir edilir ve saygı görür. Çalışanlar başarısızlık ve öğrenme deneyimleri hakkında açıkça konuşurlar.
5- Başarı ve başarısızlıklar şirket bazında organizasyonel araçlarla kayıt altına alınmakta ve çalışanlarla düzenli olarak toplantı, doküman vb. araçlarla iletişim kurulmaktadır. Riskler önceden tanımlanmaya ve ölçülmeye çalışılır.

6. İnovasyon için bir ödül politikanız var mıdır? Bu ödül kimlere veriliyor; çalışanlar, tedarikçiler, dış paydaşlar ve ortaklar?

Lütfen aşağıdakilerden yalnızca birini seçin:

1- İnovasyon faaliyetleri için bir ödül sistemi yoktur.
2- İnovasyon girişimi başarısız olursa cezalandırılmaz, ancak başarılı inovasyonlarda düzenli bir ödül de yoktur. Ödüllendirme eğer var ise düzensiz ve belirsiz kriterlere göre yapılır.
3- Çalışanlar düzenli olarak inovasyonları için ödüllendirilirler, bu ödüllendirme genellikle maddi bazda gerçekleşir. Değerlendirmeler kurum dışından uzmanlarca yapılabilir.
4- Şirket içi ve dışı ödüllendirme mevcuttur. Sadece maddi değil, yan haklar ve terfi gibi ödüller bulunur. Ödül kriterleri belirlenmiştir. Fikir pazarları ve inovasyon yarışmaları gibi faaliyetlerle kurum dışından katılımcılar da ödüllendirilebilir.
5- Maddi ödülün yanı sıra terfi ve girişimcilik bazlı ödüller de verilir (ek yan haklar, yeni şirket kurulumu, var olan şirkete sermaye yatırımı). Hedefler herkes için açıktır. Ödüllendirme süreci şirket stratejilerine ve ihtiyaçlarına göre düzenli olarak gözden geçirilir ve değiştirilir.

7. İnovasyon faaliyetleri için zaman ve bütçe ayırıyor musunuz?

Lütfen aşağıdakilerden yalnızca birini seçin:

1- İnovasyon faaliyetleri için ayrılmış zaman ve bütçe bulunmaz, çalışanlar kendi çabaları ile inovasyon yaparlar.
2- İnovasyon faaliyetlerine düzensiz bir biçimde zaman ve bütçe ayrılır, operasyonel faaliyetler halen önceliklidir.

3- Çalışanlar, bütçe detayını belirleyen bir prosedürün varlığında inovasyon yapmaya teşvik edilirler. İnovasyon faaliyetleri için ayrılacak zaman belirsizdir.
4- Kurum bütçesinde, kurum içi paydaşlarla yapılacak inovasyona ayrılmış bütçe ve zaman belirlidir. Çalışanlar bu bütçeden faydalanmak için aktif olarak teşvik edilirler.
5- İç ve dış paydaşlarla yapılacak her tür inovasyon faaliyeti için açık ve esnek bir bütçe mevcuttur, bu bütçe kurumsal bütçe ile denge içindedir. Çalışanlar inovasyon faaliyetleri için ihtiyaç duydukları zaman ve bütçeye erişebilir durumdadır.

İşbirliği Kapasitesi

8. İş birliği için partner (iş ortağı) seçerken nelere dikkat ediyorsunuz? (Çalışma kültürü, yetkinlik, coğrafi yakınlık, geçmiş tecrübeler vb.)
Lütfen aşağıdakilerden yalnızca birini seçin:

1- İş birliği yapılacak iş ortağı önceden karar verilmiş sürece veya kriterlere göre seçilmez. Çoğunlukla tesadüfler ya da eski tecrübeler ortaklıklara neden olur.
2- İş ortakları tanışıklık veya önceki işbirliklerine göre seçilir.
3- İş ortağı seçimi mevcut bilgi veya geçmiş işbirliği tecrübesine göre seçilir, potansiyel inovasyon ortakları listelenmiştir ve düzenli olarak belirli kriterlere göre gözden geçirilir.
4- İş ortakları, ortaklık sürecinin vizyon ve/veya stratejisine göre önceden açıkça belirlenmiş kriterlere göre yeniler arasından ya da eski partnerler arasından seçilebilir.
5- Ortaklık faaliyetleri için bir partner veri tabanı bulunur, burada belirli kriterlere göre ortaklar değerlendirilir. Ayrıca, potansiyel partnerleri tespit etmek için ekosistem içi ve dışı ağ yapıları sürekli olarak taranır. İş birliği sonunda iş ortağı değerlendirilir ve bu değerlendirme kayıt altına alınır.

9. İşbirliği faaliyetlerinizin çeşitliliği ve yoğunluğu hakkında ne düşünüyor musunuz? Bu iş birliklerinin etkinliği hakkında çalışmalar yapılıyor mu?
Lütfen aşağıdakilerden yalnızca birini seçin:

1- Şirketimizde iş birliklerine sadece operasyonel amaçlar için girişilir ve idame ettirilir. Kurum dışı partnerler ile inovasyon amaçlı işbirliklerine girişilmez.
2- Mevcut operasyonel iş birlikleri inovasyon faaliyetleri için düzensiz olarak kullanılır. Sadece birkaç iş birliği vardır ve bunların kapsamı dardır. Bu iş birliklerinin etkinliği ölçülmez.
3- Mevcut inovasyon iş birlikleri resmi, düşük yoğunluklu ve kısa sürelidir. İş birliğinin etkinliği bazen ölçülür.

4- İnovasyon amacıyla yapılan oldukça çeşitli iş birliği ilişkileri mevcuttur ve bunlardan fayda sağlanmaktadır. İnovasyon iş birliklerinde, yoğunluk, odaklanma ve değerlendirme bulunur. Ürün yaşam döngüsünün çeşitli aşamalarında bu iş birliklerine rastlanır (tasarımdan, satış sonrasına) ve etkin iş birliğinin ne demek olduğu önceden tanımlanmıştır.
5- İş birlikleri inovasyon faaliyetlerinin rutin bir çeşidi olarak görülür. Tüm değer zinciri boyunca görülür. İş birliklerinin etkinliği yönetim ve/veya inovasyon profesyonelleri tarafından beklenen çıktılar özelinde değerlendirilir. İş ortaklarının memnuniyetleri izlenir ve iş birliğinin etkinliğini artırmak için önlemler alınır.

10. Kurum çalışanlarınız kurum içindeki diğer iş birimleri ile ne sıklıkla ve ne tür işbirliği projeleri yaparlar?

Lütfen aşağıdakilerden yalnızca birini seçin:

1- Birimler arası iş birlikleri zayıftır, birimler arası bilgi paylaşımı zayıftır.
2- 2- Şirketimizde kurum içi inovasyon iş birlikleri mevcuttur. Ancak, bu iş birliklerinde ortak değerler ve birlikte çalışma kültürü gelişmemiştir.
3- Birimler arası iş birlikleri kurum tarafından teşvik edilir ve farklı altyapıdaki inovasyon takımlarınca yapılır. Bu takımlar ortak bir çalışma kültürü oluşturmak için heveslidir.
4- Kurum içinde çeşitli ve uzun süreli iş birliği faaliyetleri mevcuttur. Çalışanları birimler arası iş birliği yetenekleri konusunda eğiten programlar mevcuttur. Her seviyeden iş arkadaşları resmi rol ve görev tanımları dışında etkileşime girmeye hazırdır.
5- Çalışanlar farklı arkaplanlardan gelen iş arkadaşları ile çalışmak için yetkindir ve iş birliği proaktif olarak aranır ve bundan faydalanılır. İnovasyon projelerinde karar verme süreci paylaşılan değerler ve kurumsal normlar çerçevesinde yönetilir.

Bilgi Zinciri

11. Şirketiniz dışsal bilgiyi özümseme ve bunu iç bilgi ile birleştirme kapasitesine sahip mi?

Lütfen aşağıdakilerden yalnızca birini seçin:

1- Çalışanlar ve yöneticiler değerli dışsal bilgiyi fark etmez veya buna ilgi duymazlar.
2- Çalışanlar ve yöneticiler değerli dışsal bilgiyi fark ederler. Değerli dışsal bilgiyi saptamak için sektör toplantılarına katılır, bilimsel çalışmalar, lisanslar ve patentleri tararlar.
3- Yöneticiler ve çalışanlar dışsal bilgiyi eğitimler, gözlemler ve pratikler yaparak öğrenmeye ve içselleştirmeye isteklidir.

4- Yönetici ve çalışanlar dışsal bilgiyi öğrenmek için yetkindir. Bu bilgi şirketimizin Ar-Ge kapasitesi ile kurum içine transfer edilebilir. Bilginin transferi yeni bilgiyi süzerek, yorumlayarak, eskinin üzerine ekleyerek veya var olan bilgi ile inovatif bir şekilde birleştirerek yapılır.
5- Firma yeni bilgiyi operasyonlarına ve süreçlerine eklemesinin yanı sıra bu bilgi ile yeni operasyonlar, yetkinlikler, rutinler, ürünler ve kurumsal yapılar elde eder. Dışsal bilgi böylece özümsenmiş ve bundan fayda üretilmiş olur.

12. Yeni teknolojileri nasıl benimsiyorsunuz ve şirket içinde yayılımını nasıl sağlıyorsunuz? Miadı dolmuş eski teknolojilerden nasıl vazgeçiyorsunuz?

Lütfen aşağıdakilerden yalnızca birini seçin:

1- Yeni teknoloji kazanımı (patentler, teknoloji transferi ve tersine mühendislik vb. göntemlerle) şirketin ilgi alanında değildir. Yahut, yeni ileri teknolojilerin kazanımına veya dijitalleşmeye karşı bir direnç bulunmaktadır.
2- Yeni teknoloji kazanımı düzensiz pratikler ile yapılmaktadır, sorumlular ve süreç açık değildir. Bu konudaki iş gücü eğitimi yetersizdir. Fikri mülkiyet hakları korunmaz.
3- Yeni teknoloji kazanımı birimler tarafından önceden tanımlanmış süreçler ile yapılır veya süreç teknoloji kazanımı esnasında tasarlanır. Diğer yandan, birimler eski teknolojileri değerlendirir ve bunların şirkette kullanımının devam edip etmeyeceğine karar verir. Çalışanlar yeni teknolojiler hakkında eğitilir. Fikri mülkiyet hakları temel seviyede korunur.
4- Yeni teknoloji kazanımı, stratejik plan, teknoloji yol haritası vb. kurumsal bir araç çerçevesinde birimler ve merkezi bir yapı tarafından takip edilir. Kazanımın tamamlanmasını ölçen metrikler vardır. Yazılı bir fikri mülkiyet hakları stratejisi mevcuttur. Yeni teknolojinin her seviyede yaygınlaşması için eğitim programları ve entegrasyon faaliyetleri sürdürülür.
5- Yeni teknolojiler periyodik olarak takip edilir ve kurumsal etkileri ölçülür. Bir plan dahilinde ve kurumsal bazda eski teknolojilerden çıkıp çıkılmayacağına karar verilir. Çalışanlara yeni teknolojiye adapte olmak için gereken yetkinlikler kazandırılır. Tedarikçiler yeni teknolojinin ve kendilerine etkilerinin farkındadırlar.

13. Ürünleriniz veya yenilikleriniz yeni bölgelere ve bilgi ağlarına ne ölçüde nüfuz ediyor?

Lütfen aşağıdakilerden yalnızca birini seçin:

1- Şirketin çevresinde şirketin nüfuz edebileceği yerel bilgi akış mekanizmaları yoktur. Bilginin (ürün veya yenilik) nüfuz edebileceği havacılık ekosistemi olgunlaşmamıştır.
2- Çalışanlar ve/veya organizasyon, bölge içi ve/veya sektör içi bilgi ağlarının bir parçasıdır. Diğer bölgeler ve sektörlerle herhangi bir bağlantısı yoktur. Kişilerarası bilgi ağları zayıftır.

3- Çalışanlar ve şirket, sektör içi ve bölge içi ağların yanı sıra diğer sektörler ve bölgelerdeki bilgi ağlarında da faaliyet göstermektedir. Bilgi/ürün yayılımı kontrol edilmiyor ve/veya değerlendirilmiyor. Kişilerarası bilgi ağları mevcuttur.
4- 4- Çalışanlar ve şirket düzenli olarak kurum içi ve kurum dışı bilgi ağlarına dahil olurlar ve araçlar (raporlar, patentler, konferanslar, toplantılar, araştırmalar) aracılığıyla bilgi akışı sağlanır. Şirketin, şirket genelinde bilgi akışını sağlamak için bir planı ve rutini vardır. Çalışanlar bu bilgilere erişmek ve bilgi akışlarından öğrenmek için gereken kaynaklara sahiptir.
5- Şirketteki bilgi akışı iki yönlüdür: şirkete dışsal bilgi ağlarından bilgi girişi ve şirketten dışarıya bilgi çıkışı. Şirketin, kurum içi bilginin şirket dışına nasıl ve ne ölçüde açılacağına dair bir planı vardır.

Dijital Olgunluk

14. Şirketinizde, fikir üretimini ve bilgi paylaşımını desteklemek için dijital araçlar ne ölçüde kullanılmaktadır?

Lütfen aşağıdakilerden yalnızca birini seçin:

1- Şirketimizde fikir üretimini ve bilgi paylaşımını desteklemek için kullanılan dijital araçlar bulunmamaktadır.
2- Şirketimizde fikir üretimini ve bilgi paylaşımını birim bazlı mümkün kılan dijital araçlar vardır. Ancak, iş birlikleri ve projeler dijital olarak takip edilmezler.
3- Kurum içinde birim bazlı fikir üretimi, paylaşımı ve iş birlikleri süresince tüm çalışanların erişebilir olduğu dijital araçlar mevcuttur. Kurum dışı partnerlerle bu işler kısmen dijital olarak yürütülür.
4- Dijital araçlar tüm kurumda erişilebilirdir ve bu araçlar birbiri ile uyumludur. Gerektiği zaman ve tüm kademeler için fikir üretiminden bilgi izlemeye ve projelerin bitimine kadar bu araçların birbirine entegrasyonu mümkündür.
5- Bilgi üretimi, paylaşımı ve iş birlikleri için kullanılan dijital araçlar diğer dijital sistemlere bağlıdır ve bu sayede kurum, süreç ve ürünlerdeki gelişme ve değişiklikler için girdi temin ederler.

15. Üretim ve kurumsal operasyonlarınız ne ölçüde dijital?

Lütfen aşağıdakilerden yalnızca birini seçin:

1- Sistemler entegre değildir ve bazı sistemler otomatik değildir.
2- Üretim operasyonlarında ve hizmetlerde kullanılan bazı OT (Fiziksel cihazların nasıl çalıştığını izleyen ve kontrol eden donanım ve yazılım teknolojileri) ve BT (Veri veya bilgi depolamak, almak, iletmek, çalışmak ve işlemek için kullanılan teknolojiler) sistemleri entegre edilmiştir.
3- Üretim ve kurum düzeyindeki tüm OT ve BT sistemleri otomatik ağlara entegre edilmiştir. Veri alışverişi mümkündür, ancak veri analizi ve karar

verme mümkün değildir. Sistemler arasındaki letişim daha iyidir, ancak kaynak planlaması ve operasyonel talepler dijital olarak yönetilmez.

4- Üretim ve kurum düzeyindeki OT ve BT sistemleri, sorunsuz veri alışverişi ve analizi yapabilir. Sistemler arasında iyi iletişim, esneklik ve operasyonel verimlilik vardır. Çalışanlar kaynak kullanılabilirliği, operasyonel talepler veya üründeki herhangi bir değişikliğe karar verirken bu analizlerden faydalanabilirler.
5- Üretim ve kurum düzeyindeki OT ve BT sistemleri, sorunsuz veri alışverişi, analizi ve karar vermeye olanak tanıyan otomatik, birlikte çalışabilir ve esnek ağlara entegre edilmiştir. Sistemler arasında iyi iletişim, esneklik ve operasyonel verimlilik vardır. Bu sayede kaynak kullanılabilirliği, operasyonel talepler veya üründeki herhangi bir değişikliğe daha hızlı ve daha uyumlu yanıt vermek mümkündür.

