

EMERGING OPPORTUNITIES FOR THE APPLICATION OF BLOCKCHAIN:
TURKISH CASE OF R&D FUNDING

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF SOCIAL SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

EMRAH KORAMAN

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
THE DEPARTMENT OF SCIENCE AND TECHNOLOGY POLICY STUDIES

NOVEMBER 2023

Approval of the thesis:

**EMERGING OPPORTUNITIES FOR THE APPLICATION OF
BLOCKCHAIN: TURKISH CASE OF R&D FUNDING**

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ABSTRACT

EMERGING OPPORTUNITIES FOR THE APPLICATION OF BLOCKCHAIN: TURKISH CASE OF R&D FUNDING

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Ph.D., The Department of Science and Technology Policy Studies

Supervisor: Prof. Dr. Erkan ERDİL

NOVEMBER 2023, 325 pages

In many countries, public institutions support companies through R&D incentives. It is important that these supports, which are generally provided from central budgets, reach the right places, both in terms of ensuring a fair fund distribution and in ensuring the success of promising research that cannot benefit from the supports. In this dissertation, where incentive systems in Turkey and in the world are also examined, the commission consisting of academicians has a significant weight in the final decision of the R&D project proposals that go through many stages. Dissertation is basically concerned with the possible effects of the social relations and cognitive effects formed in the commission on the support decision. On the other hand, there are innovations in the way of doing business in line with the opportunities provided by digitalization. Especially with the spread of remote working, face-to-face meetings are being replaced by online meetings. However, literature research also shows that the current face-to-face evaluation system and online meetings have deficiencies in many issues such as intellectual and industrial rights, especially during the evaluation of R&D project proposals.

At this point, blockchain technology, which is popular today, offers promising application areas in matters such as protection of intellectual industrial rights,

tracking and diffusion of produced information. This dissertation aims to respond to this need with blockchain technology in the evaluation of R&D incentives.

To serve this purpose, first of all, the weight of the existing face-to-face commissions on the final decision was determined by classification learner, MRMR (maximum relevant minimum redundancy) and tobit analysis methods. As a result, it has been determined that the decision of the face-to-face commission has a great impact on the incentive decision of R&D centers. In addition, the aforementioned analyzes also identified the existence of a hierarchical power relationship between commission members in face-to-face commissions. As a result of the analyses, a comprehensive survey study was designed among academicians who had previously served as commission members in R&D center commissions, and the cognitive and social effects detected after the designed survey were quantified. Afterwards, the survey results were animated with Agent-Based Modeling (ABM), which is the most suitable simulation method for this type of study. Accordingly, it has been determined that one-third of the commission member academics delegate their decision-making authority to the commission members they see as hierarchical leaders. Since this study is a unique study method with the aspects mentioned above, the data obtained from ABM studies were also confirmed with a unique method.

As a result, it is thought that decision-making academics will make their decisions with their own will by using blockchain, which has not been used before in R&D funds. In addition, it has been determined as a result of theoretical and analytical studies carried out within the scope of dissertation that, thanks to the features of blockchain, it will further improve the R&D incentive system.

Keywords: Blockchain, decision-making, agent-based modelling, R&D incentives, hierarchical power distance

ÖZ

BLOK ZİNCİR UYGULAMASINDA ORTAYA ÇIKAN YENİ FIRSATLAR: TÜRK AR-GE FON SİSTEMİ

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Doktora, Bilim ve Teknoloji Politikası Çalışmaları Bölümü

Tez Yöneticisi: Prof. Dr. Erkan ERDİL

NOVEMBER 2023, 325 sayfa

Birçok ülkede kamu kurumları Ar-Ge teşvikleri vasıtasıyla firmaları desteklemektedir. Genellikle merkezi bütçelerden sağlanan bu desteklerin doğru yerlere ulaşması hem adil bir fon dağılımının sağlanması hemde desteklerden faydalanamayan ama gelecek vaadeden araştırmaların başarıya erişmesi açısından önem arz etmektedir. Türkiye'de ve Dünya'da teşvik sistemlerinin de incelendiği bu tezde, birçok aşamadan geçen Ar-Ge proje tekliflerin kararında komisyon üyesi akademisyenlerden oluşan komisyonun nihai kararda önemli ağırlığı bulunmaktadır. Tez temelde komisyonda oluşan sosyal ilişkiler ve bilişsel etkilerin destek kararı üzerindeki olası etkileriyle ilgilenmektedir. Öte yandan, dijitalleşmenin de vermiş olduğu imkanlar doğrultusunda iş yapış biçimlerinde de yenilikler olmaktadır. Özellikle de uzaktan çalışmanın yaygınlaşmasıyla yüz-yüze görüşmelerin yerini online toplantılar almaktadır. Ancak yapılan literatür araştırmaları da göstermektedir ki, özellikle Ar-Ge proje tekliflerinin değerlendirilmesi esnasında fikri ve sınai haklar gibi birçok konuda mevcut yüz-yüze değerlendirme sisteminin ve online toplantıların eksiklikleri bulunmaktadır.

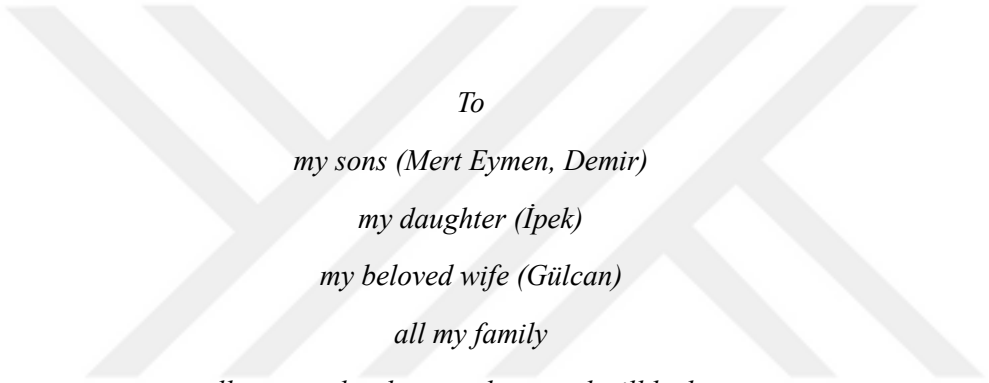
Bu noktada, günümüzde popüler olan blokzincir teknolojisi fikri sınai hakların korunması, üretilen bilginin takibi ve difüzyonu gibi konularda gelecek vaadeden

uygulama alanları sunmaktadır. Bu tezde Ar-Ge teşviklerinin değerlendirilmesinde bu ihtiyaca blokzincir teknolojisi ile cevap vermek amaçlamaktadır.

