TRIPLE HELIX MODEL AND TURKISH ROTARY WING TECHNOLOGY CENTER

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ABSTRACT

TRIPLE HELIX MODEL AND TURKISH ROTARY WING TECHNOLOGY CENTER

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A knowledge-based economy which focuses on the production and management of knowledge uses innovation as the main driver of the economic growth in order to be competitive in the global market. The triple helix model of innovation which is based on the interactions between government, university and industry creates an environment to foster knowledge-based economic development.

The main objective of this thesis is to examine the success factors of University-Industry-Government collaboration in Rotary Wing Technology Center-RWTC (Döner Kanat Teknoloji Merkezi-DKTM) in Turkey. This aim will be achieved by answering the main research questions in the field of Rotorcraft technologies: How does RWTC transfer the know-how generated in the universities to the industry?; How does RWTC contribute to creating skilled human resource needed in the

industry?; How does RWTC promote the sustainability processes in the industry? Based on google scholar database, there is no study that has explored the triple helix model in the context of a thematic technology center in defence industry in Turkey.

By using qualitative data collected from interviews with experts such as academicians, policy makers, researchers, State and company directors and analyses of statistical data about RWTC survey conducted to researchers worked in RWTC projects, this study evaluates the technology transfer on critical technologies through University-Industry-Government collaboration model in one of the priority areas of defence industry in Turkey. As a conclusion, policy implications that improve the existing model further and could also be applied to other defence industry areas are derived.

Keywords: Triple Helix Model, Innovation System, Management of R&D, Turkish Defence Industry

ÖZ

ÜÇLÜ SARMAL MODELİ VE TÜRK DÖNER KANAT TEKNOLOJİ MERKEZİ

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Bilgi üretimi ve yönetimine odaklanan bilgiye dayalı bir ekonomi, küresel pazarda rekabet edebilmek için inovasyonu ekonomik büyümenin ana itici gücü olarak kullanmaktadır. Üniversite, sanayi ve devlet arasındaki etkileşimlere dayanan üçlü sarmal inovasyon modeli, bilgiye dayalı ekonomik kalkınmayı teşvik etmek için bir ortam yaratır. Bu tezin temel amacı Türkiye'deki Döner Kanat Teknoloji Merkezinde (DKTM), Üniversite-Sanayi-Devlet işbirliğinin başarı faktörlerini incelemektir.

Bu hedefe döner kanat teknolojileri alanındaki temel araştırma soruları cevaplanarak ulaşılacaktır: DKTM, üniversitelerde üretilen teknik bilgiyi sanayiye nasıl aktarmaktadır?; DKTM, sanayide ihtiyaç duyulan kalifiye insan kaynağının yaratılmasına nasıl katkıda bulunmaktadır?; DKTM, sektördeki sürdürülebilirlik

süreçlerini nasıl teşvik etmektedir? Google akademik veritabanına dayanarak, Türkiye'de savunma sanayiinde tematik bir teknoloji merkezi bağlamında üçlü sarmal modelini araştıran bir çalışma yoktur.

Bu çalışma kritik teknolojiler üzerindeki teknoloji transferini, Türkiye'de savunma sanayiinin öncelikli alanlarından birinde Üniversite-Sanayi-Devlet işbirliği modeli aracılığıyla akademisyenler, politika yapıcılar, araştırmacılar, devlet ve şirket yöneticileri gibi uzmanlarla yapılan görüşmelerden elde edilen nitel verileri kullanarak ve DKTM projelerinde çalışan araştırmacılara yapılan DKTM anketi ile ilgili istatistiksel verilerin analizlerini yaparak değerlendirmektedir. Sonuç olarak, mevcut modeli daha da geliştiren ve diğer savunma sanayii alanlarına da uygulanabilecek politika sonuçları elde edilmektedir.

Anahtar Kelimeler: Üçlü Sarmal Modeli, İnovasyon Sistemi, Ar-Ge Yönetimi, Türk Savunma Sanayii

To My Family

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LIST OF ABBREVIATIONS

ARF	Asian/Australian Rotorcraft Forum
CFD	Computational Fluid Dynamics
EASA	European Aviation Safety Authority
ERF	European Rotorcraft Forum
FADEC	Full Authority Digital Engine Control System
VFS	Vertical Flight Society
FLIR	Forward Looking Infrared
FTA	Future-oriented Technology Analysis
FVL	Future Vertical Lift
IMAS	Integrated Modular Avionics System
NATO	North Atlantic Treaty Organization
NIS	National Innovation System
NSF	National Science Foundation
OECD	Organization for Economic Co-operation and Development
OYTEP	Ten-Year Procurement Program
PR	Public Relation
PRM	Project Review Meeting
PROSİS	Project Management Portal of RWTC

R&D	Research and Development
RWTC	Rotary Wing Technology Center
S&T	Science and Technology
SHGM	General Directorate of Civil Aviation
SME	Small and Medium-Sized Enterprise
SSB	Presidency of Defence Industries
SSIK	Defence Industry Executive Committee
TAI	Turkish Aerospace
TAF	Turkish Armed Forces
TAR	Technology Acquisition Roadmap
TEI	TUSAŞ Engine Industries
TKY	Technology Acquisition Liability
TRL	Technology Readiness Level
TTO	Technology Transfer Office
VFS	Vertical Flight Society

CHAPTER 1

INTRODUCTION

The R&D and innovation process carries many scientific, technological and commercial uncertainties. These uncertainties make it difficult for those who invest money to make predictions about the results of their investment. Scientific and technological uncertainties in R&D projects are so great that industrial companies naturally seek opportunities to reduce their risks in such projects by sharing them with other actors from the public or private sector. (Göker, 2003). For this purpose, it is necessary to build university-industry collaboration models in order to make companies work with universities and benefit from their knowledge, experience, researchers and laboratory facilities. Durgut (2007) states that relationships with the university help companies improve their competitiveness by allowing themselves to monitor technological changes and strengthen their innovation capabilities. Universities, on the other hand, benefit from these relationships by accessing new resources, technical knowledge, and industrial application opportunities.

The innovation ability of a country depends not on a single actor but on multiple actors and their successes at the same level; it was understood that these actors should act in a systemic integrity and in a certain harmony. Thereupon, based on the determination that there is convergence and overlap between the university, industry and the state, the Triple Helix Model was established. Basically, according to this model, at the different stages of the process of transforming information into an economic benefit, many mutual but complex relationships occur between the institutions of these three worlds. The so-called innovation is the product of these

complex relationships that exist between the three worlds in question and can only be represented by a triple helix. The model provides highly competent explanations about the nature of the innovation process and the closely related roles of the three worlds in this process (Göker, 2000)

Regarding these arguments, the main aim of this thesis is to examine the university-industry-government collaboration using the triple helix framework with an emphasis on rotorcraft industry in Turkey. In particular, the success factors and barriers that affects university-industry-government collaboration as a whole in Turkish Rotary Wing Technology Center (RWTC) are explored. The analysis of RWTC could clarify the effects of university-industry-government collaboration on knowledge production and transferring it to industry, creation of skilled and experienced human resource on a specific industry, retaining the sustainability of knowledge flows and human capital and development of innovative helicopter technologies. Besides, within the light of research analysis, policy implications that improve the existing model further are deduced.

This thesis uses a case study approach with the analysis of Turkish Rotary Wing Technology Center which is the first thematic Technology Center of TAI, to work on future technologies and technologies with restrictions in access related with rotary wing platforms. It is also a unique model in Presidency of Defence Industries (SSB) in which Technology Acquisition Liability (TKY-Teknoloji Kazanım Yükümlülüğü) projects are designed as a human resource creation model in the relevant sector. In SSB, TKY projects define R&D projects that aim to develop subsystems, components and technologies that will be input to main system/ platform projects with the joint work of SME and/or university/research institution under the responsibility of the main contractor. In the RWTC model, however, in addition to the development of subsystem, components and technologies that will be input to the main system/platform projects, it is aimed to train human resources needed by the industry in collaboration with the university, industry and

government. These human resources with the people raised with an expertise in certain helicopter technologies through RWTC are expected to support many helicopter projects continuously. This collaboration also contribute to knowledge transfer processes between the university and industry. As explained in detail in the rest of the thesis, throughout activities of RWTC consisting of conferences, workshops, scientific study groups, project review meetings and educations; the state representatives, academicians, RWTC researchers and TAI engineers/experts have the opportunity to come together, work together and exchange views about the projects throughout the project processes.

In this thesis, the roles of university, industry and government and their interaction with each other is closely examined by analysing this unique case study in helicopter area. The data in this research cover both qualitative and quantitative research results. An online multiple choice questionnaire/survey and semi-structured interviews were conducted in this thesis as data collection instruments. In order to manage and analyze qualitative data, the content analysis is used. For quantitative research data analysis, descriptive statistics is used.

The focus of this research is to investigate the university-industry-government collaboration and interaction as a whole in the context of RWTC. To the best of my knowledge, there is no study that has explored the triple helix model in the context of a thematic technology center in defence industry in Turkey. Indeed, a search using the keywords “triple helix model” “technology center” “defence” and “Turkey or Turkish” on the Google Scholar database produced just two hits.[1]

This dissertation contributes to the literature offering policy recommendations in the light of the analysis of the information provided by all participant groups of this case study as different than the studies found in the literature.

[1] The two hits include Bracic & Dall (2006) and Hsueh-Yirng (2005).

This thesis comprised of 7 chapters which are organized as follows: The second chapter gives the theoretical background of the literature consisting of the titles as R&D process, innovation systems and helix innovation models. These topics is related to the case study and draw the main conceptual framework of this thesis. Chapter 3 presents an overview on the evolution of Turkish helicopter industry in order to give the reader a brief information about major helicopter development projects of Turkey in the course of time. Chapter 4 describes the research methodologies used while examining the case study. Main and supplementary research questions are presented in this chapter. Chapter 5 presents the qualitative research and its analysis on RWTC. Chapter 6 presents the quantitative research and evaluates the survey results on RWTC. Chapter 7 concludes the thesis and offers policy implications to enhance the existing model further.

CHAPTER 2

LITERATURE SURVEY

In this chapter, the theoretical background of the literature which are the major concepts this thesis rests on are tried to be explained in order to understand and examine the case study from the aspects of the literature and develop technology policies. In the first subsection, the process of R&D is examined focusing on the necessity, management and commercialization of R&D concepts. In the second subsection, innovation systems are examined focusing on national innovation system, innovation networks and their properties. Finally, in the last subsection, helix innovation models are examined including triple, quadruple and quintuple helices.

In this dissertation, the focus of analysis is to construct a policy design model by analyzing the triple helix model of a thematic technology center in defence industry in Turkey from each helice's perspective. For this purpose, theoretical analysis is done to understand the main concepts framing the aforementioned case study. Throughout the examination of the case study the following issues are studied: (i) how an environment related to R&D and innovation is organized, (ii) the dynamics of the interactive processes between innovation networks (iii) the mechanism of generating know-how from existing knowledge. Therefore, the concepts and processes that will form the basis for these topics (R&D processes, innovation networks and collaboration models) have been investigated in the literature survey. At the same time, in order to develop the existing triple helix model of RWTC

further in future studies, the quadruple helix and quintuple helix collaboration models were also investigated within the scope of the literature survey.

2.1. R&D Process

2.1.1. The Need for R&D

Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.

According to Frascati Manual, "*R&D (Research and experimental development) comprise creative and systematic work undertaken in order to increase the stock of knowledge, including knowledge of humankind, culture and society, and to devise new applications of available knowledge"* (Frascati, 2015). An R&D activity should possess five main features: novel, creative, uncertain, systematic and transferable and/or reproducible.

To determine the investment decisions of government contracted R&D or private R&D and evaluate the strategies on R&D there should be a positive return and a guidance to show how to steer investments in the future because investment in R&D is expensive and risky. Policy makers are interested in social and economy-wide rate of returns while economists and private managers are interested in private rate of returns to R&D investment (Hall et al.,2009).

R&D generates value through multiple ways. First, increasing the stock of useful knowledge through publications and secured intellectual property. Second, developing human capital beyond the academic education through R&D processes. These skilled people are trained in R&D activities and gain substantial tacit knowledge through the process. Third, exploiting leading-edge scientific

instrumentation and forming new research methodologies. Finally, collaborating and forming networks with users which leads to coproduction of knowledge by means of the problems and challenges indicated by users (Georghiou, 2015).
Also, Salter and Martin (2001) mentioned two other benefits that R&D generates. First, enhancing the industrial and academic capacity of scientific and technological problem solving. Second, creation of firms like spin-offs that clustered around research intensive universities.

Akhilesh (2014) states the importance of R&D from strategic level, operational level and national level. At the strategic level, R&D provides a competitive edge in organizations. At the operational level, by managing ideas and talent in a proper way, R&D causes the development of new and improved services and products. Finally at the national level, by the development of defence technologies, R&D contributes to the security of citizens as well as by creating self-sufficiency with developed products and innovations, R&D pushes up economic growth and make the society wealthier.

2.1.2. Management of R&D

R&D management plays a crucial role for competitiveness because it shows the capability of organizations' using effective and repeatable processes in order to develop and integrate new technologies into commercialized products. Numerous companies see R&D as to some degree fuzzy, comprising high uncertainty and vague rate of return. Therefore, they consider R&D as troublesome to manage (Nobelius, 2002). Indeed, it is barely possible to plan particular R&D results due to uncertainty of results (Laliene & Liepe, 2015). However, companies succeed at managing R&D processes could estimate lead-time more precisely, reduce development costs and increase the quality of final products. These achievements in turn cause companies to take advantage of attaining greater market share and lead them to take part in a much sharper competitive edge (Nobelius, 2002).

Rothwell (1994) classified R&D management in terms of five generations (5G) in the Western World between 1950's and 1990. The transition period from 1950s (early day of booming markets) to today's global and highly competitive market reflects the way R&D has been managed and the changing perspective on R&D processes. Throughout these generations the scope, responsibility and role of the R&D function has changed and every generation brings various challenges. Therefore, organizations have to align to changes in order to adapt their strategic vision to these new challenges.

First-Generation R&D management and activities are considered the era of technology push. At this phase, it is assumed that R&D activities are carried out from an ivory tower, are seen as an overhead cost and the decision of the which technologies are required is given unilaterally. The period between 1950s and mid-1960s can be considered as the era of technology push and the focus is simply on scientific breakthroughs. The assumption behind this generation of R&D is the more R&D goes in, the more products come out (Nobelius, 2002). This generation of R&D has almost no interaction and researchers conduct their works in a position of isolation. (Akhilesh, 2014). R&D process is a linear activity and focuses on pushing the technology downstream towards the market.

Second-Generation R&D management and activities are considered the era of market pull. This part of R&D compels organizations to investigate the needs of the business. From mid-1960s to early 1970s the era of market pull take the stage. At that period, R&D units of organizations have to work with other units such as manufacturing, operations and marketing. To understand the needs of the customers, organization structures are evolved to constitute communication channels between organizations and the market (Akhilesh, 2014). During the second generation of R&D, there is a more stable relationship of supply and demand. Process-wise, R&D process is considered as a simple linear sequential process and the source of ideas for directing R&D is the market. Afterwards, R&D

units refine and develop the market originated ideas. Therefore, R&D has a reactive role to the needs of the market and the main strategic concern of companies is the marketing (Nobelius, 2002; Reger et al., 1996).

Further, Third-Generation R&D management and activities are considered as the era of coupling. At this level of R&D management, R&D and marketing work go hand in hand. This generation evolved between mid-1970s and mid-1980s. At this stage, markets are started to be considered as dynamic and changing. R&D activities have to be more goal oriented and tuned with market opportunities. Instead of the two extremes as before, R&D and marketing are more in balance and technological capabilities are tied more closely with the market needs. Moreover, not only innovation but also cost competitiveness is important for markets. R&D management become more inclusive, broaden markets' perspective and markets use R&D to be more competitive (Akhilesh, 2014). At this phase of R&D generation, there are many technology push and market pull combinations which have feedback loops and interaction among different elements. Projects are linked with both corporate and business strategies and long term strategies are started to be developed (Reger et al., 1996).

The next identified R&D management model is Fourth-Generation R&D management and activities which are considered as the era of integration. This generation started from early 1980s continues until early 1990s. At this stage of R&D management, the focus is on the integrated business processes and the scope of functionality is through the value creation process. In the dynamic market, the values of products and services are determined by customer centric demands and the main business value is measured by not only the satisfaction of the customer but also reaching beyond the expectations of the customer. There are strong upstream linkages with key suppliers and downstream linkages with demanding and active customers. Therefore, R&D becomes the integral part of the business and R&D management deals with forecasting, roadmapping, business intelligence and

budgeting also (Akhilesh, 2014). According to Reger at el., (1996), at this phase, R&D process is a parallel development process with integrated development teams. There are horizontal collaboration with joint ventures and close coupling with leading edge customers. The main focus is on the total concept rather than products as R&D is seen as an integrative activity. The growing strategic concern of this phase is the global strategies.

Finally, Fifth-Generation R&D management and activities are considered as the era of networking. This generation began from the 1990s onwards. The process is called fully integrated parallel development process. This stage focuses on 'system integration and networking' to guarantee speed of development and flexibility. Speed becomes the essential factor in R&D functioning. In order to improve the speed of development, a time-based strategy is applied. Flexibility, on the other hand, is demanded in order to respond quickly to the various demands of the customers. The process is focused on increasing product quality, performance and diversity. R&D is seen as a network activity and there are increased intra-firm and inter-firm integration. The factors including uncertain environment, high degree of configuration, severe resource constraints, dynamic and changing context and demands of the customers force R&D management to work in this network fashion with partners, suppliers, competitors, distributers and customers. There are horizontal linkages with joint ventures, collaborative research groupings and collaborative marketing arrangements. Therefore, the emphasis is on collaboration within a wider system and building up technological accumulation. To create new intellectual assets, collaborating both internally and externally to develop and implement ideas now becomes a necessity than ever. And finally, the major growing strategic concern is the environmental issues at this phase (Akhilesh, 2014; Reger et al., 1996; Nobelius, 2004).

To sum up, the five-fold classification of R&D management shows that the perspective on R&D processes, the surrounding context and prerequisites are

changing through the classified periods. In this changing environment, the challenge of staying profitable for companies is tougher than ever. While facing those changes, R&D management characteristics could bring vital competitive advantages to companies (Iansiti and West, 1997). The last seventy years of evolution of five models of R&D management is shown in Table 1.

It is worth to note that these generalized models of R&D management generations do not represent a map of where today's companies' positions while managing R&D. Throughout the whole time scale, different companies and industries have adopted the ideas and characteristics of different generations of R&D management and found the drivers of best practice and functioned through these role models (Nobelius, 2002).

To identify the hallmarks leading to the sixth generation R&D management model, the current literature explores more recent R&D management practices by examining exploratory case studies. Through these case studies, it is demonstrated that to develop a new product, an environment for collaboration and idea sharing is needed. This generation is characterized by greater multi-disciplinary approach focusing on collaboration, cross-functional communication and greater inclusion of stakeholders in the full life cycle of R&D management process. (Kensen and Pretorius, 2014).

Table 1. Generalized models of R&D Management

The Five R&D Generations			
R&D Model	**Generation**	**Time Period**	**Characteristics**
Technology Push	First	1950s-Mid 1960s	> Simple linear sequential process > R&D is seen as ivory tower activity and an overhead cost > R&D ideas can come from the R&D department > Having little or no interaction with the rest of the company > The market is a vessel for R&D products > Focusing on scientific breakthroughs > Growing strategic concern of R&D and manufacturing build-up
Market Pull	Second	Mid 1960s-Early 1970s	> Simple linear sequential process > R&D is seen as business activity > The source of ideas for directing R&D is the market > Market originated ideas refined and developed by R&D > R&D has a reactive role > R&D activities are driven by business strategy > Focusing on marketing efforts to increase the sales volume > Growing strategic concern of marketing
Coupling	Third	Mid 1970s-Early 1980s	> Sequential process with feedback loops > R&D is seen as portfolio activity > R&D ideas can come from any department > R&D and marketing work hand in hand > R&D and marketing are more in balance > Technology push and market pull combinations > Feedback loops and interaction among different elements > Structuring R&D processes > Focusing on integration at the R&D and marketing interface > Linking projects with both corporate and business strategies > Evaluating long term technology strategies > Growing strategic concern of financial issues (cost focus)
Integrated	Fourth	Early 1980s-1990	> Parallel development process with integrated development teams > R&D is seen as integrative activity > R&D ideas can come from process reinvention > Learning from and with customers > Strong upstream linkages with key suppliers > Strong downstream linkages with demanding and active customers > Horizontal collaboration with joint ventures > Close coupling with leading edge customers > Moving away from a product focus to a total concept focus > Activities are conducted in parallel by cross functional teams > Focusing on integration between R&D and manufacturing > Focusing on total concept rather than product > The Integrated Business Process > Growing strategic concern of global strategies
Network	Fifth	1990s-onwards	> Fully integrated parallel development process > System integration and extensive networking > Increased intra-firm and inter-firm integration (networking) > R&D is seen as network activity > R&D ideas can come from external sources of information > Separating or linking R and D > Flexible and customized response > Use of expert systems and simulation modeling in R&D > Strong linkages with leading edge customers > Horizontal linkages with joint ventures, collaborative research groupings, collaborative marketing arrangements > Continuous R&D > Applying time-based strategy (improving speed of development) > Integrated technology and manufacturing strategies > Focusing on corporate flexibility (organizational, product, manufacturing) > Focusing on increasing product quality, performance and diversity > Focusing on collaboration within a wider system > Focusing on technological accumulation > Growing strategic concern of environmental issues

Source: Developed and adapted from Rothwell, 1992; Reger, 1996; Nobelius, 2002; Nobelius, 2004

Sixth-Generation R&D management and activities are considered as the era of open R&D which is a system consisting of certain openness of ideas. At this level, the R&D ideas can come from intangible assets and research part of R&D is part of a larger ecosystem rather than to one company. This generation of R&D management involves taking more aspects into account (manufacturability, industrial design, interoperability, environmental and after-market considerations) and interacting with more actors outside the traditional R&D departments (suppliers, competitors, marketing and manufacturing functions and distributers). Furthermore, there is a larger risk/reward ratio than the earlier generations of R&D. There is a multi-project, multi-technology network based ecosystem which has strong connections between multi-technology research networks. The research ecosystem consists of variety of actors like universities, competitors, independent freelancers and temporary interest groups and research efforts occurs between niche-based alliances.

The actors of the ecosystem focus on technology sourcing strategies by collaborating to build up a more distributed technology sourcing structure and broader multi-technology base for high-tech products. In the end, these efforts and endeavours results in a self-learning system. The main characteristics of Sixth Generation of R&D Management is listed in Table 2.

Conducting research and development is very important in order to increase and accumulate the knowledge pool. Nevertheless, management of sixth generation R&D gives a richer picture and faces lots of methodological, operational, efficiency and strategic challenges (Kensen and Pretorius, 2014). In order to overcome these challenges, new working methods are developed in this new identifiable generation (Nobelius, 2004). In this model, the knowledge is also considered as a separate category and innovation processes are planned to create new knowledge, manage existing knowledge, store and transfer knowledge and use it again. (Swiadek and Koziol-Nadolna, 2011). Taking into account these features, this model provides an

answer to changes in today's global World and its effects on companies. It provides new solutions, structures and approaches to development and also leads to the elimination of many obstacles to development.

Table 2. Sixth Generation of R&D Management

The Sixth R&D Generation			
R&D Model	**Generation**	**Time Period**	**Characteristics**
Open	Sixth	Future	> R&D ideas can come from intangible assets > Refocus towards the research part of R&D > Research part of R&D being part of a larger ecosystem rather than to one company > Open R&D (a system where under certain openness of ideas exist) > Taking more aspects into account (manufacturability, industrial design, interoperability, environmental and after-market considerations) > Interacting with more actors outside the traditional R&D departments (suppliers, competitors, marketing and manufacturing functions and distributers) > Larger risk/reward ratio than the earlier generations of R&D > Broader multi-technology base for high-tech products > More distributed technology sourcing structure > Multi-project, multi-technology network based ecosystem > Strong connections between multi-technology research networks > Research efforts between niche-based alliances > New alliances and cooperation need to be established cross borders > Cooperation based on functions rather than technology and merging companies' combinatory capabilities > The research ecosystem consists of variety of actors like universities, competitors, independent freelancers and temporary interest groups > Self-learning system > Focusing on technology sourcing strategies

Source: Developed and adapted from Nobelius, 2004

The models of R&D management strategies have undergone several metamorphoses since 1950s. Throughout these strategies, managing R&D processes properly is considered a troublesome and a matter of debate area with no simple answers. However, to be able to choose and manage with the right strategies, companies could increase the quality of the products, reduce development costs and increase lead-time precision and in turn, strengthen their competitive advantages in many areas.

2.1.3. Commercialization of R&D

R&D is an important parameter in economic growth because it creates value. To achieve technology commercialization, the outputs of R&D must be transferred to the market efficiently. However, not every R&D developed technologies achieves market success. In this context, “valley of death” phenomenon occurs. The gap between R&D and commercialization processes are called valley of death and it is necessary to understand the asymmetry and reduce uncertainties between the R&D researchers and customers in order to overcome the valley of death. Since the risk of failure in the commercialization activities of R&D is inherently high, it is crucial to validate the needs of the customers by testing, verifying and adjusting the technology and the market throughout the commercialization process (Kim et al., 2019).

According to Jolly’s model (1997) of commercialization processes in R&D “five subprocess and four bridge” theory is proposed. In this model, five main stages are described as imagining, incubating, demonstrating, promoting and sustaining. There is also gaps between each technology commercialization stage called interest gap, technology transfer gap, market transfer gap and diffusion gap.

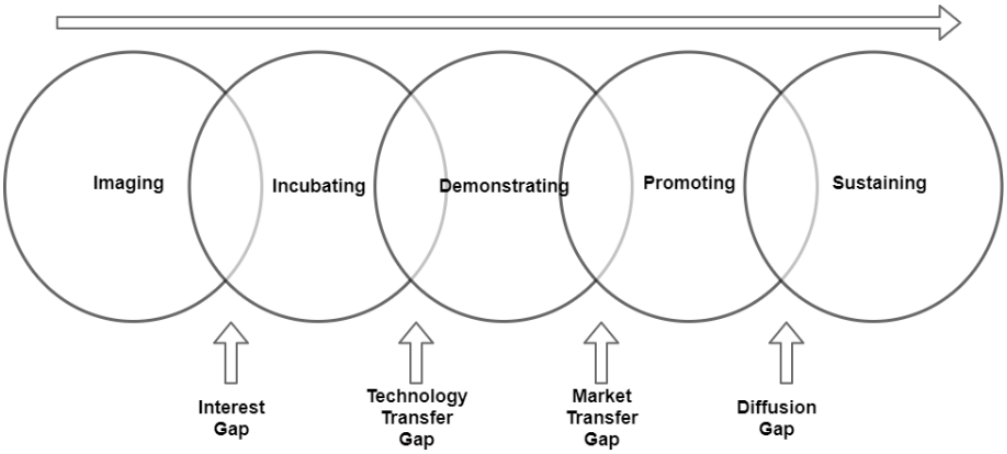

Figure 1. Technology Commercialization Process Model
Source: Adapted from Jolly (1997)

In this model, the uncertainty in technology commercialization is distributed through all stages therefore, the success at one stage does not guarantee success at another stage. In effect, each stage has an independent role for value creation.

By and large, first there is imaging stage which creates unique ideas that create value. Second, incubating stage appears where commercializability of products is defined. Third, demonstrating stage occurs where prototypes are built. Fourth, promoting stage rises which introduce built products to market. And final stage is sustaining which improves products and build markets.

Furthermore, at each R&D stage a gap appears which we called as “the valley of death” previously. First, interest gap exists between imaging and incubating stage where interested people and money is found. Second, technology transfer gap occurs between incubating and demonstrating stages. In this gap, resources are found to build prototypes and possible markets are identified. Third gap is the market transfer gap where initial markets are built and market expansions are planned. Final is the diffusion gap in which market growth strategies are developed after a new product launch.

Commercialization of R&D needs time, effort and money and external funding plays an important role. The university resources are limited and private investors are reluctant to invest in R&D in very early stages. Therefore, government programs are established and university spin-offs is found to support the commercialization of R&D. When there is insuffient or lacking research funds, these government programs that support commercialization become very conspicuous to scholars in universities. An important issue arises out of the design of these government programs. The programs have to be efficient and effective to be able to foster the creation of spin-offs. These programs have a positive effect on R&D of SMEs by reducing some investment barriers of their funding (Houweling, 2017).

Karlsson and Wigren (2012) states that without commercialization universities are scientific ivory towers where research is conducted for its own sake and commercialization helps to reduce the gap between universities and the business community for the sake of social welfare of the society.

2.2. Innovation Systems

2.2.1. National Innovation Systems

Innovation is the transformation of information into products, processes (production methods), systems and services. Key factors that play a role in this transformation are knowledge, skilled workforce and infrastructure (NSF, 2001). Innovations are substantial building blocks in national economies. As the process of innovation encompasses the stages from R&D to commercialization, national innovation policies should also encompass these stages (Goktepe, 2002). Indeed, the main theme in the national innovation policy is to increase the country's R&D ability, as well as the ability to develop the science and technology produced as a result of R&D into an economic and social benefit (Goker, 2003).

National Innovation System is a system composed of many interrelated institutions that are formed by the State and contribute to the development and diffusion of new technologies. In this system, policies are implemented to influence the innovation process and the aim is to create, accumulate and transfer knowledge, skills and talents in order to produce new technologies (Metcalfe, C. S., 1995). National Innovation System (NIS) of a country has a substantial role in the creation of innovation and includes all main components of the innovation process as well. This system covers major subsystems including R&D system, technoeconomic system, education system and cultural system and consists of several actors including universities, research institutes, companies, institutions and government. The economic development of a country depends on the interaction of these actors and coevolutionary processes of these subsystems (Krishna, 2017; Afzal, 2017;

Yoda & Kuwashima, 2019). The national innovation system emphasizes that the flows of information and technology among people, institutions and companies is the main factor supporting the innovation process. As the main focus of NIS is wealth creation, developing policies to support and network the complex relationships between these actors causes enhancing the innovative performance and the economic competitiveness of the country (OECD, 1997) In fact, the most developed countries in the World have extensive and complicated National Innovation Systems (Santonen et al., 2015).

2.2.2. Innovation Networks

Innovation is built on scientific creativity, technological feasibility and commercial realizability with the aim of high added value products and processes. In order to reach high quality outputs in research, collaborative knowledge production which relies on collaborative innovation networks have become more dominant and prevalent in time (Ahrweiler & Keane, 2013).