16. Dijital teknolojiler tedarik zincirine ne ölçüde entegre edilmiştir?

Lütfen aşağıdakilerden yalnızca birini seçin:

1- Tedarik zinciri operasyonlarında I4.0 teknolojilerinin bilgi ve uygulama eksikliği, I4.0 kavramlarını benimsemek için bazı münferit çabalar mevcut olabilir. Zaman zaman organizasyonda tedarik zinciri trendlerini benimsemeye yönelik iyileştirmeler ortaya çıkmaktadır. Tedarik zinciri operasyonlarına yeni teknolojilerin dahil edilmesinin reddedilmesi söz konusu olabilir.
2- Şirketimiz, I4.0 teknolojilerinin ve tedarik zinciri trendlerinin benimsenmesinin öneminin farkındadır. Çeşitli I4.0 teknolojileri, bir TZ trendini benimsemeyi amaçlayan süreç iyileştirmeye dahil edilmiştir. Bununla birlikte, bu teknolojiler ve çevredeki sistemler hala izole edilmiş veya kısmen entegre edilmiştir.
3- I4.0 konseptleri ve teknolojileri, SC ile birlikte sürekli olarak iyileştirme projelerine dahil edilir. Piyasadaki belirsiz davranışlarla yüzleşmek için süreçlerdeki değişiklikler çalışma kültürünün bir parçasıdır. Sistemlerin ve I4.0 teknolojilerinin ilk entegrasyonları devam ediyor ve aşırı analizler devam ediyor.
4- I4.0 konseptleri ve teknolojileri, SC ile birlikte sürekli olarak iyileştirme projelerine dahil edilir. Piyasadaki belirsiz davranışlarla yüzleşmek için süreçlerdeki değişiklikler çalışma kültürünün bir parçasıdır. Sistemlerin ve I4.0 teknolojilerinin ilk entegrasyonları devam ediyor ve aşırı analizler devam ediyor.
5- İşletme tarafından geliştirilen dijital trendlere dayalı bir SC öğrenme ve geliştirme kültürü vardır. Organizasyon, çalışanlarının tedarikçilerin süreçlerini geliştirmekle görevlendirilmesi için bir ölçüt haline gelir. Organizasyon, I4.0 konseptlerinin geliştirilmesine değerli bilgiler katıyor ve girişimin evriminde aktif bir aktör haline geliyor.

Açık İnovasyon Politika Önerisi

Açık inovasyon, yeni teknolojilerin geliştirilmesi için iç ve dış fikirlerin yanı sıra pazara giden iç ve dış yolları birleştirmeyi öneren ve bu yolla firma sınırlarının kontrollü bir şekilde bilgiye geçirgen hale geldiği bir inovasyon modelidir.

Politika yapma yetkisi sizde olsaydı, Türkiye'de havacılık sektörünün açık inovasyon olgunluğunu artırmak için neler yapardınız?

Lütfen yanıtınızı buraya yazın:.....

Anket burada sona ermiştir. Katılımınız ve zamanınız için teşekkürler.

English Version

Dear Participant,

This survey has been prepared as part of my doctoral research conducted at the Middle East Technical University Department of Science and Technology Policy Studies, aimed at measuring the "Open Innovation Maturity of the Turkish Aerospace and Defense Industry." You can access the research permission I obtained from the university's ethics committee via the link.

In this thesis, the company name and all personal and corporate information of the survey participants will be kept confidential.

For any questions or comments, you can contact me via email at …….. and by phone at ..... .

The term innovation in this survey encompasses all R&D, product development, and other innovation activities.

Open innovation is a model of innovation that values collaboration and is open to external developments rather than relying solely on internal resources for R&D and product development, allowing controlled information transfer across company boundaries.

Below, there are 5 main dimensions and 16 sub-dimensions related to open innovation parameters. In each question, the lowest maturity level is set at 1 and the highest maturity level at 5. You are expected to mark the option that you believe is most appropriate, considering your company. It is important to evaluate based on your **company's current situation** when marking.

The final section of the survey contains an open-ended question where you can specify your policy suggestions/views to enhance open innovation maturity. Filling out this section will contribute to the development of our ecosystem.

The survey is expected to take a total of 10-15 minutes.

Participant Information

What is the name of your company? (This information is only for recording participating companies and will not be used in the thesis content)

Your Position: ……
(General Manager, Deputy General Manager, Director, Chairman, Manager, Chief, Lead Engineer, Executive, Engineer, Specialist, Other)

Strategy and Governance

1. Does your company have an innovation strategy and/or vision?

Please select only one of the following:

1- There is no well-defined innovation vision or strategy established.
2- An innovation plan exists, but it is largely limited and/or primarily oriented toward short-term objectives.
3- A long-term innovation vision, mission, and strategy are established and thoroughly documented, with clearly defined strategic focus areas.
4- A strategic plan for innovation exists, is well-documented, emphasizes long-term objectives, and is integrated into the organizational strategy. It is converted into actionable goals and key performance indicators (KPIs).
5- There is a clear and actionable long-term innovation strategy in place, which is continually evolving based on the latest trend insights and adaptations to the organizational strategy.

6- How do you encourage/support/coach your employees to try new ideas? Do you provide them with feedback on this?

Please select only one of the following:

1- Leadership discourages innovation activities. There is a management resistance towards innovation activities.
2- Leadership supports innovation initiatives, and occasionally, the organization presents innovation success to employees.
3- Managers are trained to encourage employees to innovate. The organization frequently identifies key innovation success stories and disseminates them among employees.
4- Organized inspiration programs are put in place to foster innovation. Leaders and team members actively encourage innovation initiatives across all levels.
5- The results of inspiration programs are measured, assessed, and continuously enhanced. Employees at all levels consistently motivate and encourage one another to innovate in a systematic manner. Flagship projects are disseminated throughout the organization.

7- How is innovation governance* conducted in your company?

**Innovation governance is the framework of policies, procedures, decision-making authority, and accountability mechanisms implemented to ensure that innovation efforts align with the company's overall business strategy.*

Please select only one of the following:

1- Responsibilities for innovation are not formally defined. Employees assume (if any) responsibility for innovation activities on an ad-hoc basis.
2- Innovation results are measured and assessed when a project team or employee takes the initiative to do so.
3- It is clear how innovation activities are organized and who is functionally responsible for each innovation activity. This is reflected in the organizational structure and processes.
4- A clear structure for innovation exists, in which centralized and decentralized autonomy in decision-making is defined. The innovation structure encompasses functional and financial responsibilities and authorities and is integrated and aligned with the overall organizational structure and primary processes.
5- A clear structure (and agile in case) of authorities and responsibilities and for innovation activities have been defined. This governance system is integrated and aligned with the organizational structure and processes and is continuously being developed. Project teams are empowered to make decisions autonomously.

Innovation Culture

8- **Are there procedures, processes, and unwritten rules for innovative activities in your company, and how are they created?**

Please select only one of the following:

1- There is no clearly defined innovation process established.
2- Innovation is primarily regarded as a component of the R&D process. An explicit innovation process may be partially outlined and documented; however, the stages of decision-making and criteria are not clearly defined.
3- The innovation process is clearly defined and documented, featuring well-established decision points and criteria for each stage of the process.
4- Different but aligned processes for different types of innovation are defined, including stages and criteria, is clearly established, documented, and applied in practice. These innovation processes are carried out effectively and are smoothly integrated with other organizational processes.
5- Processes are created for various types of innovation, ensuring agility and alignment with other organizational processes. Proficient execution of these processes both proficiently and efficiently. An after-launch process is established to redesign organizational processes, facilitating the integration of the innovation into the organization. The design, efficiency, and execution of these innovation processes are continually assessed and enhanced.

9- **Is taking risks acceptable in your company, and are both the successes and failures of innovation recognized and tolerated?**
Please select only one of the following:

1- Failure in innovation activities is met with strict penalties, including employee layoffs, which discourages others from pursuing innovation efforts.
2- Failure in an innovation project results in a loss of reputation for the employees involved in that project.
3- Employees involved in innovation failures are not penalized or blamed for those failures. There is an awareness of lessons learned. Risk taking is neither welcomed nor punished.
4- Employees who have the courage to innovate are consistently recognized and respected, regardless of the results. They openly discuss failures and share their learning experiences.
5- Both failures and successes are documented at the company level using organizational tools and are regularly communicated to employees through meetings, documents, and other channels.

6- Do you have an award policy for innovation? Who is this award given to; employees, suppliers, external stakeholders, and partners?
Please select only one of the following:

1- There are no incentives for innovative activities.
2- Innovations are encouraged via monetary incentives on an irregular basis and without pre-defined criteria.
3- Employees are given incentives periodically according to a procedure based on a monetary basis. Assessments are made by specialists from or outside the company.
4- The incentives are not only monetary but also promotional, working benefits etc. For employees. Targets are set for incentives. Competitions or idea markets are present for outsiders to engage in company innovation activities.
5- Incentives are not only monetary but also, promotional and entrepreneurial such as, permission and capital for establishing a spin-off company. Targets are clear for everyone and screened and modified according to company needs.

7- Do you allocate time and budget for innovation activities?
Please select only one of the following:

1- No budget or time is designated for innovation activities, compelling employees to rely on their own resources to innovate.
2- Innovation activities receive time and budget on an irregular basis, provided that operational activities remain the priority. Employees conduct innovation activities mostly within their daily tasks.

3- Employees are motivated to innovate by having a procedure in place that allows them to access time and budget for their initiatives.
4- The proportion of the innovation budget relative to the overall organizational budget is well-defined. Employees are actively encouraged to utilize the procedure for accessing time and budget allocations.
5- Employees have access to separate time apart from their daily tasks (e.g., a specified number of hours per week to work on their own projects) and budget for innovation. A clear and flexible budget balanced with the overall organizational budget, is allocated for each type of innovation.

Partnership Capacity

8. What do you consider when selecting a partner (business partner) for collaboration? (Work culture, competence, geographical proximity, past experiences, etc.

Please select only one of the following:

1- The partners are not selected with a pre-decided process. Mostly consequences or acquaintances cause partnerships.
2- Partners are chosen based on affection, familiarity, and past collaborations.
3- Partner selection is based on existing knowledge of partners or experience within the network. Potential innovation partners are continuously evaluated and intentionally chosen for collaboration.
4- Partners can be selected from new ones as well as previous ones, based on vision and strategy of the partnership process.
5- There is a partner database for partnership activities, these partners are assessed with certain criteria. Also, inter-network linkages are established and employed to find new potential partners from in and out of the ecosystem.

9. What do you think about the diversity and intensity of your collaboration activities? Are there studies conducted on the effectiveness of these collaborations?

Please select only one of the following:

1- The organization does not participate in any formal collaboration with external partners for innovation. Partner relationships are established and maintained only for operational reasons.
2- Current operational partnerships are infrequently utilized for innovation activities. There are only a few partnerships, and their scope is limited. The effectiveness of these partnerships is not evaluated.
3- Current innovation partnerships are formal, low intense, short. Effectiveness is monitored in some partnerships.
4- A wide variety of external partner relationships for innovation purposes is established and utilized. There is intensity, focus, and evaluation in innovation

partnerships. These partnerships occur at various stages of the product life cycle (from design to final product) with clearly defined expectations.

5- Partnerships are viewed as a routine type of innovative activity. There are partnerships among all value chain. Effectiveness is evaluated default by management and/or innovation professionals in terms of expected outputs. Satisfaction of partners monitored and actions taken to improve the effectiveness of partnership.

10. How often do your organization's employees engage in collaboration projects with other business units within the organization, and what types of projects are they?

Please select only one of the following:

1- Cross functional collaboration is weak or absent. Knowledge sharing between cross functional teams is weak and met with resistance.

2- Innovation is sometimes carried out in cross-functional teams; however, the majority of innovation activities are conducted based on the shared values and norms of the current team or business unit.

3- The organization promotes cross-functional collaboration by forming innovation teams with diverse backgrounds.

4- There is a willingness to engage with all types of colleagues beyond formal roles and task descriptions. Training programs are established to equip employees with cross-functional, agile collaboration skills.

5- Decision-making in collaborative innovation projects is guided by the organization's strategies, common values and norms. Employees are agile and skilled at collaborating with colleagues from diverse backgrounds, and collaboration is actively pursued and utilized.

Knowledge Chain

11. Does your company have the capacity to absorb external information and integrate it with internal knowledge?

Please select only one of the following:

1- The employees / managers cannot recognize or are not interested in valuable external knowledge.

2- Employees/ managers are aware of the valuable external knowledge. They engage in sectoral meetings, monitor scientific studies and track patents licenses etc. to determine external knowledge.

3- Managers and employees can and willing to learn and assimilate external knowledge by trainings, observation and practices.

4- External knowledge can be transformed for the sake of company via R&D activities. The firm is capable of transferring knowledge by enhancing and refining its internal routines that enable the integration and combination of prior knowledge with newly acquired or assimilated information.

Transformation can be achieved by either adding or removing knowledge, or by reinterpreting and amalgamating existing knowledge in a novel and innovative way.

5- The company possesses the capacity to integrate acquired, assimilated, and transformed knowledge into its operations and routines. This capability not only allows for the refinement, enhancement, and expansion of existing processes, competencies, and knowledge but also facilitates the creation of new operations, competencies, routines, organizational structures, as well as innovative products and services.

12. How do you adopt new technologies, and how do you ensure their diffusion within the company? How do you phase outdated technologies?

Please select only one of the following:

1- Adoption of new technologies (via patents, tech. transfer, reverse engineering etc.) are not on the scope of interest. There may be opposition to the adoption of advanced technologies and digitalization, a lack of employee training, insufficient processes, failure to adhere to technological standards and protect intellectual property rights, and a lack of digital and personalized tools.

2- Adoption is done via irregular practices; the responsibility and process are not clear.

3- Adoption of new technologies is pursued by departments via pre-defined processes. Or processes are designed during adoption. Besides, the old, replaced tech. (if any) is assessed and decided to be left or stayed. Employees are trained.

4- Adoption of new technologies is pursued via departments and through a central companywide tool like strategic plan or technology road map etc. There are performance metrics measuring the completion of adoption. There is a written IPRs strategy.

5- The new technologies are screened periodically and effects on the company are monitored. Besides, the old replaced tech. (if any) is assessed and decided to be left or stayed based on a plan. Employees are trained regularly in new techs. The suppliers are aware of the new techs and their effects on them.

13. To what extent do your products or innovations penetrate new regions and information networks?

Please select only one of the following:

1- There are no local knowledge flows around the company in which the company can penetrate. The A&D ecosystem in which the knowledge (product or innovation) can penetrate is immature.

2- Employees and/or organization are a part of intraregional and/or intrasectoral knowledge networks. There is no apparent connection with other regions and sectors. Interpersonal knowledge networks are weak.
3- Employees and the company are engaged in knowledge networks in other sectors and regions as well as intrasectoral and intraregional networks. The knowledge/product diffusion is not controlled or under assessment. Interpersonal networks of knowledge exist.
4- The knowledge networks are regularly engaged in and knowledge inflow is enabled through tools (reports, patents, conferences, meetings, research). The company has a plan and routine to enable inflows of knowledge throughout the company. Employees have resources to access and learn from these inflows.
5- The knowledge flow is two sided: inflows and outflows of knowledge. The company has a plan for the degree of openness of knowledge on how and to what extent to release knowledge out of the company.