Bu amaca hizmet etmek için öncelikle mevcut yüz-yüze komisyonların son karar üzerindeki ağırlığı classification learner, MRMR (maximum relavent minimum redundancy) ve tobit analizleri yöntemleri ile tespit edilmiştir. Sonuç olarak Ar-Ge merkezlerinin teşvik kararında yüz-yüze komisyondaki kararın büyük etkililiği olduğu tespit edilmiştir. Ek olarak, anılan analizlerde yüz-yüze komisyonlarda komisyon üyeleri arasında bir hiyerarşik güç ilişkisinin varlığı da tespit edilmiştir. Yapılan analizlerin sonucunda, daha önce Ar-Ge merkezleri komisyonlarında komisyon üyeliği yapmış akademisyenler arasında kapsamlı bir anket çalışması tasarlanmış, tasarlanan anket sonrasında mevcudiyeti tespit edilen bilişsel ve sosyal etkiler numerik hale getirilmiştir. Sonrasında anket sonuçları bu tarz bir çalışma için en uygun simülasyon yöntemi olan Ajan-Bazlı Modelleme (ABM) ile canlandırılmıştır. Buna göre üçte bir oranında komisyon üyesi akademisyenin karar verme yetkisini hiyerarşik olarak lider gördüğü komisyon üyelerine devrettiği tespit edilmiştir. Bu çalışma yukarıda bahsedilen yanlarıyla daha önce benzeri olmayan bir çalışma yöntemi olduğundan ABM çalışmalarından elde edilen veriler özgün bir yöntem ile de doğrulanmıştır.

Sonuç olarak, daha önce benzer bir uygulamasına rastlanmayan blokzincirin Ar-Ge fonlarında kullanılmasıyla karar verici akademisyenlerin kararlarını kendi özgür iradeleriyle verecekleri düşünülmektedir. Ek olarak blokzincirin sahip olduğu özellikleri sayesinde Ar-Ge teşvik sistemini daha da geliştireceği tez kapsamında yapılan teorik ve analitik çalışmalar sonucunda tespit edilmiştir.

Anahtar Kelimeler: Blokzincir, karar verme, ajan bazlı modelleme, Ar-Ge teşvikleri, hiyerarşik güç ilişkisi



To
my sons (Mert Eymen, Demir)
my daughter (İpek)
my beloved wife (Gülcan)
all my family
all my angels who were born and will be born

ACKNOWLEDGMENTS

First of all, I would like to express my deepest gratitude to Prof. Dr. Erkan ERDİL for his vast knowledge, experience and above all his intense support and kindness. I can't thank him enough for his smiling and kind demeanor who never spared any kind of support as he is more of a compass than a consultant.

I would like to thank my Professors Banu Günel KILIÇ and Serkan KÜÇÜKŞENEL for their support and guidance, both in the thesis monitoring committees and in their private time.

I would like to thank to representative of Ministry of Science and Technology, I also would like to thank ASELSAN.

I would also like to express my deepest thanks to my dear friends, Yunus ÖZMODANLI, Ahmet GERGERLİ, Mesut KOÇAK and Abdullah IŞIK, whose support and opinions I always received during the dissertation.

I would like to express my deepest gratitude to my family and every member of the TEKPOL family, my second family, whose efforts I will never forget and will never forget, these days, who have always made me strong and helped me.

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LIST OF ABBREVIATIONS

ABM	Agent Based Modelling
BTYK	The Prime Minister's Supreme Council for Science and Technology
DLT	Distributed Ledger Technology
DT	Decision Tree Algorithms
EU	European Union
GERD	Gross Domestic Expenditure on R&D
GDP	Gross Domestic Product
GDSS	Group Decision Support System
GDPR	General Data Protection Regulation
IPR	Intellectual Property Rights
KOSGEB	The Small and Medium-Sized Enterprises Development Organization
ML	Machine Learning
MoIT	The Ministry of Industry and Technology
NSF	National Science Foundation
ODD+D	Overview, Design, Concepts, Details, and Decision
R&D	Research and Development
SNA	Social Network Analysis
STI	Science, Technology, and Innovation
TEYDEB	Technology and Innovation Support Programs Presidency
TUBITAK	The Scientific and Technological Council of Turkey

CHAPTER 1

INTRODUCTION

1.1. Background Information

Innovation and technological development are one of the main elements of growth in capitalist systems (Cantwell and Santangelo, 2000). When it comes to capitalism, innovation and technological developments that will benefit the public can be put in the background. In this dissertation, it is touched upon what can be changed if blockchain technology is used in the public R&D system, although it is not considered to be in the public interest, but it is expected to be beneficial if it is considered.

In order for technological innovations to be implemented in the non-profit public sector and adopted by policy makers, the innovation in question must offer a permanent and resistant innovation to the currently used system (van den Bosch and Taanman, 2006)s. For this reason, in order for the idea of applying blockchain technology in R&D fund selection, which is presented in the dissertation and is not currently implemented, to be acceptable, it should be underlined what changes it proposes in the current system. For this reason, in this dissertation, the innovations that the blockchain application is expected to make to the system are conceptually mentioned and then proven with analytical methods.