Ozman (2017) states that the process of innovation creation is not isolated and could not be attributed to an inventor solely. Instead, in her book innovation is defined as the design and creation of a novelty and the dissemination of it to society as well as a collective and a social activity which includes interactions among various actors. Actors use innovation networks in order to search external knowledge and resources that could be complementary with their activities, increase the acquisition and accumulation of new knowledge and perceive new opportunities. Indeed, in the way of exploring innovation, actors learn from each other to complement their knowledge through working within teams, communities and organizational contexts which could be represented as networks. Through several interactions within these networks inventors develop their creativity, scientific knowledge and commercial knowledge to link their innovations with the market needs further.

Through their analysis with more than 500.000 patents Singh and Fleming (2010) inferred that patents that generate breakthroughs are more likely to have more than one inventors that are working in teams. Alongside the increment in the probability of breakthroughs, they found that working in teams rather than a lone inventor also reduces the possibility of poor outcomes.

Leonard and Sensiper (1998) deduces that innovation is substantially a social and communicative process. Accordingly, innovation networks have significant importance within innovation systems and this is not a recent phenomenon. There are several actors linked each other in these networks for the creation of innovation (Pinto et al. 2015). The actors of diverse and committed stakeholders committed for the purpose of creating something new, different and carries value through the relations and interactions among each other also generates new understandings, ideas, beliefs, conventions, routines and novelty (Corsaro et al., 2012). These heterogeneous group of actors consists of companies, universities, technology centers and development organizations (Pekkarinen & Harmaakorpi, 2006). According to Ozman (2017) innovation networks consist of networks of inventors, networks of financial sources, design and manufacturing companies, marketing and sales teams, suppliers, competitors, commercial and public research labs, professional and trade associations and also the users of innovation.

In a nutshell, the innovation creation internally alone is no more adequate as long as the knowledge becomes more complex. Innovation networks not only enable knowledge and expertise interchange, but also promote opportunistic behaviour. Also, innovation networks in the context of knowledge economy are seen as a fundamental strategy for competitiveness. These networks exist as a prerequisite for the dynamics of innovation systems. As the interaction, commitment and collaboration among actors in the network grows, the innovative performance of them also increases (Pinto et al., 2015).

2.2.3. Properties of Innovation Networks

Innovation networks could be defined as "a set of actors connected by a set of ties. The actors could be people, teams, organizations, concepts, etc." (Borgatti, 2003). Innovation networks play an essential role for coordinating innovation and R&D processes (OECD, 2001). Theoretically, scholars have classified different innovation network arrangements according to their properties. These properties are related to network structure and network connectivity. Virkkala et al. (2014) tabularize the network structure and connectivity as depicted in Table 3.

Table 3. Network structure and connectivity

		Connectivity	
		High	**Low**
Structure	**Centralised**	'Gangs' with leaders Several strong ties combined with holes	Hierarchical, segmented (silos) some strong ties, many gaps or holes
	Decentralised/ diverse	The strength of weak ties	Fragmented (no or insignificant networks)

The structure of innovation networks is divided into two as centralised and decentralised/diverse networks whereas the connectivity of innovation networks is classified as high and low connectivity innovation networks.

Centralised (concentrated or segmented) networks have a distinct core dominating the entry of the peripheral members and behave like a strong source on knowledge sharing (Valerba & Vonortas 2009). In other words, there exists a complete centralised control over all actors (Yoo et al., 2008). These networks could be regarded as well-defined, stable and predictable as well as their activities are managed by a centralised hierarchic structure. Centralised network structures accelerates the communication and knowledge transfer and knowledge diffusion and urges to higher innovation levels. Nevertheless, strongly centralised networks have the risk of becoming disrupted and the knowledge diffusion among the central actors may be hindered (Teichert, 2012). An example of centralised innovation

networks could be a single company which takes part in top-down innovation initiatives (Yoo et al., 2008).

A centralised network structure with a low level of connectivity is a hierarchic organization with top-down coordination. Network relations which are rather weak have many gaps and holes. This kind of model has the risk of working of actors for the same topic without knowing each other. Besides, a centralised network structure with a high level of interaction, which is also a hierarchic organization, has many strong interactions among actors. However, the interaction of actors with the environment are rather weak and shows up as holes and gaps. This model of innovation networks acts like a "gang" with specified leaders in certain positions. Gangs might be productive and competitive to a certain extent. However, there might also be lock-ins that cause not to research and discover new directions in these gangs (Virkkala et al., 2014).

Decentralised (diverse or dispersed) networks, on the other hand, lack the central actor that acts as a knowledge broker. For this reason, overlapping structures are crucial mechanisms in order to build a strong network identity (De Man, 2008). Decentralization also induces a power delegation to down, reaching the regular employees who undertake innovation decisions. This situation causes a driving force for the rapid development of companies. In the meantime, the company should put more emphasis on the development of employees from many aspects. These includes educating and training employees, instilling ethical values to reach ethical standards, providing opportunity in making decisions and taking responsibility for these decisions. In turn, these new practices bring a different management perspective for the company in which regular employees may contribute to make important business decisions, arrange targets and a variable innovation strategy (Kralewski, 2012). An example of decentralised innovation networks could be open source community or a loosely coupled industry association working on a joint innovation project (Yoo et al., 2008).

A decentralised network structure with a high level of connectivity which consist of both strong and weak bonds is considered as an "ecology". This model of structure also has several combinations and recombinations. Finally, a decentralised network structure with a low level of connectivity has only weak bonds or almost no bonds and the network itself has a fragmented structure (Virkkala et al., 2014). In order to exchange knowledge and create innovations, networking organizations show a tendency to be close and act as complementary in cognitive and technological area (Virkkala et al., 2014). Accordingly, proximity coevolves with knowledge networks and as Padgett and Powell (2012) states "in the short run, actors create relations; in the long run, relations create actor". To examine the relations among the actors of innovation networks, different forms of proximity is also studied in the literature. Proximity is needed in some dimensions to support interaction and empower interactive learning and innovation among actors. The coevolutionary dynamics among knowledge networking and proximity are apprehended through the process of learning (cognitive proximity), integration (organizational proximity), decoupling (social proximity), institutionalization (institutional proximity) and agglomeration (geographical proximity) (Virkkala et al., 2014, Balland et al., 2015).

Cognitive proximity is generally defined as similarities of different actors in the way of perceiving, interpreting, understanding and evaluating the World (Knoben & Oerlemans, 2006). It attributes to the degree of convergence/overlap between the cognitive base (knowledge base) of various actors. A certain degree of cognitive proximity is necessary for actors in order to share and exchange knowledge, which has a tacit, idiosyncratic and cumulative nature, among each other (Virkkala et al., 2014, Ferru & Rallet, 2016). Without some convergence/overlap in knowledge bases, meaningful interactive relation is possible among the members of the organizations. Coherent communication codes and similar knowledge bases are necessary in order to communicate in an effective manner through the process of transferring and creating knowledge. As the members of the organizations interact,

exchange and produce knowledge, they reduce their cognitive distance over time and reach more similar knowledge bases. Therefore, the degree of similarity among knowledge bases of actors has a dynamic and continuously evolving process (Balland et al., 2015). Besides, as knowledge becomes more complex and innovation networks become prevalent through these cumulative learning processes, innovative actors progressively rely on each other to obtain specific knowledge and benefit from expertise of others (Argote et al., 2000).

Organizational proximity is defined as the opportunity and psychological obligation of people in various physical locations throughout the organization to communicate and engage each other and share an organizational affiliation in organizational practices through common rules, norms and routine of behaviour. Organizational practices contribute significantly in knowledge sharing. The way to handle problems collectively and having a common understanding of work procedures through sharing work experiences could be considered as examples of organizational practices. These kinds of practices also contribute to proper and effective coordination and communication at work. In organizations, the coworking experience in past projects cause the members to produce a common understanding and similar work practices regardless of members' diverse backgrounds and expertise. Moreover, building up a shared understanding over time through projects considerably lower the barrier of knowledge sharing among members of the organization no matter what the degree of extent between their cognitive levels (Criscuolo et al., 2010). Alongside, the increased willingness to share knowledge among people, the facilities to innovate also develop (Boschma, 2005). Besides, coordination is facilitated and transaction costs are decreased (Ferru & Rallet, 2016).

Social (relational) proximity is defined as the degree of common relationships which are socially embedded among people depending on the social cohesion around the relationship (Criscuolo et al., 2010). It plays a significant role in

knowledge spillovers (Virkkala et al., 2014). In innovation networks, social proximity handle the subject from the sociological perspective (Powell & Grodal, 2005) as the innovative performance of organizations is relevant to their tendency to build up bonds and relationships with similar organizations that have similar behaviours and network associates (Capone & Lazzeretti, 2015). This causes a new model of innovation network generation, the so-called "preferential attachment networks" in which new ties are prone to be formed more easily with already existing ties (Pyka & Scharnhorst, 2009). Investing time, energy and efforts require willingness and motivation for people to solve problems collaboratively and transmit complex knowledge to each other. Therefore, strong ties are advantageous in relationships among people (Cross & Sproull, 2004). The significance of social proximity in knowledge sharing could be explained through two main mechanisms: Transitivity and trust (Criscuolo et al., 2010). Transitivity of relations means that if actor A forms a tie with actor B and actor C separately, then a propensity exists to form a tie between actor B and actor C. In other words, when a common third party exists between two actors, a tendency to form a connection between these two actors through the common connection with the third party occurs (McCulloh et al., 2013). Having strong ties to common partners among colleagues have an impact as a motivational driver in relations. The second mechanism is in relation with trust. People who have a social proximity in their relations, are also presumedly trust each other, even if they do not have strong ties among themselves. Besides, individuals who knows each other very little or not a snap could develop trust for each other swiftly when both of them trust to a common friend (Criscuolo et al., 2010).

Institutional proximity is defined as the degree of similarity among the informal and formal rules, norms, codes, practices and incentives adopted by actors. The actors which have the same institutional form or context could be classified as research centres, cultural and public institutions, governmental institutes, small and large companies and academic organizations (Capone & Lazzeretti, 2015; Davids & Frenken, 2017). Institutional proximity contributes to the conditions for stability in

coordination mechanisms and attendantly, affects the level of knowledge transfer and interactive learning among actors. Having a common language, shared habits, formal and informal rules lays the foundation for the institutional coordination, knowledge transfer and interactive learning (Boschma, 2005). Nevertheless, institutional proximity may also cause some situations that also hinder collective learning and innovation. These situations include institutional lock-in and institutional inertia. Firstly, an institutional system may evolve into a condition of lock-in allowing no opportunities for newcomers and acting as a barrier to more sustainable innovations. Institutional systems are complex systems which embody mutually interdependent organizations having discrete structural positions in the system. In such a system, change may cause instability due to the disturbance of these positions (Hannan & Freeman, 1977). Powerful actors tend to resist to change in a routinised and conservative way. Because their acquired rights may be endangered or their obligations toward other actors in the system are affected (Herrigel, 1993). Consequently, the institutional lock-in does not let for far-reaching changes from the main direction (Zaleczna, 2014) and mostly there is no or a minor change takes place that do not annoy the functioning of the entire system. Secondly, too much institutional proximity may cause institutional inertia which may be defined as the resistance to change in groups to remain at the status quo. This situation could hamper the development of radical innovations which need new institutional structures and mechanisms. Consequently, institutional inertia may also lead to institutional rigidity (lock-in) which causes ultimate self-destruction of new institutional designs that are needed for the development of radical innovations. In fact, some institutional flexibility and malleability should be adopted in order to take a chance on new institutional building processes or preserve the possibility to adapt new institutions with the purpose of overcoming the creation of mismatch with the institutions and the reality (Boschma, 2005; Magone, 2017; Zaleczna, 2014).

Geographical (spatial) proximity is defined as the physical and functional distance between actors (Boschma, 2005). Statement of physical and functional distance refers not only the spatial vicinity of actors' physical locations but also transport infrastructures that facilitate accessibility and facilities that enable people to exploit certain communication technologies (Gallaud & Torre 2004). Geographical proximity facilitates knowledge transmission and spillovers, promote collaboration between local networks as actors prone to develop relationships with other actors from the same cluster and acts as a significant factor in competitiveness and innovation creation (Capone & Lazzeretti, 2015). Because effective learning needs face to face interaction and that interaction becomes easier to organize when actors are co-located. The knowledge embedded in the local environment could be disseminated spontaneously through personal contact and present in meetings (Virkkala et al., 2014). Indeed, this dimension of proximity favours and accelerates the processes of explicit knowledge exchange as well as tacit knowledge acquisition. Consequently, these processes lead to the generation of unique local competences, skills and tacit knowledge among actors which are in the same geographic region (Virkkala et al., 2014; Capone & Lazzeretti, 2015). Herein, Giuliani (2007) points out that knowledge networks within clusters are distributed unevenly and selectively emphasizing that geographical proximity is neither a sufficient or a necessary condition for knowledge exchange among actors. Nevertheless, there is also a positive correlation between geographical and non-geographical forms of proximity, indicating that geographical proximity positively affects building up other forms of proximity spontaneously. Worth mentioning, the tendency of actors' decisions are driven by the knowledge and innovation networking in order to satisfy geographical proximity with the current or possible network partners involved. For instance, companies locate their R&D laboratories close by the relevant research universities whereas locate their business service providers somewhere in the region of major clients. The process of growing and developing knowledge and innovation networks cause agglomeration in a local region and these localised networks act as a magnet over time. Furthermore, as

enhancing attractive forces to the magnet increases with rising benefits of the agglomeration, a strong inertia also formed simultaneously because of the limited space in that localised network region (Balland et al., 2015).

The network relations among different actors are shaped by different dimensions of proximity and the definitions of these five dimensions are explained above. To sum up, Davids & Frenken (2017) tabularize the operationalizations of these proximity dimensions as in Table 4.

Table 4. Operationalization of proximity dimensions

	High	Low
Cognitive Proximity	Similar Knowledge	Different Knowledge
Organisational Proximity	Intra-organisational	Inter-organisational
Social Proximity	Friendship, family ties or earlier collaboration	Absence of friendships, family ties and earlier collaboration
Institutional Proximity	Co-location in same social subsystem (academia, industry, government) or same territory	Location in different social subsystems or territories
Geographical Proximity	Less than 25 km distance	More than 25 km distance

Source: Davids & Frenken (2017)

2.3. Helix Innovation Models

National innovation systems consist of some evolutionary models with structures and dynamics at various levels. In order to constitute an analytical framework to national innovation systems, several researchers and scholars have studied and analyzed these models from many different perspectives (Yoda & Kuwashima, 2019). These underlying models in the national innovation systems includes triple helix, quadruple helix and quintuple helix models which are the so called “helices models”.

2.3.1. Triple Helix Model

In triple helix model, the main carriers of the model are university, industry and government. The triple helix theory explains national and/or regional economic

development policies, innovation policies, strategies of knowledge transfer and attempts to cope with financial crisis (Galvao et al., 2019). It focuses on innovation and knowledge production in the economy. Therefore, the model is compatible with the knowledge economy (Carayannis et al., 2012).

The concept of triple helix model is first introduced in 1990s by Etzkowitz and Leydesdorff professing a shift from a dyadic relationship of government and industry in industrial society to triadic relationship of university, industry and government in knowledge society (Ranga & Etzkowitz, 2013).

Triple helix innovation systems could work in different political environments such as democratic or non-democratic political regimes (Carayannis & Campbell, 2015). In addition, triple helix is a universal model of development and forms innovative regions in both statist and laissez faire societies.

In point of fact, there are three regimes which have different contextual conditions naming as statist, laissez faire and balanced regimes. The main roles and functions of the spheres also differ according to these regimes through the knowledge and innovation production and exchange processes. The major triad of institutional spheres interlink in different ways and triple helix model comes to existence with different variants (Etzkowitz & Leydersdorff, 2000).

In a statist regime, the role of government is overwhelmingly dominant with respect to industry and university. Therefore, the government sphere encompasses industry and university as shown in Figure 2.

In statist (etatist) regimes, bureaucratic organizations tend to take initiatives from the top level hierarchically. The ideas originated from below levels are often blocked and relatively confined. Lateral informal relations between spheres could overrule the hierarchic procedures to a limited extent (Etzkowitz, 2008).

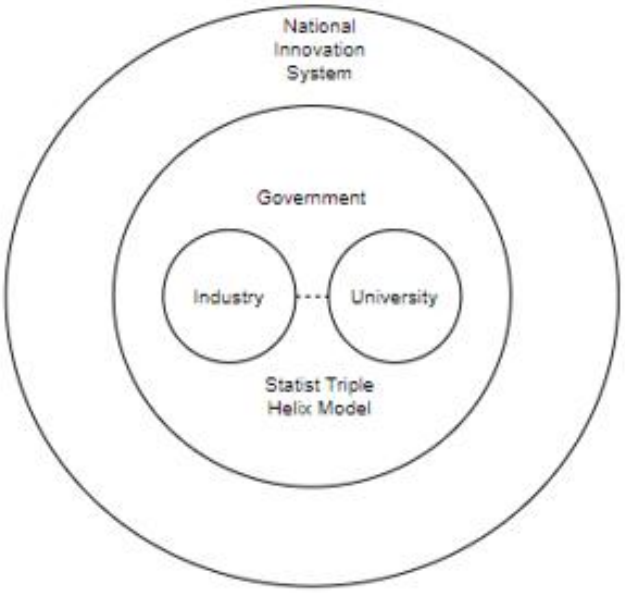

Figure 2. Statist Triple Helix Model
Source: Design by author

In statist triple helix model (Triple Helix I), government takes the coordinating role and drives academia and industry which are rather weak institutional spheres needing the guidance and/or control of the government. In other words, the entire functioning of this model depends on top-down control of university and industry by the state (Varblane et al., 2008). Government is responsible for leading the projects, allocating resources for the projects' initiave and progression and also supervising the projects' process in order to create new technological industries such as aircraft, computers and electronics (Etzkowitz, 2008). However, this dominant role of government to drive university and industry could also limit these actors' capacity to trigger and enhance innovative transformations (Virkkala et al., 2014). University, on the other hand, is mainly responsible for teaching and academic research. There is little or no incentives for the universities in order to engage their research findings with the commercialization activities. Therefore, the potential of the industry to utilize the knowledge produced in universities is limited (Sarpong et al., 2017).

In times of national emergency, the countries may reorganize themselves according to statist basis accompanied by the raise of the role of the government. For instance, US accommodated university and industry under the service of the state during the two world wars. In effect, the US military economy works under the context of statist model, hierarchically governed and coordinated by the state, with supplying university and industry substantial roles. Varblane et al. (2008) argues that many innovations were investigated largely in the areas that serves the interests of the state like military and aerospace fields. Etzkowitz (2008) exemplifies this argument as follows: while developing atomic bomb in Manhattan Project during World War II, scientific and industrial sources in certain locations are directed specifically under military control. As a matter of fact, countries that have laissez faire regime also take action like in Manhattan Project example, to solve certain problems like cancer and poverty. In fact, statist triple helix model with a good leadership, a clear target and undertaking of the necessary resources could offer great results in large scale and critical projects of a country (Etzkowitz, 2008).

In a laissez faire regime, the main emphasis is on the productive force of industry. Even though the primary sphere that drives the social and economic development is industry, the interaction between university, industry and government is limited as shown in Figure 3.

In laissez faire regimes, government intervention is limited in the economy. The actors of the economy work through the natural laws and rules of the world following their own interests in a free market and free economic competition which constitute a natural order (Keynes, 1972). The main characteristics of the laissez faire society is distinctive roles of spheres, discrete boundaries without close connections and companies as the focus of the economic activity (Etzkowitz, 2008). The spheres interact modestly through strong borders dividing them (Varblane et al., 2008). This regime is mainly characterized by intense specialization and work centralization, restricted mobility of workers, rigid and inertial boundaries between

spheres and limited and rare interaction with other spheres (Ranga & Etzkowitz, 2013).

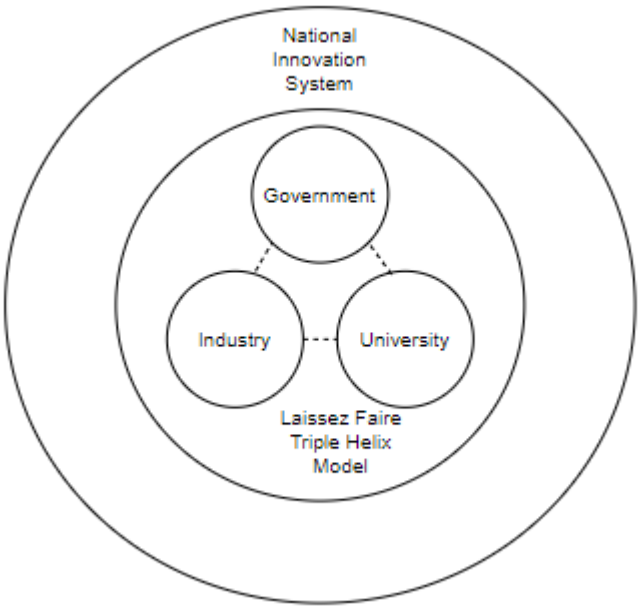

Figure 3. Laissez Faire Triple Helix Model
Source: Design by author

In laissez faire triple helix model (Triple Helix II), universities act as the main provider of skilled and trained graduates and governments act as a main regulator of the social and economic mechanisms. University and government are also considered as ancillary support structures of the industry (Ranga & Etzkowitz, 2013). The universities conduct basic research, produce knowledge by publishing scientific papers and educate and graduate people with tacit knowledge. Industry, on the other hand, seeks and tries to reach the required knowledge from the sources of universities on its own. The relationships of industry with university also tend to exist at a distance. Government become involved in activities which the industry does not take part. Moreover, government's participation in harnessing innovation activities takes place mostly in the cases of market failure (Sarpong et al., 2017).

For example, governments may supply funds to universities in order to promote research and buy products in the case of a market failure. Government also has a limited regulatory role in social and economic mechanisms and the function for sale. By the same token, industry are exposed to antitrust rules to some degree in order not to form cartels and set the price of the products. Therefore, companies are discouraged from cooperating and collaborating with each other by law. Rather, they are encouraged to operate independently from each other. Moreover, companies are expected to compete with each other for many areas including R&D and product development (Etzkowitz, 2008). In this type of triple helix model, competition is seen as the key concept whereas collaboration is considered as a threat for the success of companies (Varblane et al., 2008). Further, Sarpong et al. (2017) asserts that there is a lack of synergy between the relations of the institutional spheres in this model.

In 1970s, however, as the global industrial competition evolved, the antitrust rules loosened to a degree through giving companies permission for joint R&D and product development in US. According to the conditions of peacetime, companies was encouraged to cooperate, collaborate and form strategic alliances with other companies (Etzkowitz, 2008). The transition from discrete to overlapping institutional spheres had started to take place in the way of forming a more balanced model in time (Ranga & Etzkowitz, 2013).

In a balanced regime, university's (and also other knowledge institutions') role becomes more prominent as opposed to antecedent two regimes. As depicted in figure 4, the converging institutional spheres of university, industry and government have overlapping regions which are considered as the best environments for innovation (Ranga & Etzkowitz, 2013).

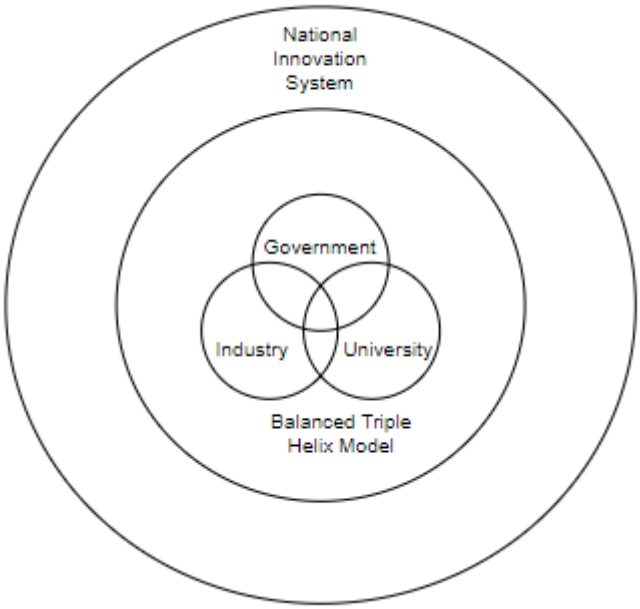

Figure 4. Balanced Triple Helix Model
Source: Design by author

In balanced regimes, each sphere's independence is sustained while catalyzing interaction between the spheres (Etzkowitz, 2008). The emergence of a balanced regime takes place in the way of the creation of the knowledge society. The transition from industrial to knowledge society is characterized by augmenting communication and interconnection among people and institutions, increased mobility of workers and financial capital and delocalization/globalization of production sites and labour. In this regime, the interaction among spheres could also constitute new forms and venues where creative synergies develop (Etzkowitz & Leydersdorff, 2000). Attendantly, hybrid (multi-sphere) institutions which act like bridge builders between university, industry and government, emerge at the intersections of the institutional spheres in order to create a more flexible overlapping system (Etzkowitz, 2002; Ranga & Etzkowitz, 2013; Virkkala et al., 2014). These hybrid institutions carry multiple characteristics of the three major helices in nature. Organizations are more in accord with the university includes

technology transfer offices and interdisciplinary research centers. Those are in accord with the industry could be listed as companies' research labs, business and technology incubators, science parks, start-up accelerators, industrial liaison offices, university-industry research consortia and private venture capital firms. Finally, those are in accord with the government consist of publicly funding research and innovation centers, government research laboratories and public venture capital firms (Cavallini et al., 2016; Mitra & Edmondson, 2015). The common objective of promoting these hybrid organizations in different organizational arrangements and functions is to actualize an innovative environment for knowledge based economic development (Etzkowitz & Leydersdorff, 2000).

In balanced (hybrid or interactive or ideal) triple helix model (Triple Helix III), the change does not remain limited with the interorganizational interactions. Also, transformations occur in intraorganizational interactions (Varga & Erdös, 2019). Under the balanced model, each institutional sphere preserves and enhances its traditional core competencies and distinct identities while taking also the role of others to some degree (Sarpong et al., 2017). From the university perspective, this means that university not only acts as a partner with government and industry but also takes the lead in order to constitute joint initiatives with these actors. In addition to their contribution on human capital flow by the regular circulation of students which brings new ideas continually and other conventional tasks, universities also begin to undertake a proactive role in academic entrepreneurial activities as an academic goal alongside their traditional teaching and research duties in the way of transforming into entrepreneurial university by encouraging the development of new academic startups, business incubators and spinoffs like a firm founder. This new role also has similar features with the traditional roles of industry and regulatory characteristics of the state (Etzkowitz, 2002; Etzkowitz, 2008). Government often promote an innovative environment consisting of the trilateral hybrid organizations and supply direct or indirect financial assistance in the manner

that acting like public venture capitalists by guaranteeing stable interactions and exhange through the contractual relations as the ultimate guarantor of the societal and economic "rules of the game". Government also encourages the engagement of universities into the innovation system and proposes incentives to universities to go beyond the traditional missions. Besides, government could hand on decision making to regional or local authorities or other organizations (Etzkowitz & Leydersdorff, 2000; Etzkowitz, 2008; Varga & Erdös, 2019). Industry, on the other hand, alongside its position as the primary source of productive activities, constitutes its own R&D facilities for endogenous innovation and supply training to workers, which is, of course, could be regarded as a traditional academic function. Companies also share knowledge and form lateral ties through joint ventures and strategic alliances (Etzkowitz, 2008; Ranga & Etzkowitz, 2011).

According to Sarpong et al. (2017) the balanced model is considered as a network in which innovation policy is a consequence of the interactions, collaborative relationships and liaisons among the three major institutional spheres and other hybrid institutions rather than the order from the government. Furthermore, direct links are constituted between university and industry to increase the capitalization of knowledge by promoting joint patents and start-up companies. In addition, the major actors of triple helix strengthen their national/international innovation networks continuously.

2.3.2. Quadruple Helix Model

Quadruple helix model is more comprehensive than triple helix model and covers triple helix as a core model. Moving beyond the triple helix model, this model includes civil society and explains also funding organizations as a fourth partner that are needed to support income growth and commercialization (Colapinto and Porlezza, 2012). According to Höglund and Linton (2018), the fourth helix should not be considered as a separate helix, rather the civil society including media and

culture surrounds the other three helices in a network of relationships as depicted in Figure 5.

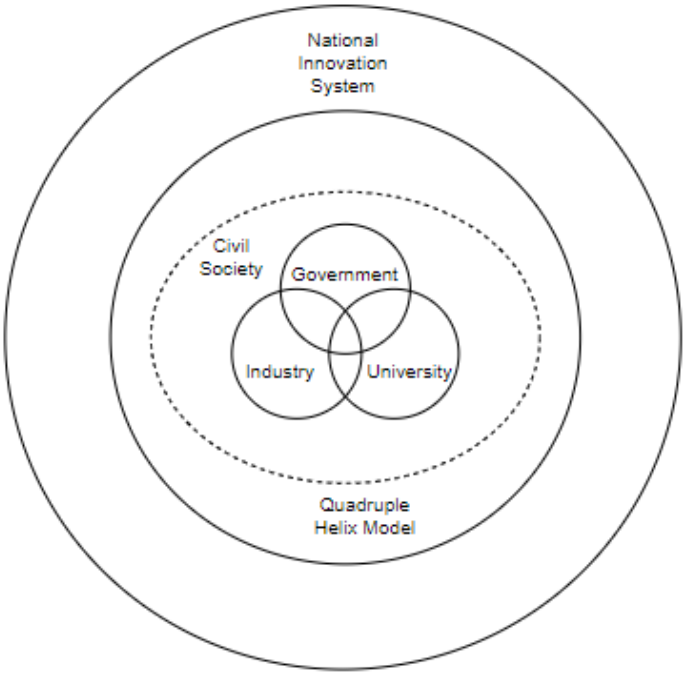

Figure 5. Quadruple Helix Model
Source: Design by author

Carayannis & Campbell (2012) state that the fourth helix is human centered and also associated with media, creative industries, culture, values, life styles and art. In this model, the sustainability of knowledge economy is needed to a coevolution with knowledge society. For this reason, the model places emphasis on knowledge society and knowledge democracy during its development process of knowledge and innovation. The involvement of civil society into innovation and knowledge production cycle could also be considered as a means for enhanced democracy in innovation processes.

Heng et al. (2012) assert that the fourth helix consists of NGOs (non-governmental organizations) and labour unions as organizations to represent different layers of

societies. These organizations consist of groups, associations, local and regional communities whose aim is to address environmental and social issues for the concerns of society. Nevertheless, these organizations should be constituted in a formalized structure and their establishment should be recognized by the government. They act as the voice of civil society and establish supportive links that build bridges among university, industry and government within the society. Kimatu (2016) also discusses that the necessity of a strong civil society and evolution of changes accompanied with the introduction of civil society in the triple helix transformed triple helix model into quadruple helix model. Civil society could contribute to development processes to become more human-sensitive within the cultural context of society. Similarly, Grundel & Dahlström (2016) argue that the inclusion of civil society in innovation policies could lead to a larger societal transformation and a shift towards a bottom-up perspective.