Digital Maturity

14. To what extent are digital tools used in your company to support idea generation and knowledge sharing?
Please select only one of the following:
1- There are no digital tools used for idea generation or sharing knowledge.
2- There are digital tools that enable idea generation and sharing knowledge on a departmental basis. Collaborations and projects are not tracked digitally.
3- Digital tools are available to all employees during idea generation, sharing and internal collaboration on departmental basis. Knowledge generation, sharing and collaborations with external partners are partially digital.
4- Digital tools are available across the organization; these tools are compatible with each other. They can be integrated when necessary and available for all related parties from idea generation and while tracking knowledge and to the end of projects.
5- Digital tools for knowledge generation, sharing and collaborations are connected to other digital systems so that they provide inputs for improvements and changes in organization, processes, or products.

15. To what extent are your production and corporate operations digital?
Please select only one of the following:
1- Systems are not integrated and some systems are not automated.
2- Some OT and IT systems that are used in production operations as well as services are integrated.
3- All OT and IT systems at the production and enterprise levels are integrated into automated networks. While data exchange is feasible, data analysis and

decision-making are not. Communication has improved, but resource planning and operational demands are not managed digitally.

4- OT and IT systems at both the production and enterprise levels are integrated into automated, interoperable, and flexible networks that facilitate seamless data exchange, analysis, and decision-making. This integration enhances communication, flexibility, and operational efficiency, while also enabling quicker and more coordinated responses to changes in resource availability, operational requirements, or product types.

5- OT and IT systems at both production and enterprise levels are unified into automated, interoperable, and flexible networks that allow for seamless data exchange, analysis, and decision-making. This integration will improve communication, flexibility, and operational efficiency, thereby enabling faster and more coordinated responses to fluctuations in resource availability, operational demands, or product types.

16. To what extent are digital technologies integrated into the supply chain?

Please select only one of the following:

1- Knowledge about and application of I4.0 technologies in supply chain (SC) operations is inadequate. There may be some isolated attempts to adopt I4.0 concepts. Resistance to incorporating new technologies into supply chain operations.

2- Some I4.0 technologies are integrated into process improvements aimed at aligning with SC trends. The organization recognizes the importance of adopting I4.0 technologies and supply chain trends. Systems remain mostly isolated.

3- Industry 4.0 technologies are consistently incorporated into improvement projects alongside the supply chain. Processes are being modified to address unpredictable supplier behavior. Initial integrations of systems and Industry 4.0 technologies are currently taking place and are subject to comprehensive analysis.

4- A comprehensive vision of SC 4.0 is formulated and disseminated among all stakeholders within the supply chain. Industry 4.0 technologies, which enable decision-making based on real-time information and support ongoing improvement efforts, are integrated into the supply chain framework. Additionally, best practices pertaining to Industry 4.0 and prevailing supply chain trends are identified and adapted to align with the organizational culture.

5- A culture of SC learning and improvement, driven by digital trends, has been established within the enterprise. It sets a benchmark, with its employees tasked with enhancing the processes of suppliers. The organization contributes valuable insights to the development of I4.0 concepts and plays an active role in the evolution of this initiative.

Open Innovation Policy Recommendation

Open innovation is an innovation model that suggests combining internal and external ideas, as well as internal and external pathways to market, for the development of new technologies, thereby allowing a controlled permeability of information across company boundaries.

If you had the authority to make policy, what would you do to increase the open innovation maturity of the aviation sector in Turkey?

Please write your answer here:

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.....

.....

The survey has now ended. Thank you for your participation and time.

D. RECOMMENDATIONS OF SURVEY RESPONDENTS

Dimension	Recommendations
Strategy & Governance	
Strategy/Roadmap	• It is unlikely that any country has the economic, human, informational, or time resources to simultaneously develop all technologies in a specific field. Therefore, it is essential to assess existing capabilities, infrastructures, and technology readiness levels to identify technological goals and focus areas that can elevate our country in the aviation sector. Long-term strategic plans should be developed accordingly, and resources should be allocated to these plans. Additionally, many companies in this sector lack a technology management plan. A comprehensive roadmap, technology gap analysis, and action plan for the aviation sector are necessary. • Within companies, the awareness and maturity levels should be measured regularly, and projects should be implemented to enhance maturity levels. • The areas of innovation required by the aviation sector should be defined as part of the national strategy, and a process that includes fair and competitive environments should be established for companies operating or wishing to operate in this sector. • I would first determine which aviation disciplines require innovation, then clarify the topics and projects that would serve these areas, keeping this information within the company due to industry dynamics. I would create subtopics that serve the relevant main topic and start discussions with academics and potential subcontractors. • Particularly in the fields of UAVs (Unmanned Aerial Vehicles) and UAM (Urban Air Mobility), we should leverage our existing know-how and momentum to produce UAVs of all sizes and classes. Instead of establishing small divisions for policymaking related to the subject, I would seek external consultancy. • I would prepare a comprehensive roadmap, monitor planning and operations aligned with this roadmap, ensure its continuous updating, and take necessary steps for its sustainability. • Analyzing user/customer needs in parallel with technological developments and creating innovation plans that enable the design of new products will ensure the effective use of limited resources. Developing work plans within the Need-Technology Competence-Resource chain will also foster technological excellence in a specific area and enhance global competitiveness.

	Otherwise, innovations with limited application areas will yield limited financial returns, and resources for future projects may not be generated. • I would define open innovation as part of corporate strategies and create a roadmap based on feedback from trained personnel.
Governance	• I would establish sector-specific technology parks focused solely on the aviation industry, facilitating the formation of consortia within these parks and creating incentive mechanisms for the development of advanced technology-oriented innovative projects. I would also assign responsibilities to the technology park management as a supervisory body. • In collaboration with the Defense Industry Presidency, I would implement various training programs and, if necessary, impose sanctions to ensure that technology issues are monitored and directed from a central structure. • Collaboration and teamwork are crucial in innovation. Therefore, I would develop and implement a system that ensures the participation and contribution of all stakeholders under the coordination of a higher institution. • A center should be established where universities, startups, SMEs, and large aviation companies can collaborate. This center would support joint R&D projects and encourage technology transfer. Additionally, I would seek ways to monitor the production capacity and capabilities of the entire industry from a single center. • A research institute could be established, composed of individuals with extensive academic and industry experience. • I would create a centralized national innovation center across the country. This would allow us to combine the know-how of companies working towards the same goal, resulting in a stronger collective knowledge base. • Under the leadership of the Defense Industry Presidency, a separate and substantial fund should be established for the development of critical technology components, utilizing a TRL (Technology Readiness Level, ranging from 1 to 9) based methodology to ensure continuous development of critical technology processes independent of any specific project. • A dedicated unit could be established within the Defense Industry Presidency for this purpose. • A system should be created to compile the innovation activities and roadmaps of all companies in the aviation sector, which would be beneficial to open this information to the sector in a controlled manner. This would allow all needs and past efforts to be tracked from a single pool, thereby clarifying potential collaborations. • I would establish an institute.

Goals, performance management	• I would make innovation activities a mandatory part of performance evaluations. • I see this as a way to raise awareness, as innovation is often perceived as having no commercial return in our country. By incorporating innovation as a competitive criterion alongside economic factors, I would ensure that it has an economic value for companies, thus fostering awareness. • I would establish a rigorous tracking system for strategic innovative goals, including budget management, milestones, and stakeholder involvement, making them indispensable and non-negotiable. • I would focus on informing employees and setting personal goals. • I would adopt a comprehensive strategy aimed at regularly monitoring and evaluating performance. • In the second phase, I would integrate annual goals into each department to promote ownership of innovation across the organization. • Subsequently, I would engage everyone in the organization as stakeholders in achieving these goals. • I would ensure that corporate objectives are more SMART (Specific, Measurable, Achievable, Relevant, Time-bound). • I would establish metrics that can measure the effects of innovation initiatives effectively.
Innovation Management	• I would select an innovation leader from each department. • I would establish a dedicated aviation-focused innovation team with technical expertise, free from routine workload, and create the company's innovative initiative plan around them. • I would set up a central project office similar to a central engineering department. This project team would collaborate with personnel from relevant departments to conduct innovation activities without disrupting operations, integrating systems progressively from simple to complex. • Since operational activities are always a priority, I would distribute employees who work specifically on innovation within the company, allowing concrete goals to be developed for the innovation activities of each department through these individuals.
Innovation Culture	
Communication	• Increasing communication is the foremost issue. Creating environments where ideas can be expressed freely and turned into action is considered one of the most important criteria. • I do not believe open innovation can succeed without employees going into the field. For example, I think it is not beneficial to call

	for external ideas while sitting at a desk. Therefore, it is crucial for all stakeholders to be "open" to each other and to understand one another correctly for open innovation to succeed. Achieving a shared vision is very important for the success of open innovation efforts. • Increasing communication between institutions.
Contests	• I would increase the variety of entrepreneurship-based competitions and incentives. • Open innovation competitions could be organized, and the ideas generated from these could be turned into projects and announced across Türkiye, paving the way for new ideas. • I would organize multiple groups to compete on the same topic within the framework of short-term projects using an expanded project structure. I would announce the results and identify the innovations that emerge. From there, I would select and fund technologies that would be directed to further phases.
Entrepreneurship/ intrapreneurship	• I would direct towards spin-off and spin-out ventures. • An infrastructure could be established to provide work if company employees start their own businesses. • Encouraging intrapreneurship and building an attraction center. • I would encourage employees of large companies to start their own firms.
Incentives	• Government incentives should be provided in relevant areas. • Reducing procedures in innovation-related work and R&D activities is encouraging. • Training, guidance, and support should be provided and increased to enhance the innovation capabilities of small and medium-sized enterprises. • Incentives can be provided to companies for innovation. • Increasing R&D incentives. • Concrete steps are being taken in our country regarding open innovation in the aviation and aerospace sector. I see the establishment of the Ankara Space and Aviation Specialized Organized Industrial Zone next to the TUSAŞ campus as one example of this. To increase information exchange among stakeholders in the sector, our Defense Industry Presidency is also conducting competency analyses and taxonomy studies. We know that policies encouraging open innovation are implemented in defense industry foundation companies, and many activities such as supporting startups and organizing projects/competitions with undergraduate and graduate students are being conducted. In addition, to promote the widespread adoption of open innovation and ensure it is embraced by employees at all levels, government

	incentives on the subject can be increased, and events can be organized to share success stories. • Considering the difficulties of conducting open innovation processes in the defense sector, efforts and support for civil aviation applications should be increased. • An additional incentive package for R&D in companies would be appropriate to systematically use part of their income for developing innovation processes beyond the topics mentioned above. • The visibility of innovative activities within and outside the company should be ensured, and their benefits/harms should be evaluated and rewarded. • "This is a critical question. I would determine the awards for employees in a way that prevents them from shirking innovation responsibilities, thus increasing motivation. This could be beyond monetary rewards, such as a family outing, a meal at a partnered restaurant for the weekend, or possibly healthcare benefits. • Incentive and financing models. • The reward system should be established as a starting point.
Innovation Culture	• Before policymaking, raising awareness within organizations and internalizing the topic could be a meaningful step. • I believe that the lack of a strong corporate culture in companies is one of the biggest obstacles to these efforts. • I would conduct necessary activities to inform about open innovation, explain its importance, and initiate pilot activities with a selected company. I would expect other firms to adopt the resulting model. • Change is a process that requires time and patience. First, I would ensure the establishment of an innovation culture. • I would organize periodic brainstorming meetings to spread the innovation process among all employees according to the goals and requirements of the aviation sector. • When considering innovation as creativity, it is present in every product and every stage of our processes, although this awareness may not be consciously recognized. This is largely due to our need as an R&D-intensive company. Most questions have been answered in this context.
Time and Budget	• Such activities and similar ones also require budget allocation and monitoring. • I would establish a corporate structure, like an academy, within a central framework where creative individuals from other structures could work part-time one day a week, along with a designated budget.

	• I would allocate funds from non-value-added processes to increase innovation maturity. • I would create projects to generate resources and provide tax advantages for companies that innovate and collaborate. • Outside of the business-focused calendar, I would ensure that employees have opportunities for non-work time to encourage innovative proposals and increase research. • I would set specific time intervals for employees to spend on research and innovation in their fields. Budgeting for innovation projects. • After a certain point, funding innovation becomes very difficult for companies. The government should increase its funding and support.
Partnership Capacity	
Partnership Capacity	• If I had authority, I would ensure that the culture of joint work and production is embraced by the industry through various incentives and obligations. • It is proposed that bidirectional open innovation activities be structured in a way that encourages mutually beneficial collaborations among stakeholders, allowing organic stakeholders to create new resources and innovations through information flow. It is suggested to create an R&D Innovation Model that includes co-financing and task distribution, ensuring the fair distribution of intellectual property rights. • It is recommended to increase the number of companies with flexible structures that have the authority to carry out guided projects in partnership with the private sector. • I would create a pool consisting of major firms and suppliers within the sector, bringing companies together based on their needs to create collaborations at the level of expertise, thus forming a more inclusive sector. Additionally, by researching internal and external markets and investing more in SMEs and startups, I would facilitate the development of the sector and its stakeholders. Since innovation cannot go beyond being an idea if it is not commercialized, I would also seek global collaborations for these innovative developments to capture market share in the global sector. • SMEs are inherently more focused on innovation, but their communication and contact with the needs authorities are low. Therefore, they have a greater need for collaborations. • Collaboration and teamwork are very important in innovation. For this reason, I would develop and implement a system that ensures the participation and contribution of all stakeholders under the coordination of a higher institution.

	• Open innovation-focused clusters should be established, similar to what global players like Airbus and Boeing do. Companies like TUSAŞ, ASELSAN, and ROKETSAN, as well as startups and academic institutions, should be brought together in these clusters. Universities should offer courses on open innovation, joint development, and technology sharing. Additionally, joint R&D efforts with industry should be encouraged. • To increase innovation in the aviation sector, international collaborations and global networks should be established. This will be important for Türkiye to gain a foothold in foreign markets, access new technologies, and develop the sector. • With these strategies, Türkiye's aviation sector can reach a more mature level in open innovation and become a strong player in global competition. • I would establish Innovation and Procurement units that maintain direct and continuous contact with the technology transfer units of universities and techno parks. • Technology consortiums could be formed with companies and R&D centers from leading countries in the aviation sector. • The biggest obstacle to innovation in Türkiye is that companies cannot come together to carry out joint projects. Since everyone strives to handle everything within their own structure, the knowledge accumulated by companies that can do these tasks with much more advanced tools and methods remains unused. There is no healthy inventory of capabilities across the country, so no one is aware of each other, and the efforts of companies eventually become insufficient, leading to incomplete projects and a lack of success on the path to innovation. I believe that the weak or nonexistent corporate cultures of companies are one of the biggest barriers to these efforts. I think it is necessary to address these problems and, if necessary, form consortiums and collaboration initiatives led by official institutions. • Large companies can constructively enhance open innovation criteria by clearly determining their business development and needs within their budgetary capabilities and collaborating with smaller firms on new technological requests or areas that need development. In this context, both small firms can achieve technology acquisition through open innovation, and large firms can save time and reach new technologies more quickly. • I would invest more in innovation, not only for our own company but also for the innovation policies of our suppliers (sub-industries), showing a tendency towards external stakeholders and collaborating with them. I would create a policy to seize opportunities and preempt threats. I developed incentive policies for companies to carry out open innovation activities with universities and techno park firms.