It is one of the responsibilities of states to their citizens that R&D incentives, which are carried out with the resources collected from taxpayers, are always carried out in a more reliable, accountable and transparent manner. Based on this fact, the incentive system needs to be equipped with developing technological opportunities in order to both develop the R&D and innovation ecosystem and distribute public resources fairly. Based on the aforementioned fact, incentive systems were first examined in

the study in order to provide a better structure for the incentive system. In order to prove how blockchain technology can contribute to existing incentive systems, many aspects of the technology are discussed in the dissertation. Since no similar study has been found in the light of current knowledge, the contribution of the study to the general literature is also mentioned in the theoretical part.

Based on the aforementioned motivation, R&D center evaluation processes were divided into sub-processes and the process that contributed the most to the result was determined by analytical methods. Accordingly, it has been determined by the analysis that the sub-process that contributes the most to the evaluation decision of R&D centers in the process is the face-to-face evaluation commissions. As a result of the analyzes made on the information of the academicians who took part in the evaluation commissions, it was determined that social and cognitive variables such as hierarchical power distance were also effective on the decision in face-to-face group decision-making processes. Finally, a simulation was conducted to determine how effective these cognitive and social effects are in the decision to identify R&D centers.

As a result of this simulation using the Agent-Based Modeling (ABM) method, it was determined that some commission members transferred their decision-making authority to other commission member academics, whom they saw as cognitive leaders, as a result of the cognitive and social effects mentioned in the dissertation. In summary, the most effective abstract and concrete variables in the process of determining R&D centers were determined, and the extent to which the most effective qualitative variables changed the result was determined by qualitative and quantitative methods. This study differs from other studies in the sense that it uses analysis methods from two different mainstreams. In addition, no similar study has been found that examines the effect of hierarchical power relations on decision-making processes. Finally, it is known that these detected cognitive and social effects will not be present if it is done with a secure and multi-center software such as blockchain. Because the current R&D center commissions are made face-to-face, these people may be exposed to the mentioned effects in a human-human type of communication, while these effects do not occur in blockchain technology where there is a human-machine-human type of communication.

1.2. Problem Definition-The Claim and Logical Framework of Dissertation

Figure 1.1 summarizes the logical framework of the study. In this study, an alternative blockchain process to the existing process of identifying R&D centers is not suggested. The main purpose of the study is to contribute to the traceability, accountability and transparency of public funds through appropriate technologies. The main purpose of the thesis is the improvement in traceability, accountability and transparency.

As a result of the theoretical and analytical studies carried out, it creates policy recommendations in areas that are likely to be lacking. While some of these suggestions are directly related to the analytical studies conducted, some of them are derived from criticisms of the selection of R&D funds in the existing literature.

1.3. Research Questions

While addressing numerous research questions throughout the study, they all revolve around a central inquiry. The primary research question is, "How can blockchain technology be expected to contribute to use of Public R&D funds?"

To answer this research question, the study begins with a comprehensive literature review. This review provides insights into global examples of R&D incentive mechanisms, the historical development of Public R&D funds in Turkey, blockchain technology, incentive evaluation processes, and how blockchain technology can impact critical stages of this process. Additionally, the study analyzes the cognitive effects on decision-making processes when transitioning decision environments to online platforms.

As stated in Figure 1.1, the starting point of the dissertation is that, with the increase in technological opportunities and the COVID-19 pandemic, online group meetings frequently replaced face-to-face meetings. The study discusses the effects of online group meetings on decision-making processes, while also examining the situation of face-to-face meetings, based on the fact that technological opportunities have

increased, and the COVID-19 pandemic has led to a frequent replacement of face-to-face meetings with online meetings.