In quadruple helix model, the role of the public is considered very substantial in order to achieve the knowledge and innovation policies and strategies successfully. The public is influenced by media, culture and values. In this manner, the fourth helix of civil society could be restated as media-based and culture-based public. The objectives and rationales of innovation policies should presented to the public by means of the media for seeking legitimation and justification. For example, media express a key role as a means through the PR (public relation) strategies of companies/institutions which construct their policies along R&D (research and development), S&T (science and technology) and innovation. Further, if we consider culture-based public, the impact of cultural artefacts on public is also very important. For instance, as cultural artefacts, movies could influence the public sense towards supporting public R&D investment. Moreover, from the gender perspective, the increasing number of women enrolling to university programs related to technical and engineering fields also changes the social images of technology in public. Therefore, by implementing the innovation policies and strategies successfully, level of consciousness, culture and values of public changes

through the development and evolution of innovation cultures which leads to the creation of a knowledge society (Carayannis et al. 2009).

Fourth helix also consists of arts, arts based research (knowledge production) and arts based innovation (knowledge application) which provide opportunities for developing interdisciplinary and transdisciplinary configurations of the outputs of science based research and promote creativity for the processes of knowledge production and innovation. Thus, it facilitates design. Creativity is also considered as a significant factor to sustain viability of innovations in the long term (Carayannis & Campbell, 2014).

In addition to the knowledge society, fourth helix of quadruple helix model also focuses on the knowledge democracy which coevolves with the knowledge society and knowledge economy. Democracy is literally defined as "the rule by the people" implying that the decisions are carried out by the majority of people. Carayannis et al. (2009) argues that knowledge, innovation and democracy have mutual dependencies. Bridging democracy with knowledge and innovation depends on the application of knowledge based and innovation based democratic polity. Put it differently, further evolution of the quality of democracy, which has four basic dimensions as freedom, equality, control and sustainable development, nurtures the innovation system. Likewise, the development and evolution of knowledge and innovation base and society's rate of increase of the access to these bases raises the quality of democracy. Therefore, the interaction between the quality of democracy and the innovation system mutually coevolves in an amplifying mode and manner (Carayannis et al., 2015).

2.3.3. Quintuple Helix Model

The theoretical concept and construction of quintuple helix are not matured enough in the literature. However, some researchers build a conceptual framework for this model without empirical validation (Sudiana et al., 2020).

The quintuple (penta) helix theory is more indepth and comprehensive than quadruple helix theory. It adds as a fifth element 'natural environments of society' as depicted in Figure 6. It explains the necessary socioecological evolution of economies and societies. In this model, the main drivers for knowledge production and innovation are the natural environments of society and economy. Therefore, it is considered as an ecologically sensitive model. The model provides transdisciplinary and interdisciplinary analysis of sustainable development and social ecology and it supports cooperation system of knowledge, know-how and innovation in order to overcome the sustainability challenge (Carayannis et al., 2012). This environmental context of society and economy also codevelop and coevolve with the knowledge democracy (Carayannis & Campbell, 2014).

Ecological issues and challenges like global warming, climate change, acid rain, air/water/agricultural pollution, ozone layer depletion, deforestation, urban sprawl and many more are considered as major subjects for the survival of humanity in a global context. A greater sociecological transition starts with activating initiatives towards sustainability step by step and consequently leads to the emergence of long term and leading knowledge societies. Living in balance with nature also brings a new quality of life, increases the value of the society and perhaps leads to a green economic wonder (Carayannis et al., 2012).

Social ecology is a highly dynamic interdisciplinary research field that have the main axioms as society and natural environment interact, codevelop and coevolve with causality directing to both aspects. It bonds the knowledge, innovation and the environment with a conceptual approach that integrates historical and current development processes and future sustainability transitions (Fischer-Kowalski, 2015). Two interrelated concepts that have a mutual relationship provide solutions in order to tackle social ecology challenges and problems: eco-innovation and eco-entrepreneurship (Rodriguez-Garcia et al., 2019) within the framework of quintuple helix (Carayannis & Campbell, 2010). Eco-innovation is any innovation that have

fewer negative effects on sustainable development than the use of relevant alternatives. Through the production phases of eco-innovation, environment friendly processes are carried out by using fewer sources, less toxic material, polluting less through various processes and not relying upon the consumption of fossil fuels (Kemp, 2011). Eco-entrepreneurship (ecopreneurship) is defined as discovering the gaps in the market and exploring new business opportunities considering to protect the environment in order to reach environmental sustainability (McEwen, 2013). The term could be briefly explained as "entrepreneurship through an environmental lens" (Chopra, 2014).

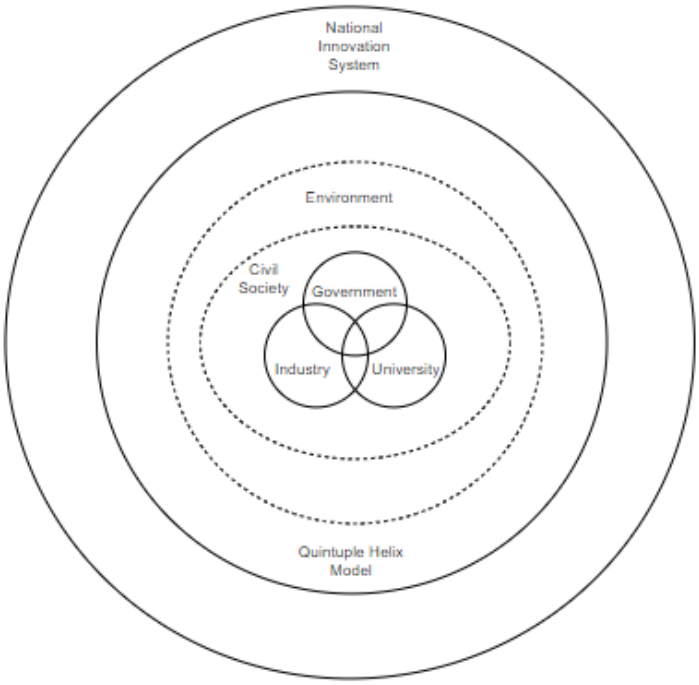

Figure 6. Quintuple Helix Model
Source: Design by author

The quintuple helix innovation model promotes the creation of win-win solutions between ecologists, science and innovation. It also creates synergy among economic growth, development of society and democracy (Carayannis et al., 2010). Formulation of long term innovative strategies and policies are affected by the

invention and understanding the importance of new green technologies and innovative processes as an irreplaceable source to satisfy sustainable development (Provenzano et al., 2016).

Helix innovation models within the framework of national innovation systems are explained conceptually above. To sum up, the main features of these three helices are tabularized as in Table 5.

Table 5. Helix Innovation Models

Innovation Models	**Characteristics**
Triple Helix Model	Knowledge Economy
	University-Industry-Government
Quadruple Helix Model	Knowledge Society & Knowledge Democracy
	University-Industry-Government-Civil Society
	The fourth helix associated with media, creative industries, culture, values, life styles, art, NGOs and labour unions
	Coevolution of knowledge economy with knowledge society
Quintuple Helix Model	Socio-ecological Transition
	University-Industry-Government-Civil Society-Natural Environment
	The fifth helix associated with the natural environments of society
	Transdisciplinary (interdisciplinary) analysis of sustainable development and social ecology

Source: Developed and adapted from Carayannis et al., (2012) and Heng et al. (2012)

2.4. Discussion on the Triple Helix Model of RWTC

In the light of the literature review, Rotary Wing Technology Center could be evaluated in terms of triple helix model in different regimes. In this part, with the examination of the main roles and functions of the institutional spheres which forms RWTC model, characteristics of the current RWTC model will be analyzed briefly and which triple helix model it is closer to; statist, laissez faire or balanced triple helix models will be examined. Also, how the current model can evolve into the ideal triple helix model will be discussed.

According to the statements of the literature review, RWTC model has features mostly from statist and balanced triple helix models. The features of RWTC according to different triple helix models in accord with the literature review are given below:

For Statist Triple Helix Model:

Literature Review: Government is responsible for leading the projects, allocating resources for the projects' initiave and progression and also supervising the projects' process in order to create new technological industries such as aircraft, computers and electronics.

RWTC Model: In RWTC, the government is the main responsible for providing financial resources. RWTC model is designed for the purpose of supporting the rotorcraft industry with specialized and trained human resources and ensuring the acquisition of future rotorcraft technologies through R&D in Turkey. In addition to financial support, the government acts as a mechanism that approves the initiation of RWTC projects, monitors project processes and provides feedback when necessary.

Literature Review: Many innovations were investigated largely in the areas that serves the interests of the state like military and aerospace fields.

RWTC Model: RWTC model is designed as a specialized model in the field of rotary wing technologies, which is a subject of the defense and aviation industry.

For Balanced Triple Helix Model:

Literature Review: Hybrid (multi-sphere) institutions which act like bridge builders between university, industry and government, emerge at the intersections of the institutional spheres in order to create a more flexible overlapping system. These hybrid institutions carry multiple characteristics of the three major helices in

nature. Organizations are more in accord with the university includes technology transfer offices and interdisciplinary research centers.

RWTC Model: RWTC activities are carried out under Özgün Helicopter Program contract. Within the scope of RWTC projects, sub-contracts are signed between TAI and universities / SMEs and submitted for the approval of SSB. Contracts with universities can also be made with university technology transfer offices, which is an intermediate mechanism.

Literature Review: Each institutional sphere preserves and enhances its traditional core competencies and distinct identities while taking also the role of others to some degree. From the university perspective, this means that university not only acts as a partner with government and industry but also takes the lead in order to constitute joint initiatives with these actors. In addition to their contribution on human capital flow by the regular circulation of students which brings new ideas continually and other conventional tasks, universities also begin to undertake a proactive role in academic entrepreneurial activities as an academic goal alongside their traditional teaching and research duties in the way of transforming into entrepreneurial university by encouraging the development of new academic startups, business incubators and spinoffs like a firm founder.

RWTC Model: In RWTC model, the tasks of the university are designed to carry out R&D projects in helicopter technologies and to carry out the thesis of master and doctoral students in accordance with these projects. Besides universities, SMEs are also involved in RWTC projects. Among these SMEs, there are also academic SMEs or SMEs established by young entrepreneurs who graduated from university.

Literature Review: Industry, alongside its position as the primary source of productive activities, constitutes its own R&D facilities for endogenous innovation

and supply training to workers, which is, of course, could be regarded as a traditional academic function.

RWTC Model: In RWTC model, researchers have the opportunity to enter TAI Academy's lectures on the subjects they need in the project. Sometimes RWTC researchers work with the engineers at TAI for a few days and exchange information.

According to the literature review , it is inferred that RWTC model carries the characteristics of statist and balanced triple helix models more. However, in RWTC model, new methods can be searched and applied in case the current conditions and practices are insufficient. RWTC has been built in such a flexible structure. In this context, in order to adapt to changing conditions and the needs of the time, solutions are produced by taking into account the establishment purpose and obligations of RWTC. Eventually, the triple helix structure of the RWTC model will develop over time and approach the ideal structure to the extent that:

1. Identifying all the identified deficiencies and problems by the people involved in each actor of the triple helix and presenting them to the top managers with solution suggestions
2. Consideration of these solution suggestions while making decisions by decision makers

2.5. Concluding Remarks on the Literature Review

The literature review presented in this thesis attempts to investigate and explain the main dynamics, characteristics and evolution of university-industry-government collaboration and also the evolution of the related concepts affecting or contributing to this collaboration over time.

In the first part of the literature review, the concept of R&D process is analyzed since R&D plays a major role and considered as the main pillar for the construction of knowledge base of innovation systems through the interactions of university, industry and government relations. The necessity of R&D is explained as through its benefits and positive returns in order to give the reasons of investing in R&D. Then, the management of R&D is elucidated by examining six generations of R&D management named as technology push, market pull, coupling, integrated, network and open R&D models. These generations of R&D management and activities have different characteristics and bring competitive advantages as well as challenges to companies. Therefore, to develop an understanding on the evolution of R&D management is critical for a company to develop policies and take actions for effective R&D management. Lastly, commercialization of R&D is reviewed as it is crucial to channel and transfer of R&D technologies to the necessary areas in industry and business community.

In the second part of the literature review, innovation systems which has a substantial role in the creation process of innovation which encompasses the stages from R&D to commercialization are explained. Firstly, national innovation systems, the main focus of which is the enhancement of the innovative performance and the economic competitiveness of a country are represented. Secondly, innovation networks which include several interactions among various actors and play an essential role for coordinating innovation and R&D processes are explained and their importance for the creation of innovation is clarified. Finally, properties of innovation networks are elaborated in terms of network structure and network connectivity and also the relations among the actors of innovation networks are examined through different forms of proximity as cognitive, organizational, social, institutional and geographical proximity.

In the last part of the literature review, helix innovation models inside the national innovation systems are elaborated. These models are key drivers of R&D and

innovation studies in economies based on knowledge. Firstly, triple helix model are introduced and its forms in different regimes (Statist, laissez faire and balanced regimes) are identified. Then, a more comprehensive model which includes civil society as the fourth helix are explained. In this model, knowledge democracy coevolves with knowledge society and knowledge economy. Finally, quintuple helix model where fifth helix represents the natural environment are explained. This model offers a broader framework than quadruple helix model and aims to satisfy sustainable development as well as knowledge democracy.

To conclude, in the global competitive environment, sustainable economic growth of a country is based on R&D and innovative activities because new technologies and high value-added products emerge through the endeavor of these activities. Increasing investments in R&D area, improving the level of education of the work force, developing policies for effective R&D management and commercialization, understanding the dynamics of innovation networks and developing strategies to constitute these networks in the forms of helix models accelerates the development of both public and private sectors and in turn, improves the living standards of the society. Overall, R&D and innovation processes exist in complex frameworks which includes several actors, roles, dynamics and characteristics and as these frameworks evolve, the quality and variety of outputs of these processes develop continuously contributing to the wealth of the nations.

The literature survey enable this study to understand and elaborate the theoretical foundations of the concepts related to R&D process, innovation systems and helix innovation models and their evolutionary developments. In order to design technology policies in the context of enhancing university-industry-government collaboration models, this dissertation uses the perspective of this evolutionary approach and tries to develop strategies considering these evolutionary dynamics comprehensively. This dissertation contributes to the literature offering policy recommendations in the light of the analysis of the information provided by all

participant groups of this case study as different than the studies found in the literature.

CHAPTER 3

AN OVERVIEW ON THE EVOLUTION OF TURKISH HELICOPTER INDUSTRY

This chapter explains the importance of technology roadmapping in technology strategy of a country and elucidates the necessity and development of the establishment of a rotorcraft industry by introducing major helicopter projects in line with the technological targets of Turkey in rotorcraft area.

Technological change occurs at an ever faster rate today, affect all other areas of our lives and shape the way the tomorrow's World work. Future-oriented technology analysis (FTA) is very important for policy and decision makers in order to be aware of the future opportunities and searching better approaches in today's uncertain environment. FTA also brings long-term vision for 10-15 years later for companies which decide on R&D priorities. The overlapping forms of future-oriented technology analyses includes foresight, forecasting, roadmapping, planning and assessment. (Yazan, 2016) According to Akkerman (2006), there exists neither general consensus of these terms nor an aggrement on their proper use, overlaps and boundaries. However, technology roadmapping could be defined as a flexible and powerful planning technique to identify, select and develop suitable emerging technologies on the purpose of meeting strategic and commercial goals. According to Garcia and Bray (1997), the major uses of technology roadmapping in technology strategy are;

- ✓ Technology roadmapping could help to build up a consensus on the needs and the technologies required to fulfill these needs
- ✓ Technology roadmapping could constitute a mechanism to help specialists to predict technology developments in focused areas.
- ✓ Technology roadmapping could provide a framework to coordinate and plan technology developments either in an organization or in entire industry.

The main benefits of technology roadmapping in technology strategy are;

- ✓ Technology roadmapping could help to identify technology gaps to be filled and critical technologies to be focused to meet strategic targets.
- ✓ Technology roadmapping could help to identify ways to enhance R&D investments by the way of coordinating R&D activities either in an organization or in entire industry.

The first Technology Acquisition Roadmap (TAR) is prepared to supply the necessary defence systems and platforms for Turkish Armed Forces with domestic facilities of the country in 2006. In this roadmap, it is aimed to address forward planning, implementation and follow-up activities in a strategic management approach in order to create a competent defence technology base focused on the needs of the Turkish Armed Forces. At the point reached today; In line with the modernization needs of the Turkish Armed Forces, in order to create and support the technology base required by domestic development projects; it is required to focus on the R&D projects that aim to develop the technology demonstration and product-oriented development in which the prioritized subsystem, components and technologies will be gained. In the context of TAR activities, 6 strategic aim was constituted. First, to establish the necessary technological infrastructure in line with the modernization needs of the Turkish Armed Forces. Second, within the framework of defence R&D activities, the establishment of a structure in which industry and university collaboration is provided effectively. Third, implementation of the Technology Acquisition Liability (Teknoloji Kazanım Yükümlülüğü) within

the scope of each procurement project. Fourth, guiding R&D and technology acquisition activities on a sectoral basis. Fifth, monitoring R&D and technology activities through relevant international organizations. At last, creating programs and supporting competitions to support innovation in the defence industry. Within the framework of these strategic objectives, the Technology Acquisition Roadmap will open the way for the development of defence systems and platforms, which are planned to be procured based on the needs of the Turkish Armed Force's Ten-Year Procurement

The Ten Year Procurement Program (OYTEP-On Yıllık Tedarik Programı) will provide the subsystem/component/technology acquisition determined primarily for the procurement of the necessary technological infrastructure.[2]

Technology Acquisition Roadmap has been prepared based on the technology base needed by the systems to be procured under OYTEP.[2] In the context of TAR activities, the major platform projects in helicopter area are also started.

The importance of helicopters are arisen from the advantages they have in comparison with the airplanes. Indeed, helicopters could do many things that airplanes could not. Therefore, these whirlybirds are often used for various missions specifically. First, they could move up and down in a straight way. By this ability, they could rescue people from hard-to-reach places like oceans or mountains or they can easily approach near to or at hospitals or congested areas during search and rescue or medical operations. Because they could take off and land while there isn't a runway. They could easily take off and land in spots in a forest, in the snow, in the sea or on the top of a building. Second, they could hover or fly at low speed in the air. This ability has critical importance also in search and rescue, medical operations as well as safety and surveillance operations. Third, they could flip

[2] Teknoloji Yönetim Stratejisi, 2011-2016, Savunma Sanayii Müsteşarlığı, p.26

within the air in ways that airplanes could not like moving sideways or backwards. These abilities could also give the pilot the chance to move in a flexible way in many operations and emergencies like moving through precision-extinguish fires. Fourth, they could fly at super low altitudes. Therefore, they could fly in between skyscrapers in urban areas. Indeed, helicopters have an important place in solving urban transportation problems that increase with the growth of cities. And last, they could autorotate in ground safely in case of an engine failure.

In terms of usage, Turkish Armed Forces has one of the most largest helicopter fleets in the World. In terms of number of military helicopters, Turkey is located in eighth place with almost 500 military helicopters behind the US, Russia, China, South Korea, India, Japan and France as shown in Table 6.

Table 6. World Helicopter Fleet Strength by Country, 2020

Ranking	Country	Number of Military Helicopters
1	USA	5768
2	Russia	1522
3	China	911
4	South Korea	803
5	India	722
6	Japan	637
7	France	589
8	Turkey	497
9	Italy	439
10	Germany	386

Source: Developed and adapted from https://www.globalfirepower.com/aircraft-helicopters-total.asp

In civilian helicopter arena, on the other hand, Turkey is in tenth place across Europe (shown in Table 7) and it is expected that there will be an increase in civilian helicopter usage of both Turkish Armed Forces and other public institutions and organizations.

Table 7. Number of registered Civil Helicopters in Europe, 2012

Ranking	Country	Number of Civil Helicopters
1	United Kingdom	426
2	Germany	220
3	Spain	198
4	Italy	153
5	France	132
6	Norway	95
7	Switzerland	66
8	Austria	59
9	Poland	44
10	Turkey	42
11	Portugal	33
12	Netherlands	33

Source: Developed and adapted from https://www.statista.com/statistics/487241/number-of-helicopters-in-europe-by-country-ifr-fleet/

Turkey has a geographical structure containing high mountains and hillsides and climate conditions reaching high temperatures. For this reason, the rotary wing air vehicles which have the necessary performance and maneuverability capabilities in addition to their vertical take-off and landing capabilities, possess strategic

importance in the geographical and climatic conditions of Turkey. According to Yazan (2014), rotary wing technology systems could also support a wide range of combat operations including search and rescue, carrying out troops and equipments, armed escort, executive transport, electronic warfare, air-to-air capability, area target capability and anti-armor capability with their main military functions. In civil range, the rotary wing technology systems is used for commercial air transport, public services, firefighting, emergency medical services and offshore energy.
Considering that similar conditions and needs apply to other countries in the nearby geography; Turkey's helicopter industry has a chance to become an important actor not only in domestic market but also in regional and international markets. As a matter of fact, helicopter technologies have the capacity to create competition, cooperation and dependency power worldwide and these technologies require an advanced industrial and technology infrastructure.

In the World early helicopter development was carried out by the United States, Germany, France, England, Italy and Spain through the years from 1900 to 1940 (Sheil, 1984). In Turkey, the helicopter industry was finally born when major helicopter platform projects begun. Throughout activities of RWTC consisting of conferences, workshops, scientific study groups, project review meetings and educations, it is aimed to support these projects in terms of human resources with the people raised with an expertise in certain helicopter technologies through RWTC as shown in figure 7.

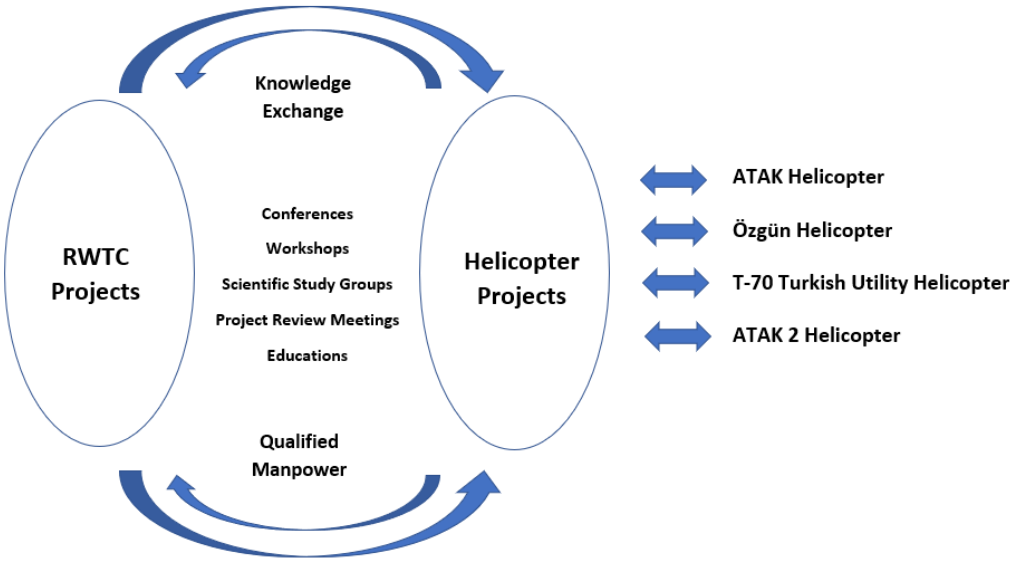

Figure 7. RWTC and Helicopter Projects Working Model

3.1. ATAK Helicopter

In helicopter area, the nationalization studies were started with T129 ATAK (Advanced Attack and Tactical Reconnaissance Helicopter) program which was contracted on 07 September 2007. The helicopter is based on the AgustaWestland AW129 (A129 International) helicopter which was the latest variant of Agusta A129 Mangusta helicopter in Italian army at that time. It was developed by Turkish Aerospace Industries (TAI) in collaboration with AgustaWestland and Aselsan. TAI was the prime contractor and in charge of the final assembly of the helicopter. First maiden flight of T129 P1 prototype was achieved on 28 September 2009 at AgustaWestland's facility in Vergiate, Italy. This prototype was crashed during high altitude hover tests near Verbania in Northern Italy on 19 March 2010 because of the power loss in its tail rotor. First successful flight of the Turkish prototype took place in TAI's facilities in Ankara on 17 August 2011.[3,4]

[3] T129 Attack Helicopter, Turkey https://web.archive.org/web/20140512223219/http://www.army-technology.com/projects/t129-attack-helicopter/

[4] AW129 Multirole Combat Helicopter

The design features of T129 includes an alluminum alloy frame with a five bladed main rotor and two bladed tail rotor. It has a wheeled landing gear and two LHTECH CTS800-4A turboshaft engines equipped with FADEC (full authority digital engine control system) which controls all aspects of the helicopter's engine performance. The helicopter is designed to carry two crew members and 1200 kg weaponry payload such as anti-tank guided missiles, Stinger air-to-air missiles, 70 mm rockets and 70 mm guided rockets at four hard points. Moreover, a 20mm turreted three-barrel gun system is set on the nose turret and the helicopter is equipped with the FLIR (forward looking infrared) system Aselsan ASELFLIR-300T.[3,4]

Aselsan also developed and produced the mission computer, navigation, communication, targeting and electronic warfare systems. In addition, AgustaWestland integrated high performance new engines, AFCR (automatic flight control system) and air vehicle monitoring system. TAI was mainly responsible for production and integration processes of the helicopter.[5]

The first ATAK Helicopter, which was produced by TAI, was delivered on 22 April 2014 and production and delivery activities still continue.[6] The photos of T129 ATAK Helicopter are shown in figure 8.

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https://www.airforce-technology.com/projects/aw129-helicopter/

[5] ATAK (Turkish Attack and Reconnaissance Helicopter)
https://www.globalsecurity.org/military/world/europe/atak.htm

[6] TSK ilk Atak'ı teslim aldı
https://www.dunya.com/gundem/tsk-ilk-ataki-teslim-aldi-haberi-244771

Figure 8. T129 ATAK Helicopter[7]

3.2. ÖZGÜN Helicopter

The Indigeneous Helicopter Program, which was carried out with the aim of meeting the multirole utility helicopter needs of the Turkish Armed Forces and other authorities with a unique platform, was initiated by the Defence Industry Executive Committee (SSİK) decision held on 15 June 2010 and the program budget and schedule were agreed with SSİK on January 3, 2013.[8] With the acquisition of knowledge, experience and talents in ATAK program, T625 Indigenous Helicopter Program was contracted on 26 June 2013. TAI is the prime contractor working with other Turkish aerospace contractors in the T625 Turkish Light Utility Helicopter Project. GÖKBEY is the first Multirole Utility Helicopter developed and produced with domestic facilities and realized its first flight on September 6, 2018. First certification flight was achieved on 29 June 2019.[9]
The photos of GÖKBEY Helicopter are shown in figure 9.

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[7] T129 ATAK Galeri
https://www.tusas.com/urun/t129-atak

[8] GÖKBEY
https://www.tusas.com/urun/gokbey

[9] Gökbey helikopteri ilk sertifikasyon uçuşunu yaptı
https://www.aa.com.tr/tr/bilim-teknoloji/gokbey-helikopteri-ilk-sertifikasyon-ucusunu-yapti/1519149

Figure 9. GÖKBEY Helicopter[8]
(the left photo is illustrated and the right is the real helicopter)

Within the scope of Indigenous Helicopter Program, designs and productions of critical systems such as transmission, rotor system and landing gear, as well as aerostructures are designed from scratch in TAI and 4-axis dual redundant automatic flight control system is developed by ASELSAN.

The design features of T625 includes five bladed main rotor and four bladed tail rotor. It has retractable landing gears and two LHTECH CTS800-4AT turboshaft engines, equipped with FADEC.[8] The helicopter is designed to carry two crew members and additionally 10 passengers in low density configuration and 12 passengers in high density configuration.[10]

Studies regarding the certification of the Gökbey helicopter by SHGM (General Directorate of Civil Aviation) are continuing with the program and this process is planned to be followed by EASA (European Aviation Safety Authority) certification validation.

[10] Gökbey nedir? Gökbey helikopterinin özellikleri nelerdir?
http://www.hurriyet.com.tr/gundem/gokbey-nedir-gokbey-helikopterinin-ozellikleri-nedir-41049833

3.3. T-70 Turkish Utility Helicopter

On 21 February 2014, SSB (Presidency of Defence Industries) initiated a new program named T-70 Turkish Utility Helicopter Program with TAI as prime contractor and with other subcontractor companies; Sikorsky Aircraft Corp., ASELSAN, TEI and Alp Aviation to produce T-70 helicopters (Turkish variants of Sikorsky S-70i International Blackhawk Helicopter). A total number of 109 helicopters are aimed to be produced with a production model under licence and delivered to its users in Turkey. The helicopters are planned to be used both in military and civilian areas such as cargo, search and rescue, fire fighting, air ambulance and coastal security.[11,12]

Within the scope of the T-70 Turkish Utility Helicopter Program TAI's work scope includes manufacturing, final assembly operations, tests and integrated logistics support of all airframe structures and composite rotor blades. T700-TEI701D turboshaft engines are built under license of GE-General Electric by TEI-Turkish Engine Industries.[11,12]

Additionally, ASELSAN is responsible for developing and integrating avionics and also developing an enhanced digital cockpit known as Integrated Modular Avionics System (IMAS) in collaboration with Sikorsky Aircraft. Furthermore, Alp Aviation is in charge of production and assembly of gearbox, dynamic components and landing gears.[11,12]

The helicopter is going to be produced a number of 109 in Turkey for 10 years, based on International Blackhawk helicopter. The helicopter is expected to supply

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[11] T70-Turkish Utility Helicopter Program
https://www.tusas.com/en/product/t70-utility-helicopter-program

[12] Türk Genel Maksat Helikopter Programı (GMHP)
https://www.tei.com.tr/detay/turk-genel-maksat-helikopter-programi-gmhp3

the needs of various civil and military organizations in Turkey.[13]The photos of T70 Turkish Utility Helicopter are shown in figure 10.

Figure 10. T70 Turkish Utility Helicopter[14]

3.4. ATAK 2 Helicopter

Multirole Heavy Combat Helicopter (Ağır Sınıf Taarruz Helikopteri-ATAK 2) is contracted between SSB and TAI on 22 February 2019. The helicopter's transmission, rotor systems and landing gears are going to be designed domestically with the capabilities gained in T625 and ATAK programs. It has an increased payload capacity with respect to ATAK helicopter and aimed at performing its missions in harsh geographical and environmental conditions. The first ATAK 2 is planned to perform its first flight in early 2024 according to contract schedule.[15,16] The photo of ATAK 2 Helicopter are shown in figure 11.