	• The integration of R&D units into agreements made within the framework of inter-company and university-industry collaboration will increase open innovation maturity. I would monitor relevant activities only within the scope of research and development, distribute them to universities and potential subcontractors, and supervise their progress at certain intervals. I would continue with those who succeed and part ways with firms or universities that do not produce results. I would collect outputs from successful firms or universities, expect the team responsible for the main topic within the company to integrate inputs from different sources, and aim for the desired outcome. If the result is positive, I would have them plan integration according to the project timeline. In this way, I would bring external knowledge and technological developments inside without releasing critical data. • The sector remains limited as we only talk about military aviation in Türkiye. To engage in open innovation, we need to interact with entities outside the defense industry. When adapting to a new technology, rather than opening a relevant department, I would pursue technology partnerships, company acquisitions, or mergers. Instead of each team establishing its own AI team, I would form partnerships with an AI firm to stay focused on the aviation aspect. To develop open innovation in Türkiye's aviation sector, I would focus on creating collaboration-oriented ecosystems and strengthening international partnerships. • Similar companies could be brought together to organize workshops, promoting the dissemination of national knowledge. • To effectively manage such a process, it is essential to be a company that attracts ideas, technology, and development potential in the defense industry. Since this interaction will involve reciprocity, it is necessary to be in a position where something can be gained by ensuring that something is also taken from oneself. This way, an innovation model with controlled permeability created on the paths to market can lead to a process where every partner benefit. • I would establish a strong collaboration platform among universities, research centers, and companies in the aviation sector. This platform would encourage the sharing of necessary information and resources for open innovation. • I would make strategic agreements to develop joint projects with institutions like the European Union and NASA. • Platforms should be established for university partnerships, where processes and budget operations can progress more efficiently, accelerating the new technology development process. • Increasing Intense Communication and Collaboration

	• In the rapidly evolving fields of aviation and space, it is necessary to increase pre-competitive collaborations and prepare stakeholders for coordination under the role of platform producer. Stakeholders in the sector are currently focused on project-based work; instead, they should focus on capability acquisition and expertise development to become global players while addressing national needs, thus enabling the development of a sustainable industry. R&D projects and support can be used as instruments to promote and disseminate collaborations rather than as financial resources. • Innovation topics related to goods or services in aviation should be tracked according to the types of aircraft produced and shared with stakeholders as needed, requesting contributions. • Budgets that can be allocated to SMEs can be given to departments. With these budgets, tasks that cannot be prioritized or executed within the company can be accomplished. • I would show clear goals to our industry for localization. • Close collaboration with universities should be particularly supported. • I would recommend defining a large organization and resources within a massive plan, primarily focusing on transparency, traceability, and accountability, and establishing partnerships with leading foreign firms in the sector up to a certain stage. • Clustering and collaboration programs, international cooperation • I would establish smaller subsidiary companies that can collaborate with institutes and are not focused on production or products, contributing annually from the R&D share to ensure the research of new technologies and bring topics to the designated technology readiness levels. • Our company tries to conduct open innovation activities, especially in collaboration with universities. Additionally, partnerships are being made with specialized firms to produce products suitable for aviation needs. Increasing and spreading these collaborations would be beneficial. • I would ensure that personnel sent by our company work with them for an extended period (6 months/1 year).
Knowledge Chain	
Adoption of new techs	• I would advocate for the opening of products and services that are planned to be phased out to external entities. This could involve making ownership rights, such as patents or utility models, public. Processes could be defined for developing technologies related to these products and services through ideathons, hackathons, or open calls, facilitating the collection of product development proposals based on new technologies within the organization. A

	strategy would be followed to at least allow incremental innovation proposals. • In this direction, products could be distributed to firms, enabling them to specialize in certain areas. • I would prioritize the development of new technologies.
Benchmark/Best practices	• I would understand and implement practices from developed countries in this area. • I would analyze challenging competitors that I could benchmark against, avoiding unnecessary risks. • I would conduct benchmarking activities with similar firms in other countries. • I would mandate that best practices be applied and standardized across all firms. • The open innovation strategies of successful countries could be analyzed and adapted for Türkiye. • Participation in international projects could be increased, and collaborative efforts with industry-leading firms could be pursued. • Benchmarking studies could be conducted with strong countries and firms, or partnerships could be established with powerful companies. • I would encourage innovation leaders from renowned companies (e.g., Elon Musk) to engage in innovation activities within similar Turkish companies (e.g., TUSAŞ). • Additionally, there should be a clear example: someone who has brought an idea from scratch, experienced the process, finalized their idea, commercialized it, and marketed it. This creates a strong motivation—if they can do it, why can't I? Employees need to see this process to inspire new ideas and develop a sense of purpose. • I would promote the intensification of cross-functional benchmarking activities.
Knowledge Diffusion in Networks	• I believe the concept of open innovation is very important and beneficial. Unfortunately, the lack of awareness among decision-makers across all manufacturing sectors, not just in aviation, regarding current literature undermines the speed, quality, and outcomes of processes. • I would ensure that successful interdisciplinary communication examples are disseminated more effectively to relevant sector employees. • I would organize periodic events such as panels, fairs, and congresses that bring stakeholders together, making their participation mandatory.

	• To enhance innovation maturity, I would hold weekly routine meetings where employees summarize current literature and engage in brainstorming sessions. • To boost innovation in the aviation sector, international collaborations and global networks should be established. This will be crucial for Türkiye to gain a foothold in foreign markets, access new technologies, and foster sectoral development. These strategies can elevate Türkiye's aviation sector to a more mature level in open innovation and make it a strong player in global competition. • The frequency of innovation workshops with stakeholders could be increased, and working groups from different firms could be established in identified areas. • There are insufficient platforms for sharing innovation ideas in our country. More frequent congresses and conferences discussing innovations in aviation could be organized. Participation in events like UHUK should be encouraged not only from academia but also from industry. • Additionally, I would send individuals capable of innovation, who have not yet progressed to the incubation stage, to international congresses and fairs. Many talented engineers struggle to mature their ideas due to the pressures of projects or fail to recognize the value of their ideas or access the external support needed for development. In our society, congresses and fairs are often seen merely as social outings, whereas their purpose is to observe others' work and identify missing pieces in one's own innovation. • The outputs resulting from this integration should be communicated to all stakeholders through seminars and conferences. Innovation should be realized with the understanding that it is an art for society (rather than just for products), highlighting the need for innovation and supporting open innovation. • I would ensure Türkiye's aviation sector participates more effectively in international innovation networks. • I would organize inter-company workshops and oversee them at a high level, hosting them directly within the relevant technical units. • Innovation workers could hold periodic assemblies to integrate innovation into every level of the organization. • Initially, I would involve youth in innovation workshops without any restrictions at local, regional, and then national levels, focusing on results-oriented goals in both theoretical and practical aspects. • A joint innovation network should be established with stakeholders under the company's control (including suppliers, subsidiaries, university partnership programs, and sister

	companies under foundations) and integrated with stakeholders outside the company's direct control (customers, international organizations and institutions, competitors, etc.). • I would facilitate the establishment of innovation summits and collaborative platforms with stakeholders and leading industry figures, both domestic and foreign.
Training & workforce competencies	• Universities should offer courses on open innovation, joint development, and technology sharing. Education alone would not be sufficient. I would utilize case studies and scenario planning (wargaming) to translate theoretical knowledge into practical applications, demonstrating the effects of innovation. • Awareness training in innovation should be increased. • I would promote the dissemination of open innovation training and awareness programs. • To emphasize its importance, I would raise awareness about innovation being as critical as operational processes. • Training and campaigns focused on innovation could be organized. • I would prioritize training for personnel to enhance awareness on the subject, and then create a roadmap based on feedback from trained staff. • Attention-grabbing training sets should be prepared. • To develop a culture of open innovation within the company, training should be provided to employees and managers, highlighting its importance and sharing success stories. • Focus on education and human resources. • I would ensure the quality of employees and employers improves in cultural, technical, and ethical areas. • A significant gap in the sector is the lack of qualified workforce. To make the existing workforce more competent and prevent them from leaving the sector, I would establish a centralized structure to monitor, educate, and evaluate the development of this workforce.
Digital Maturity	

Digital maturity	• I would place even more importance on digitalization and strive to create value. • Improving the digital infrastructure. • Managing all supply processes in an end-to-end digital system with all stakeholders; including demand forecasting, triggering requests, assigning them to users in a digital environment, and executing offer/tender/decision/order processes through the digital system. • It would be beneficial to transition to a professional system like SAP to ensure that the systems within the company communicate with each other and to facilitate all types of tracking. • Transitioning to an open-source structure for software within the company. • I would strive to improve the digital infrastructure.
(Digital) Knowledge Sharing	• Creating a portal among companies serving the aviation sector that possess sufficient maturity and ensuring information transfer through the portal could be beneficial for the rapid progress of projects and processes. • Intellectual property rights must be protected at all costs. • Platforms can be created for sharing these rights. A knowledge inventory can be established for companies, and the controlled sharing of this knowledge can be facilitated through platforms designed for sharing information among companies working in similar fields. • While cybersecurity (CS) issues are very important today, the CS practices implemented in our company are very strict and rigid, which causes us to fall short in many areas (information exchange), leading to difficulties in accessing cloud-based applications, insufficient benefit from the AI ecosystem, etc. This results in our company lagging in keeping up with technology. • I would create a platform where companies in the aviation sector can share both their own innovations and the innovations they are aware of. • A CLOUD for the defense industry. • I could create a portal that can be accessed with special authorization, allowing companies to securely share the information they have, hold regular meetings about the information shared here, identify topics that need to be worked on with a committee, and dedicate the issue to a team or company that is already working on it or motivated to do so, and I would follow the results. • Additionally, I would strive to reach external resources through a permeable platform for sharing information and communicating needs. For example, I would define the work done by a system or equipment needed and request solution proposals from external

	resources. I would aim to support any potentially beneficial solutions as much as possible. • Furthermore, the dissemination of information, monitoring of capabilities, creating a database, and centrally tracking areas of expertise are important for identifying areas open to innovation and guiding new technology investments. • The interfaces of defense industry companies should be interactive and up to date with each other. • Making experience-sharing activities within and between companies widespread and effective could be beneficial. • Organizing internal conferences aimed at promoting information sharing. • By creating digital platforms that can be used throughout the sector, information exchange among stakeholders can be encouraged. Guarantees can be provided for the protection of the ideas of stakeholders participating in open innovation, and measures can be taken regarding this issue. • I would establish a platform where all companies working in this sector could share their capacity and technological levels to a certain extent, considering competition among each other, and highlight activities that increase mutual cooperation to create synergy, striving to achieve better and more advanced technology through collective intelligence. • Extracting a discipline-based knowledge inventory of all the company's projects and ensuring authorized access to this information. • Establishing open innovation platforms for data and information sharing. • I would like to ensure the permeability of information in a controlled manner with the company's internal and external stakeholders.

E. CURRICULUM VITAE

Arzu Şahin

Education

Master's Degree / Middle East Technical University
Social Policy (3,79/4) 2010-2013
Bachelor's Degree / Middle East Technical University
Business Administration (3,50/4) 2002-2007

Experience

- To analyze, forecast and report sectoral, regional and economic trends, to conduct market analysis studies, to lead revision of strategic planning process, to conduct external environment analysis for Strategic Plan.
- To initiate, coordinate and participate in sectoral collaboration and business development activities.
- To plan, design, implement and manage TUSAS Digital Transformation Process. To manage maturity assessment, prioritization, target definition and project decision processes, to conduct project monitoring and revision.
- Take role in strategic projects like open innovation, customer satisfaction, sustainability (CDP) and process management etc.

- To manage app. 800 million dollars credit volume with more than 200 clients. To initiate, sustain and manage relationships with exporter sectors and firms.
- To analyze exporters' financial outlook and offer relevant Turk Eximbank's products according to the state's export policies. To analyze and develop

insights about firms and decide on loan allowances and restructuring debts by collaborating with related departments.

- To represent Turk Eximbank and take action in business development activities regarding Turkish Export policies.
- To work at new product and process development projects

- To manage and direct Turkish Money Market desk.
- To monitor, examine and report Turkish and global economic indicators and to report them to top management.
- To manage short term cash flows and placements and to manage capital and money market operations (bond, repo, derivatives, swap).

- To manage the whole white collar and blue-collar recruitment and talent management processes, to develop and establish the competence-based interview system.
- To take responsibilities in planning company strategy (master plan) and develop corporate social responsibility projects with universities and NGOs.
- To prepare and present trainings to the whole company (innovation, corporate culture, productivity).

- To lead flawless execution of holistic merchandising & trade marketing plans.
- To develop and enhance long term partnership with distributors or national key accounts and build selling and training capability for sellers and distributor teams.

F. TURKISH SUMMARY / TÜRKÇE ÖZET

1. Giriş

Şirketler, rekabet avantajı elde etmek ve hayatta kalmak için etkili yenilikçi fikirler arayışındadır. Yenilik ve yaratıcılık, yalnızca şirketler için değil, bölgeler ve ekonomiler için de başarıya ulaşmanın temel unsurlarıdır. Teknoloji, tarihsel olarak büyümenin ana katalizörü olmuştur ve yenilik, icattan ticarileştirmeye kadar her şeyi kapsayarak teknolojik ilerlemenin temeli olmaktadır.

İş dünyası ve pazarlar, doğal ekosistemler gibi sürekli evrim gerektiren yapılar olarak tanımlanabilir. Yenilik, bu evrimi ve devrimi besler; dolayısıyla yenilik, sadece güncel bir endişe değil, sürekli bir gerekliliktir. Yönetim araştırmacıları, yenilik yapabilme yeteneğinin bir şirketin performansı için kritik olduğunu savunmaktadır. Ancak akademik literatür, organizasyonların yenilik yeteneklerini değerlendirme ve geliştirme yöntemleri konusunda sınırlı bir rehberlik sunmaktadır.

Mevcut literatürde, yenilikçi performans için evrensel olarak kabul edilen bir ölçüm veya standart bir gösterge seti bulunmamaktadır. Bununla birlikte, uzmanlar, bir şirketin yenilik kapasitesini değerlendirmek için bazı anahtar faktörler belirlemektedir; bunlar arasında Ar-Ge harcamaları, yeni ürünlerin pazar payı, yeni ürünlerden elde edilen gelir, patent sayıları ve yenilikçi ürünler yer almaktadır. Ayrıca, yeniliğin tekil veya izole bir çaba olmadığı, aksine diğerleriyle sürekli iş birliği yapma kapasitesi olduğu vurgulanmaktadır. Yenilik, karmaşık ve değişken bir mekanizma gibidir; bu nedenle, garantili bir formül yoktur, ancak uygun unsurları bir araya getirerek yenilik şansını artırmak mümkündür.

Teece, dinamik yetenekler teorisi aracılığıyla, değişken bir ortamda rekabet avantajı elde etme yeteneklerini anlamaya çalışmaktadır. Bu teori, kaynak temelli bakış açısına

dayanmakta ve yalnızca içsel kaynaklara sahip olmanın rekabet avantajı için yeterli olmadığını vurgulamaktadır. İçsel yetenekler, yeni çözümler geliştirmek için gerekli yenilik potansiyelini sağlasa da, dönüşüm yeteneği, organizasyonların piyasa fırsatları ve teknolojik ilerlemeler gibi değişen koşullara uyum sağlaması için kritik öneme sahiptir. Bu bağlamda, açık inovasyon kavramı dinamik yetenekler çerçevesinde önemli bir yere sahiptir.

Açık inovasyon, organizasyonların yeniliklerini geliştirmek için hem dışsal hem de içsel fikirleri kullanması gerektiğini savunmaktadır. Chesbrough ve Bogers (2014), açık inovasyonu "amaçlı olarak yönetilen dış ve iç bilgi akışlarına dayalı dağıtılmış bir inovasyon süreci" olarak tanımlamıştır. Dinamik yetenekler, iç ve dış yetenekleri etkili bir şekilde koordine etme ve yeniden dağıtma yeteneğini içerir. Ayrıca, bu yetenekler, açık inovasyon stratejisi için gerekli olan organizasyonel çeviklik ve girişimcilik içgörüsünü teşvik etmektedir.