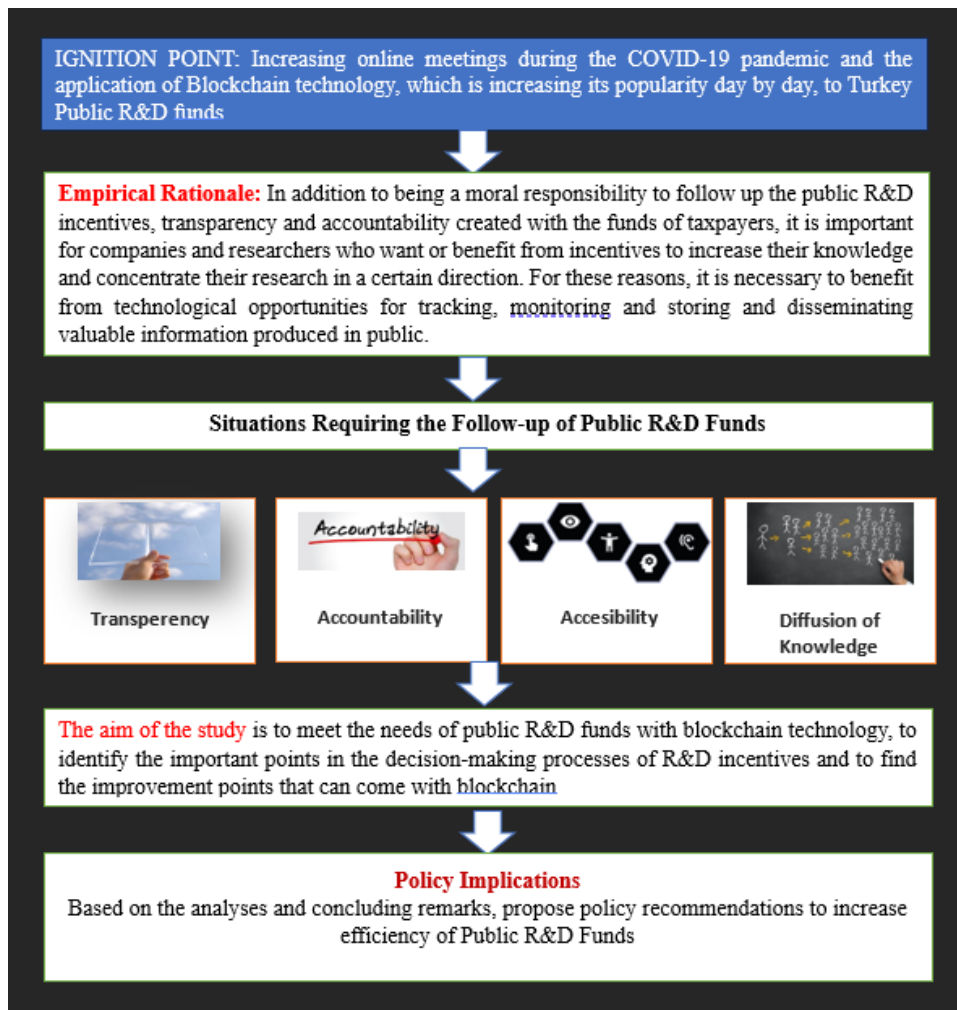


Figure 1. 1. Logical Framework of Dissertation

The dissertation discusses the current status of the decision processes of the Turkish R&D funding system in addition to the impact of online meetings on decisions. Figure 1.1 includes the parts that need to be improved in the funding system. As stated in Figure 1.1, the starting point of the dissertation is that, with the increase in technological opportunities and the COVID-19 pandemic, online group meetings frequently replaced face-to-face meetings. The study discusses the effects of online group meetings on decision-making processes, while also examining the situation of face-to-face meetings, based on the fact that technological opportunities have increased and the COVID-19 pandemic has led to a frequent replacement of face-to-face meetings with online meetings.

The dissertation discusses the current status of the decision processes of the Turkish R&D funding system in addition to the impact of online meetings on decisions. Figure 1.1 includes the parts that need to be improved in the funding system.

1.4. Dissertation Outline

The dissertation comprises seven chapters. Following the introduction, the first chapter presents a literature review on key topics. This includes an examination of global R&D incentive mechanisms, the historical evolution of Public R&D funds in Turkey, blockchain technology, and the evaluation processes of incentives.

The third chapter provides information on the data and methodologies employed in the study. The fourth chapter analyzes the results of qualitative and quantitative preliminary analyses conducted using this data.

In the fifth chapter, the analysis, and results, which constitute the core of the thesis, are presented. The sixth chapter offers policy discussions and recommendations based on the analysis results. Finally, the concluding section synthesizes all findings and disseminates the results.

CHAPTER 2

CONCEPTUAL FRAMEWORK AND THEORETICAL BACKGROUND

2.1. R&D Incentives in Turkey

Many countries attach importance to Science, Technology, and Innovation (STI) policies in order to reach their sustainable development goals. For this purpose, it is long-standing tradition for countries distribute R&D incentives. In this dissertation, how the incentive mechanisms' efficiency can be improved, and how the incentives can be distributed equally by using emerging technologies are considered. In this part, stages of the incentive mechanisms in Turkey and their current situation are discussed in order to better examine the issue.

The first R&D incentives were given in the 1990s in spite of the fact that the public R&D incentives in Turkey are based on the first Turkish Science Policy prepared in September 1980 covering the years 1983-2003. The opinion that this breakthrough, which is relatively late compared to the establishment of the Republic of Turkey, is still not at the desired level is held both by individuals and by the European Commission (European Commission, 2000). In addition to not being at desired level, resources for research , and innovation are scattered (Çiftçi, Erdil & Pamukçu, 2016). History of public incentives in Turkey is mentioned briefly in order not to deviate from the focus of the dissertation.

In this part, after mentioning existing incentive mechanisms in Turkey, Ministry of Industry and Technology's R&D Center Incentive support used in the modeling part of the dissertation is discussed in detail. Since the main axis of this dissertation is that incentives in Turkey do not have superiority compared to their counterparts in the world, incentives are not mentioned in detail and compared.

2.1.1. The History of R&D Incentives in Turkey

Innovation is path dependent (Umane & Ghirardato, 2011), so the small historical events leading to it are of great importance (Diebolt & Hauptert, 2016). incentives are important components for innovation systems. For this reason, development of incentives in Turkey is important (Edquist, 2015). The purpose of this part is to reveal the historical background of the regulations on R&D incentives in Turkey.

Widely specialized R&D incentives appeared for the first time in the world in the 1990s (European Commission, 2014). In Turkey, specialized R&D Law with a private sector focus was enacted in 2008 by the abolished Ministry of Industry and Trade (Resmi Gazete, 2008). This law contributed to the dissemination of R&D incentives to wider masses and to increase awareness of the concepts of R&D and innovation. However, it is important to talk about the path passed prior to this law, in which Research and Development activities are mentioned for the first time, and to shed light on the present and the future. Therefore, in this part Turkey's journey of R&D incentives are briefly mentioned.

Few institutional structures were inherited from the Ottoman Empire to the young Turkish Republic, which was the case in most of the areas (Yay, 2019). It was also the same for the incentives towards industry. The Ottoman state first established the "Islah-ı Sanayi Komisyonu in 1866 with a purpose that tradesmen would unite among themselves and establish companies, increase the quality of products, produce in accordance with certain standards, and improve technical education.

However, in spite of the fact that the existing capital accumulation could not be channeled into investments and European capitalism often prevented investments, a positive result could not be obtained in industrialization efforts. Thereupon, it was announced in 1873 that customs and tax exemptions would be granted to those who would establish factories, in 1888, these exemptions were extended to include items necessary for factory construction, and in 1897, tax exemption for a period of ten years was introduced to establish new factories. On the other hand, several factories operating in fields such as sugar, textiles, glass, porcelain, paper, matches, and rubber were granted limited privileges for certain periods and regions. Customs and exemptions were granted for machinery and tools and equipment to be brought from

Europe for the first time when large factories were established. Again, export and internal customs exemptions were granted for the products manufactured in these factories (Oz& Buyrukoglu, 2015).