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[13] T70 Genel Maksat Helikopter Projesi
http://www.millisavunma.com/t70-genel-maksat-elikopter-projesi/

[14] T70 Genel Maksat Helikopteri Programı
https://www.tusas.com/urun/t70-genel-maksat-helikopteri-programi

[15] Turkey launches Full-Scale Development of the ATAK-2 Attack Helicopter
https://www.defense-aerospace.com/articles-view/feature/5/200288/turkey-launches-full_scale-development-of-the-atak_2-attack-helicopter.html

[16] Multirole Heavy Combat Helicopter
https://www.tusas.com/en/product/Heavy%20Duty%20Attack%20Helicopter

Figure 11. ATAK 2 Helicopter[17]

3.5. Future Forecast for Turkish Helicopter Industry

With ATAK, Özgün Helicopter and T-70 Turkish Utility Helicopter Projects, domestic helicopter design, development, production, certification, testing capabilities, control of critical systems, system integration and international marketing competencies have been gained. ATAK 2 Project was also launched in order to make the competencies for helicopter design and production cost-effective, and to meet the ongoing helicopter needs of the TAF (Turkish Armed Forces) and other public users domestically. Within this framework, a competitive product family will be created in the international market.[15]

Turkish Helicopter Industry has reached an important level today in structural parts, body production and final assembly. In this context, the main objectives of the sector in the upcoming period are: 1) designing and manufacturing of pal, power transmission systems, avionics systems, engines, which are critical for helicopter technology 2) creating an infrastructure for all modifications that will be required during the lifetime of helicopters with domestic facilities.[18]

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[17] Ağır Sınıf Taarruz Helikopteri https://www.tusas.com/urun/A%C4%9F%C4%B1r%20S%C4%B1n%C4%B1f%20Taaruz%20Helikopteri

[18] Savunma Sanayii Sektörel Strateji Dokümanı 2018-2022

CHAPTER 4

METHODOLOGY

This chapter draws a framework for the research methodology of this thesis. Research design, research questions and the way data is collected, generated, analyzed and evaluated is explained respectively.

4.1. Research Design

In this research, the case study Turkish Rotary Wing Technology Center (RWTC) analysis are implemented by using both qualitative and quantitative research methods.

Case study research design which provides a comprehensive, intensive and holistic description and analysis of a case is used in the various disciplines of social sciences, This case may be a specific organization, region of a country, a certain event, process or study program etc. Conducting a case study provides detailed data from several perspectives of a specific case and these data may be collected through both qualitative and quantitative research methods. Qualitative research methods generally use information gathering techniques such as "observation, semistructured interview, unstructured interview and analysis of written documents". Quantitative research methods, on the other hand, have techniques such as "survey, questionnaire, structured observation, structured interview and experiment" (Ylikoski and Zahle, 2019). According to Stake (2005), case study is not a methodological preference, rather a preference of what to be studied and

explored. Several methods could be employed in order to study “the case”. Therefore, one could study the case analytically, holistically, hermeneutically or culturally etc. Mixed methods may also be used in order to understand the case from many perspectives like using both qualitative and quantitative methods.

The findings from qualitative and quantitative research methods are analyzed and used for designing policy implications to improve the existing model further in the seventh chapter. The research goals of this study are designated as in the following statements in the light of the information gained through literature survey.

Research Goals:

1. Identification of characteristics, mechanisms and dynamics of RWTC model
2. Identification of success factors and barriers for RWTC in the light of the research analysis
3. Developing suggestions on policy implications of this thematic technology center model which could also be adapted for other defence industry areas in Turkey

The main research questions of this study which are designed to achieve the research goals are given in the following statements.

Main Research Questions:

1. How does RWTC transfer the know-how generated in the universities to the industry?
2. How does RWTC contribute to creating skilled human resource needed in helicopter industry?
3. How does RWTC promote the sustainability processes in helicopter industry?

In a similar vein, supplementary research questions are also designed to understand the internal mechanisms and dynamics behind the main research questions in detail.

Supplementary Research Questions:

1. In order to make the university and the industry better understand each other, what are the gaps that need to be filled?
2. What are the ways to strengthen and improve the communicative relationships and synergies between the university, industry and government?
3. What improvements and supports should be provided to increase the participation and performance of academics and students in RWTC projects?

4.2. Research Method

An online multiple choice questionnaire/survey and semi-structured interviews were conducted in this thesis as data collection instruments. Both interview and survey questions are approved by METU Human Subjects Ethics Committee (Appendix A).

4.2.1. Interviews

Semi-structured interviews were constructed for the academics, state, company directors and experts that worked/ are working in RWTC projects. The interviews consists of comprehensive and in depth questions that in order to understand the characteristics, dynamics and operation mechanism of the RWTC from the perspective of triple helix model. These questions address the following topics:

1. Motivation of starting such a thematic technology center
2. Roles of each triple helix actor
3. Management issues

4. Project selection procedure
5. Project evaluation procedure
6. Intellectual propert rights issues
7. Periodic meetings to monitor the proceedings of the projects
8. Existence and dynamics of teamwork
9. Expectations of people at the onset of the projects
10. Challenges faced by people in each organization
11. Gaps needed to be filled to make people from both parties understand each other and improve their performance further
12. Future opportunities provided to researchers working/worked in RWTC projects
13. Advantages and disadvantages of RWTC model with respect to other triple helix models in foreign countries

The time allocated for each interview took around 1 to 1,5 hours. Most of interviews were conducted with a voice recorder and a few of them were written interviews. A total number of 11 semi-structured interviews were conducted between the period of May 2019 and May 2020. The interview questions are given in appendix C.

4.2.2. Questionnaire

The multiple choice questionnaire was constructed for the researchers that worked/ are working in RWTC projects. The questionnaire consists of both demographic questions and triple helix model-related questions.

The demographic questions were designed to determine the following characteristics of participating researchers:

1. Researchers' start date of working in RWTC project
2. Researchers' finish date of working in RWTC project

3. Whether researchers are working/worked in an institution/company or not while working in RWTC project
4. Researchers' position at the institution/company while working on RWTC project
5. Researchers' ongoing education while working on RWTC project
6. Whether there are any other researchers worked/working on their RWTC project
7. The number of students and academicians worked/working on their RWTC Project

The triple helix model-related questions were designed to investigate the following issues from the researchers' perspective:

1. The rationale of working in RWTC Project
2. Benefits of university-industry-government collaboration to researchers
3. Benefits of university-industry-government collaboration to companies
4. Benefits of university-industry-government collaboration to universities
5. Difficulties faced by university, industry and government while working together in RWTC model
6. Improvements that can be made to the RWTC model to encourage researchers and ensure their continuity in RWTC projects
7. Gaps that should be filled in the RWTC model to improve university-industry-government collaboration further

In order to evaluate the survey results easier, the questions were designed as close ended questions. The questionnaire was prepared on the online survey website "surveey.com" and sent the survey link via e-mail to around 70 researchers worked/are working on RWTC projects. A total number of 23 researchers replied the questionnaire between the period of March 2020 and April 2020.

4.3. Data Analysis

Data analysis is an analytic process of interpretation of data with applying various forms of logic to the research. Interpretation process consists of explanation of the findings, developing answers to questions, deduction of specific results and constitution of patterns in an analytical framework (Best and Khan, 2006). Data analysis process is an exploratory, complex and creative process which brings order, structure and meaning to the collected raw data (Marshall and Rossman, 1999).

Once the data is collected through interviews and survey, data analysis methods are applied to get meaningful insights from the mass of the collected data. There are several data analysis methods used in qualitative and quantitative research separately.

For qualitative research data analysis, convenience sampling is used. Convenience sampling is a subset of nonprobability sampling methods where the selections are not done randomly. Convenience sampling is defined as the technique in which the members of the target population are selected with respect to easiness of accessibility to contact with each person. The easiness of accessibility for participants depends on several criteria such as geographical proximity, time availability and willingness to attend to the research etc. Therefore, convenience samples are sometimes considered as “accidental samples”. Convenience sampling is a rather affordable and easy technique, accordingly it is used commonly in research. In addition, the main assumption considered when studying through convenience sampling technique is that supposing the target population as homogeneous (Etikan et al., 2016).

In order to manage and analyze qualitative data, the content analysis is used. Content analysis is a technique for dividing large amount of texts into smaller parts according to their contents by coding. Firstly, key ideas, priori and emerging issues

and recurring themes in the dataset are identified and codes/labels are assigned to these themes. Then, coding data are grouped together into categories that are related to each other through their content or context. As of this process a qualitative data analysis software called QDA Miner (Qualitative Data Analysis Miner) is used.

For quantitative research data analysis, descriptive statistics is used. Descriptive statistics is the discipline which transforms collected raw data into a form that describes the main features of an entire or a sample population in a study. In order to characterise data based on its properties, descriptive statistics use numerical methods and graphical tools. Numerical methods include measures of central tendency (mean, median and mode), measures of dispersion (range, variance, standard deviation and skew), measures of frequency (count, percent and frequency) and measures of association (chi-square and correlation). Graphical tools include histograms, scatter plots and sociograms etc. As of this process a quantitative data analysis software called SPSS Statistics software is used.

CHAPTER 5

QUALITATIVE STUDY ON RWTC

This chapter presents the qualitative research that has been implemented among the experts that worked/ are working in RWTC projects such as academicians, policy makers, State and company directors. Data collection was carried out by conducting interviews about the triple helix model of RWTC. The interview questions was prepared within the light of the information through the literature survey and aims to gain a general knowledge about the working dynamics and key issues and also seeks answer to how the current triple helix model of RWTC can be further developed. The demographic characteristics of the interviewees who answered the questionnaire is given in table 8. Responses of each triple helix model related question about RWTC are analyzed in the following subsections.

Table 8. Statistics about the demographic characteristics of the RWTC interviewees

The Number of Interviewees	11
Distribution according to the organizations they serve	3 Public Institution 3 Private Company 5 University
Distribution by position at the institution/company while working on RWTC project	5 Academician 4 Expert 2 Director
Average working experience of the interviewees in RWTC projects	38,7 months

5.1. Rationale and Emergence of RWTC

Rotary Wing Technology Center (Döner Kanat Teknoloji Merkezi- DKTM), which is the first thematic Technology Center of TAI, was established in TAI METU Technopolis facilities under the aggreement between SSB and TAI in 2014. The Technology Acquisition Liabilities of Özgün Helicopter and T-70 Turkish Utility Helicopter projects are realized within the scope of RWTC.

One interviewee who previously worked in TAI explained the emergence of RWTC at that time as follows:

> Normally, while TKYs[19] (Technology Acquisition Liability) are distributed to 1 or 2 SMEs, all the money that is currently the R&D share of that helicopter project is distributed to universities under the name of RWTC and distributed to the research. We even made an agreement saying "Let the R&D share be distributed to academics in order to research the technologies needed" with the contribution of SSB's R&D Department and the Helicopter Department.

He also detailed the rationale for the establishment of RWTC as follows:

> We said, why can't we give the money directly to the academics, so let's distribute the money to the universities, so they can research, but there are a lot of challenges. For example, you can not employ assistants at the university, personnel cadre is required. The cadres of the university are limited. For example, 10- 15 people work in an SME. As I said, it is impossible to gather a group of 15 people at the university. Then we said that we should use these 15 people over technocentres or as TAI employees and continue as such. The main reason for this was the burden of existing legislation. Therefore, it is still not easy to do business through universities today. That's why an office called Technology Transfer Office was established in METU to make processes easier. Otherwise, when there is such an R&D project, how will the project work?

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[19] TKY projects define R&D projects that aim to develop technology-intensive subsystems and components that will provide input to system / platform projects. These projects are carried out under the subcontracts of the relevant system / platform projects. TKY projects model is considered as a method that supports the creation of the technology base required by the supply projects carried out in line with the defence system needs of the Turkish Armed Forces and SSB R&D Projects Roadmap.

In order to reach the targeted levels in helicopter technologies, to meet the domestic needs with originally designed helicopter platforms and to establish a helicopter industry which is competitive in the international helicopter market, it was necessary to constitute a model in which the universities (engaging in basic research) and the industry (producing commercial goods) work together under the control and support of the State. Although, it has been aimed to develop national and original systems and platforms in Turkey since 2000s, it was observed that, except consultancy of professors, the industry could not be utilized from the university. With the proposed model, the state-university-industry sides could have a closer relationship with each other, learn each other's needs, transfer their knowledge and experiences to each other, and look at the events from each other’s side.

One interviewee from the state expressed the rationale of RWTC as follows:

> Normally, it is difficult to keep students at universities after graduation. For this purpose, RWTC model was planned so that both students are financed and raised in the subjects needed by the industry. Initially, it was planned that students would be given a workplace in TAI. Then, it was decided that a single center was not feasible as RWTC also worked with universities outside Ankara.

It should be emphasized at this point that the main target, which forms the basis of the RWTC model, is to reach a pool of trained human resources that are continuous and sustainable.

Also, another interviewee from the State indicated the main targets of RWTC as:

> The primary targets of RWTC are to raise the human resources needed by the industry in the field of rotary wing technology and to ensure that the technology that will be needed in the future is gained through R&D.

It should be noted at this point that being able to produce new and innovative technologies is not something that can happen spontaneously. For this reason, the path of raising human resources and contributing to sustainable processes and the

path to the new and innovative technologies of tomorrow are processes that develop in harmony and coordination with each other.

To put it in more detail, the most prominent goals of RWTC could be listed as follows:

- ✓ To contribute to the training of new people who are specialized in certain fields, technological and scientific depth, and have knowledge and experience, both within the industry and academia
- ✓ To build bridges between academy and industry
- ✓ To ensure the continuity of the information and technology production activities of the established industry-academy bridges and newly growing human resources
- ✓ To contribute to the acquisition of new and innovative technological and scientific knowledge, theory, technique, method, process or products that exceed the existing technological situation
- ✓ To contribute to the acquisition of state of the art technology in a way that reduces or eliminates foreign dependency
- ✓ Also, one should not consider these goals independent from each other and should evaluate them as a whole. In order to reach these goals, RWTC roadmap which approaches the unsolvable problems of today and focuses on the new and innovative technologies of tomorrow is constituted.

5.2. RWTC Program as a Triple Helix Model

According to the "triple helix" approach that RWTC is based on, the success and efficiency of university-industry collaborations increase with the establishment of a common area where the state, industry and academia can work together. According to this approach, under normal circumstances; (1) the state is responsible for setting up policy-making, giving direction, funding and constituting tracking systems, (2) the industry is responsible for developing competitive products in global and local market conditions and (3) academy is responsible for conducting

research that goes beyond the current level of technology by following the scientific and technological agenda. However, as long as the developments in these fields of activity remain disconnected, it is not possible to achieve sufficient success. When these three groups approach each other and start working together, in other words, when exchange of information about each other's agenda, success, deficiency, blockage points and problems is possible, visible increases in efficiency and success percentage can be observed. The ideal triple helix model of RWTC and the responsibilies of actors in this model are built as shown in Figure 12.

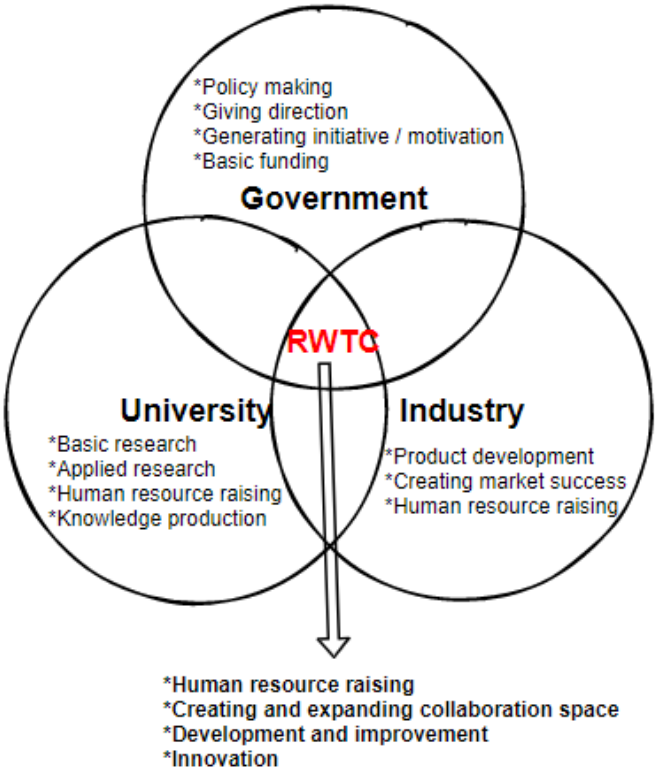

Figure 12. Ideal Triple Helix Model of RWTC

An academic interviewee expressed the benefits of university-industry-state collaboration in the following words:

> University-industry-state collaboration is spoken all over the world, and this is done and desired in all developed countries. The university is initially an educational institution, so it educates people. At the same time, basic research is carried out at the university. The industry, on the other hand, needs to grow products and ensure that its products develop. These products need to make money and return to the economy. Therefore, university and industry should support each other because they need each other. Industry will tell the university what to do, what it needs. It should also support financially so that universities can do these researches. The state has to coordinate and guide them. Therefore, all of them should be in close contact with other engineers and people so that smart, logical works come out. That's why a collaboration is always the cure of the century. Forget about the benefit, it is a need.

Another academic interviewee expressed the need of university-industry-state collaboration in the following words:

> First of all, university facilities are limited, knowledge is very good. Industry knowledge is limited. Information on one side and resources on the other. It brings information and equipment together to combine them and the project that the industry needs is being worked on. You need a guide for this. Otherwise, the academics is studying their own subject. In case of collaboration, academics turn to this area to improve the infrastructure. Manpower development benefit already exists. On a subject basis, the industry directs.

These comments are in accordance with the literature survey stating that; The universities conduct basic research, produce knowledge by publishing scientific papers and educate and graduate people with tacit knowledge. Industry, on the other hand, seeks and tries to reach the required knowledge from the sources of universities on its own (Sarpong et al., 2017). Also, government supply direct or indirect financial assistance in the manner that acting like public venture capitalists by guaranteeing stable interactions and exhange through the contractual relations as the ultimate guarantor of the societal and economic “rules of the game” (Etzkowitz & Leydersdorff, 2000; Etzkowitz, 2008; Varga & Erdös, 2019).

Another academic interviewee agreed with these statements and explained the gains of university and industry in triple helix model:

> The industry has a certain technological infrastructure and human resources. The industry especially trains this engineer power in projects and brings them to a certain place. But this is restricted to existing technological knowledge and often to relatively obsolete information. In this sense, the university can collaborate with the industry with current and future technologies, and enable the industry to use those technologies with the contribution of using current technologies that we call state of the art technologies in projects of the industry. Sometimes, I think it takes something together to keep up with these new technologies in order to leap technologically. The industry also does some things, but it should be able to check what it does in collaboration with the university and calibrate itself.

The benefits gained by university and industry while working on R&D projects through the triple helix model is enormous as stated above. Developing relations between the actors and the mutual division of labor while conducting R&D projects lead to a win-win situation for all actors. This process is also identified in the literature and expressed from a wider perspective as follows: The transition from industrial to knowledge society is characterized by augmenting communication and interconnection among people and institutions, increased mobility of workers and financial capital and delocalization/globalization of production sites and labour (Etzkowitz & Leydersdorff, 2000).

The same interviewee also explains the benefits of triple helix collaboration for each actor as follows:

> The university trains people and if it collaborates with the industry to train those people, the quality increases. More up-to-date practical technologies are passed through the filter of the university and transmitted to students, and students are trained with it. The result is a better graduate quality. Of course, since the industry also hires those graduates, it gains indirectly from there. The state is usually the authorities requesting the results of the projects. They also win in terms of the quality and performance of the products they demand

because these processes are better, higher quality and higher technology. So there is something powerful here.

While catalyzing interaction between the triple helix spheres through R&D processes value generation occurs through multiple ways. The statements above are also in accordance with these ways which are given in the literature survey as: First, increasing the stock of useful knowledge through publications and secured intellectual property. Second, developing human capital beyond the academic education through R&D processes. These skilled people are trained in R&D activities and gain substantial tacit knowledge through the process. Third, exploiting leading-edge scientific instrumentation and forming new research methodologies. And finally, collaborating and forming networks with users which leads to coproduction of knowledge by means of the problems and challenges indicated by users (Georghiou, 2015).

5.3. Organization and Implementation in RWTC

RWTC organization consist of three main pillars that work together:

1. The state represented by Presidency of Defence Industries (SSB).
2. The industry represented by TAI and SMEs
3. The universities

In RWTC model, the state is responsible for financing the projects as well as contributing to the RWTC management processes with its experts. TAI is responsible for the administrative management, monitor and follow-up of RWTC projects and will benefit from the project outputs in the scope of ongoing helicopter projects. TAI also supplies technical support to projects and trainings for researchers when necessary during project processes. SMEs and universities are responsible of execution and conducting research activities of their own RWTC projects and raising qualified people in the field of helicopter technologies through their subcontracts with TAI.

In RWTC, the implementation processes are as follows: Firstly, the candidate projects are selected in line with the TAI rotary wing technology roadmap and RWTC roadmap is created. The prepared RWTC roadmap and also the selected candidate projects are presented to SSB for approval. Then, subcontract preparation studies of the approved projects in RWTC roadmap are realized. While creating RWTC project designs, the most suitable contractual side is also determined for each project and subcontracts which are planned to be signed between TAI and these organizations are prepared. Then, these subcontracts are also presented to the approval of SSB. In this context, the following organizations have been worked up to date as a subcontract partner with TAI:

1. Revolving fund units of public universities
2. Foundation companies of foundation universities,
3. Technology Transfer Offices of universities (TTOs)
4. Small and Medium Enterprises (SMEs)

5.4. RWTC Roadmap and Innovation Activities

The subjects to be studied at RWTC will be in line with the TAI Rotary Wing Technology Roadmap. In the RWTC model, it is aimed that these subjects do not directly contribute to helicopter projects in the short term, but to work on future technologies or technologies with restrictions in access. However, RWTC outputs are expected to serve all helicopter projects.

The projects to be carried out in the Rotary Wing Technology Center are designed for the following purposes:

1. Considering the needs of the helicopter projects being carried out
2. Aiming to mature new / innovative technologies that can make a difference from other products in the market

For RWTC projects, RWTC roadmap is prepared in order to determine goals, objectives and principles of RWTC and this roadmap includes the ongoing and

planned to be started projects within the framework of several “research focuses”, application areas of projects’ outputs and analysis of whether these projects’ relations in an integrity or not.

The concept of “research focuses” is basically based on the following principles:

1. To regulate the use of all kinds of resources (time, people, test / experiment mechanisms, subject, etc.) within the same focus in an efficient and non-repeatable way.
2. To activate the communication channels that will allow studies, knowledge and experiences within the same focus to feed each other.
3. To combine enabling / advancing technology studies, which will enable the traditional helicopter concept to move towards more innovative design solutions like individual blade control, in a manageable and dynamic focus and associating these innovative studies with the top product concepts (advanced rotorcraft, tilt rotor, compound helicopter, stopped rotor etc.) within the framework of a plan and roadmap.

RWTC roadmap consist of three periods as shown in figure 13. These periods are seeding period, product period and integration period. The research focuses consists of topics like fast helicopter / low emission, rotor aeroelasticity, computational fluid dynamics, production technologies, impact analysis and simulation, power transmission systems and enhanced helicopter safety. The knowledge and technological gains provided by RWTC projects will provide input to many projects in the aviation field, especially major helicopter platform projects of Turkey.

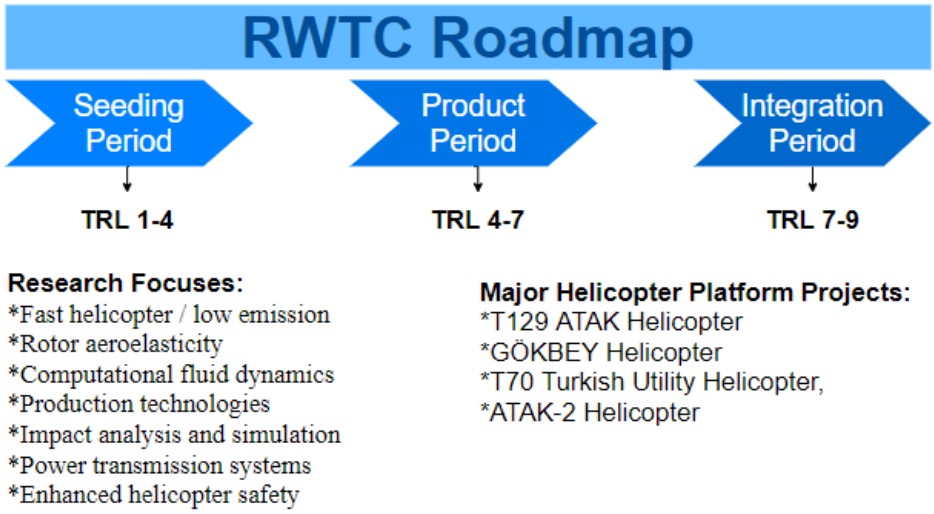

Figure 13. RWTC Roadmap

While determining the technology roadmap to be created within the framework of RWTC research focuses, the research topics in the following international programs / forums are closely followed:

1. Horizon 2020 projects
2. Future Vertical Lift (FVL) Programs
3. The Vertical Flight Society (VFS) Annual Forums
4. European Rotorcraft Forum (ERF)
5. Asian / Australian Rotorcraft Forum (ARF)
6. NATO Working Groups on Vertical Lift

At the same time, contributions are made to the roadmap in line with the experiences, researches and visions of the experts and engineers of the TAI Helicopter Group and TAI Directorate of Innovation.

One interviewee who works in TAI RWTC explained the achievements of RWTC in international programs as follows:

> We have become a center that is now appearing both domestically and internationally. We hosted ARF 2019 this year, especially with the great contribution of our Deputy General Manager of Helicopter. Here, projects from RWTC had 2 important awards. We also had 7 presentations. Current Asian / Australian Rotorcraft Forum in abroad, we have made a very important name for Turkey. Last year, in South Korea Asian / Australian Rotorcraft Forum (ARF 2018) they said to our engineers that "you did a landing operation from Turkey". A higher participation than South Korea's participation was provided by the Turkish counterparts.

This fact matches up with the findings of Singh and Fleming (2010) that alongside the increment in the probability of breakthroughs, they found that working in teams rather than a lone inventor also reduces the possibility of poor outcomes. Also, Pinto et al. (2015) supports these achievements of RWTC with the following statements: as the interaction, commitment and collaboration among actors in the network grows, the innovative performance of them also increases.

5.5. Project Selection Process

RWTC roadmap is a dynamic, updatable and living document that could be shaped according to the needs of industry at any time. The main research topics are written in the contract and these topics include critical technologies of the rotorcraft such as rotor, transmission, gearbox systems etc. The projects on the roadmap are classified according to the research focuses created within these main topics. While selecting projects for the roadmap, the process flow consists of the following phases as shown in figure 14.

The project call process of RWTC, which was launched for the first time in 2014, can be summarized as follows. Project pre-applications were collected online on the web-based PROSİS. In order to understand the projects in more depth, presentations were made by the project managers about the project proposals and the questions of TAI technical experts about the candidate projects were answered. In addition to the project subject, these presentations included the identification of

technological situation, targeted contributions and the project execution plan. As evaluators for project presentations; RWTC, SSB R&D Department, SSB Helicopter Department experts and representatives and the related TAI and TEI field experts according to the project topics attended. The main purpose of the evaluative team in these presentations is not to act as a pass-fail board regarding the project proposal, but to try to understand the possible contributions and features of the project in depth.

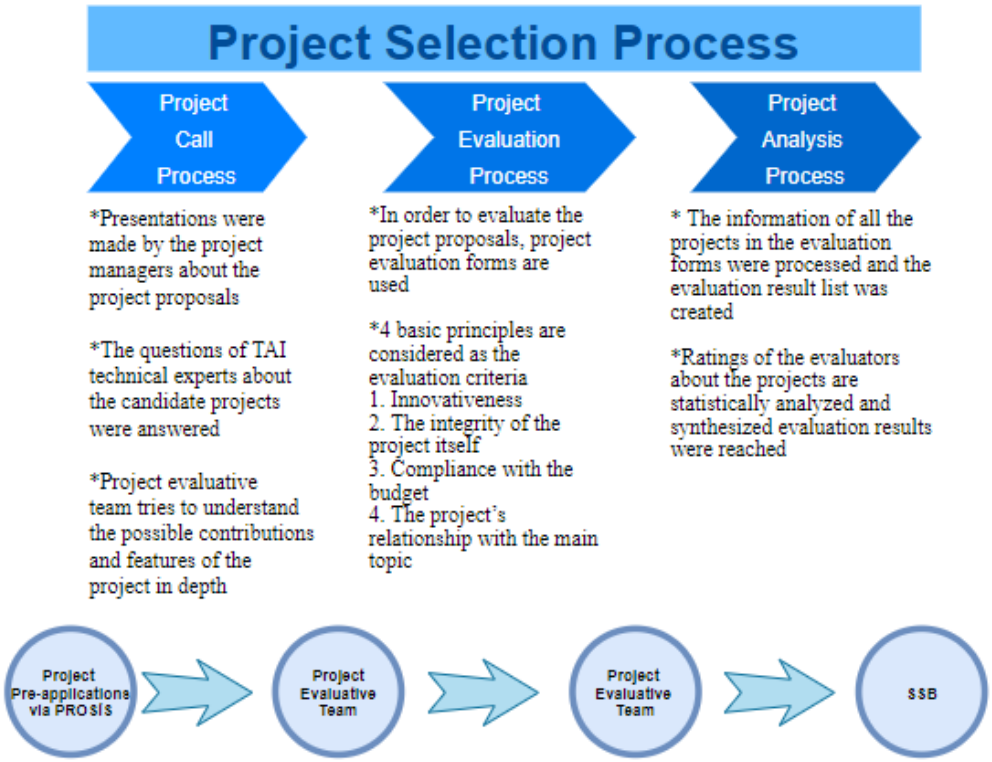

Figure 14. RWTC Project Selection Process

One interviewee who previously worked in TAI RWTC explained the project call process as follows:

> The main topics of work at RWTC are the critical technologies of the helicopter, rotor, rotor aeroelasticity, and power transmission systems as written under the contract. The detailed topics to be studied within the

> framework of these main topics come to us with the determination of the academicians or researchers who can study this and their suggestions on this subject. Most of the time, we have determined these issues, in other words, we make the announcement that "we want to work on these issues". And there are academicians who approach these issues saying "I have an idea".