Son yıllarda, organizasyonel yenilik yeteneğini değerlendirmek ve geliştirmek için olgunluk modelleri geliştirilmiştir. Ancak, mevcut olgunluk modelleri genellikle sektörlerin benzersiz özelliklerini göz ardı etmekte ve ampirik doğrulama eksikliği göstermektedir. Açık inovasyon olgunluğunun, farklı iç ve dış bağlamlarda farklı anlamlar taşıdığı belirtilmektedir. Bu çalışma, Türk A&D sektöründe dinamik yetenekler teorisine dayalı bir açık inovasyon olgunluk modeli geliştirmeyi ve bu modeli ampirik olarak doğrulamayı amaçlamaktadır.

Günümüzün yüksek rekabetçi ve küresel iş ortamında, havacılık ve savunma (A&D) sektörü, yenilik süreçlerini genişletmek için dış ortaklarla iş birliği yapma çabası içindedir. Şirketler, tedarikçiler, müşteriler ve akademik kurumlar gibi dış kaynaklardan yararlanarak yenilikçi fikirler ve teknolojiler geliştirmeye yönelmektedir. Bu bağlamda, A&D şirketleri gizlilik endişeleri ve geleneksel iç Ar-Ge çabalarına olan bağımlılıkları nedeniyle kapalı inovasyon sistemlerini açma yolunda adımlar atmaktadır. Açık inovasyon (OI), şirketlerin bilgi sızıntısı riskine rağmen dış bilgiyi kullanarak yenilik yapma yeteneklerini artırmalarını sağlamaktadır.

Açık inovasyon, şirketlerin hem içsel hem de dışsal fikirleri kullanarak yeniliklerini geliştirmeleri gerektiğini öne sürmektedir. OI, şirketlerin bilgi akışlarını yönetme yeteneklerini geliştirmekte ve yeni ürünlerin yaratılmasına yardımcı olmaktadır. Bu yaklaşım, A&D sektöründe bilgi birikimlerinin paylaşımını teşvik ederek, yenilikçi süreçlerin gelişmesine katkıda bulunmaktadır. Ancak, açık inovasyon uygulamaları, sektördeki gizlilik kaygıları ve tasarım karmaşıklığı nedeniyle paradoksal bir durum sergileyebilir. Örneğin, Boeing, Lockheed ve Airbus gibi sektör liderleri, açık inovasyon çerçevesine katılmak ve yenilikçiliklerini artırmak için programlar ve yarışmalar düzenlemektedir.

Literatürde, A&D sektöründe açık inovasyon uygulamalarına dair çalışmalar sınırlıdır ve çoğunlukla Brezilya ve Kanada gibi ülkelerdeki havacılık kümelerine odaklanmaktadır. Armellini ve diğerleri, havacılık sektörünün "kapsama içinde açık" veya "donma aşamasında" olduğunu belirtirken, bu sektörün OI'yi benimseme potansiyelinin yüksek olduğunu öne sürmektedir. Ancak, Zuluaga ve diğerleri, Kolombiya A&D endüstrisinde OI'nin yaygın bir uygulama olmadığını bulmuşlardır. Farklı ülkelerdeki A&D endüstrisini kapsayan çalışmalar, sektördeki açık inovasyon paradigmasını daha belirgin hale getirebilir.

A&D endüstrisinin yenilik süreci, ürün odaklı olarak tanımlanmakta ve resmi fikri mülkiyet koruma mekanizmalarının (örneğin patentler) benimsenme oranı, gizlilik ve tasarım karmaşıklığı gibi stratejik yöntemlerle karşılaştırıldığında düşük seviyelerde kalmaktadır. A&D şirketleri, son yıllarda önemli teknolojik, organizasyonel ve kurumsal değişiklikler yaşamış ve bu nedenle sınırlarını açmanın yollarını bulmak zorunda kalmışlardır. Ayrıca, Covid-19 pandemisi, sektörün krizlere karşı savunmasız olduğunu ortaya koymuştur. Pandemi, havacılık sektörünün ticari tarafını ciddi şekilde etkilemiş ve 2020 yılında hava yapısalları pazarında gelirlerin %50 oranında düştüğü bildirilmiştir.

Teknolojik gelişmeler, A&D sektörünün yenilik algısını yeniden şekillendirmekte ve yeni teknolojiler, özellikle insansız askeri uçaklar ve siber çözümler gibi alanlarda yenilikçi yaklaşımlar gerektirmektedir. Türkiye'de A&D sektörü, artan Ar-Ge

harcamalarına rağmen sınırlı gelir artışı yaşamaktadır. 2019 ve 2020 yıllarında Ar-Ge harcamaları, sırasıyla gelirlerin %15 ve %14'ünü oluşturmuştur. Bu oran, dünya genelinde %4,1'dir ve sektör, bu oranı azaltmanın yollarını tartışmaktadır. A&D sektöründe yenilik, daha az kaynakla yeni ürün ve hizmetler sunma vaadiyle önemli bir araç haline gelmektedir. Bu bağlamda, açık inovasyon, bilgi akışları ve ortaklıklar aracılığıyla şirketlerin yenilikçiliklerini artırmalarını sağlamaktadır.

Diğer yandan, dijital çağın ortaya çıkması, organizasyonların veri ekosistemlerini yönetme ve değişen piyasa koşullarına uyum sağlama biçimlerini önemli ölçüde dönüştürmüştür. Bu dönüşüm, Türkiye'nin havacılık ve savunma (A&D) sektöründe özellikle önemlidir; burada dijital teknolojilerin entegrasyonu, dinamik yetenekleri artırmaktadır. Bu yetenekler, organizasyonların bilgi ve bilgiyi daha etkili bir şekilde üretme, dağıtma, erişme ve koruma yeteneklerini geliştirmektedir. Açık inovasyon ile dinamik yetenekler arasındaki kesişim noktası oldukça kritik olup, dijital teknolojiler, organizasyonların piyasa değişikliklerine daha hızlı uyum sağlamalarını mümkün kılan araçlar sunmaktadır.

Sonuç olarak, Türkiye'deki A&D sektöründeki lider şirketler, açık inovasyon potansiyelini keşfetmiş ve yakın zamanda bir açık inovasyon programı başlatmıştır. Bu çalışma, dinamik yetenekler teorisine dayalı bir model geliştirmeyi, ve bu modeli kullanarak anonim olarak adlandırılan bir ana üretici firma (OEM) etrafında Türk A&D sektöründeki açık inovasyon çabalarını incelemeyi amaçlamaktadır. Böylelikle, Türk A&D ekosisteminin açık inovasyon olgunluğunu ortaya koymayı ve sektördeki yenilikçiliği artırmaya yönelik önerilerde bulunmayı hedeflemektedir.

Araştırmanın Amaçları

Bu araştırmanın temel amacı, Türk A&D sektöründeki şirketler için özel olarak tasarlanmış bir açık inovasyon olgunluk indeksi geliştirmek ve bu modelin ampirik uygulamasını yaparak sektörün açık inovasyon olgunluğuna dair bir çıkarım yapmaktır. Bu indeks, şirketlerin mevcut açıklık durumlarını belirlemeye yardımcı olacaktır. Önerilen olgunluk indeksi, dinamik yetenekler perspektifine dayanmakta ve beş ana kategori içermektedir:

1. **Strateji ve Yönetim**
2. **İnovasyon Kültürü**
3. **Ortaklık Kapasitesi**
4. **Bilgi Zinciri**
5. **Dijital Olgunluk**

Bu kategoriler, sistematik bir literatür taraması, uzman değerlendirmeleri ve sektör profesyonellerinin değerlendirmeleri ile belirlenen 16 boyuta ayrılmaktadır. AHP (Analitik Hiyerarşi Süreci) yöntemi kullanılarak modelin A&D sektörü için özelleştirilmesi ve bu boyutların karşılaştırmalı ağırlıklarının belirlenmesi sağlanmıştır.

Araştırma Soruları

Çalışma, üç ana araştırma sorusunu yanıtlamayı hedeflemektedir:

1. Türk havacılık sektöründeki açık inovasyon olgunluğunun parametreleri nelerdir?
2. Türkiye'deki A&D şirketlerinin açık inovasyon olgunluk seviyesi nedir?
3. Türk A&D endüstrisinin açık inovasyon olgunluğunu artırmak için hangi politika önerileri neler olabilir?

Çalışmanın Yeniliği ve Literatüre Katkıları

Bu araştırma, açık inovasyon, olgunluk modelleri ve Türk A&D endüstrisi hakkında önemli katkılar sunmaktadır. Bu çalışma, Türk Havacılık ve Savunma Endüstrisi'nin açık inovasyon olgunluğunu ölçmeyi amaçlayan ilk akademik girişimdir. Daha önce, açık inovasyon kavramının sektöre uygunluğu tartışma konusu olmuştur; ancak son küresel gelişmeler, bu kavramın sektördeki büyük oyuncular tarafından uygulanmasına yol açmıştır. Türk A&D şirketlerinde açık inovasyon uygulamalarının ortaya konmasının, literatüre önemli bir katkı sağlayacağı öngörülmektedir.

Dijital teknolojilerin ve olgunluklarının inovasyon olgunluğu bağlamında değerlendirilmesine dair birkaç çalışma bulunmaktadır. Bu araştırma, dijital olgunluğu bilgi üretimi ve paylaşımı, operasyonlar ve üretim ile tedarik zincirinin açık inovasyon

kapasitesi olarak kapsamaktadır. Bu açıdan, araştırma, dijital dönüşüm ile açık inovasyon arasındaki ilişkiyi daha kapsamlı bir şekilde anlamak için benzersiz bir kaynak olabilir.

Literatürdeki mevcut inovasyon olgunluk modelleri, olgunluk boyutlarının birbirleriyle karşılaştırmalı önemini nadiren incelemektedir. AHP yöntemini kullanan modeller oldukça azdır. Önerilen model, uzman görüşlerine dayanarak açık inovasyon boyutlarını ağırlıklandırmakta ve böylece A&D sektörü için yeteneklerin önceliğini ve karşılaştırmalı önemini ortaya koymaktadır. Bu yöntem, birkaç fayda sağlayabilir. İlk olarak, diğer sektörlerdeki olgunluk modeli çalışmalarında örnek teşkil edebilir. Ayrıca, bu modelin gelecekteki şirketler arası karşılaştırmalarda ve yıllık olgunluk takip çalışmalarında pratik kullanım için uygun bir model oluşturmasına olanak tanıyacağı düşünülmektedir.

Mevcut inovasyon olgunluk modelleri genellikle ampirik doğrulama eksikliği taşımakta ve pratik ölçümlere sahip olanlar genellikle bir şirket veya bir grup şirketle sınırlı kalmaktadır, endüstri veya ekosistem yerine. Bu araştırma, Türk A&D endüstrisini bir inovasyon ekosistemi yaklaşımıyla izlemeyi önermektedir. Bu çaba, literatüre özgün bir katkıdır. Bu araştırma, bir OEM şirketini merkeze alarak etrafında şekillenen ekosistemi incelemek ve açık inovasyon olgunluğunu anlamak için yenilikçi bir yaklaşım sunmaktadır.

Tezin Taslağı

Tez şu şekilde yapılandırılmıştır:

- **Bölüm 1**: Giriş, çalışmanın hedeflerini ve önemini özetlemektedir.
- **Bölüm 2**: Araştırma ile ilgili akademik literatürün gözden geçirilmesi.
- **Bölüm 3**: Model geliştirme ve ampirik doğrulama aşamalarında kullanılan niteliksel ve niceliksel araştırma metodolojilerinin detaylı açıklamaları.
- **Bölüm 4**: Önerilen açık inovasyon olgunluk modelinin sunumu.
- **Bölüm 5**: Toplanan verilerden elde edilen sonuçların sunumu ve bulguların tartışılması.

- **Bölüm 6**: Anketten elde edilen iç görülerin sunulması ve Türk havacılık ve savunma endüstrisinde açık inovasyon olgunluğunu geliştirmeye yönelik politika önerilerinin sunulması.

Özetle, bu tez sektöre özel bir açık yenilikçilik olgunluk indeksi geliştirmeyi, şirketlerin mevcut açıklık durumlarını anlamayı ve gelecekte bu olgunluğun geliştirilmesi için gereken politika araçlarına rehberlik etmeyi amaçlamaktadır. Türk A&D ekosistemindeki benzersiz zorlukları ve fırsatları ele alarak, bu araştırma sadece akademik literatüre katkıda bulunmakla kalmayıp, aynı zamanda yenilik yeteneklerini artırmak isteyen sektör paydaşları için pratik çıktılar sunmaktadır.

Literatür Taraması

Çalışmanın literatür taraması bölümü, açık inovasyon, dinamik yetenekler ve bunların havacılık ve savunma (A&D) sektöründeki uygulamalarıyla ilgili anahtar kavramları incelemektedir. Bu bölüm, çalışmaya ilişkin teorik çerçeveleri ve ampirik bulguları özetleyen birkaç alt bölümden oluşmaktadır.

Açık İnovasyon

Açık inovasyon, Henry Chesbrough tarafından popüler hale getirilen bir terimdir ve inovasyonu hızlandırmak ve ürün ve hizmetlerin değerini artırmak için dış ve iç fikirlerin ve pazara erişim yollarının kullanılmasını ifade eder. Bu paradigma değişimi, firmaların yalnızca iç AR-GE'ye dayandığı geleneksel kapalı inovasyon modelinden uzaklaşmayı sağlar. İnceleme, açık inovasyonun organizasyonlara daha geniş bir bilgi tabanına erişim sağladığını, maliyetleri azalttığını ve inovasyon döngülerini kısalttığını vurgulamaktadır. Ayrıca, çalışmalar A&D gibi karmaşık endüstrilerde inovasyonu teşvik etmek için bilgi akışlarının etkili bir şekilde yönetilmesinin önemini vurgulamaktadır.

Dinamik Yetenekler Teorisi

Dinamik yetenekler teorisi, organizasyonların hızla değişen ortamlara uyum sağlamak için iç ve dış yetenekleri entegre etme, geliştirme ve yeniden yapılandırma yeteneğine sahip olması gerektiğini öne sürmektedir. Bu çerçeve, firmaların teknolojik ilerlemeler ve piyasa değişimleri karşısında nasıl rekabet avantajı geliştirebileceğini anlamak için önemlidir. Literatür, dinamik yeteneklerin üç temel süreci kapsadığını önermektedir: fırsatları algılama, bu fırsatları değerlendirme ve bu fırsatları değerlendirmek için kaynakları dönüştürme. Bu teori, organizasyonların dış bilgi kaynaklarına yanıt vermek için çevik ve duyarlı olmalarının gerekliliğini vurguladığı için açık inovasyon ile uyumludur.

Havacılık ve Savunma Sektöründe İnovasyon

A&D sektörü, yüksek yatırım maliyetleri, uzun geliştirme döngüleri ve sıkı düzenleyici gerekliliklerle karakterize edilmektedir. Tarihsel olarak, bu sektördeki şirketler, fikri mülkiyet konusundaki endişeler ve hassas bilgilerin paylaşımına ilişkin potansiyel riskler nedeniyle açık inovasyonu benimsemekte temkinli davranmışlardır. Ancak, son trendler daha işbirlikçi inovasyon yaklaşımlarına doğru yavaş bir kaymayı göstermektedir. Literatür, A&D şirketlerinin geleneksel olarak kapalı inovasyon modellerine dayandığını, ancak teknolojik zorlukların artan karmaşıklığı ve rekabet baskılarının onları açık inovasyon stratejilerini keşfetmeye yönlendirdiğini ortaya koymaktadır.

A&D şirketlerinin açık inovasyon uygulamalarını hayata geçirmekte karşılaştıkları zorluklar mevcuttur. Bunlar arasında değişime karşı kültürel direnç, bilgi sızıntısı endişeleri ve işbirlikçi çabaları etkili bir şekilde yönetmek için sağlam yönetişim çerçevelerine ihtiyaç duyulması bulunmaktadır. Bu zorluklara rağmen, literatür ayrıca A&D firmalarının tedarikçiler, araştırma kurumları ve hatta rakiplerle stratejik ortaklıklar yoluyla inovasyon yeteneklerini artırma fırsatlarını da vurgulamaktadır. Açık inovasyonu benimseyerek, şirketler daha dinamik ve yanıt verebilir bir inovasyon ekosistemi oluşturabilirler.