Teşvik-i Sanayi Law, which was enacted in 1927, can be seen as the first legal regulation that indirectly supported the research and development activities of the Republic of Turkey founded in 1923, in addition to exempting all kinds of equipment to be used in industry from customs duty, some incentives within the scope of this law include allocating ten hectares of treasury lands outside the municipal borders free of charge to those who want to establish industrial facilities, selling the treasury lands within the borders of the municipality to industrial enterprises with a maturity of ten years, and allowing private enterprises to establish telephone-telegraph transmission lines. It has been made possible by the decision of the Council of Ministers to allocate free poles to those who install electricity transmission lines, to apply a 30% discount in the transportation of all kinds of industry-related materials via TCDD roads and to give a premium of 10% of their production to companies that invest in the field of industry,

After the 1950s, with the determination of the economic potential and resources in the country, more private sector applications were developed. Therefore, credit opportunities specific to private sector expanded, entrepreneurship in foreign trade was encouraged and precautionary packages were implemented in order to increase agricultural production and ensure continuity. In this period, when the infrastructure investments of various sectors accelerated, the “Foreign Capital Incentive Law” was enacted in 1951 in order to ensure capital accumulation in the private sector and to attract foreign investors to the country. In addition, “Turkey Industrial Development Bank” was established to provide medium and long-term investment loans in industry. In the post-1960 period, with the planned economy, incentive and guidance measures began to be implemented efficiently, and the incentive system was determined according to the conditions of the day and took its current form.

The first attempt in the field of science and technology was realized with the Five-Year Plan in 1963. The Scientific and Technological Council of Turkey (TUBITAK) was established in the same year. In the first years of its establishment, TUBITAK

became the institution responsible for science and technology policies in Turkey, implicitly without an official policy document. In the Fourth Five-Year Plan covering the years 1973-1977, the compatibility of the concept of technology policy with industry and employment and investment policies were defined (Saritas, Taymaz & Tumer, 2006).

Despite all this, science and technology were not among the priority issues in the calendar of policy makers until the 1980s. The implementation of a systematic incentive system in Turkey took place in the 1980s. The industrialization strategy based on import substitution was abandoned, and the export-oriented industrialization strategy was adopted. Detailed targets, and policies in the field of science and technology were prepared with the document "Turkish Science Policy: 1983-2003" prepared by TUBITAK in 1980. Again, with this strategy document, the Prime Minister's Supreme Council for Science and Technology (BTYK), which is responsible for administration of science and technology policies in Turkey, was established. BTYK has become responsible for the administration, coordination and design of science and technology policies in the country.

With the effect of "Turkish Science and Technology Policy: 1993-2003" and the Seventh 5-Year Development Plan (1996-2000) documents published by BTYK, a National Innovation System (NIS) has been prepared, and in this context, many new incentives have been created (MoSF, 2009).

The aim of the incentive system (Akdeve, 2013), which was put into effect in 2009, is to direct savings to high value-added investments, to increase production and employment, to ensure the continuity of investment trend and sustainable development. It also included encouraging large-scale investments with high technology and R&D content that is increase international competitiveness, increasing foreign direct investments, eliminating regional development differences and supporting investments to protect the environment.

2.1.2. Recent Situation in R&D Incentives in Turkey

The Ministry of Industry and Technology (MoIT) is the main body in Turkey that is the responsible for coordinating STI activities. Apart from MOIT, there are 6 other

institutions that are effective in STI. Of these, Ministry of National Education (MoNE) and Higher Education Council (YOK) are responsible for determining education policies in Turkey and integrating these policies with STI policies (TEKPOL, 2020).

TUBITAK, on the other hand, is an operational institution responsible for the production and dissemination of knowledge, the direction of resources and market formation and it is one of the leading institutions providing financial support to R&D and innovation expenditures. TUBITAK provides grants for:

- R&D
- Innovation
- Human resources
- R&D and innovation networks
- Science and society.

The other institutions that responsible for R&D incentives are The Small and Medium-Sized Enterprises Development Organization (KOSGEB) and the Technology Development Foundation of Turkey (TTGV). Turkish Patent Institute (TPE) carries out the procedures related to industrial and intellectual property rights. Turkish Accreditation Agency (TURKAK) deals with the accreditation of organizations and laboratories. Turkish Statistical Institute (TURKSTAT) is the body responsible for providing statistical information related to R&D, innovation and industry, among others (Çiftçi, Erdil & Pamukçu, 2016).

In spite of the fact that it is regulated in different legislation, it is possible to classify R&D supports provided to R&D activities in Turkey in 2 main groups as monetary incentives and tax reduction/exemption.

Grants

Monetary grants at various rates and amounts are provided by state institutions such as TUBITAK, KOSGEB, Development Agencies and the Ministry of Industry and Technology for R&D expenditures made within the scope of R&D activities.

The application made is evaluated by TUBITAK and, and if all the conditions are met, the grant to be provided for the relevant R&D project is approved. R&D projects approved by TUBITAK; Up to 60% grant is provided, including personnel costs, materials to be used, consultancy, travel, and general expenses.

2.1.2.1. Tax Discounts and Exceptions

The Law on Supporting R&D and Design Activities No. 5746 provides special incentives for R&D and design projects supported by R&D and Design Centers and state institutions. The incentives provided under the law are as follows: R&D and design discount, fee income tax exemption, stamp duty exemption (Deloitte Turkey, 2021).

Another indirect R&D incentive law implemented by the Ministry of Industry and Technology (MoIT) is the Technology Development Zones Law No. 4691, which came into force on 06.07.2001. Within the scope of this law, university-industry cooperation technological information production and trade, productivity increase in the production process, technology transfer, creation of an internationally competitive technological infrastructure, it is aimed to increase employment and to support investments in technology-intensive areas. Tax incentives within the scope of Law No. 4691 are classified as:

- Incentives for the managing company,
- Technology incentives and technology development for companies operating in development zones.
- Incentives for the personnel employed in the regions (Tüm & Dokuzoğlu, 2020).