While defining project call process, he also exemplified the first project call process as follows:

> We used the project calls a lot at the beginning. We called this the "seeding period". Actually, in the first days we did this, we didn't call it seeding. We later realized that what we did was seeding. It was like this. We got too much on the subject. At first, nearly 100 project proposals came to us. These were all good projects from academics. Therefore, this evaluation process was very painful. It was the summer of 2014, if I remember correctly.

Another interviewee from TAI RWTC explained the project call process with the following words:

> RWTC's perception here is to find the right academician and the right research assistant at the university. We have a PROSIS (web based project management system) system. We try to collect every project we do, if its academic basis is high, from all universities by calling from the PROSIS system. Universities can, of course, provide projects with such a wide technological scope with certain SMEs, because the existing infrastructure of the universities at that time has difficulties in providing those advanced technology mechanisms.

The same interviewee also specifies the role of the state throughout this process as follows:

> No matter how expert academics is in his field, he needs to collaborate with the industry in order to reach a technology that we have mentioned for the first time. Of course, while these searches continue, we feel the coordination of SSB very much. For example, if there is another support in the project that is related to another SME or another factory, SSB knows that well. When we need that information, "the project actually takes place here, what will you add to it?" SSB guides us with such feedback.

In accordance with the literature survey statements, government is responsible for leading the projects, allocating resources for the projects' initiave and progression and also supervising the projects' process in order to create new technological industries such as aircraft, computers and electronics (Etzkowitz, 2008).

After the project call process, the projects were presented in workshops organized by RWTC. One interviewee from TAI RWTC explained these workshops with the following words:

> We held the RWTC workshops for 2 consecutive years in July or August. This is a workshop where we invite our teachers and researchers working in all of our RWTC projects and bring them all together. Because generally everyone knows their own project. Within the scope of RWTC, which projects do we do on other subjects? In this 1-day program, everyone allocated according to their subjects makes a presentation of 15-20 minutes. I think we created an environment of synergy in this way.

After the project presentations were made, the project evaluation process takes place. In order to evaluate the project proposals, project evaluation forms are used. These forms comprise four parts. Each section consists of questions that test the topics given below:

1. The place where the project proposal positions itself within the scope of its subject, the gaps it will fill and the contributions it aims to provide
2. Technological contribution dimensions of the project proposal (groundbreaking, innovative, nationalizing, supportive and developing)
3. Feasibility and maturity level of project setup
4. General evaluation of the project proposal

The evaluation process of the projects was expressed by the former TAI RWTC worker as follows:

> We have 4 basic principles in evaluation criteria and we have an evaluation guide related to this. For the evaluation criteria here, we first got our approval from the Presidency of Defense Industries. The first of these criteria is

> innovativeness, the second is the integrity of the project itself, and there are also sub-evaluation questions. Because we ask experts participating in this evaluation to give points to the prepared survey questions. Third, compliance with the budget. Because sometimes there is an unrealistic budget, such as "You cannot do this much with 3 or 5 people". We also have criteria regarding its relation to the main subject, namely the applicability of the proposed subject.

Another interviewee from TAI RWTC explained the project evaluation process as follows:

> The main point here is that the projects are evaluated and carried out largely independently of each other, objectively and in an unrelated manner. It is very important whether the two different projects create integrity at the next level or not, that is, whether they serve the next higher product. In other words, even if we are doing low level technology preparation levels from time to time, we always keep in mind how this will ultimately affect the product at the top level. And as a result, projects are either suitable in their own right or not suitable. While evaluating the projects, we go to the point of questioning the project setup from time to time. Because academic feedback also takes us to the point of expressing the project in a different way.

Questioning the project setup again and benefiting from academic feedbacks through the project evaluation process is especially valid for R&D management activities in the era of coupling where R&D and market needs go hand in hand. Indeed, as stated in the literature survey, through the third generation R&D management process, there are many technology push and market pull combinations which have feedback loops and interaction among different elements. Projects are linked with both corporate and business strategies and long term strategies are started to be developed (Reger et al., 1996).

In the project analysis part, the information of all the projects in the evaluation forms were processed and the evaluation result list was created. Ratings of the evaluators about the "technological contribution dimensions" and "outcome evaluations" of the projects were statistically analyzed. Then, the eligibility

percentages of the projects were calculated and ranked from top to bottom. These results were also examined in detail in the light of the specified parameters and synthesized evaluation results were reached.

After the project flow processes of the project selection procedure, evaluation results are classified under 3 main headings:

1. Projects proposed to be started with their current state
2. Project proposed to be reconstructed by making changes or merging with other projects
3. Unsuitable projects

5.6. Project Execution Process

RWTC has acted with the aim of establishing and effectively implementing the triple helix model since its establishment. In order to develop and support this collaboration model, the following activities are carried out within RWTC as shown in figure 15.

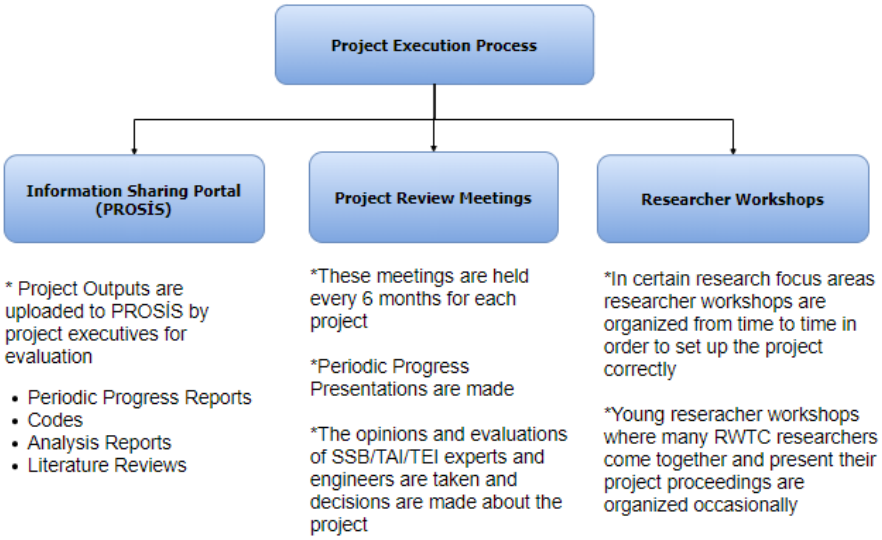

Figure 15. RWTC Project Execution Process

The process of monitoring and evaluating the project progress and project outputs is structured on two equally important layers that support each other as described below:

The first layer consists of project-specific outputs that are recorded at the contract level and must be delivered to the RWTC. These outputs are; "periodic progress reports" to be prepared as given in the annex titled "progress report format" of the contracts and other outputs (codes, analysis reports, literature reviews etc.) specified in detail in the annex titled "job description" of the contracts. These delivery outputs are uploaded by the project executives to the web-based project management system (PROSIS) and any evaluation process is carried out on PROSIS. Following their upload to the system, these outputs are directed to TAI-TEI and SSB field experts determined specifically for the project through the system for evaluation. If deemed necessary, other academicians (domestic / international) who are experts in the project can be included in the assessment pool in a controlled manner. Evaluators will forward their evaluations to TAI RWTC managers via PROSIS. Notifications to the project manager will be made by RWTC managers, taking into account the evaluations. This process can be monitored by SSB staff who are authorized to reach PROSIS via PROSIS.

With the completion of the evaluations of the delivery outputs, evaluation meetings are held. These meetings are called “project review meetings” and they are held every 6 months for each project. In these meetings, in the presentations made by the project manager and researchers, information is given about the project process and work. In line with this information, the opinions and evaluations of SSB / TAI /TEI experts and engineers are taken and decisions are made about the project. The main agenda of these meetings is determined by the periodic progress reports. These meetings are also the meetings where the decisions of the projects to continue, stop or close. An interviewee who formerly worked in TAI RWTC explained project review meetings as follows:

> We do project reviews with SSB every 6 months, but we actually follow each project every month. So where are they, what are they doing, where are they blocked? Our expectations are more or less clear, so in order not to encounter any surprises in a 6-month review meeting, we follow where they are stuck during the whole process and try to complete them with additional measures if there are any delays. We are trying to finish the project on schedule and in line with its goals.

Indeed, in order for the RWTC to reach its goals successfully and to make the model sustainable, it is necessary to observe and evaluate the whole process in line with the technical, scientific, social and economic parameters and to find solutions to the problems that may occur with the necessary measures.

For Kale et al. (2002), these regular meetings can help actors to develop their external network of collaborative partner contacts. It also leads to greater learning through sharing and contribute each other's knowledge and know-how. It also facilitates to learn how to work in a collaborative way.

In the second layer called monitoring and evaluation layer, the main focus is basically on the project process and the actual flow of the project. Active process follow-ups and observations are carried out monthly or if deemed necessary more frequently, or with less formal meetings and visits that have not been previously planned. During these observations, it is aimed to create a continuous awareness on the subjects such as how intensely and in which frameworks the project team members are working, how progress has been made, what problems have been experienced, how possible risks can be prevented, and what kind of knowledge has been reached that have not turned into tangible outputs. In particular, the studies and working processes of the researchers (graduate students) being trained are under the scrutiny.

In accordance with the process described above, the same interviewee also explained the activities conducted by project executives during active project process with the following words:

> "Where did you get stuck and what could not be calculated", we ask. Where they get stuck or can't figure it out, we activate expert friends here. So, if it is not always on your hands, you may encounter a situation such as failure or incompletion in the 3rd year of the project. Therefore, we follow not only a 6-month review, but every month, each project by asking "What are you doing, which stage are we in, did these things realized or not?"

The researchers in universities study RWTC project subjects in their Ms or PhD studies and are supported by SSB financially. In this study process, their studies are supported and evaluated by not only their academic advisors but also experts and engineers in industry. The process that RWTC researchers take support of advisors from industry was expressed by the former TAI RWTC worker as follows:

> We cannot assign it as a one-to-one industry consultant, but we have relevant experts who follow each project. Responsibility is under the management of RWTC because in the early stages of the project, for example, a load-related friend follows the project when the load is calculated, and then a friend from the pal team can follow when we start to produce samples. Therefore, as RWTC, we follow the whole project and ensure that the relevant expert follows the project. According to the project phases, as the project progresses, another expert becomes more helpful.

Also, the same interviewee expressed how RWTC researchers can benefit from TAI's facilities as part of the projects during these project processes as follows:

> Researchers come to Project Review Meetings. Sometimes, for example, we take researchers from different cities to courses here. Those outside of Ankara stay in our guesthouse. They attend certain courses of the TAI Academy. They take the lessons here at the points they need in the projects. When they have to follow something about production, they come and stay here. Sometimes they stay with our friends for a day or two and work. Therefore, wherever we see what is missing, we are trying to get those friends to train here by convincing the managers here. Again, RWTC plays the role.

Furthermore, researcher workshops are organized from time to time in order to be able to deal with certain research focus issues. One interviewee from TAI RWTC explained the rationale of these workshops with the following words:

> What makes the project a project is actually how we worked before it. For example, in the CFD (Computational Fluid Dynamics) project, we prepared a workshop a few years ago. From time to time, a single workshop on very complex issues is not enough to set the project correctly. That is why we did not settle with this workshop, and did one more workshop. After that, the CFD project was created.

With the combination of these two layers mentioned above, it is aimed to ensure that project progress monitoring and evaluations do not depend on evaluation meetings that will be held only every 6 months and outputs such as reports to be delivered only. Active follow-up of the process itself is considered to be a prerequisite for creating "trust" and "transparency" grounds, which are essential not only for the technical success of the projects but also for the establishment of efficient university-industry collaborations.

These statements are related with the literature part that defines social (relational) proximity as the degree of common relationships which are socially embedded among people depending on the social cohesion around the relationship (Criscuolo et al., 2010). The social proximity plays a significant role in knowledge spillovers (Virkkala et al., 2014). Trust is also an important mechanism that cause and strengthen the social proximity in knowledge sharing through organizations and people (Criscuolo et al., 2010).

5.7. Technology Readiness Level in RWTC Projects

Technology readiness level (TRL) concept is used as a project follow-up and management tool in the RWTC studies, from project design, creation, suggestion collection- evaluation stages to the project completion point where project gains are revealed.

TRL is a systematic measurement method developed to evaluate the maturity of the developed technology and to compare the maturity levels of different technologies consistently. It is a metric of 1-9 levels used to qualitatively determine how mature the technology is for use as shown in figure 16 and this scale is also accepted by SSB.

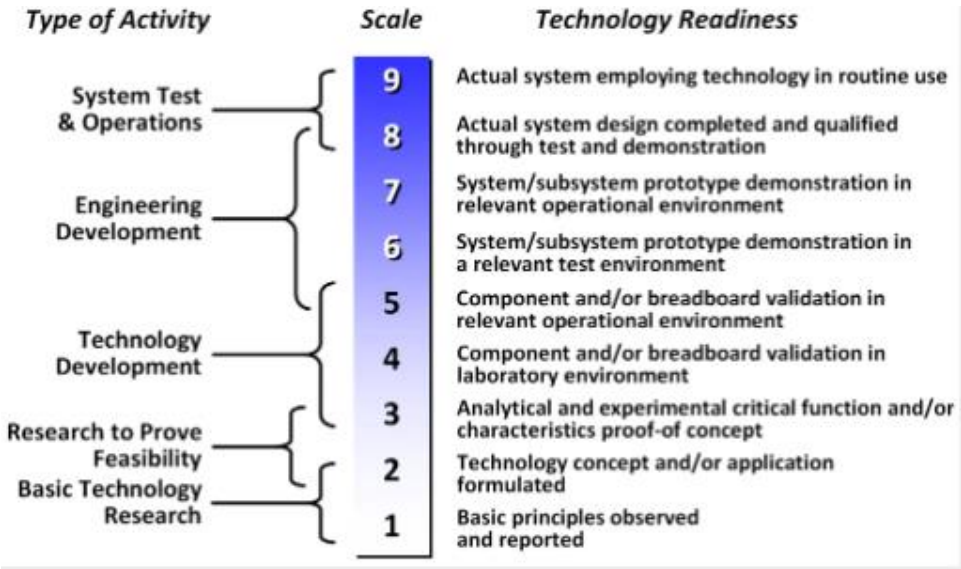

Figure 16. NASA Technology Readiness Level (TRL) scale
(Credit: J.M. Snead.)

In this context, RWTC evaluates and carries out projects within the scope of TRL 1-6, while Deputy General Manager of Helicopter evaluates and conducts projects within the scope of TRL 7-9.

An academic interviewee evaluated TRL studies in general from the following point of view:

> The university conducts basic research. There is a technology readiness level, and TRL 1-3 level ideas come out in universities. Its maturation and so on can also be done in industry. But the industry has neither the time nor the excitement to do basic research. Nor did I see the industry engage in 1-3 level research. However, if you want to create a product that makes a difference in the sector, you need TRL 1-3. You need a new innovation. Innovation often

> comes from small groups. It comes out of universities and small companies. It's like this all over the world.

To assess the technical outputs of the projects, technology readiness level guide is used in RWTC projects. To date, experts have determined technology readiness level by the qualitative assessment according to the definitions in the technology readiness level guide which was prepared by SSB and TAI. Recently, a more quantitative technology readiness level measurement guide is published procedurally by TAI. Therefore, there is a possibility to make a more detailed evaluation by this guide for future studies.

RWTC project process consist of different periods which are also related with the technology readiness level of the projects. As mentioned before, the execution process of projects which were selected in the first project call period were named as “seeding period”. The seeding period projects were studied mostly through TRL 1-4. With the seeding period projects, a certain level of maturity has been reached in some study areas and research focuses. By combining the gains of these projects carried out separately, a stage has been reached where it will be possible to demonstrate technology at the sub-system level. In line with this goal, roof projects have been designed and started in the related study areas. This period is called the “product period” in which projects will be planned to be studied mostly through TRL 4-7. In the research areas where the seeding period is deemed appropriate, it has continued to work on the enabling technologies within the methods applied so far.

An interviewee from TAI RWTC explained the transition from “seeding period” to “product period” as follows:

> We have completed quite a few 17-18 projects during the seeding process on the RWTC roadmap. We now have a few projects to integrate them. As a top product group project, we have projects to be carried out by the Helicopter Deputy General Manager. We are making preparations for them. We will

> continue the support we receive from our professors working in the projects in the seeding period, this time as a consultant in the top product group projects. RWTC will not manage directly. These projects will generally be carried out under the Helicopter Deputy General Manager.

An interviewee who worked formerly in TAI RWTC expressed these periods with the following words:

> Some of our projects have achieved their goals as we expected, but they did not reach the qualities we can use in the future. We said at the time that this was actually a "seeding period" that we have been doing for 3-4 years at RWTC. So let's not continue the projects we started in large numbers as before. Let these maturing projects move to a higher technology readiness level. We called this a "product period". Let's take these and integrate them together. We are in that period now. Let's combine what we can combine. That's why we created such roof projects. Therefore, we see the studies in RWTC in phase by phase. Then we say that after producting them, a helicopter integration activity was carried out.

Reger at el., (1996) also stated that at the integration phase of R&D management, R&D process is a parallel development process with integrated development teams. The main focus is on the total concept rather than products as R&D is seen as an integrative activity.

5.8. Ensuring Continuity in RWTC

Innovation activities point to a different level of talent than routine production activities. In such activities, mental processes (research, concept development, design etc.) come to the fore. The process itself requires a different human profile, such as researchers, employees with exceptional features, engineers skilled in design and construction, and experts who can manage R&D and innovation activities. The determining factor in the innovation process is the 'mental capital' created by such people and the main source of mental capital is society (Göker, 2003).

In the seminal report, which has a very important place in the history of science, technology and innovation policies, presented to the US president Roosevelt by Scientific Research and Development Office Director Vannevar Bush, it is stated that (Bush, V., 1945):

"… Raising scientists is a long and expensive process. Studies have shown that there are talented individuals in every segment of the population; however, among them, those who do not have the necessary financial means cannot go to higher education, with a few exceptions. If it is not the fate of the family, but the talent of the person, who will study higher education in science, then we can ensure that the quality increases at every level of scientific activity. To develop scientific competence in American youth, the state must provide undergraduate and postgraduate scholarships to a large number of young people. Necessary plans should be made to attract young people who are capable of responding to national needs in the field of science."

This support warning from Bush's young brains is still true for all countries.

Young researchers constitute the most important part of the sustainable and qualified human resources pool in RWTC. In order to increase the efficiency and success of RWTC, it is very essential to train young researchers who have the skills and interest in conducting research-oriented study in a continuous way.

In RWTC, some researchers are employed in TAI as a part time RWTC researcher and use the facilities of TAI. They also use their universities' laboratories during this part time study with TAI. Therefore, they can easily concentrate on their research studies. Researchers working in cities other than Ankara are mostly employed in spin-off companies and SMEs part time or full time. These companies are mostly an academician spin-off companies and SMEs. There are also some

researchers who are Ms and PhD students working as research assistants within the university.

In order to obtain more efficient results from the projects and ensure continuity in RWTC projects, it is very important to guarantee the opportunities offered to the researchers during the project period and after the project. In order to achieve this, basic elements that motivate researchers to work on RWTC projects have been identified.

The motivations of researchers working in RWTC projects are articulated around the following four main motives:

1. An environment based on mutual trust and transparency
2. Wage and insurance continuity
3. Support through steering and education of researchers
4. Career and job opportunities

Firstly, to build up, support and maintain the environment of trust is a crucial factor to solve the problems in the projects in this model as mentioned in the previous chapters.

Secondly, researchers' wages and insurance are also quaranteed by RWTC project contracts. Researchers feel safe financially with a reasonable wage and insurance that have continuity which is paid for their full time or part time labor. Like a research assistant working at a university, RWTC researcher is in a flexible environment, concentrate on his/her research and does Ms or PhD.

A former TAI RWTC worker affirmed these two main motives with the following statements:

> Above all, creating an atmosphere of trust. As long as we created an atmosphere of mutual trust and managed transparently, we actually solved the problems. In fact, we always chased after people. And by keeping one-on-one

> communication with our fellow researchers, when they come here to the evaluation meetings, "Does he get his salary in full? Does he have full insurance?" by asking, we tried to provide that trust environment for our friends.

Thirdly, the opportunities provided to researchers include being lead and guided by experts/engineers working in related fields with their study in TAI and taking courses from TAI Academy which are also mentioned previously. These kind of supports throughout the research not only contribute to the RWTC project itself but also creates a positive motivation on researchers.

And lastly, it is also necessary for the young researchers whose projects have been completed to continue their careers on the relevant subject after the project in order to benefit and use this accumulated knowledge by the industry.

An academic interviewee explained his/her ideas on the importance of studying and working in related fields both in academia and industry as follows:

> In my opinion, the expectations of the students who do their graduate studies in a mechanism in collaboration with the university and industry are to develop themselves and become competent there. Also, while the student is doing this work, he/she can see from the beginning that he/she can make a difference there. Therefore, there should be a mutual interaction between the university and the industry and the roadmap should be determined that way. Therefore, the student, the faculty member and the industrial organization should know that this student is catching up with this subject, doing this job and will continue to work on it.

Another academic interviewee made an overall assessment of the benefits of this collaboration model on graduate researchers in the following statements:

> Financial support is very important. Otherwise, the students would go. They wouldn't do their masters well. They also saw the practice, so it was an experience they had never had anywhere else. In this project model, the student sees how the engineer at TAI works, sees the policies, and works one

> to one with the professor since we are included. Ultimately, he/she saw how to work in industry, and if he/she enters that subject, he/she will start at a very high level, like helicopter or something. There is know-how. It has been very beneficial in employment, networking and reference issues. Subject expertise has been a lot. They all hold degrees, postgraduate degrees. They had professional working experiences as engineers.

After getting their graduate degrees, RWTC researchers find opportunities to work in related fields of their studies in the helicopter industry. This creation and acquisition of human resource, which conducts basic research and applied research at universities and use the outputs of these researches in the design, development and production phases in industry, is an effective, long term technology transfer method which contributes to organizational learning in itself.

An interviewee from TAI RWTC stated the opportunities provided by TAI to the researchers after the RWTC project was completed as follows:

> Researchers, of course, feel and learn about the business processes that correspond to that technology in the industry with the evaluations and participation of our engineers and experts. And while continuing to collaborate and talk about that project, they suddenly find themselves working at TAI.

Another interviewee from TAI RWTC explained after project process for researchers with these words:

> In fact, yes, we encourage you in this sense. As they work at TAI while working on the project, they both work with us and learn about the processes and principles. Afterwards, we have already employed most of them. So, I think it is a great encouragement for researchers both during and after the project.

After the working period in RWTC projects, many researchers got job offers from the industry in the related field, some of them preferred to stay at a university as an academician and some of them chose to go abroad for further studies. In most of

the decisions regarding the continuation of the careers of the employees outside of Ankara, it is observed that the local labor market conditions (personal needs / requests, new project / working subjects of the project executive academics, dominant sectors in the city where the project is carried out, etc.) are determinant. In general, after completing their Ms or PhD thesis in RWTC projects, researchers have met many opportunities contributing to their careers.

5.9. Concluding Remarks on the Qualitative Study

In this chapter, the explanations, views and suggestions of state experts/directors, industry experts/directors and academics who took part in RWTC projects are analyzed by using qualitative data. In order to explain the structure and operation of RWTC, systematic issues related to all RWTC projects have been studied in an integrative framework. In this qualitative study, the main headings which consist of rationale and emergence of RWTC, RWTC program as a triple helix model, organization and implementation in RWTC, RWTC roadmap and innovation activities, project selection process, project execution process, technology readiness level in RWTC projects and ensuring continuity in RWTC are discussed and evaluated by comparing the findings of the literature review.

In the light of analysis of these qualitative data, not only the general organization and implementation of RWTC but also the internal mechanisms and dynamics behind this model is examined. To this end, with this qualitative study, detailed explanations have been made on the following main topics that are at the basis of the RWTC model:

1. Transferring the knowledge in the university to the industry
2. Raising the trained human resources needed by the helicopter industry
3. Ensuring the sustainability of projects and trained researchers

Some basic stylized facts deduced from qualitative analysis are presented as follows:

Stylized fact 1: With the effective construction of triple helix model, the state-university-industry sides could have a closer relationship with each other, learn each other's needs, transfer their knowledge and experiences to each other, look at the events from each other’s side and work in harmony and coordination with each other.

Stylized fact 2: Technology roadmap is prepared with the regulation of all kinds of resources (time, people, test / experiment mechanisms, subject, etc.) in order to identify, select and develop suitable emerging technologies on the purpose of meeting strategic and commercial goals.

Stylized fact 3: With the triple helix model approach, developing relations between the actors and the mutual division of labor while conducting R&D projects lead to a win-win situation for all actors.

Stylized fact 4: Active follow-up of the project processes is considered to be a prerequisite for creating "trust" and "transparency" grounds, which are essential not only for the technical success of the projects but also for the establishment of efficient university-industry collaborations.

Stylized fact 5: Supporting researchers financially with a reasonable wage and insurance that have continuity is an important element that motivate researchers to work on RWTC projects.

Stylized fact 6: Giving researchers opportunies to attend classes in TAI Academy and take support from experts and engineers in industry during project processes is very essential to steer and educate researchers with the facilities of the industry.

Stylized fact 7: Providing researchers opportunities to continue their careers on the relevant subject after the project is not only an important motivating element for

researchers to join these collaboration model projects but also gives industry to benefit and use the accumulated knowledge gained by researchers during the project processes.

The main target of the qualitative study is to examine the RWTC model and its working mechanisms and also to gain insight from many aspects on the views of the academics, experts and directors that work in RWTC projects. After the qualitative study, quantitative study is conducted in order to examine the views and experiences of researchers who work/worked in RWTC projects as in the following chapter.

CHAPTER 6

QUANTITATIVE STUDY ON RWTC

This chapter presents the quantitative research that has been implemented among the researchers that worked/ are working in RWTC projects. Data collection was carried out using a questionnaire about the triple helix model of RWTC. The questionnaire was prepared within the light of the information through the literature survey and sent to the RWTC researchers through e-mail. In this chapter, first, the demographic characteristics of the researchers who answered the questionnaire are introduced. Then, the responses of each triple helix model related question about RWTC at each subsection are tried to be analyzed. According to the responses of the researchers, these issues are analyzed by using descriptive statistics.

6.1. Demographic Characteristics of RWTC Researchers

Some statistics about the demographic characteristics of the 23 RWTC researchers who have filled the questionnaire are tabularized in Table 9. Since there is no specific question about the researchers' name or identity (in order to make them feel free to answer the questions and ensure the confidentiality), the responses are analyzed statistically and the demographic information of the RWTC researchers are summarized.

By using the statistical data in Table 9, a bar chart based on the researchers' positions in the institution they work for is created as in Figure 17.

By using the statistical data in Table 9, a bar chart based on the researchers' educational level while working on RWTC project is also created as in Figure 18.

Table 9. Statistics about the demographic characteristics of RWTC researchers who have filled the questionnaire

The number of RWTC researchers to whom the questionnaire was sent as an e-mail	70
The number of RWTC researchers who replied the questionnaire	23
Average working experience of the participants of the questionnaire	23,87 months
Distribution by position at the institution/company while working on RWTC project	3 Students 3 Research Assistants 1 Instructor 7 Researchers 1 Scientific Project Expert 2 R&D Staffs 6 Engineers
Distribution by educational level while working on RWTC project	2 Bachelor 13 Master 2 Master & PhD 6 PhD
Average number of people in the researchers' project group that are/were working on RWTC project	3,39

The questionnaire was responded by twenty-three researchers in RWTC model. As can be seen from the Figure 17, the highest rate among the survey participants is Master students. 13 researchers were pursuing their Ms education, composing of 56% of the total respondents. 6 researchers were pursuing their PhD education, composing 26% of the total respondents. Finally, 2 researchers were pursuing both Ms and PhD educations and 2 researchers were pursuing their undergraduate education.

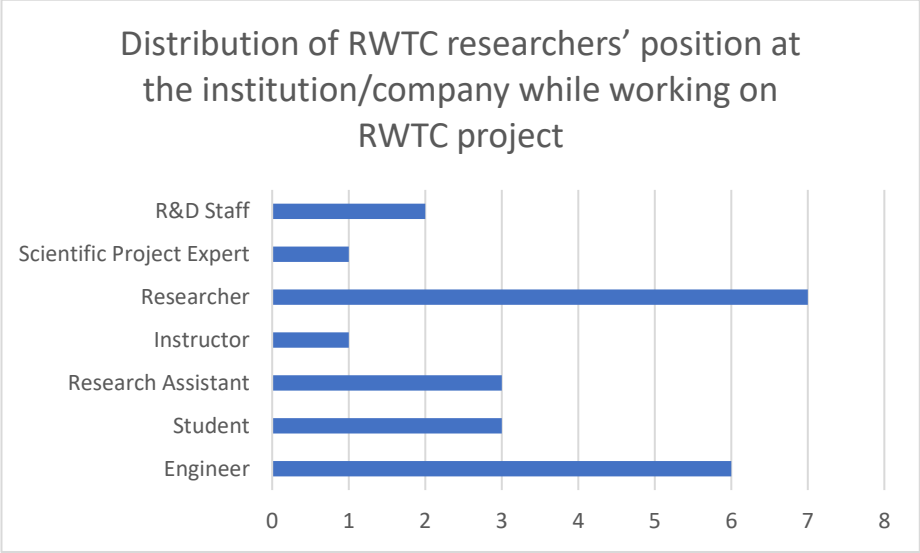

Figure 17. Distribution of RWTC researchers' position at the institution / company while working on RWTC Project

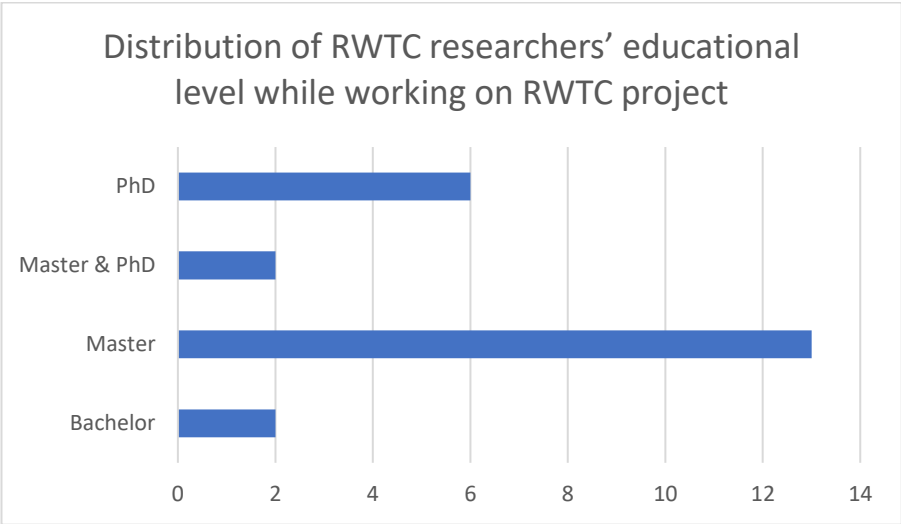

Figure 18. Distribution of RWTC researchers' educational level while working on RWTC Project

6.2. Rationale of Working in RWTC

Rotary Wing Technology Center (RWTC) Program has been launched in 2014. Since then, many projects in the field of helicopter technologies have been carried out and many researchers have been educated and trained within the scope of RWTC program.