Olgunluk Modelleri

Olgunluk modelleri, bir organizasyonun inovasyon yeteneklerini değerlendirmek ve zaman içinde iyileştirmeleri yönlendirmek için yapılandırılmış bir çerçeve sağlar. Literatür, çeşitli bağlamlarda geliştirilmiş çeşitli olgunluk modellerini tartışmakta ve endüstri özel adaptasyonların gerekliliğini vurgulamaktadır. Gözden geçirme, birçok modelin mevcut olduğunu belirtmesine rağmen, özellikle A&D sektöründe açık inovasyon bağlamında ampirik doğrulamanın eksik olduğunu ortaya koymaktadır. Bu boşluk, Türk A&D endüstrisinin benzersiz özelliklerini ve zorluklarını dikkate alan özel bir olgunluk modelinin geliştirilmesinin önemini vurgulamaktadır.

Dijital Dönüşüm ve İnovasyon

Dijital dönüşüm, açık inovasyon uygulamalarını geliştirmede kritik bir rol oynamaktadır. Literatür, dijital teknolojilerdeki ilerlemelerin bilgi paylaşımını, iş birliğini ve dış iç görülerin inovasyon süreçlerine entegrasyonunu kolaylaştırdığını önermektedir. Dijital araçlar ve platformlara yatırım yapan şirketler, açık inovasyonu etkili bir şekilde kullanma konusunda daha iyi bir konumda olmaktadırlar. Literatür dijital olgunluk ile açık inovasyon arasındaki kesişimi vurgulayarak, organizasyonların her ikisini de geliştirmeleri gerektiğini savunmaktadır.

Özetle, literatürdeki çalışmalar organizasyonların dış bilgi akışlarını içeren inovasyon stratejilerini uyarlamalarının gerekliliğini vurgulamakta ve bu süreçleri etkili bir şekilde yönetmek için iç yetenekleri de geliştirmeleri gerektiğini belirtmektedir. Bu çalışmada gerçekleştirilen ve daha evvel geliştirilen modelleri analiz ettiğimiz sistematik literatür taraması mevcut araştırmaları sentezleyerek, literatürdeki boşlukları tanımlamaktadır. Ayrıca, olgunluk modellerinin ampirik araştırma ile doğrulanmasının önemi ve Türk A&D endüstrisindeki açık inovasyon uygulamalarını geliştirmenin gerekliliğini vurgulanmaktadır.

Metodoloji

Çalışmanın metodoloji bölümü, Türk havacılık ve savunma (A&D) endüstrisinin açık inovasyon olgunluğunu değerlendirmek için kullanılan araştırma tasarımını, veri toplama yöntemlerini ve analitik yaklaşımları özetlemektedir.

Çalışma, araştırma problemini kapsamlı bir şekilde anlamak için nitel ve nicel teknikleri birleştiren karma yöntemler yaklaşımını kullanmaktadır. Bu yaklaşım, sektördeki paydaşlardan çeşitli bakış açılarını yakalayarak açık inovasyon olgunluğunun sağlam bir analizini yapılmasına olanak tanımaktadır. Çalışma, Türk havacılık ve savunma (A&D) sektörünün özel bağlamına uyarlanmış bir açık inovasyon olgunluk modelinin geliştirilmesi etrafında yapılandırılmıştır.

Sistematik Literatür Taraması

Metodolojinin ilk aşaması, açık inovasyon, dinamik yetenekler ve olgunluk modelleri üzerine mevcut araştırmaları belirlemek için sistematik bir literatür taraması (SLT) gerçekleştirmeyi içermektedir. SLR, 2010 ile 2024 arasında yayımlanan ilgili çalışmaların kapsamlı bir şekilde ele alınmasını sağlamak için yapılandırılmış bir süreç izlemektedir. İnceleme, araştırmanın teorik temellerine dair içgörüler toplamak, literatürdeki boşlukları vurgulamak ve olgunluk modelinin geliştirilmesine katkıda bulunmak amacıyla yapılmaktadır.

SLT süreci birkaç ana adımdan oluşmaktadır:

- **Araştırma Sorularının Belirlenmesi**: İnceleme, açık inovasyon olgunluğunun parametrelerini, A&D sektörünün mevcut durumunu ve inovasyon yeteneklerini etkileyen faktörleri anlamaya odaklanmaktadır.
- **Veri tabanı Seçimi**: Literatür taraması için Google Scholar, IEEE Xplore, Science Direct ve Scopus gibi dört ana akademik veri tabanı seçilmiştir.
- **Anahtar Kelime Geliştirme**: Açık inovasyon ve inovasyon olgunluk modelleri ile ilgili bir anahtar kelime seti geliştirilerek arama sürecinin kolaylaştırılması sağlanmıştır.

- **Dahil Etme ve Hariç Tutma Kriterleri**: İncelemede hangi çalışmaların dahil edileceğini belirlemek için belirli kriterler oluşturulmuş, böylece yalnızca ilgili ve yüksek kaliteli araştırmaların dikkate alınması sağlanmıştır.

SLT'den Elde Edilen Bulgular

SLT sonuçları açık inovasyon olgunluğunu anlamaya katkıda bulunan 37 çalışmayı göstermektedir. Bu araştırmalardan ana temalar ve kavramlar derlenerek, önerdiğimiz olgunluk modeli için bir temel sağlanmıştır. Değerlendirmeler mevcut olgunluk çerçevelerinin sektöre özgü uyarlamalarına duyulan ihtiyacı vurgulamakta ve A&D sektöründe ampirik doğrulamanın önemini belirtmektedir.

Olgunluk Modelinin Geliştirilmesi

SLT'den elde edilen iç görüler temel alınarak bir açık inovasyon olgunluk modeli geliştirilmiştir. Model, beş ana kategori içermektedir: Strateji ve Yönetişim, İnovasyon Kültürü, Ortaklık Kapasitesi, Bilgi Zinciri ve Dijital Olgunluk. Her kategori, A&D endüstrisinde açık inovasyonu teşvik etmek için gerekli yetenekleri yansıtan belirli boyutları kapsamaktadır.

Boyutlar ve Kategoriler:

- **Strateji ve Yönetişim**: Bu kategori, iyi tanımlanmış bir inovasyon stratejisi, yönetim desteği ve inovasyon süreçlerini kolaylaştıran yönetişim yapılarının varlığına odaklanmaktadır.
- **İnovasyon Kültürü**: Bu kategori, süreçler, risk toleransı, teşvikler ve inovasyon faaliyetleri için zaman ve bütçe tahsisi dahil olmak üzere inovasyonu teşvik eden organizasyonel kültürü incelemektedir.
- **Ortaklık Kapasitesi**: Bu boyut, ortak seçimi, ortaklık yoğunluğu ve etkinliği ile iç iş birliğinin etkinliğini değerlendirmektedir.

- **Bilgi Zinciri**: Bu kategori, organizasyonun özümseme kapasitesini, yeni teknolojilerin benimsenmesini ve bilginin organizasyon içinde ve dışında yayılmasını değerlendirmektedir.
- **Dijital Olgunluk**: Bu boyut, bilgi üretimi, paylaşımı, tedarik zinciri ve genel operasyonel verimliliği artırmada dijital teknolojilerin inovasyona etkisine odaklanmaktadır.

Veri Toplama Yöntemleri

Ampirik araştırma, bir öncü OEM şirketinin (Şirket A olarak anılacaktır) ve tedarikçi ve ortaklar ekosisteminin açık inovasyon olgunluğunu değerlendirmek amacıyla anketler ve görüşmeler yoluyla veri toplamayı içermektedir.

Anket

Olgunluk modeline dayalı olarak tasarlanmış dijital bir anket, 5 dereceli Likert ölçeğinde yanıtları yakalamak için yapılandırılmıştır. Anket, ismi gizli tutulan bir OEM şirketinin (Şirket A) orta ve üst düzey yönetimine ve inovasyon ekosistemindeki paydaş firmalara dağıtılmıştır. Anket, modelde belirlenen çeşitli boyutların olgunluk seviyeleri hakkında nicel veriler toplamayı hedeflemektedir.

Görüşmeler

Anketin yanı sıra, Şirket A'nın üst yönetimi ve teknoloji yöneticileri ile yarı yapılandırılmış görüşmeler yapılmıştır. Bu görüşmelerin iki ana amacı vardır:

- **Anket Bulgularının Doğrulanması**: Görüşmelerden elde edilen nitel veriler, anketten elde edilen nicel bulguları desteklemek ve bağlamlandırmak için yardımcı olmaktadır.
- **İç görülerin Keşfi**: Görüşmeler, açık inovasyon ve uygulamasıyla ilgili organizasyonel uygulamalar, zorluklar ve algılar hakkında daha derin iç görüler sağlamaktadır.

Örneklem Seçimi

Anket ve görüşmeler için katılımcıların seçimi, toplanan verilerin sektörü temsil etmesini sağlamak amacıyla belirli kriterlere göre yapılmıştır. Çalışma hedefleri:

- **Şirket A**: İnovasyon stratejileri ve uygulamalarıyla doğrudan ilgili yöneticiler ve yöneticiler.
- **Ekosistem Katılımcıları**: Şirket A ile çeşitli projelerde iş birliği yapan tedarikçiler ve ortaklar gibi önemli paydaşlar.

Veri Analizi

Anketler ve görüşmelerden toplanan veriler, hem nicel hem de nitel yöntemler kullanılarak analiz edilmektedir.

Nicel Analiz

Anketlerden elde edilen nicel veriler, her boyut ve kategori için olgunluk seviyelerini belirlemek amacıyla analiz edilmektedir. Bulguları özetlemek için tanımlayıcı istatistikler kullanılmakta ve organizasyonun inovasyon yetenekleri içindeki güçlü ve zayıf alanları belirlemek için karşılaştırmalar yapılmaktadır.

Nitel Analiz

Görüşmelerden elde edilen nitel veriler, tematik analiz yöntemi kullanılarak analiz edilmektedir. Bu, açık inovasyon uygulamalarıyla ilgili tekrar eden temaları ve iç görüleri belirlemek için yanıtların kodlanmasını içermektedir. Nitel bulgular, nicel sonuçlarla birleştirilerek Şirket A ve ekosisteminin açık inovasyon olgunluğuna dair bütünsel bir anlayış sağlanmaktadır.

Geçerlilik ve Güvenilirlik

Araştırma bulgularının geçerliliğini ve güvenilirliğini sağlamak için birkaç önlem uygulanmaktadır:

- **Pilot Test**: Anket aracını iyileştirmek ve netliği ile alaka düzeyi hakkında geri bildirim toplamak için bir alt yüklenici ile pilot bir çalışma yapılmıştır.
- **Uzman Doğrulaması**: Olgunluk modeli ve anket soruları, açık inovasyon olgunluğunun hedeflenen boyutlarını doğru bir şekilde yakaladığından emin olmak için sektör uzmanları tarafından gözden geçirilmiştir.
- **Tutarlılık Kontrolleri**: Yanıtların tutarlılığı, toplanan nicel verilerin güvenilirliğini doğrulamak için nitel mülakat sonuçları ile karşılaştırma yaparak sağlanmıştır.

Metodoloji bölümü, Türk A&D endüstrisinde açık inovasyon olgunluğunu değerlendirmek için kullanılan araştırma tasarımı, veri toplama ve analiz yöntemlerinin kapsamlı bir özetini sunmaktadır. Karma yöntemler yaklaşımını benimseyerek, çalışma, açık inovasyon uygulamalarının anlaşılmasına katkıda bulunan ve sektörde stratejik kararları bilgilendiren sağlam bulgular sunmayı hedeflemektedir. Özel bir olgunluk modelinin geliştirilmesi ve nitel ile nicel verilerin entegrasyonu, çalışmanın A&D endüstrisinin karşılaştığı benzersiz zorluklara olan alaka düzeyini ve uygulanabilirliğini artırmaktadır.

Önerilen Açık İnovasyon Olgunluk Modeli

Bu bölümde, Türk havacılık ve savunma (A&D) endüstrisi için özel olarak tasarlanmış bir açık inovasyon olgunluk modelinin geliştirilmesi özetlenmektedir. Bu modelin, bu sektördeki organizasyonların açık inovasyon yeteneklerini değerlendirmek ve geliştirmek için bir çerçeve işlevi görmesi amaçlanmıştır. Modelin yapısı, boyutları ve geliştirilme gerekçesi, ayrıca endüstri paydaşları için uygulanabilirliği ve etkileri bu bölümde detaylandırmaktadır.

Açık inovasyon olgunluk modeli, dinamik yetenekler ve açık inovasyon prensiplerinin teorik temellerine dayanmaktadır. Bu model, organizasyonlara mevcut inovasyon uygulamalarını değerlendirmek ve iyileştirme alanlarını belirlemek için yapılandırılmış bir yaklaşım sunmayı amaçlamaktadır. Model, inovasyonun tek tip bir süreç olmadığını; aksine, A&D sektöründeki firmaların karşılaştığı özel bağlam ve zorlukları anlamayı gerektirdiğini kabul etmektedir.

Olgunluk modeli, her biri açık inovasyon yeteneğinin kritik bir boyutunu temsil eden beş ana kategoriden oluşmaktadır. Bu kategoriler şunlardır:

1. Strateji ve Yönetişim
2. İnovasyon Kültürü
3. Ortaklık Kapasitesi
4. Bilgi Zinciri
5. Dijital Olgunluk

Strateji ve Yönetişim

Bu kategori, inovasyon çabalarının organizasyonel hedeflerle stratejik uyumuna odaklanmaktadır.

Ana boyutları şunlardır:

- **İnovasyon Stratejisi**: Karar alma ve kaynak tahsisini yönlendiren net ve tutarlı bir inovasyon stratejisinin varlığı.
- **Yönetim Desteği**: Üst yönetimin inovasyon girişimlerini aktif olarak destekleme ve teşvik etme derecesi.
- **Yönetişim**: İnovasyon süreçlerinde iş birliğini ve hesap verebilirliği kolaylaştıran resmi yönetim çerçevelerinin kurulması.

İyi tanımlanmış bir strateji ve sağlam yönetim yapıları, inovasyon çabalarının genel iş stratejisi ile etkili bir şekilde entegre edilmesini sağlamak için kritik öneme sahiptir.

İnovasyon Kültürü

İnovasyon kültürü kategorisi, yaratıcılığı ve risk almayı teşvik eden organizasyonel ortamı incelemektedir.

Ana boyutlar şunlardır:

- **Süreç geliştirme**: İnovasyon faaliyetlerini yönetmek içi geliştirimiş süreçler ve bu süreçlerin nasıl oluşturulduğu.

- **Risk Toleransı**: Organizasyonun deney yapmayı teşvik etme ve başarısızlık olasılığını kabul etme derecesi.
- **İnovasyon Teşvikleri**: Çalışanların yenilikçi katkılarını ödüllendirmek ve tanımak için mevcut mekanizmalar.
- **Zaman ve Kaynak Tahsisi**: Organizasyonun inovasyon faaliyetleri için özel zaman ve kaynak tahsis etme derecesi.

Güçlü bir inovasyon kültürü, çalışanları yaratıcı problem çözme ve işbirlikçi çabalarla motive etmek için gereklidir.

Ortaklık Kapasitesi

Bu kategori, organizasyonun etkili ortaklıklar kurma ve sürdürme yeteneğini değerlendirmektedir.

Ana boyutlar şunlardır:

- **Ortak Seçimi**: İş birliği için uygun ortakları belirleme ve seçme süreçleri ve kriterleri.
- **Ortaklık Yoğunluğu ve Etkinliği**: Ortaklarla etkileşimlerin derinliği ve sıklığı, ortak projeler ve bilgi paylaşımını içermektedir.
- **İç İş birliği**: İç ekipler ve departmanlar arasındaki işbirliğinin etkinliği.