Within the framework of the law numbered 4691, similar to the law numbered 5746, R&D and design discount, fee income tax exemption, and stamp duty exemption are provided to the companies in the technology development zone, while the expenses of the Technology Development Zone related to the necessary land procurement, infrastructure and administrative building construction are covered by the Ministry.

2.1.3. TUBITAK Incentives

Incentives provided by TUBITAK are given under five main headings. These are academic, industry, public, scientific activity and science society. TUBITAK incentives are distributed by sub-organizations within its body. One of the sub-institutions provided by industry-oriented incentives in TUBITAK is called TEYDEB (Technology and Innovation Support Programs, 2021). TEYDEB; in order to contribute to the increase of our country's R&D capability, innovation culture and competitiveness; It is the center of programs that support project-based R&D activities, development and sustainability of the national innovation-entrepreneurship ecosystem. Support programs within TEYDEB are:

- 1501 TUBITAK Industry R&D Projects Support Program,
- 1503 TUBITAK Project Markets Support Program,
- 1505 TUBITAK University-Industry Cooperation Support Program,
- 1507 TUBITAK SME R&D Startup Support Program,
- 1509 TUBITAK International Industry R&D Projects Support Program,
- 1511TUBITAK Priority Areas Research, Technology Development, and Innovation Projects Support Program,
- 1512 TUBITAK Techno-enterprise Capital Support Program,
- 1513 TUBITAK Technology Transfer Offices Support Program,
- 1514 TUBITAK Venture Capital Support Program,
- 1515 TUBITAK Preliminary R&D Laboratories Support Program,
- 1601 TUBITAK Capacity in Innovation and Entrepreneurship Fields Increasing Support Program and
- 1602 TUBITAK Patent Support Program.

2.1.4. Application and Commission Evaluation for TUBITAK and R&D Center Incentives

The general lines of applications to TUBITAK grant programs and MoIT's R&D Centers Incentives are explained. In spite of the fact that this flow could change depending on the status of the support programs, the operation is discussed in general terms in this part.

Initially, the project owner firm presents business plan to TUBITAK and/or MoIT online or in print in accordance with the format published on the TUBITAK and MoIT website. The business plan is divided into fields in terms of its subject and subjected to preliminary evaluation by the relevant unit in TUBITAK and MoIT in accordance with the provisions of the legislation.

At the next stage, the business plan is forwarded to academicians who are experts in the field. Their business plan is to evaluate technological level and its innovative aspect, fitness of project plan, the infrastructure of the firm, economical profits, and national acquisitions. After the evaluation, each academician from the audience prepares a report and presents.

Prepared reports are checked and evaluated by state (MoIT or TUBITAK according to use) experts and presented to the committee to make a final decision (Kubas, 2016).

2.1.5. Commission Structure

In this part, only the panel system (face to face commissions), which is the subject of this dissertation is explained. This panel system is the final decision-making mechanism for both MoIT and TUBITAK.

The TUBITAK commissions, consisting of 5 or maximum 9 people, can evaluate at most 10 business plans at a time. The business plans in question, on the other hand, receive the opinion of the Group Management Committee (GYK) and/or the Group Management Committee Secretariat (GYKS). If these opinions are not sufficient, the commission may also consult the "Out of Panel Advisor" opinions.

Panelists, also known as commission members, are selected from experts in the field, considering the provisions of the relevant legislation, and the decision for each business plan (project application) is made by secret ballot and open counting method. Ultimately, the decision of the project application is made based on the majority of votes.

In incentives for R&D Centers conducted by the MOIT, a commission consisting of 5 people is established after the audience reports. This commission consists of 2 academicians, 1 sector representative, 1 Treasury and Finance Ministry Representative and 1 MOIT representative (Gazete, 2008).

Countries implement incentive mechanisms in line with their own dynamics. Policymakers can design and implement monitoring and evaluation programs to ensure that these incentives achieve the desired results. The success of the incentives is important in terms of both the correct use of public resources and achieving the desired social welfare. Yet, the selection of the companies to be promoted was almost never touched upon in the literature while examining the incentive mechanisms and revising them in line with the needs. In spite of the fact that the selection of projects to be funded is a factor that can directly affect the success of the incentive. While it is an undeniable fact that the selection of the right projects is directly influential in obtaining more accurate results, the traditional commission structure described in the previous part appears almost unchanged in the incentive mechanisms of a lot of countries. At this point, this dissertation tries to draw attention to how important the selection of projects supported/to be supported by this incentive is as important as the goodness of the processes of the R&D incentive mechanism, and that this issue can be improved with the help of changing technological opportunities.

2.2. Ex-ante Project Evaluation

Resources used to support projects in public incentives are generally provided from the internal revenues of the countries, that is, from taxes. Therefore, transparency and accountability are as important as designing the right incentive mechanisms, as well as supporting the right projects. In addition, the Ex-ante Project Evaluation has a direct effect on the performance of projects, and thus the performance of the incentive. The total benefit of an improvement that can be made about Ex-ante Project Evaluation will be great. Based on this fact, this chapter discusses the Ex-ante Project Evaluation and its variants.

It is possible to evaluate a project in two stages from the idea phase to the realization phase. The evaluation part at the decision and idea stage is called ex-ante. The

evaluation made at the beginning of the implementation phase, at the end of the interim after the final phase is called the ex-post evaluation (Samset & Christensen, 2017).

Ex-ante evaluation is of great importance in terms of finding the most suitable one among the projects and using the resources efficiently (Samset & Christensen, 2017). Additionally, an evaluation made among different alternatives of the projects to be invested can at least reduce or minimize the future costs although the selected project is not always the best choice among projects.

On the other hand, most of the studies in the literature on the evaluation of R&D funds have focused especially on the evaluation of the supported projects. In spite of the fact that there are many reasons for this situation, ex-post project evaluation is relatively easier than ex-ante project evaluation. This is because the outputs of supported R&D projects are more traceable and tangible (Falk & Svensson, 2020), such as sales, patents and publications.