The evaluation of the motivational determinants that caused RWTC researchers to study in RWTC projects was carried out with the findings obtained from the analysis of the responses given to the 8th question. These motivational determinants are also listed in table 10. The respondent researchers score this question which is given below according to the importance level of factors that caused them to take part in RWTC projects on a scale of 1-5 points:

8-Please rate the importance of the factors behind the rationale of your preference of working at RWTC project. (1: less important 5: very important)

Table 10. Rationale of Working in RWTC

Ranking	Reasons	Mean	Std Dev.	Slightly/ Not Important	Neutral	Important/ Very Important
1	To continue my academic education on a topic of interest	4,435	0,992	4,3%	8,7%	86,9%
2	To use the opportunities of industry while writing a thesis	4,174	0,778	0,0%	21,7%	78,2%
3	To write a Master/PhD thesis on a subject related to my field of work	4,130	1,100	13,0%	13,0%	73,9%
4	To be employed on a topic related to my thesis while writing a thesis	4,044	0,976	8,7%	17,4%	73,9%
5	To write a thesis on a subject that industry needs	3,913	1,164	13,0%	17,4%	69,5%
6	To have the opportunity to meet and work with people related to the subject I work in the industry	3,870	1,140	13,0%	17,4%	69,6%

The ranking of the motivational factors are created according to the responses of the mean value of each factor. The responses to the questionnaire indicate that four motivational factors among all factors have a mean value higher than 4 and are considered more important by the respondent researchers. These motivational factors include the following choices with the percentage of responses considered by the researchers as important/very important behind the rationale of their preference of working in RWTC Projects: a) continuing their academic education on a topic that they are interested in (86,9%), b) using the opportunities of industry while writing their thesis (78,2%), c) writing a Master/PhD thesis on a subject related to their field of work (73,9%) and d) being employed on a topic related to their thesis while writing a thesis (73,9%). Also, none of the respondents consider using the opportunies of industry while writing their thesis as less important. This fact commensurate with the statement of Etzkowitz and Leydersdorff (2000) which remarks that the interaction among triple helix spheres constitute new forms and venues where creative synergies develop. Reaching the opportunities of industry also contributes to synergy creation and this situation affects researchers positively and act as a motivational factor of their preference of working in such a collaboration project model.

6.3. Benefits of U-I-G Collaboration to Students

The evaluation of benefits of university-industry-government collaboration to students was carried out with the findings obtained from the analysis of the responses given to the 9th question which is given below. These benefits are also listed in Table 11.

9- Please rate the benefits of university-industry-state collaboration to the student in general. (1: less important 5: very important)

The responses to the questionnaire indicate that six benefits among all factors have a mean value of 4 or higher and are considered more important by the respondent

researchers. These benefits include the following choices with the percentage of responses considered by the researchers as important/very important: a) increasing the level of learning by using theoretical and practical knowledge together (86,9), b) experiencing the challenges and obstacles that may be encountered while working in projects (86,9), c) learning the applications in business life and to adapt to the business life faster and easier in the future (87%), d) helping students explore their interests in the subject they work (78,2), e) developing different design methods and techniques (78,3) and f) providing a project experience that students can add to their CVs (73,9).

Table 11. Benefits of U-I-G Collaboration to Student

Ranking	Gains	Mean	Std Dev.	Slightly/ Not Important	Neutral	Important/ Very Important
1	Increasing the level of learning by using theoretical and practical knowledge together	4,478	0,846	4,3%	8,7%	86,9%
2	Experience the challenges and obstacles that may be encountered while working in projects	4,391	0,839	4,3%	8,7%	86,9%
3	To learn the applications in business life and to adapt to the business life faster and easier in the future	4,304	0,703	0,0%	13,0%	87,0%
4	Helping students explore their interests in the subject they work	4,174	0,984	8,7%	13,0%	78,2%
5	Developing different design methods and techniques	4,000	1,044	8,6%	13,0%	78,3%
6	Providing a project experience that students can add to their CVs	4,000	1,044	13,0%	13,0%	73,9%
7	To contribute to the formation of professional synergy and energy among students	3,870	1,217	13,0%	26,1%	60,9%
8	Helping students explore potential companies for their work	3,826	1,029	13,0%	21,7%	65,2%
9	To benefit from the training opportunities of the company	3,261	1,137	26,1%	21,7%	52,2%

As shown in table 11, the main benefit that takes the highest mean value of university-industry-government collaboration to students is to increase the level of learning by using theoretical and practical knowledge together. This benefit is achieved by students with having an access in the industrial processes and in turn gaining an understanding on the industrial way of thinking. This fact validates the statement of Ozman (2017) which remarks that innovation networks increases the chance of new knowledge acquisition and accumulation and also people of innovation actors learn from each other to complement their knowledge. Additionally, learning applications in business life and adapting to the business life faster and easier in the future is considered important/very important by the highest percent of respondents as shown in table 11. This fact is also in compatible with the statement of Crisculolo et al. (2010), defining organizational proximity as the opportunity and psychological obligation of people in various physical locations throughout the organization to communicate and engage each other and share an organizational affiliation in organizational practices through common rules, norms and routine of behaviour. Therefore, one can conclude that researchers working in companies and SMEs within the framework of RWTC projects also gain organizational proximity with other workers in those organizations through organizational practices. These organizational practices include the way to handle problems collectively and having a common understanding of work procedures through sharing work experiences.

6.4. Benefits of U-I-G Collaboration to Companies

The evaluation of benefits of university-industry-government collaboration to the companies was carried out with the findings obtained from the analysis of the responses given to the 10th question which is given below. These benefits are also listed in Table 12.

10-Please rate the benefits of university-industry-state collaboration to the companies in general. (1: less important 5: very important)

Table 12. Benefits of U-I-G Collaboration to Companies

Ranking	Gains	Mean	Std Dev.	Slightly/ Not Important	Neutral	Important/ Very Important
1	Raising human resources on the subjects needed by the industry	4,478	0,730	0,0%	13,0%	87,0%
2	Keeping companies aware of the state of the art developments in science	4,348	0,573	0,0%	4,3%	95,6%
3	Adapting the techniques and methods used in academic studies to business life	4,217	0,850	4,3%	13,0%	82,6%
4	Developing different design methods, techniques and approaches from the accumulated knowledge	4,130	0,757	4,3%	8,7%	86,9%
5	Discussion of problems in group environment and finding solutions	4,130	0,968	8,7%	13,0%	78,3%
6	Contributing to the creation of independent and creative ideas	4,087	0,848	0,0%	30,4%	69,5%
7	Contributing to professional synergy and energy formation within the company	3,565	1,037	17,4%	30,4%	52,1%
8	Contributing to the creation of competitive environment within the company	3,043	1,261	34,7%	26,1%	39,1%

The responses to the questionnaire indicate that six benefits among all factors have a mean value of 4 or higher and are considered more important by the respondent researchers. These benefits include the following choices with the percentage of responses considered by the researchers as important/very important: a) Raising human resources on the subjects needed by the industry (87,0), b) Keeping companies aware of the state of the art developments in science (95,6), c) Adapting the techniques and methods used in academic studies to business life (82,6), d) Developing different design methods, techniques and approaches from the

accumulated knowledge (86,9), e) Discussion of problems in group environment and finding solutions (78,3) and f) Contributing to the creation of independent and creative ideas (69,5).

As shown in Table 12, the main benefit that takes the highest mean value of university-industry-government collaboration to companies is to raise the human resources on the subjects needed by the industry. This opinion is also compatible with the statement of Ranga and Etzkowitz (2013) which expresses that universities act as the main provider of skilled and trained graduates. They also claim that this feature makes universities the ancillary support structure of the industry. Sarpong et al. (2017) also specifies the main function of universities as to conduct basic research, produce knowledge by publishing scientific papers and educate and graduate people with tacit knowledge.

Moreover, keeping companies aware of the state of the art developments in science is considered important/very important by the highest percentage of respondents as shown in Table 12. This opinion is also supported by the statements of Akhilesh (2014), Reger et al. (1996) and Nobelius, (2004) while drawing the framework of 5th generation R&D management, so-called the era of networking through the fully integrated parallel networking process. They claim that this process of 5th generation R&D management is focused on increasing product quality, performance and diversity. Therefore, the emphasis is on collaboration within a wider system and building up technological accumulation which leads to the state of the art developments in science and technology. Iansiti and West (1997) states that such characteristics accompanied by the evolving R&D management generations could bring vital competitive advantages to companies.

One can also infer that the rest of the statements in ranking scale could be considered as the crucial factors that support to keep companies aware of the state of the art developments in science and technology.

6.5. Benefits of U-I-G Collaboration to Universities

The evaluation of benefits of university-industry-government collaboration to universities was carried out with the findings obtained from the analysis of the responses given to the 11th question which is given below. These benefits are also listed in Table 13.

11-Please rate the benefits of university-industry-state collaboration to the university in general. (1: less important 5: very important)

Table 13. Benefits of U-I-G Collaboration to Universities

Ranking	Gains	Mean	Std Dev.	Slightly/ Not Important	Neutral	Important/ Very Important
1	Strengthening the technical equipment and infrastructure of the university	4,6087	0,65638	0,0%	8,7%	91,3%
3	Enables the university to follow the sector's problems, needs and perspective more closely	4,4783	0,66535	0,0%	8,7%	91,3%
2	Strengthening inter-institutional relations and paving the way for potential future collaborations	4,4783	0,73048	0,0%	13,0%	87,0%
4	Contributing to the improvement of the quality of education of the university	4,1304	0,86887	4,3%	17,4%	78,2%
5	Contributing to the formation of an environment based on teamwork	3,8696	1,05763	13,0%	21,7%	65,2%
6	Contributing to the creation of a competitive environment within the university	3,3913	1,26990	21,7%	34,8%	43,5%

The responses to the questionnaire indicate that four benefits among all factors have a mean value of 4 or higher and are considered more important by the respondent researchers. These benefits include the following choices with the percentage of responses considered by the researchers as important/very important: a) strengthening the technical equipment and infrastructure of the university (91,3), b) strengthening inter-institutional relations and paving the way for potential future

collaborations (87,0) c) enabling the university to follow the sector's problems, needs and perspective more closely (91,3) and d) contributing to the improvement of the quality of education of the university (78,2)

As shown in Table 13, the main benefit of university-industry-government collaboration to the university that takes the highest mean value and the least deviation is strengthening the technical equipment and infrastructure of the university. This characteristics of RWTC is supported by the governments' direct or indirect funding within the framework of triple helix model (Etzkowitz, 2008). Enabling the university to follow the sector's problems, needs and perspective more closely and strengthening inter-institutional relations and paving the way for potential future collaborations are evaluated as the second and third highest important benefit to universities. These statements are also in compatible with the 4th generation R&D management where R&D is seen as an integrative activity and the main focus is on the integration between R&D and industrial needs (Akhilesh, 2014).

6.6. Difficulties of U-I-G Collaboration While Working Each Other

The evaluation of the most important difficulties faced by the university, industry and government while working together in RWTC model was carried out with the findings obtained from the analysis of the responses given to the 12th question which is given below. These difficulties are also listed in Table 14.

12-Please rate the most important difficulties faced by the university, industry and the state while working together in RWTC model. (1: less important 5: very important)

The responses to the questionnaire indicate that one difficulty among all factors have a mean value which is higher than 4 and is considered more important by the respondent researchers as shown in Table 14. This difficulty is the salaries of

students working in the project are lower than those working in industry (73,9). RWTC researchers doing MSc or PhD, earn less money in comparison with a typical engineer in industry. Nevertheless, work schedules and commitments are different than a full time engineer in industry. Still, pecuniary issues are important motivational factors for researchers.

Table 14. Difficulties of U-I-G Collaboration while working each other

Ranking	Difficulties	Mean	Std Dev.	Slightly/ Not Important	Neutral	Important/ Very Important
1	The salaries of students working in the project are lower than those working in industry	4,174	0,937	4,3%	21,7%	73,9%
2	R&D project outputs do not always turn into the product needed by the industry	3,913	0,996	4,3%	26,1%	69,5%
3	Concerns about future employment of students working in the project	3,565	1,199	21,7%	21,7%	56,5%
4	Problems in the production process of the project outputs	3,522	1,201	17,4%	26,1%	56,5%
5	Lack of technical equipment and equipment in the projects	3,000	1,044	21,7%	47,8%	30,4%

Worth mentioning, R&D project outputs do not always turn into the product needed by the industry is ranked 2nd according to the mean values of the responses. Nobelius (2002) states that numerous companies see R&D as to some degree fuzzy, comprising high uncertainty and vague rate of return. Therefore, they consider R&D as troublesome to manage. Indeed, it is barely possible to plan particular R&D results due to uncertainty of results (Laliene & Liepe, 2015). Since the expectation from RWTC projects necessitates outputs, this nature of R&D could be considered as a risk factor through the research and development process. In addition, the least rated difficulty is found as lack of technical equipment and equipage in the projects with 30,4% of RWTC researchers.

6.7. Possible Improvements in RWTC Model

The evaluation of the improvements that can be made to the RWTC model to encourage students and ensure their continuity in projects was carried out with the findings obtained from the analysis of the responses given to the 13th question which is given below. These improvements are also listed in Table 15.

13-Please rate the improvements that can be made to the RWTC model to encourage students and ensure their continuity in projects. (1: less important 5: very important)

The responses to the questionnaire indicate that eight improvements among all factors have a mean value of 4 or higher and are considered more important by the respondent researchers. These improvements include the following choices with the percentage of responses considered by the researchers as important/very important: a) arrangements for funding and research continuity (91,3), b) arrangements for increasing educational opportunities (87,0), c) regulations for increasing the number of scientific articles (82,6), d) taking measures for longer-term cooperation between the parties (78,3), e) improvements in the evaluation process of the project results (82,6), f) regulations for increasing the patent application (73,9), g) regulations for increasing the patent application (73,9) and h) arrangements to ensure an equitable working environment between the parties (73,9).

Table 15. Possible Improvements in RWTC Model

Ranking	Improvements	Mean	Std Dev.	Slightly/ Not Important	Neutral	Important/ Very Important
1	Arrangements for funding and research continuity	4,391	0,656	0,0%	8,7%	91,3%
2	Arrangements for increasing educational opportunities	4,348	0,832	4,3%	8,7%	87,0%
3	Regulations for increasing the number of scientific articles	4,261	0,964	8,7%	8,7%	82,6%
4	Taking measures for longer-term cooperation between the parties	4,217	0,795	0,0%	21,7%	78,3%
5	Improvements in the evaluation process of the project results	4,174	0,937	8,7%	8,7%	82,6%
6	Arrangements for the parties to work in harmony with the common objective	4,174	0,834	0,0%	26,1%	73,9%
7	Regulations for increasing the patent application	4,043	1,107	8,6%	17,4%	73,9%
8	Arrangements to ensure an equitable working environment between the parties	4,000	0,953	8,7%	17,4%	73,9%
9	Necessary arrangements for the development of trust between the parties	3,957	0,976	8,7%	21,7%	69,6%
10	Regulations to improve product quality	3,826	1,029	13,0%	21,7%	65,2%
11	Regulations for the promotion of new company	3,739	1,054	13,0%	30,4%	56,5%
12	Regulations for increasing product diversity	3,696	1,105	13,0%	26,1%	60,9%
13	Balanced regulations on intellectual property rights between the parties	3,609	1,033	17,4%	26,1%	56,5%
14	Regulations to reduce costs and risks	3,391	1,158	21,7%	21,7%	56,5%

As shown in Table 15, the main improvement that takes the highest mean value in RWTC model in order to encourage students and ensure their continuity in projects is arrangements for funding and research continuity. This result is in compatible with the most important difficulty that RWTC researchers raised in the former question. Funding continuity throughout the project period is a crucial pecuniary issue for researchers while taking a decision to join in such R&D projects which

take for about two or three years. Research continuity also arises as an important improvement since it is an important criterion to establish the continuity of the research by putting research outputs as inputs for the next possible research. The fourth highest ranked improvement which is taking measures for longer-term cooperation between the parties also related with the first highest ranked improvement and in RWTC projects these issues are considered and built while constituting new projects. For example, after the seeding period of the initial projects, new projects are being designed to combine the previous projects' outputs under the same roof. The second and third highest ranked improvement is arrangements for increasing educational opportunities with 87 % and regulations for increasing the number of scientific articles with 82,6% respectively. Since RWTC projects are related to defence industry, confidentiality issues raises about the publication of scientific articles. This finding supports Gökpınar (2013) who have stated that the obstacle to the free flow of information is regarded as confidentiality and competition. However, it is also evaluated that what is called confidential is ambiguous / subjective, and therefore, everything necessary or unnecessary is given a high degree of confidentiality.

6.8. Gaps to be Filled in RWTC Model

The evaluation of the gaps that should be filled in the RWTC model in order to improve university-industry-government collaboration was carried out with the findings obtained from the analysis of the responses given to the 14th question which is given below. These gaps are also listed in Table 16.

14-Please rate the gaps that should be filled in the RWTC model in order to improve university-industry-state collaboration. (1: less important 5: very important)

The responses to the questionnaire indicate that two gaps among all factors have a mean value of 4 or higher and are considered more important by the respondent researchers. These gaps include the following choices with the percentage of

responses considered by the researchers as important/very important: a) organizing conferences where project outputs can be presented with the participation of all parties (78,3) and b) organizing congresses and conferences aimed at improving university, industry, state cooperation with the participation of all parties (78,2).

Table 16. Gaps to be Filled in RWTC Model

Ranking	Gaps	Mean	Std Dev.	Slightly/ Not Important	Neutral	Important/ Very Important
1	Organizing conferences where project outputs can be presented with the participation of all parties	4,130	0,757	0,0%	21,7%	78,3%
2	Organizing congresses and conferences aimed at improving university, industry, state cooperation with the participation of all parties	4,130	0,869	4,3%	17,4%	78,2%
3	Development of intermediate mechanisms for better communication between the parties	3,870	0,968	8,7%	26,1%	65,2%

As shown in Table 16, the main gaps that takes the highest mean values that should be filled in the RWTC model are organizing conferences where project outputs can be presented with the participation of all parties and organizing congresses and conferences aimed at improving university, industry, state cooperation with the participation of all parties. My findings share a common with those of Cross and Sproull (2004) in terms of 'social proximity' since they agreed with this opinion by pointing out that investing time, energy and efforts require willingness and motivation for people to solve problems collaboratively and transmit complex knowledge to each other. Therefore, strong ties are advantageous in relationships among people. These ties among all parties and organizations may also be strengthened by these regular conferences and congresses.

6.9. Additional Suggestions for the RWTC Model

The evaluation of the additional suggestions for improving the RWTC program was carried out with the findings obtained from the analysis of the responses given to the 15th question which is given below.

15-Please write your additional suggestions for improving the RWTC program. (If you have no suggestions, write "none".)

There are several suggestions provided by RWTC researchers for improving the current model. Featured suggestions are listed below:

- ✓ The working conditions of the employees can be improved,
- ✓ More participation of RWTC researchers to trainings and conferences held abroad can be supported,
- ✓ Activities should be organized in order to connect RWTC researchers more to the project and increase their motivation,
- ✓ Researchers' personal rights and wages can be improved according to the standards of any other engineer working in the same projects,
- ✓ Setting up a success criterion for the program and providing assurance for the continuation of employment for those researchers who meet this criterion when the fund in the project is finished,
- ✓ Increasing the duration of the projects to 5 years or ensuring project continuity after the project ends (Shorter project durations affects the project work and personnel performance negatively because everyone had the question of what will happen next in terms of employment towards the end of the project.),
- ✓ Strengthening communication between RWTC staff in TAI and university staff in R&D studies.

6.10. Concluding Remarks on the Quantitative Study

In this chapter, the views and suggestions of RWTC researchers are analyzed by using quantitative data. In this analysis, the rationale of researchers to join RWTC projects, benefits and difficulties of university-industry-government collaboration in RWTC model and improvements and gaps to be filled in RWTC model to move the current model further are discussed and evaluated by comparing the findings of the literature review. In the light of analysis of these quantitative data, RWTC can be considered as an exemplary thematic model in defence industry which carries out the remarkably common properties of the triple helix model. Some basic stylized facts deduced from quantitative analysis are presented as follows:

Stylized fact 1: Reaching the opportunities of industry contributes to synergy creation and this situation affects researchers positively and act as a motivational factor of their preference of working in university-industry-government collaboration project model.

Stylized fact 2: Innovation networks increases the chance of new knowledge acquisition and accumulation and also people of innovation actors learn from each other to complement their knowledge.

Stylized fact 3: Researchers working in companies and SMEs within the framework of RWTC projects gain organizational proximity with other workers in those organizations through organizational practices.

Stylized fact 4: The university-industry-government collaboration within a wider system and building up technological accumulation leads to the state of the art developments in science and technology.

Stylized fact 5: Enabling the university to follow the sector's problems, needs and perspective more closely, strengthening inter-institutional relations and paving the

way for potential future collaborations lead to the integration between R&D activities and industrial needs.

CHAPTER 7

CONCLUSION

7.1. Main Issues and Research Findings

This dissertation presents triple helix model by examining the case study Turkish Rotary Wing Technology Center (RWTC). For this purpose, it tried to identify the success factors of university-industry-government collaboration in the light of the answers of the research questions. It examined how RWTC transfer the know-how generated in the universities to the industry; how RWTC contribute to creating skilled human resource needed in the industry and how RWTC promote the sustainability processes in the industry. The theoretical framework for the analysis is constructed upon the R&D process and management, innovation systems and networks and helix innovation models. The literature survey shows that the main paradigms and evolution phases of these topics plays an important role in constructing a favorable university-industry-government collaboration model. In the light of the literature survey and the case study, the following conclusions are derived from the analysis of RWTC model:

Universities are the main source of science and knowledge. However, technology and the economic value created by it are achieved through much more complex relationships and collaborations. Therefore, systems established with university-industry-state collaboration models are considered as the main elements of today's knowledge-based economy systems.

- ✓ In the knowledge economy, information and technology are expressed as the most important production source and the most important way to move to the knowledge economy is to invest in knowledge. Government decisions to support R&D programs, policies implemented in the designated priority technology areas, and constructed work and collaboration models are important examples that demonstrate the role of the state in promoting knowledge production.

- ✓ In order to ensure an increase in Turkey's innovation performance strategic technology areas must be determined and new collaboration models should be provided for educating people in these specialized areas. Policies should invest in training of graduate students beyond the academic education by exploiting the facilities and experience of the industry. Also, developing strategies for education with these collaboration models in order to give young people an opportunity of working and pursuing their education simultaneously in their home country is important for avoiding the brain drain.

- ✓ Preparing and implementing roadmaps for the purpose of determining priority areas for technological needs nationwide and planning future technologies are suitable methods. In this way, actors can develop the path to be followed by future R&D studies and identify the partners with whom they will collaborate.

- ✓ Investments in basic research make actors to conribute to and keep up with the World science system. To be able to understand the knowledge produced by others can only be developed through investing in, performing and contributing to research.

- ✓ Guiding researchers about their projects, enabling them to benefit from the educational opportunities offered by the industry, providing social rights and an efficient working environment, and providing career opportunities in the subject they work at the end of the project; is crucial to maintaining an environment of trust and maintaining sustainability.

7.2. Policy Implications

The contribution of the dissertation to the literature is to construct a policy design model by analyzing the triple helix model of a thematic technology center in defence industry in Turkey from each helice's perspective. As far as the policy recommendations are concerned to improve the existing model further in the light of the literature survey and RWTC model analysis, several policy implications are derived as given in Table 17 and Table 18.

In this process, the policy design model built on three pillars consisting of policy aim, policy tool and policy target is used. The policy aim indicates the motivations for solving the policy problem. The policy tool is the instrument used to achieve the policy aim. Policy target is defined as the measurable criterion set in order to evaluate the success of the policy recommendation. Policy recommendations based on these three pillars are designed at micro, meso and macro levels.

Initially, micro level policy recommendations are designed to improve the management processes and functioning of each RWTC project and the working conditions and rights of newly trained human resources. Secondly, meso level policy recommendation is designed to positively affect the motivation of researchers in all RWTC projects and to create synergy. Finally, macro level policy recommendation is designed to create awareness about collaboration models in the whole country.

At micro level, firstly, it is recommended that *making up-to-date regulations on salary and personal rights for project workers* (Table 17). In the data analysis, it is found that the most important difficulty faced by the university, industry and government while working together in RWTC model is *the salaries of students working in the project are lower than those working in industry* (Table 6). Even if work schedules and commitments are different than a full-time engineer in industry, pecuniary issues are still important motivational factors for researchers. Therefore, main purpose of this policy recommendation (the policy aim) is *to determine wages and personal rights provided to the RWTC project workers within the framework of their responsibilities and job shares in the project.* For this purpose, *to make wage and personal rights arrangements according to balanced criteria for all RWTC project workers during the project call process* could be used as a policy tool. The policy target to achieve by this policy recommendation is *to rearrange the RWTC researcher fee rates considering the most current situation and the standards of other workers' personal rights and wages in RWTC projects.*

At micro level, secondly, it is recommended that *ensuring sustainability in RWTC projects.* In the data analysis, it is found that the most important improvement that can be made to the RWTC model is to encourage students and ensure their continuity in projects is *arrangements for funding and research continuity* (Table 7). In addition to this, one of the most important difficulty faced by the university, industry and government while working together in RWTC model is *concerns about future employment of students working in the project* (Table 6). Moreover, as stated in the qualitative research analysis, one of the main motives that RWTC researchers are articulated around is specified as wage and insurance continuity. By this policy recommendation, it is aimed *to ensure funding and research continuity for researchers and to solve concerns about future employment of researchers* (Table 17). This policy recommendation could be realized by *either increasing the project durations or ensuring project continuity after the project ends.* Moreover, *planning new studies with the researchers who have done successful projects* before

is another policy tool that offers solution. Funding continuity throughout the project period is a crucial pecuniary issue for researchers while taking a decision to join in such R&D projects which take for about two or three years. Research continuity also arises as an important improvement since it is an important criterion to establish the continuity of the research by putting research outputs as inputs for the next possible research. The main policy target to reach by this policy implication is *to provide assurance for the continuation of employment to researchers who meet the specified success criteria when the project is finished.*

At micro level, thirdly, it is recommended that *increasing publishing opportunities for RWTC researchers.* In the data analysis, it is found that one of the most possible improvements that can be made to the RWTC model is *regulations for increasing the number of scientific articles* (Table 7). The main purpose of this policy recommendation is *to support participation of RWTC researchers to domestic and international conferences more and to increase the number of scientific articles.* As a policy tool, *allocating sufficient budget for conference participation in project contracts* is offered. However, there exists one more concern related to this issue. Since RWTC projects are related to defence industry, confidentiality issues also raise about the publication of scientific articles. What is called confidential is ambiguous / subjective, and therefore, everything necessary or unnecessary is given a high degree of confidentiality. Therefore, *to develop criteria of confidentiality issues for the publication of scientific articles* would be another policy tool. To realize the policy recommendation of supporting the publication of scientific articles, the policy target is *to promote publishing certain number of publications for each project.*

At micro level, lastly, it is recommended that *employing experts and consultants in RWTC who have both academic career at university and experience in industry* (Table 18). One of the gaps to be filled in RWTC model is *the development of intermediate mechanisms for better communication between the parties* (Table 8).

These intermediate mechanisms consist of people who understand both sides with both academician perspective and industry perspective. The policy aim of this recommendation *is to strengthen communication between RWTC staff in TAI and researcher/academics in RWTC projects.* In addition to this, with expertise of these people, another policy aim which is *correctly evaluating the potential of the proposed projects to turn into products* also be satisfied. To achieve these purposes, the policy tool to use is *to promote employing PhD and post doc level workers in RWTC.* The policy targets to implement this policy recommendation is *to make accurate decisions in RWTC project selections and to make university and industry understand each other better and work more efficiently.*

At meso level, only policy recommendation is *to take measures for creation of synergy between RWTC researchers* (Table 18). The policy aim behind this recommendation is *to increase RWTC researchers' motivations and connections with each other.* In the quantitative research data analysis, it is stated that activities should be organized in order to connect RWTC researchers more to the project and increase their motivation. In table 8 it is given that, the most important gap to be filled in RWTC model in order to improve university-industry-government collaboration is *organizing conferences where project outputs can be presented with the participation of all parties.* Therefore, the policy tool to satisfy this need is *to organize workshops where project outputs can be presented with the participation of all parties.* Moreover, in the qualitative research, it is asserted that one of the main motives of RWTC researchers is to take support from experts and engineers in industry through steering and education. Another policy tool to realize this motive is *to organize trainings for researchers in necessary fields.* The policy target could be formulated by *organizing workshops about the project proceedings and organizing trainings related to helicopter technologies at least once a year.*
At macro level, it is recommended that *promoting more intense dialogue between the scientific community, industry, state and the general public.* The policy aim of this recommendation is *to increase awareness of helix collaboration models for*

both parties. In the quantitative research, one of the most important gaps to be filled in RWTC model in order to improve university-industry-government is *to organize congresses and conferences aimed at improving university, industry, state cooperation with the participation of all parties* (Table 8). This statement is used as policy tool for this policy recommendation. The policy target is *to organize congresses and conferences about certain themes to enhance helix collaboration models at least once a year*

Table 17. Policy Implications to Enhance RWTC Model Further (continued)

At	Policy Recommendations	Policy Aims	Policy Tools	Policy Targets
Micro Level	To make up-to-date regulations on salary and personal rights for project workers	*To determine wages and personal rights provided to the RWTC project workers within the framework of their responsibilities and job shares in the project	*To make wage and personal rights arrangements according to balanced criteria for all RWTC project workers during the project call process	*To rearrange the RWTC researcher fee rates considering the most current situation and the standards of other workers' personal rights and wages in RWTC projects
Micro Level	To ensure sustainability in RWTC projects	*To ensure funding and research continuity for researchers *To solve concerns about future employment of researchers	*Either to increase the project durations or to ensure project continuity after the project ends *To plan new studies with the researchers who have done successful projects before	*To provide assurance for the continuation of employment to researchers who meet the specified success criteria when the project is finished
Micro Level	To increase publishing opportunities for RWTC researchers	*To support participation of RWTC researchers to domestic and international conferences more *To increase the number of scientific articles	*To allocate sufficient budget for conference participation in project contracts * To develop criteria of confidentiality issues for the publication of scientific articles	*To promote publishing certain number of publications for each project

Table 18. Policy Implications to Enhance RWTC Model Further

At	Policy Recommendations	Policy Aims	Policy Tools	Policy Targets
Micro Level	To employ experts and consultants in RWTC who have both academic career at university and experience in industry	*To correctly evaluate the potential of the proposed projects to turn into products *To strengthen communication between RWTC staff in TAI and researcher/academics in RWTC projects	*To promote employing PhD and post doc level workers in RWTC	*To make accurate decisions in RWTC project selections *To make university and industry understand each other better and work more efficiently
Meso Level	To take measures for creation of synergy between RWTC researchers	*To increase RWTC researchers' motivations and connections with each other	*To organize workshops where project outputs can be presented with the participation of all parties *To organize trainings for researchers in necessary fields	*To organize workshops about the project proceedings at least once a year *To organize trainings related to helicopter technologies at least once a year
Macro Level	To promote more intense dialogue between the scientific community, industry, state and the general public	*To increase awareness of helix collaboration models for both parties	*To organize congresses and conferences aimed at improving university, industry, state cooperation with the participation of all parties	*To organize congresses and conferences about certain themes to enhance helix collaboration models at least once a year

7.3. Possible Future Research

It has been obtained from this thesis that, university-industry-government collaboration in the triple helix framework strengthens the knowledge dissemination and collective learning processes on both sides, increases the qualified workforce, the technology level of the industry and leads to an innovation-based economic development. In order to strengthen the dynamic interaction, relationship and collaboration between the actors of the current triple helix model of RWTC, it is important to monitor, evaluate and enhance this collaboration model with the right policy tools. This approach will help to understand the complex dynamics of the information society and develop new innovation and development strategies. Therefore, the next research subject would to investigate how the strategic interactions of triple helix model evolve into more advanced models. These models are quadruple helix and quintuple helix models. At the core of these models there exists triple helix model. The media / society in the quadruple helix model and the natural environment in the quintuple helix model are defined as the environments surrounding the three main actors of the triple helix model. At the same time, these factors (media/society and natural environment) are considered not as actors of innovation processes, but as factors affecting triple helix actors' qualifications and decision processes, and contribute to the formation of a more productive, sustainable and environmentally sensitive innovation ecosystem. As a result, examining how the triple helix model can be evolved into quadruple and quintuple helix models is of great importance for the creation of a more enhanced innovation ecosystem.