Güçlü ortaklıklar kurmak, organizasyonun dış bilgi ve kaynaklara erişimini artırarak başarılı inovasyon için kritik öneme sahiptir.

Bilgi Zinciri

Bilgi zinciri kategorisi, organizasyonun inovasyon süreci boyunca bilgiyi etkili bir şekilde yönetme yeteneğine odaklanmaktadır.

Ana boyutlar şunlardır:

- **Özümseme Kapasitesi**: Organizasyonun dış bilgiyi tanıma, özümseme ve uygulama yeteneği.

- **Bilgi Yayılımı**: Bilgilerin iç ve dış paylaşım süreçleri, içgörülerin etkili bir şekilde yayılmasını sağlamaktadır.
- **Yeni Teknolojiyi Benimseme**: İnovasyonu kolaylaştıran yeni teknolojileri benimseme isteği ve yeteneği.

İyi yönetilen bir bilgi zinciri, organizasyonların dış içgörülerden faydalanmasını ve inovasyon yeteneklerini artırmasını sağlar.

Dijital Olgunluk

Bu kategori, inovasyon süreçlerini desteklemek için dijital teknolojilerin entegrasyonunu değerlendirmektedir.

Ana boyutlar şunlardır:

- **Dijital Araçlar ve Platformlar**: Dijital araçların iş birliği, iletişim ve bilgi paylaşımını kolaylaştırmak için ne ölçüde kullanıldığı.
- **Dijital üretim ve operasyonlar**: Organizasyonun üretim süreçlerinde ve operasyonlarındaki dijital olgunluk derecesi
- **Dijital tedarik zinciri**: Tedarikçilerle ilişkilerde dijital olgunluk seviyesi

Dijital olgunluk, A&D sektöründe giderek daha önemli hale gelmektedir, çünkü organizasyonların daha verimli çalışmasını ve piyasa değişikliklerine hızlı bir şekilde yanıt vermesini sağlar.

Olgunluk Seviyeleri

Önerilen model, organizasyonları Seviye 1 (Başlangıç) ile Seviye 5 (Optimize) arasında beş olgunluk seviyesine ayırmaktadır. Her seviye, organizasyonun açık inovasyon uygulamalarını benimsemedeki ilerlemesini yansıtmaktadır.

- **Seviye 1: Başlangıç** – Bu seviyedeki organizasyonlar, inovasyon için minimal yapılandırılmış süreçlere sahiptir ve tutarlı bir stratejiye sahip değildir.
- **Seviye 2: Gelişmekte** – Organizasyonlar, bazı yenilikçi uygulamaları hayata geçirmeye başlar, ancak yönetim ve kültürde önemli zorluklarla karşılaşmaktadır.

- **Seviye 3: Planlı** – Organizasyonlar, resmi yönetim yapıları ve tanımlanmış bir inovasyon stratejisi oluşturmuş, orta düzeyde ortaklık ve bilgi yönetimi yeteneklerine sahiptir.
- **Seviye 4: Olgun** – Organizasyonlar, dış ortaklarla güçlü iş birliği sergilemekte ve sağlam bir inovasyon kültürü ile etkili bilgi yönetimi uygulamalarına sahip olmaktadır.
- **Seviye 5: İlham Verici** – Organizasyonlar, açık inovasyonu stratejik çerçevelerine tamamen entegre etmiş, sürekli inovasyonu yönlendirmek için dijital araçlar ve ileri düzey ortaklıklardan yararlanmakta ve diğer firmalara öncülük etmektedir.

Açık inovasyon olgunluk modeli, sadece teoriye bir katkı değil aynı zamanda Türk A&D sektöründeki organizasyonlar için pratik bir araç olarak tasarlanmıştır. Sektördeki firmalar bu modeli birkaç farklı şekilde kullanabilir:

Kendini Değerlendirme: Organizasyonlar, mevcut olgunluk seviyelerini anlamak ve iyileştirme alanlarını belirlemek için modeli kullanarak kendilerini değerlendirebilirler.

Stratejik Planlama: Model, organizasyonların inovasyon çabalarını iş hedefleriyle uyumlu hale getirmelerine yardımcı olarak stratejik planlama süreçlerini iyileştirebilir.

- **Karşılaştırma**: Şirketler, inovasyon yeteneklerini rakip şirketler ve tedarik zincirlerindeki şirketlerle karşılaştırarak bilgi paylaşımını ve en iyi uygulamaların yayılımını kolaylaştırabilirler.

Diğer yandan, önerilen model, A&D sektöründeki çeşitli paydaşlar için önemli etkilere sahiptir:

Yöneticiler ve İdareciler: Model, inovasyon yeteneklerini değerlendirmek ve geliştirmek için net bir çerçeve sunarak bilinçli karar alma süreçlerini mümkün kılmaktadır.

Politika Yapıcılar: Modelden elde edilen içgörüler, politika yapıcıların A&D endüstrisinde inovasyonu destekleyen ortamlar geliştirmelerine rehberlik edebilir.

Akademisyenler ve Araştırmacılar: Model, açık inovasyon ve dinamik yetenekler konusundaki akademik tartışmalara katkıda bulunarak gelecekteki araştırmalar için bir temel sağlamaktadır.

Önerilen açık inovasyon olgunluk modeli, Türk havacılık ve savunma endüstrisinde inovasyon yeteneklerini değerlendirmek ve geliştirmek için kapsamlı bir çerçeve sunmaktadır. Strateji, kültür, ortaklıklar, bilgi yönetimi ve dijital olgunluk gibi kritik boyutlara odaklanarak, organizasyonlara uygulanabilir iç görüler sağlamaktadır. A&D sektörü gelişmeye devam ederken, bu modelin benimsenmesi, organizasyonların açık inovasyonun karmaşıklıklarını aşmalarına ve sürdürülebilir rekabet avantajı elde etmelerine yardımcı olabilir.

Ampirik Çalışma

Bu bölüm, Türk havacılık ve savunma (A&D) endüstrisinin açık inovasyon olgunluğunu değerlendirmek amacıyla yapılan ampirik araştırmanın bulgularını sunmaktadır. Araştırma, önde gelen bir orijinal ekipman üreticisi (OEM) ve onun ekosistemine odaklanmaktadır. Bu bölüm, anketlerden elde edilen nicel verileri ve görüşmelerden elde edilen nitel iç görüleri sentezleyerek, sektördeki açık inovasyon uygulamalarının mevcut durumuna dair kapsamlı bir genel bakış sunmaktadır.

Araştırma ilk olarak Şirket A'nın orta ve üst düzey yöneticileri ile gerçekleştirilmiştir. E-posta yöntemi ile anket formatında hazırlanan açık inovasyon ölçeği 300'ün üzerinde yöneticiye iletilmiş ve elektronik olarak anketi cevaplamaları beklenmiştir. Geri dönüş oranını artırmak için ilgili yöneticilerle yüz yüze ve telefonla görüşmeler yapılmış ve ankete katılımları hatırlatılmıştır. Geri dönüşler 1 ayda tamamlanmış ve geri dönüş sayısı 121 olmuştur. Şirket A'nın olgunluk analizi yapılırken, bu 121 katılımcının yanı sıra, olgunluk ölçeğinin oluşturulma aşamasında yarı yapılandırılmış formatta üst düzey yöneticilerle yapılan mülakatlar da dikkate alınmıştır. Ayrıca şirketin kurumsal dokümanları, prosedürleri, sistemleri, süreçleri gözden geçirilmiş ve gözlemler yapılmıştır. Bu yöntemle nicel olarak toplanan verinin nitel verilerle

doğrulanmasına ve olgunluk ölçeğinin güvenilirliğinin teyitine çalışılmıştır. Analizler nicel ve nitel verilerin birbiri ile uyumlu ve anlamlı bir bütün olarak çalıştığını göstermektedir. Şirket A'nın ekosisteminde yer alan firmalara anket bu bulgu ışığında gönderilmiştir.

Türk havacılık ve savunma ekosisteminin açık inovasyon olgunluğunu anlamak için Şirket A'nın yanı sıra ekosistemde yer alan firmalara da ulaşmak hedeflenmiştir. Havacılık ve savunma sektörü sektörün gerektirdiği karmaşık teknolojiler ve bütünleyici tedarik zinciri yapısı nedeniyle bir ekosistem olarak anılmaktadır. Sektör genel olarak oligarşik bir yapıda olup ana bir firma etrafında şekillenen orta ve küçük ölçekli firmalardan oluşmaktadır. Sektörün ürün ve hizmetlerin müşterileri, devlet kurumları ve/veya hava yolu şirketleri gibi kurumsal yapılardır. Bu kurumlar büyük ölçekli satın alım ihaleleri açmakta ve işi genellikle OEM denilen entegratör firmaya vermektedir. Bu sebeple tek başına Şirket A'yı incelemek yerine, bu şirketin etrafında konuşlanan Türk havacılık ve savunma ekosistemine dahil şirketler de araştırmaya dahil edilmiştir. Önerilen açık inovasyon olgunluk ölçeği firma yetkinliklerini ölçmek üzere tasarlandığından, üniversiteler, araştırmacılar, meslek örgütleri, politika yapıcılar ve müşteriler araştırma dışında bırakılmıştır. Esasen, Şirket A'nın tedarik zincirinde yer alan alt yüklenicilere, proje ortaklarına ve sistem üreticilerine ulaşmak hedeflenmiştir. Ekosistemde anketin ulaştığı firmaların 200 üzerinde olduğu düşünülmektedir. 52 firma ankete geri dönüş yapmıştır. Bu firmaları gözlemlemek ve kurumsal sistemlerine erişerek nicel sonuçları teyit etmek mümkün olmamıştır, ancak Şirket A'da elde edilen anket güvenilirliğinin ekosistem firmalarında da devam ettiği varsayılmıştır.

Anket verilerinin nicel analizi, önerilen modelin beş kategorisi ve 16 boyutu için olgunluk seviyelerinin net bir resmini sunmaktadır. Sonuçlar aşağıda özetlenmiştir:

Strateji ve Yönetişim

Olgunluk Seviyesi: Bulgular, OEM'in bu kategoride seviye 3 (Planlı) bir olgunluk seviyesinde olduğunu göstermektedir.

- Strateji: Tanımlanmış bir inovasyon stratejisi mevcuttur, ancak uygulaması her bölümde ölçeklenmiş ve uygulanır değildir.
- Yönetim Desteği: İnovasyon girişimleri için yönetim desteği orta düzeydedir; bazı yöneticiler inovasyonu aktif olarak desteklerken, diğerleri tereddüt etmektedir.
- Yönetişim: yapıları mevcuttur, ancak inovasyon süreçlerindeki roller ve sorumluluklar konusunda belirsizlik bulunmaktadır.

İnovasyon Kültürü

Olgunluk Seviyesi: Organizasyon, inovasyon kültürü açısından seviye 3 (Planlı) olarak derecelendirilmektedir.

- Süreç geliştirme: inovasyon faaliyetleri için tanımlı bir süreç mevcuttur ancak bu sürecin performans göstergeleri net değildir ve tüm şirkete yaygın olarak uygulanmamaktadır.
- Risk toleransı: Çalışanlar, yenilikçi faaliyetlere katılma isteği göstermektedir, ancak başarısızlık korkusu ve sınırlı risk toleransı gibi önemli engeller bulunmaktadır.
- Ödüllendirme: İnovasyon için teşvikler mevcuttur, ancak bu ödüller açık kriterlere göre ve periyodik olarak uygulanmamaktadır; ayrıca teşviklerin içeriği çeşitlendirilmemiştir.
- Zaman ve bütçe: İnovasyon faaliyetleri için ayrılmış ve günlük iş yükünün dışında tanımlı bir zaman ve belirli açık bütçeler yoktur. Çalışanlar günlük iş yükleri ile beraber bu faaliyetleri sürdürürler.

Ortaklık Kapasitesi

Olgunluk Seviyesi: OEM, ortaklık kapasitesi açısından seviye 3 (planlı) bir olgunluk seviyesine sahiptir.

- Ortak seçimi: ortak seçimi bilgi ve geçmiş tecrübelere göre yapılır. Potansiyel ortaklar değerlendirilir ancak sistematik bir seçim kriteri yoktur, seçim yapılırken bir strateji ve vizyon ortaya konulmaz ve ortakların performans değerlendirilmesi belirgin değildir.

- İş birliği yoğunluğu ve etkinliği: iş birliği yoğunluğu resmi ve çoğunlukla kısa vadelidir. İş birlikleri belli alanlara yoğunlaşmıştır ve etkinlikleri düzenli takip edilmez.
- İç iş birliği teşvik edilir, ancak departmanlar arası birlikte çalışma kültürü oturmamıştır, bu konudaki eğitim ve destekler gelişime açıktır.

Bilgi Zinciri

Olgunluk Seviyesi: Bilgi zinciri kategorisi seviye 3 (Planlı) olarak derecelendirilmiştir.

- Özümseme kapasitesi: çalışanlar ve yöneticiler dışsal bilgiyi tanıma ve öğrenme konusunda heveslidir. Ancak bu bilgiyi transfer etmek ve içsel bilgi ile birleştirmek için bir sistem ve yeterli olgunluk bulunmayabilir.
- Yeni teknolojilere adaptasyon: teknolojiler ilgili bölümler tarafından takip edilir, teknolojinin adaptasyonu için süreçler mevcuttur. Ancak bu bir stratejik plana göre yapılmaz ve teknolojiye uyumun performans göstergeleri takip edilmez.
- Teknoloji benimseme ilerlemektedir, ancak yeni araçlar için eğitim ve destek konusunda eksiklikler bulunmaktadır.

Dijital Olgunluk

Olgunluk Seviyesi: OEM ve ekosistem dijital olgunluk açısından seviye 3 (Planlı) olarak ölçülmüştür.
- Dijital bilgi üretimi ve paylaşımı: digital araçlar üzerinden bilgi üretimi ve paylaşımı yapılabilir.
- Dijital üretim ve faaliyetler: Üretimde ve kurumsal operasyonlarda dijital araçlar entegre bir şekilde çalışır. Digital veri analizi, karar alma ve kaynak planlama yaygın olarak bulunmamaktadır.
- Dijital tedarik zinciri: bazı tedarik zinciri teknolojilerine entegrasyon sağlanmış olsa da, genel olarak izole yapılar mevcuttur. Geliştirme projeleri henüz planlanmamıştır ve dijital entegrasyon zayıftır.

Şirket A'nın ve ekosistemin açık inovasyon olgunluğunu özetleyen tablo aşağıda verilmiştir. Ampirik çalışmanın son bölümünde katılımcılardan açık inovasyon olgunluğunu artırmak için politika önerileri istenmiştir. Toplam 126 kişi öneri vermiş olup, gelen önerilerin sayısı 178 adettir. Bu öneriler 5 olgunluk kategorisine göre gruplandırılarak analiz edilmiştir.