Due to the risky and unpredictable nature of R&D projects, it is naturally a difficult process to examine these projects before they apply for funding (Cho *et al.*, 2011). On the other hand, an efficient evaluation made at the very beginning of the project application positively affects the successful conclusion of the R&D project. In addition, more appropriate funding of projects supported by public resources is undoubtedly important for the efficient management of public resources. However, as mentioned at the beginning, ex-ante project evaluations have many handicaps compared to ex-post project evaluations (Bulathsinhala, 2015). For this reason, this part is devoted to literature studies on ex-ante project evaluation with examples from around the world.

As a result, in this sub-part the methods used for the selection of private or public R&D funds, and the selection criteria are explained. After mentioning the shortcomings of these evaluation methods, the expert evaluation method, which is the most frequently used method in the selection of R&D projects of both public and private sector, is discussed, and its inadequacies are mentioned. This sub-part is also

important for the dissertation, because the expert evaluation method is commonly used in the selection of projects in the public R&D funding program, and expert evaluation method is mostly used in ex-ante evaluations. Finally, this part is closed after briefly summarizing public R&D funding, mentioning the specific obstacles to the assessment using public funds.

2.2.1. R&D Evaluation Methods

There is no consensus in the literature on the number and types of evaluation methods used in the selection of R&D projects. In spite of the fact that the nomenclature is different, many evaluation methods that are essentially similar in content have been recorded in the literature.

Poh et al. (2001) in their study, basically divide the R&D evaluation methods into two subsections (Figure 2.1). Accordingly, the most basic evaluation methods appear as “Weighting & Ranking Methods and Benefit-Contribution Methods”. As stated by *Poh et al.* (2001) “Weighting & Ranking Methods” is one of the most preferred evaluation methods. As is detailed in the following parts of the study, “Scoring Method”, which is a sub-break of “Weighting & Ranking Methods”, is the most frequently used evaluation method in MOIT and TUBITAK subsidies examined in the dissertation.

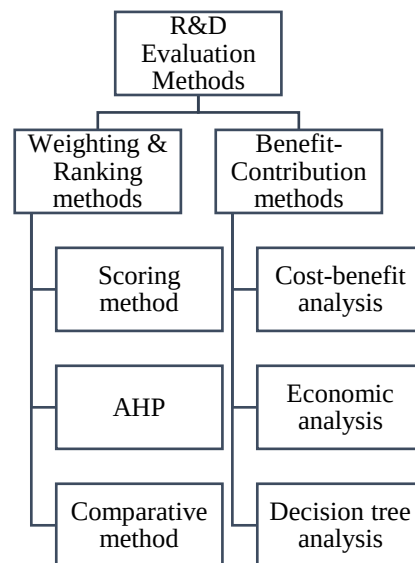


Figure 2. 1. Classification of R&D Project evaluation methods (Poh, Ang& Bai, 2001).

In the “Comparative Method” shown in Figure 2.1, an evaluation is made by comparing the applied project with the other projects. Although this method is easy, it involves a lot of subjective evaluation. Despite the scoring method’s success in the evaluation of complex projects, it may not give correct results if the evaluation criteria are not set up well. In AHP (Analytical Hierarchy Process¹) method, on the other hand, the problem, which was complex at the beginning, is tried to be evaluated in a hierarchical order (Poh, Ang and Bai, 2001).

In economic methods, the return, and the total payment of the projects are tried to be calculated. However, when it comes to R&D projects, such calculations can be mistaken due to the imprecise nature of the projects. Another drawback of this method is that while there are too many criteria in the evaluation of R&D projects, only economic contributions are taken into account in economic evaluation models (Poh, Ang & Bai, 2001).

In the cost / benefit method, which is another widely used method, it tries to make a comparative analysis between inputs and outputs. In this method, the units used in comparing costs and benefits (information costs for example) are different (Poh, Ang & Bai, 2001).

The decision-tree method, on the other hand, is a method used in successive and optional decision-making situations. In the evaluation of R&D projects, there may not be such a hierarchical and gradual situation (Poh, Ang & Bai, 2001).

As are result, in addition to the methods mentioned above, relatively new methods such as mathematical programming, decision support systems, data envelopment and neural network methods have started to be used (Derakhti, 2020). However, these methods also have aspects that are subject to criticism. First of all, while using mathematical models, any user may not benefit from these programs in the same way.

¹ Analytic Hierarchy Process (AHP) is generally a relative measurement method. In this method, rather than the main measure of a value, the ratio between its counterparts is looked at.(Aste, Tasca and Di Matteo, 2017)

In mathematical models that are planned to be used in this dissertation, the users (decision-makers in project selection) must be at a certain level of digital literacy. In addition, in applications where artificial intelligence (AI) is used, such as neural networks, the precision of the decision depends on the data training of the algorithm. Moreover, cognitive factors that experts cannot put into words during decision-making but have a positive effect on the decision cannot be modeled with AI (Cheng, Liou &Chiu, 2017).

In the detailed report that is prepared by the US Department of Energy, in addition to the aforementioned evaluation methods are peer review/expert judgment, bibliometric methods - counts and citation analysis program, data mining, hotspot patent analysis program, network analysis, case study method program, survey method, historical tracing method program and spillover analysis using a combination of methods. Since this dissertation benefits from blockchain technology to improve the peer review/expert judgment method, detailed criticisms on this subject is kept for later.