Another research subject is the investigation on how policies and enforcement mechanisms could be formed to enhance helix innovation models further in defence sector to promote dual use technologies for the purpose of taking advantage of the potential for a commercial market. Beşikçi (2020) describes the potential benefits of dual-use technology as follows:

- ✓ Accelerating the technology acquisition process by more effective participation of SMEs that do not have enough military product marketing opportunities
- ✓ Decrease in product unit costs with the expansion of production volume as a result of the expansion of the market volume.
- ✓ Increasing competition positively affects efforts to improve product features

A director from SSB explained the approaches and activities to dual-use technologies within the scope of the SSB R&D and Technology Management Department as follows (Aziz, 2020):

"…We have gradually started to sign our planned advanced technology projects in order to acquire critical technology and accelerate the 'dual-use national technology move' in sectors that will feed each other technologically."

It is anticipated that bringing dual-use technologies to the agenda under the leadership of SSB will accelerate the realization of research studies on this subject. This strategy also helps to form a portfolio-based approach for the outputs of the basic research since the contribution of a single piece of basic research may extend to a variety of technological and product developments.

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APPENDICES

A. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

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21 Ocak 2020

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Erkan ERDİL

Danışmanlığını yaptığınız **Merve TIRAŞ'ın "Üçlü Sarmal Modeli ve Döner Kanat Teknoloji Merkezi"** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **036-ODTU-2020** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Prof.Dr. Mine MISIRLISOY
Başkan

Prof. Dr. Tolga CAN
Üye

Doç.Dr. Pınar KAYGAN
Üye

Dr. Öğr. Üyesi Ali Emre TURGUT
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Dr. Öğr. Üyesi Şerife SEVİNÇ
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Dr. Öğr. Üyesi Müge GÜNDÜZ
Üye

Dr. Öğr. Üyesi Süreyya Özcan KABASAKAL
Üye

B. INTERVIEW QUESTIONS

B.1 TURKISH VERSION OF INTERVIEW QUESTIONS FOR SSB

Mülakat Soruları (SSB)

1. Helikopter teknolojileri için bir Döner Kanat Teknoloji Merkezi kurma fikri nasıl ortaya çıktı?
2. DKTM'nin hedefleri nelerdir?
3. Üniversite-Sanayi-Devlet işbirliği modeli olarak geliştirilen DKTM bu aktörler tarafından nasıl destekleniyor?
4. DKTM'de çalışılacak projeler seçilirken nasıl bir süreç izleniyor? Aday projelerin değerlendirmelerini yapacak heyet/kişiler nasıl seçiliyor? Aday projeler değerlendirilirken hangi kriterlere bakılıyor?
5. Aday proje değerlendirme sürecinin iyileştirilmesi ve proje seçiminde daha isabetli kararlar alınması için önerileriniz nelerdir?
6. DKTM projelerinde sanayinin ihtiyaç duyduğu konular ve üniversitelerin çalışma alanları arasında uygun kesişmeler nasıl sağlanıyor?
7. Firma ve üniversitelerle iletişim kurduğunuzda bazı problemlerle karşılaştınız mı? SSB'nin bu problemleri bazı örneklerle nasıl çözdüğünü lütfen belirtir misiniz?
8. Üniversitelerin katılımı ne durumda? DKTM, üniversitelerin katılımını nasıl arttırıyor?
9. DKTM Projelerinde başarı ölçümünü nasıl yapıyorsunuz? Projelerde neleri başarı ve neleri başarısızlık olarak kabul ediyorsunuz?
10. Projelerdeki başarı/başarısızlık durumlarında ödül/ceza mekanizmaları var mı, varsa bu mekanizmalar nasıl işliyor?
11. DKTM Projelerinde Aralık 2014-Ocak 2018 tarihleri arasında THS 1-4 arası çalışmalar gerçekleştirilmiştir. Bu projelerde DKTM yol haritasında hedeflenenler hangi ölçüde gerçekleşmiştir?

- Projelerin verilen süre içerisinde tamamlanma oranları,
- Projelerde hedeflenen proje olgunluk düzeyine ulaşma oranları,
- Proje kapsamındaki lisans üstü tezlerin tamamlanma oranları,
- Projede yetişmiş insan kaynağının ilgili sektörde istihdam edilme oranları

12. Projelerin sonunda ulaşılan THS seviyesini ölçmek için kullandığınız bir yöntem var mı? Proje teknik çıktılarını nasıl değerlendiriyorsunuz?
13. Projelerde çalışan master ve doktora öğrencilerine üniversite danışmanlarının yanı sıra projelerinde rehberlik yapmak için sanayiden de bir danışman veriliyor mu?
14. Size göre DKTM modelinde üniversite ve sanayinin birlikte çalışırken yaşadığı en büyük zorluklar nelerdir? İki tarafın birbirini daha iyi anlayabilmesi için hangi konularda boşlukların doldurulmasına ihtiyaç var?
15. DKTM modelinde üniversite-sanayi-devlet işbirliğinin geliştirilmesi ya da daha etkin hale getirilmesi için önerileriniz nelerdir?
16. DKTM'nin gelecekteki iş planı nedir?
17. Size göre DKTM için gelecekte gerçekleşebilecek en iyi, en ilginç ve en kötü sonuçlar neler olabilir?

B.2 ENGLISH VERSION OF INTERVIEW QUESTIONS FOR SSB

Interview Questions (SSB)

1. How did the idea to establish a Rotary Wing Technology Center for helicopter technologies come about?

2. What are the goals of RWTC?

3. How is the RWTC developed as a University-Industry-Government collaboration model supported by these actors?

4. What kind of a process is followed when selecting the projects to be worked on in RWTC? How are the committee / persons to evaluate the candidate projects selected? Which criteria are taken into consideration when evaluating candidate projects?

5. What are your suggestions for improving the candidate project evaluation process and making better decisions in project selection?

6. How are the appropriate intersections between the subjects required by the industry and the fields of study of universities in RWTC projects?

7. Did you encounter some problems when communicating with companies and universities? Could you please indicate how the SSB solved these problems with some examples?

8. How is the participation of universities? How does RWTC increase the participation of universities?

9. How do you measure success in RWTC Projects? What do you consider as success and failure in projects?

10. Are there reward / punishment mechanisms in case of success / failure in projects, if so, how do these mechanisms work?

11. TRL 1-4 studies were carried out in RWTC Projects between December 2014 and January 2018. To what extent were the targets of the RWTC roadmap achieved in these projects?

• The completion rates of the projects within the given time,

• The ratios of reaching the targeted project maturity level in the projects,

• Completion rates of postgraduate theses within the scope of the project,

• The rate of employment of the human resources trained in the project in the relevant sector

12. Is there a method you use to measure the TRL level achieved at the end of projects? How do you evaluate the technical outputs of the project?

13. Are masters and PhD students working in the projects provided with a consultant from the industry to guide their projects in addition to university advisors?

14. In your opinion, what are the biggest difficulties faced by the university and industry working together in the RWTC model? On which subjects do the gaps need to be filled so that the two sides can understand each other better?

15. What are your suggestions for improving or making more effective university-industry-government collaboration in the RWTC model?

16. What is RWTC's future business plan?

17. In your opinion, what could be the best, most interesting and worst outcomes for RWTC in the future?

B.3 TURKISH VERSION OF INTERVIEW QUESTIONS FOR TAI

Mülakat Soruları (TAI)

1. Helikopter teknolojileri için bir Döner Kanat Teknoloji Merkezi kurma fikri nasıl ortaya çıktı?
2. Ne zaman bu birime katıldınız? Daha önceki iş tecrübeleriniz nelerdi? Kısaca bahseder misiniz?
3. DKTM'nin hedefleri nelerdir?
4. Üniversite-Sanayi-Devlet işbirliği modeli olarak geliştirilen DKTM bu aktörler tarafından nasıl destekleniyor?
5. DKTM projelerinde sanayinin ihtiyaç duyduğu konular ve üniversitelerin çalışma alanları arasında uygun kesişmeler nasıl sağlanıyor?
6. DKTM'de çalışılacak projeler seçilirken nasıl bir süreç izleniyor? Aday projelerin değerlendirmelerini yapacak heyet/kişiler nasıl seçiliyor? Aday projeler değerlendirilirken hangi kriterlere bakılıyor?
7. Aday proje değerlendirme sürecinin iyileştirilmesi ve proje seçiminde daha isabetli kararlar alınması için önerileriniz nelerdir?
8. DKTM projelerinden beklentileriniz nelerdi? Ne ölçüde bu beklentilerinize karşılık bulabildiniz (üniversiteden, öğrencilerden, süreçten vb.)?

9. Üniversitelerle ve KOBİlerle iletişim kurduğunuzda bazı problemlerle karşılaştınız mı? Firmanızın bu problemleri bazı örneklerle nasıl çözdüğünü lütfen belirtir misiniz?
10. Üniversitelerin ve KOBİlerin katılımı ne durumda? DKTM, üniversitelerin ve KOBİlerin katılımını nasıl arttırıyor?
11. DKTM projelerinin fikri-sınai-mülkiyet hakları proje bitiminde kime ait oluyor?
12. DKTM Projelerinde başarı ölçümünü nasıl yapıyorsunuz? Projelerde neleri başarı ve neleri başarısızlık olarak kabul ediyorsunuz?
13. Size göre öğrencilerin üniversite-sanayi-devlet işbirliği projelerine katılımını artırmak için proje süreçleri ve proje sonrası sunulan imkanlarda nasıl iyileştirmeler yapılmalıdır? Proje bitiminde ilgili sanayide istihdam edilme konusunda, projede çalışan öğrenciler için ne gibi avantajlar sağlandığını düşünüyorsunuz? (Network, referans, konu uzmanlığı, lisansüstü derecesi, tecrübe vb.)
14. Size göre DKTM modelinde üniversite ve sanayinin birlikte çalışırken yaşadığı en büyük zorluklar nelerdir? İki tarafın birbirini daha iyi anlayabilmesi için hangi konularda boşlukların doldurulmasına ihtiyaç var?
15. Size göre yurtdışındaki örneklerde ülkemizdeki üniversite-sanayi-devlet işbirliği projelerine göre gözlemlediğiniz avantajlar ve dezavantajlar nelerdir?
16. Size göre üniversite-sanayi-devlet arasındaki iletişimsel ilişkileri ve sinerjileri en üst düzeye çıkarmak için güçlendirmenin ve iyileştirmenin yolları nelerdir? Farklı ülkelerdeki uygulamalardan esinlenip Türkiye'de daha iyi modeller oluşturmak ve uygulayabilmek için bu konuda nasıl çıkarımlar yapabiliriz?

B.4 ENGLISH VERSION OF INTERVIEW QUESTIONS FOR TAI

Interview Questions (TAI)

1. How did the idea to establish a Rotary Wing Technology Center for helicopter technologies come about?

2. When did you join this unit? What were your previous work experiences? Could you briefly mention?

3. What are the goals of RWTC?

4. How is RWTC developed as a University-Industry-Government collaboration model supported by these actors?

5. How are the appropriate intersections between the subjects required by the industry and the fields of study of universities in RWTC projects?

6. What kind of process is followed when selecting the projects to be worked on in RWTC? How are the committee / persons to evaluate the candidate projects selected? Which criteria are taken into consideration when evaluating candidate projects?

7. What are your suggestions for improving the candidate project evaluation process and making better decisions in project selection?

8. What were your expectations from the RWTC projects? To what extent have you met these expectations (from the university, students, process, etc.)?

9. Did you encounter some problems when communicating with universities and SMEs? Could you please indicate how your company solves these problems with some examples?

10. How is the participation of universities and SMEs? How does RWTC increase the participation of universities and SMEs?

11. Who owns the intellectual property rights of RWTC projects at the end of the project?

12. How do you measure success in RWTC Projects? What do you consider as success and failure in projects?

13. In your opinion, how should improvements be made in project processes and post-project opportunities to increase students' participation in university-industry-government collaboration projects? At the end of the project, what kind of advantages do you think are provided for the students working in the

project in terms of employment in the relevant industry? (Network, reference, expertise, graduate degree, experience, etc.)

14. In your opinion, what are the biggest difficulties faced by the university and industry working together in the RWTC model? On which subjects do the gaps need to be filled so that the two sides can understand each other better?

15. According to you, what are the advantages and disadvantages that you observe in foreign examples compared to university-industry-government collaboration projects in our country?

16. In your opinion, what are the ways to strengthen and improve the communicative relationships and synergies between university-industry-government to maximize? How can we make inferences about this subject by inspiring the applications in different countries to create better models and implemented in Turkey?

B.5 TURKISH VERSION OF INTERVIEW QUESTIONS FOR ACADEMICS

Mülakat Soruları (Akademisyenler)

1. Sizce genel olarak üniversite-sanayi-devlet işbirliğinin faydaları nelerdir?
2. Daha önce üniversite-sanayi-devlet işbirliği projelerinde yer aldınız mı? Kısaca bahseder misiniz?
3. Katıldığınız üniversite-sanayi-devlet işbirliği projelerinden beklentileriniz nelerdi? Ne ölçüde bu beklentilerinize karşılık bulabildiniz (firmadan, öğrencilerden, süreçten vb.)?
4. Katıldığınız üniversite-sanayi-devlet işbirliği projelerinde çalıştığınız konuların sanayide bir uygulama alanı bulması çalışma motivasyonunuzu nasıl etkiliyor?
5. Katıldığınız üniversite-sanayi-devlet işbirliği projelerinde çalışılan konuların firmanın performansına nasıl bir katkı sağladığını

düşünüyorsunuz? Bu projelerde siz beraber çalıştığınız firmaya neler kattığınızı düşünüyorsunuz?

6. Katıldığınız üniversite-sanayi-devlet işbirliği projelerinde sanayinin ihtiyaç duyduğu konular ve üniversitelerin çalışma alanları arasında uygun kesişmeler nasıl sağlanıyor? Size göre çalışılacak konuların ve projelerin seçilmesi sürecinde nasıl iyileştirmeler yapılabilir?
7. Katıldığınız DKTM projesinde fikri-sınai-mülkiyet hakları proje bitiminde kime ait oluyor?
8. Katıldığınız üniversite-sanayi-devlet işbirliği projelerinde başarı ölçümünü nasıl yapıyorsunuz? Projelerde neleri başarı ve neleri başarısızlık olarak kabul ediyorsunuz?
9. Size göre öğrencilerin üniversite-sanayi-devlet işbirliği projelerine katılımını artırmak için proje süreçleri ve proje sonrası sunulan imkanlarda nasıl iyileştirmeler yapılmalıdır? Proje bitiminde ilgili sanayide istihdam edilme konusunda, projede çalışan öğrenciler için ne gibi avantajlar sağlandığını düşünüyorsunuz? (Network, referans, konu uzmanlığı, lisansüstü derecesi, tecrübe vb.)
10. Size göre akademisyenlerin ve öğrencilerin projelere katılımını ve performanslarını artırmak için nasıl iyileştirmeler yapılmalı ve destekler sağlanmalıdır? Sizce bu konuda üniversiteler nasıl prosedürler formüle edebilir?
11. Size göre üniversite-sanayi-devlet işbirliği projelerinde üniversite ve sanayinin birlikte çalışırken yaşadığı en büyük zorluklar nelerdir? İki tarafın birbirini daha iyi anlayabilmesi için hangi konularda boşlukların doldurulmasına ihtiyaç var?
12. Size göre yurtdışındaki örneklerde ülkemizdeki üniversite-sanayi-devlet işbirliği projelerine göre gözlemlediğiniz avantajlar ve dezavantajlar nelerdir?
13. Size göre üniversite-sanayi-devlet arasındaki iletişimsel ilişkileri ve sinerjileri en üst düzeye çıkarmak için güçlendirmenin ve iyileştirmenin yolları nelerdir? Farklı ülkelerdeki uygulamalardan esinlenip Türkiye'de

daha iyi modeller oluşturmak ve uygulayabilmek için bu konuda nasıl çıkarımlar yapabiliriz?

B.6 ENGLISH VERSION OF INTERVIEW QUESTIONS FOR ACADEMICS

Interview Questions (Academics)

1. What do you think are the benefits of university-industry-government cooperation in general?

2. Have you ever been involved in university-industry-government collaboration projects? Could you briefly mention?

3. What were your expectations from the university-industry-government collaboration projects you participated in? To what extent have you met these expectations (from the company, students, process, etc.)?

4. In the university-industry-government collaboration projects you participated in, how does the fact that your subjects find an application area in the industry affect your motivation to work?

5. How do you think the subjects studied in the university-industry-government collaboration projects you participated in contribute to the performance of the company? What do you think you have contributed to the company you work with in these projects?

6. In the university-industry-state cooperation projects you participate in, how are the appropriate intersections between the subjects required by the industry and the fields of study of the universities ensured? In your opinion, what improvements can be made in the selection of the subjects and projects to be studied?

7. Who owns the intellectual-industrial property rights in the RWTC project you participated in at the end of the project?

8. How do you measure success in university-industry-government collaboration projects you participated in? What do you consider as success and failure in projects?

9. According to you, what kind of improvements should be made in the project processes and opportunities offered after the project in order to increase the participation of students in university-industry-government collaboration projects? At the end of the project, what kind of advantages do you think are provided for the students working in the project in terms of employment in the relevant industry? (Network, reference, expertise, graduate degree, experience, etc.)

10. According to you, what kind of improvements should be made and support should be provided to increase the participation of academicians and students in projects and their performance? In your opinion, what kind of procedures can universities formulate in this regard?

11. In your opinion, what are the biggest difficulties faced by the university and industry working together in university-industry-government collaboration projects? On which subjects do the gaps need to be filled so that the two sides can understand each other better?

12. In your opinion, what are the advantages and disadvantages that you observe in foreign examples compared to university-industry-state collaboration projects in our country?

13. In your opinion, what are the ways to strengthen and improve the communicative relationships and synergies between university-industry-government to maximize? How can we make inferences about this subject by inspiring the applications in different countries to create better models and implemented in Turkey?

C. TURKISH SUMMARY / TÜRKÇE ÖZET

1. Giriş ve Teorik Çerçeve

Ar-Ge ve inovasyon süreçleri birçok bilimsel, teknolojik ve ticari belirsizlik taşımaktadır. Bu belirsizlikler, yatırımcıların yatırımlarının sonuçları hakkında tahminlerde bulunmalarını zorlaştırmaktadır. Ar-Ge projelerindeki bilimsel ve teknolojik belirsizlikler o kadar fazladır ki, sanayi şirketleri doğal olarak bu tür projelerdeki risklerini kamu veya özel sektörden diğer aktörlerle paylaşarak azaltma yollarını aramaktadırlar. (Göker, 2003). Bu amaçla, şirketlerin üniversiteler ile çalışması ve üniversitelerin bilgi, deneyim, araştırmacı ve laboratuvar imkanlarından yararlanmaları için üniversite-sanayi işbirliği modellerinin oluşturulması gerekmektedir. Durgut (2007), üniversiteyle olan ilişkilerin, şirketlerin teknolojik değişiklikleri izlemelerine ve inovasyon yeteneklerini güçlendirmelerine izin vererek şirketlerin rekabet güçlerini artırmalarına yardımcı olduğunu belirtmektedir. Üniversiteler ise yeni kaynaklara, teknik bilgiye ve endüstriyel uygulama fırsatlarına erişerek bu ilişkilerden yararlanmaktadır.

Bir ülkenin yenilikçilik yeteneği tek bir aktöre değil, birden çok aktöre ve bunların aynı düzeydeki başarılarına bağlıdır; bu aktörlerin sistemik bir bütünlük içinde ve belli bir uyum içinde hareket etmesi gerekmektedir. Üçlü sarmal modeline göre, bilgiyi ekonomik bir faydaya dönüştürme sürecinin farklı aşamalarında, bu üç dünyanın kurumları arasında birçok karşılıklı ama karmaşık ilişki ortaya çıkmaktadır. İnovasyon, söz konusu üç dünya arasında var olan bu karmaşık ilişkilerin ürünüdür. Model, inovasyon sürecinin doğası ve bu süreçte üç dünyanın yakından ilişkili rolleri hakkında oldukça yetkin açıklamalar sağlar (Göker, 2000). Bilgi üretimi ve yönetimine odaklanan bilgiye dayalı bir ekonomi, küresel pazarda rekabet edebilmek için inovasyonu ekonomik büyümenin ana itici gücü olarak kullanmaktadır. Üniversite, sanayi ve devlet arasındaki etkileşimlere dayanan üçlü

sarmal inovasyon modeli, bilgiye dayalı ekonomik kalkınmayı teşvik etmek için bir ortam yaratmaktadır.

Bu tezin temel amacı Türkiye'deki Döner Kanat Teknoloji Merkezinde (DKTM), Üniversite-Sanayi-Devlet işbirliğinin başarı faktörlerini incelemektir. Bu hedefe döner kanat teknolojileri alanındaki temel araştırma soruları cevaplanarak ulaşılacaktır: DKTM, üniversitelerde üretilen teknik bilgiyi sanayiye nasıl aktarmaktadır?; DKTM, sanayide ihtiyaç duyulan kalifiye insan kaynağının yaratılmasına nasıl katkıda bulunmaktadır?; DKTM, sektördeki sürdürülebilirlik süreçlerini nasıl teşvik etmektedir? Google akademik veritabanına dayanarak, Türkiye'de savunma sanayiinde tematik bir teknoloji merkezi bağlamında üçlü sarmal modelini araştıran bir çalışma yoktur.

DKTM modelini oluşturan kavramların literatür çalışmaları çerçevesinde teorik altyapısı ArGe süreçleri, inovasyon sistemi, üçlü sarmal modeli başlıkları altında incelenmiştir. Aynı zamanda ileride yapılacak çalışmalarda DKTM'nin mevcut üçlü sarmal modelini daha da geliştirmek için, dörtlü sarmal ve beşli sarmal işbirliği modelleri de literatür araştırması kapsamında incelenmiştir. Literatürde yer alan bu kavramların evrimsel gelişim süreçleri detaylı olarak analiz edilmiş ve bu kapsamda edinilen bilgiler DKTM modeli çalışmaları kapsamında yapılan niteliksel ve niceliksel araştırmalar için girdi teşkil etmiştir. Bu incelemeler kapsamında aşağıdaki konular detaylı açıklanmıştır:

(i) Ar-Ge ve inovasyonla ilgili bir ortamın nasıl organize edildiği
(ii) İnovasyon ağları arasındaki etkileşimli süreçlerin dinamikleri
(iii) Mevcut bilgiden know-how üretme mekanizması

Kamu sözleşmesine dayanan Ar-Ge veya özel sektör Ar-Ge'sinin yatırım kararlarını belirlemek ve Ar-Ge stratejilerini değerlendirmek için pozitif bir getiri ve gelecekte yatırımların nasıl yönlendirileceğini gösteren bir kılavuz olmalıdır çünkü Ar-Ge'ye yatırım pahalı ve risklidir. Politika yapıcılar sosyal ve ekonomik açıdan getiri oranlarıyla ilgilenirken, ekonomistler ve şirket yöneticileri Ar-Ge yatırımlarının özel getiri oranıyla ilgilenirler (Hall ve diğerleri, 2009).

Ar-Ge yönetimi, rekabetçilik yeteneği açısından çok önemli bir rol oynamaktadır çünkü bu kavram, organizasyonların yeni teknolojileri ticari ürünlere entegre etmek ve geliştirmek için etkili ve tekrarlanabilir süreçler kullanma kapasitesini gösterir. Çok sayıda şirket, Ar-Ge'yi yüksek belirsizlik ve belirsiz getiri oranı içeren bir aktivite olarak görmektedir. Bu nedenle, Ar-Ge faaliyetlerini yönetmenin zahmetli olduğunu düşünmektedirler (Nobelius, 2002). Gerçekten de, sonuçların belirsizliği nedeniyle belirli Ar-Ge çıktılarını planlamak neredeyse imkansızdır (Laliene & Liepe, 2015). Bununla birlikte, şirketler Ar-Ge süreçlerini yönetmede başarılı olabilir, teslimat sürelerini daha kesin bir şekilde tahmin edebilir, geliştirme maliyetlerini düşürebilir ve nihai ürünlerin kalitesini artırabilirler. Böylece bu başarılar, şirketlerin daha fazla pazar payı elde etme ve daha iyi bir rekabet edebilirlik avantajlarına sahip olmalarına neden olmaktadır (Nobelius, 2002).

Günümüzün hızla değişen dünyasında, şirketler için kârlı kalmak her zamankinden daha zor olmaktadır. Bu değişikliklerle yüzleşirken, Ar-Ge yönetiminin niteliği şirketlere çok önemli rekabet avantajları sağlayabilmektedir (Iansiti ve West, 1997). Ar-Ge yönetim strateji modelleri, 1950'lerden beri çeşitli dönüşüm süreçlerinden geçmiştir. Bu stratejiler çerçevesinde, Ar-Ge süreçlerinin doğru bir şekilde yönetilmesi, zahmetli ve basit cevapları olmayan bir tartışma konusu olarak görülmektedir. Ancak doğru stratejileri seçebilen ve Ar-Ge faaliyetlerini etkili bir şekilde yönetebilen şirketler, ürünlerin kalitesini artırabilmekte, geliştirme maliyetlerini düşürebilmekte, zamanında teslimat yapabilmekte ve karşılığında birçok alanda rekabet yeteneklerini güçlendirebilmektedir.

Ar-Ge'nin ticarileştirilmesi zaman, çaba ve para gerektirmekte ve bunun için dış finansman önemli bir rol oynamaktadır. Üniversite kaynakları sınırlıdır ve özel yatırımcılar çok erken aşamalarda Ar-Ge'ye yatırım yapma konusunda isteksizdir. Bu nedenle, devlet programları oluşturulmakta ve Ar-Ge'nin ticarileştirilmesini desteklemek için üniversiteye yardımcı kuruluşlar bulunmaktadır. Ticarileştirmeyi destekleyen bu hükümet programları, üniversitelerdeki akademisyenler için oldukça dikkat çekicidir. Bu hükümet programlarının, spin-off'ların yaratılmasını teşvik edebilmesi için verimli ve etkili olması gerekir. Bu programlar, yatırım

engellerini azaltarak KOBİ'lerin Ar-Ge'si üzerinde olumlu bir etkiye sahiptir (Houweling, 2017).

İnovasyon sistemleri, Ar-Ge'den ticarileştirmeye kadar olan aşamaları kapsayan inovasyon yaratma sürecinde önemli bir role sahiptir. Gerçekten de, ulusal inovasyon politikasının ana teması, ülkenin Ar-Ge kabiliyetini artırmanın yanı sıra, Ar-Ge sonucunda üretilen bilim ve teknolojiyi ekonomik ve sosyal bir fayda haline getirme ve geliştirme kabiliyetini artırmaktır (Göker, 2003).

Ulusal İnovasyon Sistemi, Ar-Ge sistemi, teknoekonomik sistem, eğitim sistemi ve kültürel sistem dahil olmak üzere önemli alt sistemleri kapsar ve üniversiteler, araştırma enstitüleri, şirketler, kurumlar ve hükümeti içeren birkaç aktörden oluşur. Bir ülkenin ekonomik gelişimi, bu aktörlerin etkileşimine ve bu alt sistemlerin birlikte evrim sürecine bağlıdır (Krishna, 2017; Afzal, 2017; Yoda ve Kuwashima, 2019). Ulusal İnovasyon Sistemi, inovasyon sürecini destekleyen ana unsurun insanlar, kurumlar ve şirketler arasındaki bilgi ve teknoloji akışı olduğuna vurgu yapmaktadır. Ulusal İnovasyon Sisteminin esas amacı refah seviyesini arttırmak olduğundan, bu aktörler arasındaki karmaşık ilişkileri desteklemek ve geliştirmek için politikalar tasarlamak, ülkenin inovatif performansının ve ekonomik rekabet gücünün artmasına neden olmaktadır (OECD, 1997). Gerçekte de, dünyanın en gelişmiş ülkeleri kapsamlı ve karmaşık Ulusal İnovasyon Sistemlerine sahiptir (Santonen ve diğerleri, 2015).

İnovasyon, katma değeri yüksek ürün ve süreçlere ulaşmak amacıyla bilimsel yaratıcılık, teknolojik fizibilite ve ticari gerçekleştirilebilirlik üzerine inşa edilmiştir. Araştırmada yüksek kaliteli çıktılara ulaşmak için, işbirliğine dayalı inovasyon ağları üzerine kurulan işbirliğine dayalı bilgi üretimi zamanla daha etkili ve yaygın hale gelmiştir (Ahrweiler ve Keane, 2013).