Tablo Şirket A ve Ekosisteminin Açık İnovasyon Olgunluk Seviyeleri

Kategori	**Şirket A Kategori Olgunluk Seviyesi**	**Ekosistem Kategori Olgunluk Seviyesi**	**Boyut**	**Şirket A Boyut Olgunluk Seviyesi**	**Ekosistem Boyut Olgunluk Seviyesi**
Strateji ve Yönetişim	3.1	3.0	İnovasyon Stratejisi	3.3	3.1
			Yönetim Desteği	3.0	3
			Yönetişim	**2.9**	**2.6**
Inovasyon Kültürü	2.9	2.8	Süreç Geliştirme	**2.9**	**2.5**
			Risk Toleransı	**3.4**	**3.1**
			Ödüller	**3.1**	**2.3**
			Zaman ve Bütçe	**2.5**	**2.8**
İş Birliği Kapasitesi	**2.8**	**3.1**	Ortak Seçimi	3.2	3.1
			Ortaklık Yoğunluğu ve Etkinliği	3.1	3.1
			Kurum İçi İş Birliği	**2.7**	**3.1**
Bilgi Zinciri	**3.1**	**3.3**	Özümseme Kapasitesi	3.1	3.2
			Yeni Teknolojilere Uyum	**3.1**	**3.4**
			Bilgi Ağlarına Erişim	3.2	3.3
Dijital Olgunluk	2.9	2.9	Dijital Bilgi Üretimi ve PAylaşımı	3.0	3.1
			Dijital Üretim ve Operasyonlar	**3.2**	**2.9**

			Dijital Tedarik Zinciri	2.2	2.3
Şirket A'nın Açık İnovasyon Olgunluğu				**3.0**	
Ekosistemin Açık İnovasyon Olgunluğu				**3.0**	

Stratejik Uyum

Görüşülen kişiler, inovasyon stratejilerinin genel iş hedefleriyle uyumlu olmasının önemini vurgulamıştır. Bazı yöneticiler, inovasyon stratejisinin mevcut olduğunu, ancak tüm departmanlar tarafından tam olarak benimsenmediğini ve bu durumun parçalı çabalara yol açtığını belirtmiştir.

Kültürel Engeller

Geri dönüşler inovasyonu engelleyen kültürel engelleri, muhafazakar bir zihniyet ve risk almaktan kaçınma olarak belirtmiştir. Yöneticiler, deneyimi teşvik eden ve başarısızlığı öğrenme fırsatı olarak kucaklayan bir kültürel değişime ihtiyaç duyulduğunu ifade etmiştir.

İşbirlikçi Uygulamalar

Önerilerde, özellikle üniversiteler ve teknoloji firmalarıyla mevcut ortaklıkların gücü vurgulamıştır. Bu iş birliklerinin başarılı projelere ve yeniliklere yol açtığı belirtilmiştir; ancak bu ilişkileri yönetmek için yapılandırılmış yaklaşımlara ihtiyaç olduğu ifade edilmiştir.

Bilgi Yönetimi

Öneriler sektörün bilgi paylaşımı için mekanizmalara sahip olduğunu, ancak bunların etkin olmadığını ortaya koymuştur. Birçok yönetici kritik bilgilere erişimde zorluklar bildirmiştir; bu da yenilik yapma yeteneklerini engellemektedir. Görüşülen kişiler, bilgiye daha iyi erişim sağlamak için bilgi yönetim sistemlerinin (bulut teknolojisi) geliştirilmesini önermiştir.

Dijital Dönüşüm

Yöneticiler, dijital dönüşümün yeniliği yönlendirmedeki önemini kabul etmiştir. Ancak, dijital teknolojilerin faydalarını en üst düzeye çıkarmak için daha fazla eğitim ve desteğe ihtiyaç duyulduğunu dile getirmişlerdir.

Ampirik araştırmadan elde edilen bulgular Türk A&D endüstrisindeki açık inovasyon olgunluğuna dair öngörüler sunmaktadır. Her ne kadar tüm sektörün olgunluğu daha kapsamlı çalışmalara açık olsa da, sektörün başat şirketlerinden biri ve onun etrafında konuşlanmış ekosistemi incelemek sektörün açık inovasyon olgunluğu için önemli bir gösterge niteliğindedir. Nicel ve nitel veriler, organizasyonun inovasyon yeteneklerindeki güçlü ve zayıf yönleri ortaya koymakta ve gelecekteki stratejik hedef ve politika araçları için değerli iç görüler sunmaktadır. Belirlenen boşlukları ele alarak ve mevcut güçlü yönlerden yararlanarak, katılımcı şirketler inovasyon uygulamalarını geliştirebilir ve Türk havacılık ve savunma sektörünün genel rekabetçiliğine katkıda bulunabilirler. Açık inovasyon kavramı yaşayan ve zaman içinde değişime uğrayabilecek bir olgudur. Geliştirdiğimiz ölçek de bu yapıya uyumlu olarak tasarlanmış ve gelecekte iyileştirmeye açıktır.

Sonuçlar ve Politika Önerileri

Bu bölüm, Türk havacılık ve savunma (A&D) endüstrisinin açık inovasyon olgunluğu ile ilgili araştırma bulgularından çıkarılan sonuçları sunmakta ve sektör içindeki inovasyon yeteneklerini artırmaya yönelik uygulanabilir politika önerileri

içermektedir. Bu bölüm, ampirik verilerden elde edilen içgörüleri sentezlemekte, paydaşlar için daha sağlam bir inovasyon ekosistemini teşvik etmek amacıyla stratejik eylemler ve politika araçları önermektedir.

Açık İnovasyon Olgunluğunun Mevcut Durumu

Bu araştırma, incelenen OEM şirketi ve ekosistemindeki firmalar temel alındığında, Türk A&D endüstrisinin, açık inovasyon uygulamalarında planlanmış bir olgunluk seviyesi (seviye 3) sergilediğini ortaya koymaktadır. Ana olgunluk kategorilerine baktığımızda benzer sonuçlar elde edilmiştir. Hemen tüm boyutlar bu seviyesin etrafında toplanmış olup daha ileri aşamalar olan olgun (seviye 4) ve ilham verici (seviye 5) kademelerinde performans gösteren bir açık inovasyon yetkinliği bulunmamaktadır. Şirket A ve ekosistem karşılaştırmalı olarak incelendiğinde oldukça benzer yapılar ortaya çıkmıştır. Her iki örneklem arasındaki kayda değer (%10-%25 arasında) olgunluk seviyesi farkları inovasyon yönetişimi, risk toleransı, ödüllendirme, zaman ve bütçe, kurum içi iş birlikleri, yeni teknolojilerin adaptasyonu ve dijital üretim ve operasyonlar boyutlarında meydana gelmiştir. Bu boyutlardaki farklılıkların değerlendirilmesi gelecekteki araştırmaların konusu olabilir.

Bulgular, net bir inovasyon stratejisinin mevcut olduğunu, ancak uygulamanın departmanlar arasında tutarsız olduğunu ve kültürel yapının risk almayı engellediğini göstermektedir. Araştırmanın kritik bir sonucu, inovasyon stratejilerinin genel iş hedefleriyle uyumlu hale getirilmesinin gerekliliğidir. Departmanlar arasında tutarlı bir entegrasyon eksikliği, parçalı inovasyon çabalarına yol açmakta ve bu da inovatif girişimlerin potansiyel etkisini azaltabilmektedir. Tüm yönetim seviyelerinin inovasyon stratejisini anlamasını ve desteklemesini sağlamalıdır. Araştırma, organizasyon kültürünün inovasyon sonuçlarını şekillendirmedeki rolünü vurgulamaktadır. Muhafazakar bir zihniyet ve başarısızlık korkusu, çalışanlar arasında yaratıcılığı ve risk almayı engelleyen yaygın engellerdir. Daha yenilikçi bir ortam oluşturmak için organizasyonlar, denemeler yapmayı ve başarısızlıktan öğrenmeyi değerli kılan bir kültürü aktif olarak teşvik etmelidir.

Dijital olgunluk, açık inovasyon yeteneklerini etkileyen kritik bir faktör olarak tanımlanmaktadır. Bulgular, sektörün dijital araçları benimseme konusunda ilerleme kaydettiğini, ancak veriyi ve teknolojiyi inovasyon için etkili bir şekilde kullanmada hala önemli bir boşluk bulunduğunu önermektedir. Dijital dönüşüm girişimlerini hızlandırmak, bilgi yönetimini ve karar alma süreçlerini geliştirmek için önemlidir. Etkin bilgi yönetimi uygulamaları, inovasyonu kolaylaştırmak için hayati öneme sahiptir. Araştırma, birçok çalışanın ilgili bilgilere erişimde zorluklar yaşadığını ve bunun inovasyon çabalarına katkıda bulunma yeteneklerini engellediğini göstermektedir. Organizasyonlar, tüm seviyelerde bilgi paylaşımını ve erişilebilirliği teşvik eden sağlam bilgi yönetim sistemlerine yatırım yapmalıdır.

Politika Önerileri

Araştırmadan çıkarılan sonuçlara dayanarak, Türk A&D endüstrisinde açık inovasyon uygulamalarını geliştirmek için strateji ve politika araçları sunulmaktadır

Destekleyici Bir İnovasyon Ekosistemini Teşvik Etmek

İşbirlikçi ve iyi koordine edilen bir ekosistem, bilgi paylaşımını ve kaynakların etkin olarak bir araya getirilmesini teşvik eder; bu da daha yenilikçi çözümlere ve teknolojik ilerlemelere yol açabilir. Politika yapıcılar, sanayi, akademi ve hükümet arasında işbirliğini teşvik ederek inovasyon için destekleyici bir ortam yaratmalıdır. Bu, fonlama girişimleri, inovasyon merkezleri ve işbirlikçi araştırma projeleri aracılığıyla gerçekleştirilebilir.

Kültürel Değişimi Teşvik Etmek

Risk almayı ve deneme yapmayı kucaklayan bir kültürü teşvik ederek, organizasyonlar çalışanları inovasyon girişimlerine daha aktif bir şekilde katılmaları için güçlendirebilir. Organizasyonlar, inovasyon dostu bir kültürü teşvik etmeyi amaçlayan programlar uygulamalıdır. Bu, yaratıcılık, risk yönetimi ve başarısızlıktan öğrenmenin önemi üzerine odaklanan eğitim oturumlarını içermektedir.

İnovasyon Stratejilerini İş Hedefleriyle Uyumlu Hale Getirmek

İnovasyon çabaları ile iş hedefleri arasında net bir uyum, girişimlerde tutarlılığı artırır ve organizasyonel performansa olan etkileri maksimize eder. Şirketler, inovasyon stratejilerinin genel iş hedefleriyle yakından uyumlu olduğundan emin olmalıdır. Bu, hedefleri ve beklentileri netleştirmek için yönetim ile çalışanlar arasında düzenli iletişim gerektirir.

Dijital Dönüşüme Yatırım Yapmak

Dijital olgunluğun artırılması, organizasyonların verileri karar alma süreçleri için kullanmalarını, süreçleri kolaylaştırmalarını ve iş birliğini geliştirmelerini sağlayacaktır. Organizasyonlar, gelişmiş teknolojilere ve veri analitiği yeteneklerine yatırım yaparak dijital dönüşümü önceliklendirmelidir. Ayrıca dijital araçları etkili bir şekilde kullanmaları için eğitim ve destek sağlanmalıdır.

Bilgi Yönetim Sistemlerini Güçlendirmek

Etkin bilgi yönetimi uygulamaları, organizasyonun bilgiyi özümseme kapasitesini artırarak dışsal bilgiyi daha iyi kullanmasını ve inovasyon sonuçlarını iyileştirmesini sağlar. Şirketler, bilgi paylaşımını ve erişilebilirliği kolaylaştıran kapsamlı bilgi yönetim sistemleri geliştirmeli ve uygulamalıdır. Çalışanlar ve ortaklar arasında iş birliği ve bilgi alışverişi için platformlar oluşturulmalıdır.

Merkezi bir yapı ile inovasyon yönetişimi ve teşvikleri düzenlemek

Şirketler tekrarlayan projeler ve verimsiz kaynak kullanımının önüne merkezi bir otoritenin geçebileceğini belirtmektedir. Bu çerçevede var olan bir kuruma inovasyon faaliyetlerini koordine etme ve teşvik etme görevi verilebilir yahut yeni bir kurumsal mekanizma ile ekosistemin inovasyon yönetişimi sağlanabilir.

Araştırmanın kısıtları ve Gelecek için Araştırma Önerileri

Bu çalışma, gelecekteki araştırmalar için yol açabilecek sınırlama ve fırsatlar sunmaktadır. Bu bölümde, başlıca sınırlamaları kısaca özetleyecek ve gelecekteki

araştırmalar için potansiyel alanlar önereceğiz. Bu araştırmada kullanılan açık inovasyon yetkinliklerini ölçmeye çalışan 16 boyutu yansıtan anket soruları, nicel olarak açık inovasyon olgunluğunu ölçmeyi amaçlamıştır. Bunun yanı sıra, nitel yapıdaki Şirket A'da üst düzey yöneticilerle yapılan mülakatlar ve yazılı ve yazılı olmayan deliller ve gözlemler nicel bulguları doğrulamak için kullanılmıştır. Ancak, ekosistem için böyle bir doğrulama mümkün olmamıştır. Bu nedenle, nitel çalışmalar aracılığıyla ekosistem olgunluğunu daha derinlemesine anlamak ve böylece bu araştırmanın sonuçlarını doğrulamak, Türk A&D endüstrisinin OI olgunluğunu ölçmekle ilgilenen gelecekteki araştırmacılara yeni çalışma alanları sağlayabilir.

Bu çalışmada, Türk A&D sektörünün OI olgunluğunu projekte etmek için inovasyon ekosistemi yaklaşımı kullanılmaktadır. Başat bir havacılık OEM şirketi, çalışmanın ana noktası olarak konumlandırılmıştır ve Şirket A'nın ekosisteminde yer alan tedarikçiler, araştırma ve üretim ortakları ile alt yükleniciler incelenmiştir. Gelecekte, araştırmacılar bu çalışmanın verileri ile karşılaştırmak ve daha genellenebilir sonuçlar elde etmek için anketi daha geniş bir örnekleme dağıtabilir veya elektronik, silah sistemleri, mühimmat, kara ve deniz sistemleri gibi diğer segmentleri araştırabilirler. A&D endüstrisinde açık inovasyon, sektör şirketlerinin yenilik sistemlerini açma çabalarına rağmen nadiren incelenmiştir ve endüstrinin açık inovasyon sistemleri ile olan ilişkisini daha iyi anlamak için araştırmacılara geniş fırsatlar sunulmaktadır.

Bu araştırma, firma seviyesi bir yetenek modeli geliştirmeyi ve firmaların olgunluğunu A&D şirketlerinin yöneticileri tarafından yanıtlanan bir çalışma ile ölçmeyi hedeflemektedir. Araştırmacılar, üniversiteler, müşteriler ve hükümet ile sanayi kuruluşları gibi paydaşlar kapsam dışında tutulmuştur. Gelecekte, araştırmacılar açık inovasyon olgunluğunu yalnızca şirket düzeyinde değil, daha geniş bir paydaş yelpazesini kapsayacak şekilde ölçmek için bir metodoloji geliştirebilirler. Ayrıca, araştırmacılar yanıtlayıcı olarak yöneticiler yerine çalışanlara odaklanabilir ve bu iki farklı tarafın açık inovasyon algısındaki farklılıkları inceleyebilirler.

Bu araştırmada kullanılan AHP tekniği, diğer endüstriler için özel sonuçlar ortaya çıkarma fırsatına sahiptir. Her sektörün kendine özgü öncelikleri, kültürü, teknoloji ile

ilişkisi ve açıklık algısı ve ihtiyacı vardır. Bu nedenle, sektöre özel bir olgunluk modeli tasarlamak için boyutları belirlemek ve ağırlıklandırmak, araştırmacıların gelecekte daha fazla çalışma yapmaları için teşvik edici olabilir.

Bu araştırmanın, gelecekteki politika çalışmaları için etkileri ve iç görüleri vardır. Bu araştırmanın ana hedefleri, bir model tasarlamak ve Türk A&D endüstrisinin açık inovasyon olgunluğunu belirlemek için ampirik bir çalışma yapmaktır. Bütünleyici bir çalışma olarak, katılımcıların politika önerileri, Şirket A'nın, ekosisteminin ve nihayetinde endüstrinin olgunluk seviyesini artırmak için politikalar ve stratejiler önermek amacıyla toplanmıştır. Bu araştırmada elde edilen bulgular ve veriler, ana odağı politika geliştirmek olan ve Türk A&D sektörünün açık inovasyon olgunluğu ile ilgilenen araştırmacılara kapı açabilir.

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