Aktörler, birbirlerinin faaliyetlerini tamamlayabilecek bilgi ve kaynakları araştırmak, yeni bilgi edinimini ve birikimini artırmak ve yeni fırsatların farkına varmak için inovasyon ağlarını kullanırlar. Gerçekten de, inovasyonu keşfetme

amacıyla, aktörler, ağlar olarak nitelendirilebilecek ekipler, topluluklar ve organizasyonel bağlamlar içinde çalışarak birbirlerinden bilgilerini tamamlamayı öğrenirler. Bu ağlar içindeki çeşitli etkileşimler yoluyla mucitler, inovasyonlarını pazar ihtiyaçları ile daha fazla ilişkilendirmek için yaratıcılıklarını, bilimsel ve ticari bilgilerini geliştirirler.

Bu heterojen aktörler grubu; şirketler, üniversiteler, teknoloji merkezleri ve geliştirme organizasyonlarından oluşmaktadır (Pekkarinen & Harmaakorpi, 2006). Özman'a (2017) göre inovasyon ağları, mucit ağları, finansal kaynak ağları, tasarım ve üretim şirketleri, pazarlama ve satış ekipleri, tedarikçiler, rakipler, özel ve kamu araştırma laboratuvarları, profesyonel ve ticari birlik/dernek/odalar ve ayrıca inovasyon kullanıcılarından oluşur.

Bilgi ekonomisi bağlamında inovasyon ağları, rekabet edebilirlik için temel bir strateji olarak görülmektedir. Bu ağlar, inovasyon sistemlerinin dinamikleri için bir ön koşul olarak değerlendirilmektedir. Ağdaki aktörler arasındaki etkileşim, bağlılık ve işbirliği arttıkça, onların inovatif performansı da artmaktadır (Pinto vd., 2015).

Bilgi alışverişi ve inovasyon yapabilmek için, ağ örgütleri birbirlerine yakın olma ve bilişsel ve teknolojik alanda tamamlayıcı olma eğilimi gösterir (Virkkala vd., 2014). Buna göre, yakınlık bilgi ağlarıyla birlikte gelişir ve Padgett ve Powell'ın (2012) belirttiği gibi "kısa vadede aktörler ilişkiler yaratır; uzun vadede ilişkiler aktör yaratır". İnovasyon ağlarının aktörleri arasındaki ilişkileri incelemek için literatürde farklı yakınlık biçimleri de incelenmiştir. Aktörler arasındaki etkileşimi desteklemek ve etkileşimli öğrenmeyi güçlendirmek için bazı boyutlarda yakınlık gereklidir. Bilgi ağları ve yakınlık arasındaki evrimsel dinamikler; bilişsel yakınlık, örgütsel yakınlık, sosyal yakınlık, kurumsal yakınlık ve coğrafi yakınlık aracılığıyla kavranmaktadır. (Virkkala vd., 2014; Balland vd., 2015).

Bilişsel yakınlık genel olarak farklı aktörlerin dünyayı algılama, yorumlama, anlama ve değerlendirme biçimindeki benzerlikleri olarak tanımlanmaktadır

(Knoben ve Oerlemans, 2006). Çeşitli aktörlerin bilişsel tabanı (bilgi tabanı) arasındaki yakınsama / örtüşme derecesine işaret etmektedir.

Örgütsel yakınlık, kurum/kuruluş/şirketlerde çalışan kişilerin, ortak kurallar, normlar ve davranış rutinleri aracılığıyla örgütsel uygulamalarda birbirleriyle iletişim kurma, etkileşim kurma ve örgütsel bir yakınlık paylaşma fırsatı olarak tanımlanmaktadır. Örgütsel uygulamalar bilgi paylaşımına önemli ölçüde katkıda bulunmaktadır. Sorunları kolektif olarak ele almanın ve iş deneyimlerini paylaşarak ortak bir iş yöntemi anlayışına sahip olmanın yolu, örgütsel uygulamalara örnek olarak düşünülebilir.

Sosyal yakınlık, ilişkiler çerçevesindeki sosyal kaynaşmaya bağlı olarak insanlar arasındaki toplumsal ilişkilerin derecesi olarak tanımlanmaktadır (Criscuolo vd., 2010). Bilgi yayılmalarında önemli bir rol oynamaktadır (Virkkala vd., 2014).

Kurumsal yakınlık, aktörler tarafından benimsenen gayri resmi ve resmi kurallar, normlar, kodlar ve uygulamalar arasındaki benzerlik derecesi olarak tanımlanmaktadır. Aynı kurumsal biçime veya bağlama sahip olan bu aktörler; araştırma merkezleri, kültür kurumları, kamu kurumları, devlet kurumları, küçük ve büyük şirketler ve akademik kuruluşlar olarak sınıflandırılabilir (Capone ve Lazzeretti, 2015; Davids ve Frenken, 2017). Kurumsal yakınlık, koordinasyon mekanizmalarının istikrar koşullarına katkıda bulunmakta ve buna bağlı olarak, aktörler arasında bilgi transferi ve etkileşimli öğrenmenin düzeyini etkilemektedir.

Coğrafi yakınlık, aktörler arasındaki fiziksel ve işlevsel uzaklık olarak tanımlanmaktadır (Boschma, 2005). Fiziksel ve işlevsel mesafe, sadece aktörlerin fiziksel konumlarının yakınlığını değil, aynı zamanda erişilebilirliği kolaylaştıran ulaşım altyapılarını ve insanların belirli iletişim teknolojilerinden yararlanmasını sağlayan tesisleri de ifade etmektedir (Gallaud & Torre 2004). Coğrafi yakınlık, bilgi aktarımını ve yayılımını kolaylaştırmakta, yerel ağlar arasındaki işbirliğini teşvik etmekte ve rekabet yeteneği ve inovasyon yaratmada önemli bir faktör olarak değerlendirilmektedir (Capone ve Lazzeretti, 2015).

Ulusal inovasyon sistemleri, çeşitli düzeylerde yapı ve dinamiklere sahip bazı evrimsel modellerden oluşur. Ulusal inovasyon sistemlerine analitik bir çerçeve oluşturmak için, birçok araştırmacı ve akademisyen bu modelleri farklı perspektiflerden incelemiş ve analiz etmiştir (Yoda ve Kuwashima, 2019). Ulusal inovasyon sistemlerindeki bu temel modeller, "sarmal modelleri" olarak adlandırılan üçlü sarmal, dörtlü sarmal ve beşli sarmal modellerini içermektedir.
Üçlü sarmal modelinde ana unsurlar üniversite, sanayi ve devlettir. Üçlü sarmal teorisi, ulusal ve / veya bölgesel ekonomik kalkınma politikalarını, inovasyon politikalarını, bilgi transferi stratejilerini ve finansal krizle baş etme girişimlerini açıklamaktadır (Galvao vd., 2019). Ekonomide inovasyon ve bilgi üretimine odaklanılmaktadır. Dolayısıyla model bilgi ekonomisiyle uyumludur (Carayannis vd., 2012).

Aslında, devletçi, serbest piyasa ve dengeli rejimler olarak adlandırılan farklı bağlamsal koşullara sahip üç rejim vardır. Aktörlerin temel rolleri ve işlevleri de bilgi ve inovasyon üretimi ve değişim süreçleriyle bu rejimlere göre farklılık gösterir. Bu aktörler farklı yollarla birbirine bağlanmakta ve üçlü sarmal modeli farklı biçimlerde ortaya çıkmaktadır (Etzkowitz ve Leydersdorff, 2000).

Devletçi rejimde, devletin rolü sanayi ve üniversite üzerinde kuvvetli bir biçimde baskın olmaktadır. Serbest piyasa rejiminde en önemli unsur sanayinin üretken gücü olarak görülmekte ve üniversite, sanayi ve devlet arasındaki etkileşim sınırlı olmaktadır. Dengeli bir rejimde ise üniversitenin (ve ayrıca diğer bilgi kurumlarının) rolü, önceki iki rejimin aksine daha belirgin hale gelmektedir. Üniversite, sanayi ve devletin kesişen kurumsal alanları, inovasyon için en iyi ortamlar olarak kabul edilmektedir.

Dörtlü sarmal modeli, üçlü sarmal modelinden daha kapsamlıdır ve çekirdek model olarak üçlü sarmalı içermektedir. Bu model, sivil toplumu içermekte ve aynı zamanda, gelir artışını ve ticarileşmeyi desteklemek için gerekli olan dördüncü bir ortak olarak finansman kuruluşlarını açıklamaktadır (Colapinto ve Porlezza, 2012).

Höglund ve Linton'a (2018) göre, dördüncü sarmal ayrı bir sarmal olarak düşünülmemeli, bunun yerine medya ve kültürü de içeren sivil toplum, bu ilişkiler ağında diğer üç sarmalın etrafını çevirmektedir.

Beşli sarmal teorisi, dörtlü sarmal teorisinden daha derin ve kapsamlıdır. Bu model 'toplumun doğal ortamlarını' beşinci bir unsur olarak eklemektedir. Ekonomilerin ve toplumların gerekli sosyoekolojik evrimini açıklamaktadır. Bu modelde, bilgi üretimi ve inovasyonun ana itici güçleri, toplumun ve ekonominin doğal ortamlarıdır. Bu nedenle ekolojik olarak duyarlı bir model olarak kabul edilmektedir. Model, sürdürülebilir kalkınma ve sosyal ekolojinin disiplinler arası analizini yapmakta ve sürdürülebilirliği sağlamak için bilgi ve inovasyon tabanlı işbirliği sistemlerini desteklemektedir (Carayannis ve diğerleri, 2012).

2. Yöntem ve Bulgular

Bu araştırmada, Döner Kanat Teknoloji Merkezi (DKTM) analizi hem nitel hem de nicel araştırma yöntemleri kullanılarak yapılmaktadır.

Nitel ve nicel araştırma yöntemlerinden elde edilen bulgular analiz edilmiş ve yedinci bölümde mevcut modeli daha da geliştirmek için politika uygulamalarının tasarlanmasında kullanılmıştır. Bu çalışmanın araştırma hedefleri, literatür taramasından elde edilen bilgiler ışığında aşağıdaki ifadelerde olduğu gibi belirlenmiştir.

Araştırma Hedefleri:

1. DKTM modelinin özelliklerinin, mekanizmalarının ve dinamiklerinin tanımlanması
2. Araştırma analizleri ışığında DKTM modeli için başarı faktörlerinin ve engellerin belirlenmesi
3. Türkiye'deki diğer savunma sanayi alanlarına da uyarlanabilecek bu tematik teknoloji merkezi modelinin politika uygulamalarına ilişkin öneriler geliştirmek

Bu çalışma kapsamındaki araştırma hedeflerine ulaşmak için hazırlanan temel araştırma soruları aşağıdaki ifadelerde verilmiştir.

Temel Araştırma Soruları:

1. DKTM, üniversitelerde üretilen teknik bilgiyi sanayiye nasıl aktarmaktadır?
2. DKTM, sanayide ihtiyaç duyulan kalifiye insan kaynağının yaratılmasına nasıl katkıda bulunmaktadır?
3. DKTM, sektördeki sürdürülebilirlik süreçlerini nasıl teşvik etmektedir?

Benzer şekilde, tamamlayıcı araştırma soruları da temel araştırma sorularının arkasındaki iç mekanizmaları ve dinamikleri ayrıntılı olarak incelemek için tasarlanmıştır.

Tamamlayıcı Araştırma Soruları:

1. Üniversite ve sanayinin birbirini daha iyi anlamasını sağlamak için doldurulması gereken boşluklar nelerdir?
2. Üniversite, sanayi ve devlet arasındaki iletişimsel ilişkileri ve sinerjileri güçlendirmenin ve iyileştirmenin yolları nelerdir?
3. Akademisyenlerin ve öğrencilerin DKTM projelerine katılımını ve performansını artırmak için ne gibi iyileştirmeler ve destekler sağlanmalıdır?

Bu tezde veri toplama aracı olarak çevrimiçi çoktan seçmeli sorulardan oluşan bir anket ve yarı yapılandırılmış mülakatlardan faydalanılmıştır.

Mülakatlar kapsamında DKTM projelerinde çalışmış / çalışmakta olan akademisyenler, araştırmacılar, uzmanlar, devlet ve şirket yöneticileri görüşülmüştür. Mülakatlar, DKTM modelinin özelliklerini, dinamiklerini ve çalışma mekanizmasını üçlü sarmal modeli perspektifinden anlamak için kapsamlı ve derinlemesine sorulardan oluşmaktadır. Her mülakat yaklaşık 1 ila 1,5 saat sürmüştür. Mayıs 2019-Mayıs 2020 dönemi arasında toplam 11 yarı yapılandırılmış mülakat gerçekleştirilmiştir.

Çoktan seçmeli sorulardan oluşan anket, DKTM projelerinde çalışan / çalışmakta olan araştırmacılar için hazırlanmıştır. Anket hem demografik sorulardan hem de üçlü sarmal modeli ile ilgili sorulardan oluşmaktadır. Anket sonuçlarını daha kolay değerlendirmek için sorular kapalı uçlu sorular olarak tasarlanmıştır. Anket çevrimiçi anket web sitesi "surveey.com" üzerinde hazırlanmış ve anket bağlantısı e-posta yoluyla DKTM projelerinde çalışmış / çalışmakta olan yaklaşık 70 araştırmacıya gönderilmiştir. Mart 2020 - Nisan 2020 dönemi arasında toplam 23 araştırmacı ankete cevap vermiştir.

Nitel verileri yönetmek ve analiz etmek için içerik analizi kullanılmıştır. İçerik analizi, çok sayıda metni içeriklerine göre kodlayarak daha küçük parçalara ayırma tekniğidir. Bu analiz için QDA Miner (Qualitative Data Analysis Miner) veri analiz yazılımı kullanılmıştır.

Nicel araştırma veri analizi için tanımlayıcı istatistikler kullanılmıştır. Tanımlayıcı istatistikler, toplanan ham verileri, bir çalışmadaki popülasyonun tümünün veya bir kısmının temel özelliklerini tanımlayan bir biçime dönüştüren disiplindir. Bu analiz için SPSS Statistics veri analiz yazılımı kullanılmıştır.

3. Sonuç ve Politika Önerileri

3.1. Nitel Araştırma Sonuçları

Gerçekleştirilen nitel araştırmada DKTM'nin yapısını ve işleyişini açıklamak için, DKTM projeleriyle ilgili sistematik konular bütünleştirici bir çerçevede incelenmiştir. Bu çalışmada verilen ana başlıklar altında; DKTM'nin gerekçesi ve ortaya çıkışı, üçlü sarmal modeli çerçevesinde DKTM programı, DKTM'de organizasyon ve uygulama, DKTM yol haritası ve inovasyon faaliyetleri, proje seçim süreci, proje yürütme süreci, DKTM projelerindeki teknoloji hazırlık seviyeleri ve DKTM'de süreklilik, literatür taramasının bulguları karşılaştırılarak tartışılmış ve değerlendirilmiştir. Bu nitel verilerin analizi ışığında, sadece DKTM'nin genel organizasyonu ve uygulaması değil, aynı zamanda bu modelin arkasındaki iç mekanizmalar ve dinamikler de incelenmiştir.

Nitel analizden çıkarılan bazı temel stilize gerçekler aşağıdaki gibi sunulmuştur:

Stilize gerçek 1: Üçlü sarmal modelinin etkili bir şekilde yapılandırılmasıyla, devlet-üniversite-sanayi tarafları birbirleriyle daha yakın ilişki kurabilir, birbirlerinin ihtiyaçlarını öğrenebilir, bilgi ve deneyimlerini birbirlerine aktarabilir, olaylara birbirlerinin penceresinden bakabilir ve birbirleriyle uyum ve koordinasyon içinde çalışabilirler.

Stilize gerçek 2: Stratejik ve ticari hedeflere ulaşmak amacıyla gelişmekte olan mümkün kılan teknolojileri belirlemek, seçmek ve geliştirmek için her türlü kaynağın (zaman, insanlar, test / deney mekanizmaları, konu vb.) düzenlenmesi ile teknoloji yol haritası hazırlanır.

Stilize gerçek 3: Üçlü sarmal modeli yaklaşımıyla, Ar-Ge projeleri yürütürken aktörler arasındaki ilişkilerin geliştirilmesi ve karşılıklı iş bölümü tüm aktörler için bir kazan-kazan durumu yaratmaktadır.

Stilize gerçek 4: Proje süreçlerinin aktif bir şekilde takip edilmesi, sadece projelerin teknik başarısı için değil, aynı zamanda verimli üniversite sanayi işbirlikleri kurulması için de gerekli olan "güven" ve "şeffaflık" zeminlerinin oluşturulması için bir ön koşul olarak kabul edilmektedir.

Stilize gerçek 5: Araştırmacıları devamlılığı olan makul bir ücret ve sigortayla finansal olarak desteklemek, onları DKTM projeleri üzerinde çalışmak için motive eden önemli bir unsurdur.

Stilize gerçek 6: Araştırmacıları sanayinin imkanları ile yönlendirmek ve eğitmek için onlara TUSAŞ Akademi'deki derslere katılma ve proje süreçleri boyunca sektördeki uzman ve mühendislerden destek alma fırsatları vermek çok önemlidir.

Stilize gerçek 7: Araştırmacılara proje sonrasında ilgili konuda kariyerlerine devam etme fırsatı sağlamak, araştırmacılar için bu gibi işbirliği modeli projelerine

katılmaları doğrultusunda önemli bir motive edici unsur olmasının yanı sıra, sanayi için proje süreçleri sırasında araştırmacılar tarafından kazanılan birikmiş bilgilerden yararlanma ve kullanma olanağını sunar.

Nitel çalışmanın ana hedefi, DKTM modelini ve çalışma mekanizmalarını incelemek ve aynı zamanda DKTM projelerinde çalışan akademisyenlerin, uzmanların ve yöneticilerin görüşleri hakkında birçok yönden içgörü elde etmektir. Nitel çalışma sonrasında, DKTM projelerinde çalışan / çalışmakta olan araştırmacıların görüş ve deneyimlerini aşağıdaki bölümde olduğu gibi incelemek amacıyla nicel çalışma yapılmıştır.

3.2. Nicel Araştırma Sonuçları

Gerçekleştirilen nicel araştırmada, DKTM araştırmacılarının görüş ve önerileri nicel veriler kullanılarak analiz edilmiştir. Bu analizde, araştırmacıların DKTM projelerine katılma sebepleri, DKTM modelinde üniversite-sanayi-devlet işbirliğinin faydaları, yaşanan zorluklar ve mevcut modeli daha ileriye taşımak için yapılması gereken iyileştirmeler ve doldurulması gereken boşluklar, literatür taramasındaki bulgularla karşılaştırılarak tartışılmış ve değerlendirilmiştir. Bu nicel verilerin analizi ışığında, DKTM, savunma sanayinde üçlü sarmal modelinin temel özelliklerini taşıyan örnek bir tematik model olarak değerlendirilmektedir. Nicel analizden çıkarılan bazı temel stilize gerçekler aşağıdaki gibi sunulmuştur:

Stilize gerçek 1: Sanayinin fırsatlarına ulaşmak sinerji yaratılmasına katkıda bulunmakta ve bu durum araştırmacıların üniversite-sanayi-devlet işbirliği proje modellerinde çalışma tercihlerinde önemli bir motivasyon faktörü olmaktadır.

Stilize gerçek 2: İnovasyon ağları, inovasyon aktörlerindeki kişilerin birbirlerinden öğrenme şansını artırarak, yeni bilgi kazanımı ve birikimine sebep olmaktadır.

Stilize gerçek 3: DKTM projeleri kapsamında şirketlerde ve KOBİ'lerde çalışan araştırmacılar, çalıştıkları işyerlerindeki diğer çalışanlarla örgütsel uygulamalar aracılığıyla örgütsel yakınlık kazanırlar.

Stilize gerçek 4: Daha geniş bir sistem içerisinde üniversite-sanayi-devlet işbirliğinin ve teknolojik birikimin oluşturulması, bilim ve teknolojide en yeni gelişmelere yol açmaktadır.

Stilize gerçek 5: Üniversitenin sanayinin sorunlarını, ihtiyaçlarını ve bakış açısını daha yakından takip etmesini sağlamak, kurumlar arası ilişkileri güçlendirmek ve gelecekteki olası işbirliklerinin önünü açmak, Ar-Ge faaliyetleri ile sanayi ihtiyaçlarının birbirlerine entegre olmasına yol açmaktadır.

3.3. Politika Önerileri

Bu tezin literatüre katkısı, Türkiye'de savunma sanayinde yer alan üçlü sarmal modeli kuramı üzerine inşa edilmiş bir tematik teknoloji merkezini, her bir aktörün bakış açısıyla analiz ederek bir politika tasarım modeli oluşturulmasını sağlamaktır. Literatür araştırması ve DKTM model analizleri ışığında mevcut modeli daha da iyileştirmek için çeşitli politika önerileri tasarlanmıştır.

Bu süreçte politika amacı, politika aracı ve politika hedefi ayakları üzerinde kurgulanan bir politika tasarım modeli kullanılmıştır. Politika amacı politika sorununun çözümündeki motivasyonları işaret etmektedir. Politika aracı, politika hedefine ulaşmak için kullanılan enstrümandır. Politika hedefi ise, politika önerisinin başarısını değerlendirebilmek için konulan ölçülebilir kriter olarak tanımlanmıştır. Bu üç ayak üzerine kurulan politika önerileri ise mikro, meso ve makro seviyelerde kurgulanmıştır.

Mikro seviyedeki politika önerileri her bir DKTM projesinin yönetim süreçlerinin, işleyişinin ve DKTM'nin en önemli hedefi olan yeni yetişen insan kaynağının şartlarının iyileştirilmesi için; meso seviyedeki öneriler tüm DKTM projelerindeki araştırmacıların projelerdeki motivasyonlarını olumlu yönde etkilemek ve sinerji

oluşturmak için; makro seviyedeki öneriler ise tüm ülkede işbirliği modellerine ilişkin bir bilinç ve farkındalık yaratmak için kurgulanmıştır.

Mikro seviyedeki politika önerilerinin ilki *proje çalışanlarının maaş ve özlük haklarına ilişkin güncel düzenlemelerin yapılması*dır. Veri analizi sonuçları üniversite, sanayi ve devletin DKTM modelinde birlikte çalışırken karşılaştığı en önemli zorluğun, *projede çalışan öğrencilerin maaşlarının sanayide çalışanlara göre daha düşük kalması*nın olduğunu göstermektedir. DKTM araştırmacılarının çalışma programları ve taahhütleri, sanayideki tam zamanlı bir mühendisten farklı olsa bile, maddi konuların araştırmacılar için hala önemli motivasyon faktörleri olarak görülmektedir. Bu nedenle, bu politika önerisinin temel amacı (politika amacı), *projedeki sorumlulukları ve iş payları çerçevesinde DKTM projesi çalışanlarına sağlanan ücretleri ve özlük haklarını belirlemek*tir. Bu amaçla, *proje çağrı sürecinde tüm DKTM proje çalışanları için dengeli kriterlere göre ücret ve özlük hakları düzenlemeleri yapmak* bir politika aracı olarak kullanılabilir. Bu politika önerisiyle ulaşılması gereken politika hedefi, *en güncel durumu ve DKTM projelerindeki diğer çalışanların özlük hakları ve ücretlerinin standartlarını dikkate alarak DKTM araştırmacı ücret oranlarını yeniden düzenlemek*tir.

Mikro seviyedeki ikinci politika önerisi ise, *DKTM projelerinde sürdürülebilirliğin sağlanması*dır. Verilerin analizinde, DKTM modelinde yapılabilecek en önemli iyileştirmenin, öğrencileri projeler için teşvik etmek ve devamlılıklarını sağlamak amacıyla *finansman ve araştırma sürekliliğine yönelik düzenlemeler* olduğu görülmüştür. Buna ilave olarak, üniversite, sanayi ve devletin DKTM modelinde birlikte çalışırken karşılaştığı en önemli zorluklardan biri, *projede çalışan öğrencilerin gelecekteki istihdamına ilişkin endişeler*dir. Ayrıca, nitel araştırma analizinde belirtildiği gibi, DKTM araştırmacılarının ana motivasyon unsurlarından biri ücret ve sigorta sürekliliği olarak belirlenmiştir. Bu politika önerisi ile *araştırmacılar için finansman ve araştırma sürekliliğinin sağlanması* ve *araştırmacıların gelecekteki istihdamına ilişkin endişelerin giderilmesi* amaçlanmaktadır. Bu politika önerisi, *proje sürelerinin uzatılması*yla veya *proje bittikten sonra projenin sürekliliğinin sağlanması*yla gerçekleştirilebilir. Üstelik

daha önce başarılı projeler yapmış araştırmacılarla yeni çalışmalar planlamak, çözüm sunan bir başka politika aracıdır. Yaklaşık iki veya üç yıl süren bu tür Ar-Ge projelerine katılma kararı alan araştırmacılar için proje süresi boyunca finansman sürekliliği çok önemli bir maddi konudur. Araştırma çıktılarını bir sonraki muhtemel araştırmaya girdi olarak koyarak araştırmanın sürekliliğini sağlamak da önemli bir gelişme olarak ortaya çıkmaktadır. Bu politika uygulamasıyla ulaşılacak ana politika hedefi, *proje bittiğinde belirlenen başarı kriterlerini karşılayan araştırmacılara istihdamlarının devamı için güvence sağlamak*tır.

Mikro düzeyde üçüncü öneri *DKTM araştırmacıları için bilimsel makale yayınlama olanaklarının artırılması*dır. Veri analizinde, DKTM modelinde yapılabilecek en olası iyileştirmelerden birinin *bilimsel makale sayısını artırmaya yönelik düzenlemeler* olduğu görülmüştür. Bu politika önerisinin temel amacı, *DKTM araştırmacılarının yurt içi ve yurt dışı konferanslara katılımını daha fazla desteklemek ve bilimsel makale sayısını artırmak*tır. Bir politika aracı olarak, *proje sözleşmelerine konferans katılımı için yeterli bütçe tahsis edilmesi* önerilmektedir. Ancak bu konuyla ilgili bir durum daha söz konusudur. DKTM projeleri savunma sanayi ile ilgili olduğundan, bilimsel makalelerin yayınlanması konusunda da gizlilik sorunları gündeme gelmektedir. Gizli denen şey belirsiz / özneldir ve bu nedenle gerekli veya gereksiz her şeye yüksek derecede gizlilik verilmektedir. Bu nedenle, *bilimsel makalelerin yayınlanması için gizlilik konularına ilişkin kriterler geliştirmek* başka bir politika aracı olacaktır. Bilimsel makalelerin yayınlanmasını desteklemeye yönelik politika önerisini gerçekleştirmek için politika hedefi, *her proje için belirli sayıda yayının yayınlanmasını teşvik etmek*tir.

Mikro düzeyde son olarak, *DKTM'de hem üniversitede akademik kariyere hem de sanayide deneyime sahip uzman ve danışmanların çalıştırılması* önerilmektedir. DKTM modelinde doldurulması gereken boşluklardan biri, *taraflar arasında daha iyi iletişim için ara mekanizmaların geliştirilmesi*dir. Bu ara mekanizmalar, hem akademisyen hem de sanayi bakış açısına sahip ve her iki tarafı anlayan insanlardan oluşmaktadır. Bu önerinin politika amacı, *TUSAŞ'taki DKTM personeli ile DKTM*

*projelerindeki araştırmacı / akademisyenler arasındaki iletişimi güçlendirmek*tir. Bunun yanı sıra bu kişilerin uzmanlıkları sayesinde *önerilen projelerin ürüne dönüşme potansiyelini doğru bir şekilde değerlendirmesi* de bir başka politika amacı olarak hedeflenmiş olacaktır. Bu amaçlara ulaşmak için, kullanılacak politika aracı, *DKTM'de doktora ve doktora sonrası çalışanların istihdamını teşvik etmek*tir. Bu politika önerisini uygulamak için politika hedefi, *DKTM proje seçimlerinde doğru kararlar alınması ve üniversite ile sanayinin birbirini daha iyi anlamasını ve daha verimli çalışmasını sağlamak*tır.

Meso seviyedeki tek politika önerisi, *DKTM araştırmacıları arasında sinerji oluşturmak için önlemler almak*tır. Bu önerinin ardındaki politika amacı, *DKTM araştırmacılarının motivasyonlarını ve birbirleriyle olan bağlantılarını artırmak*tır. Nicel araştırma veri analizinde, *DKTM araştırmacılarını projeye daha fazla bağlamak ve motivasyonlarını artırmak için faaliyetler düzenlenmesi gerektiği belirtilmekte*dir. Ayrıca üniversite-sanayi-devlet işbirliğini geliştirmek için DKTM modelinde doldurulması gereken en önemli boşluğun, *proje çıktılarının tüm tarafların katılımıyla sunulabileceği konferansların düzenlenmesi olduğu belirtilmekte*dir. Bu nedenle, bu ihtiyacı karşılayacak politika aracı, *proje çıktılarının tüm tarafların katılımıyla sunulabileceği çalıştaylar düzenlemek*tir. Ayrıca nitel araştırmada, *DKTM araştırmacılarının temel motivasyonlarından birinin, yönlendirme ve eğitim yoluyla sektördeki uzman ve mühendislerden destek almak olduğu ileri sürülmekte*dir. Bu motivasyon unsurunun hayat geçirilmesi için bir diğer politika aracı, *gerekli alanlarda araştırmacılara eğitimler düzenlemek*tir. Bu politika önerisini gerçekleştirmek için *yılda en az bir kez proje süreçleri ile ilgili çalıştaylar düzenlemek ve helikopter teknolojileri ile ilgili eğitimler düzenleyemek* politika hedefi olarak belirlenmiştir.

Makro seviyede, *üniversite, sanayi, devlet ve sivil toplum arasında daha yoğun bir diyaloğun teşvik edilmesi* önerilmektedir. Bu önerinin politika amacı, *tüm taraflar için de sarmal işbirliği modellerine ilişkin farkındalığı artırmak*tır. Nicel araştırmada üniversite-sanayi-hükümeti geliştirmek için DKTM modelinde doldurulması gereken en önemli boşluklardan biri *tüm tarafların katılımıyla*

*üniversite, sanayi, devlet işbirliğini geliştirmeye yönelik kongre ve konferanslar düzenlemek*tir. Bu ifade, bu politika önerisi için politika aracı olarak sunulmuştur. Politika hedefi, *en az yılda bir kez sarmal işbirliği modellerini geliştirmek için belirli konular hakkında kongreler ve konferanslar düzenlemektir.*

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