However, in the report, it was mentioned that the quality and success of this method is directly related to the expert, that the expert may have conflict of interest during the evaluation the expert may have insufficient information, the evaluation criteria are problematic. In this case, it can be said that there is an asymmetrical information distribution (asymmetric information) between project presenters and project evaluators. Again, in the report, although bibliometric analyses are thought to be more suitable for ex-post evaluation, bibliometric analyses such as citation analysis can be performed to provide data on the importance of the project subject to grant application. However, the quality of data such as patents and articles used in such studies is the subject of an ongoing debate. The quality of the journals in which the publications are published is also part of this problem. Finally, it is also an obstacle that bibliometric indicators such as publications or patents differ by industry. In spite of the fact that Social Network (SNA), Organizational Network (ONA) and Network Analyses (NA) create a forecast through maps, they cannot provide fully transparent quantitative data about the project. Again, the dynamic nature of network analysis²

² In short, Network Analysis Method is a method that examines the relationships and effects between the elements included in the network.(Butts, 2008).

causes it to be a time dependent analysis. It is a costly method as many interviews are required for network analysis. The case study method³, on the other hand, cannot give a quantitative analysis result, although it tells a story about the history of the project. In the survey method⁴, there is a target audience and biasedness problem for a long time. Again, historical tracing method⁵ may not provide quality data for the most appropriate decision due to the dynamic nature of innovation. Finally, spillover analysis is a costly method because it is a complex and difficult analysis method (US Department of Energy, 2007).

Huang et al. (2008), rather than reviewing the flaws of the evaluation criteria one by one comprehensively discussed the shortcomings of the evaluation of method-independent R&D projects. The selection models are in their study:

- (1) Insufficient evaluation of multidimensional and generally related projects,
- (2) Inadequate evaluation of non-financial issues,
- (3) Failure to give the necessary importance to the project by the project evaluators (asymmetric information), and
- (4) About the project outputs after the evaluators. They emphasize that he has deficiencies such as not having knowledge or not using the outputs (Huang, Chu & Chiang, 2008).

2.2.2. Public R&D Evaluation

Due to the unpredictable and risky nature of R&D projects and the inability of small companies to allocate sufficient resources to R&D activities, the public supports companies with R&D incentives and direct supports (Huang, Chu and Chiang, 2008). There are many models in the selection of R&D projects, which were discussed in detail in the previous part. However, many of these models are methods used by

³ “A case study is a general term for the exploration of an individual, group or phenomenon” (Starman, 2013)

⁴ Survey method is a method of collecting data through surveys.(Orel, 2019)

⁵ Historical Tracing Method (a.k.a. Process Tracing) is a study that examines the effect of a situation on the case in detail with empirical evidence (Beach, 2017)

private sector managers in determining the R&D projects to be invested. On the other hand, there may be some restrictions specific to the public in the evaluation of private sector projects that apply for incentives and exemptions to the public. First of all, public R&D projects are mostly long-term projects of strategic importance. For this reason, financial evaluation tools are insufficient to evaluate such projects. Again, political factors can affect the project results in determining these projects. Finally, government policies can also affect the selection of the projects evaluated (Huang, Chu & Chiang, 2008).

The most frequently used method in determining public funds is the peer review/expert judgment method detailed in the previous part. Although some of the shortcomings of this method are mentioned, another issue not mentioned in that part is the subject of expert selection. Especially in public projects, this expert selection can be more problematic. An efficient evaluation may not emerge after the selection of experts made by public officials who do not have the competence of experts (Sun et al., 2008).

Project evaluation criteria of public institutions are a dynamic process, although they can include country or even institution-specific elements. Project evaluation criteria can be revised continuously in line with the needs. In this part, the project evaluation practices of some institutions are discussed.

The investigations begin by referring to the evaluation criteria of the National Science Foundation (NSF), which is a competent institution in public funds in the United States and is known to use peer review/expert judgment in the evaluation of R&D projects.

NSF makes the evaluation of R&D projects under three main headings. These are: (1) Public Relevance, (2) Quality of technology, and (3) Performance. Criteria such as compliance with public policies, potential to create new jobs, compatibility with other publicly supported R&D projects, and finding clear targets are evaluated by experts under the first heading (Kim & Chang, 2013). While the clarity and suitability of research outputs, originality, potential market size and suitability of

technology are evaluated under the second heading, NSF requires experts to evaluate factors such as profitability and import substitution under the last heading according to existing investments.

The European Union has published guidelines for incentive applications made within the union. In this book, project evaluation criteria are discussed in detail. Accordingly, it is understood that the evaluation is made with the peer review/expert judgment method, and the number of evaluators who votes and, in some cases, a weighting among the voters is included in this guide. Accordingly, an evaluation committee of three people is foreseen for projects up to EUR 5.000.000. In order for the assessors to be suitable for their competencies, a detailed assessment is also made by the employees, and the method of assessment is also included in the guide.

It is stated that the experts must also sign a commitment to their impartiality. In addition, in order to ensure transparency, the evaluation meeting is also recorded with a video camera.

The chairman of the commission can request extra information from the evaluators after the evaluation, and the chairman can also request extra information / documents for the justification of the decision.

In the evaluation where technical and financial evaluation is made in separate sessions, each evaluator seals the letter containing his/ her score and submits it to the president. Only projects with a score of 75 out of 100 or higher are considered for technical evaluation.

After each evaluator's evaluation, the chair asks the evaluators for explanation for their decision. As a result, the evaluators can change their opinions and scores within the scope of the explanations made. The scores given as a result of economic, and technical evaluations are processed by a formula in a way that the weights of economic and technical evaluations are different. As a result, the evaluated projects are ranked from the highest rated to the lowest. The management decides in which order the support is stopped in line with the budget possibilities (European Commission, 2016).

In this subsection, which includes the evaluation methods and evaluation criteria of R&D projects, the limits of the existing evaluation methods are addressed briefly. When the collective evaluation of the existing methods is made, the limited participation and subjectivity appear as a deficiency in almost all of the methods. Secondly, the evaluation process is rarely. In addition, it is understood that there is a lot of examples of political biases or evaluators' lack of information. In the method presented in this dissertation, many participants in different roles can take part in the evaluation made in the blockchain environment, and the evaluation made can be traced transparently. Finally, valuable information generated during the evaluation of projects to be supported by public funds can be recorded and, if necessary, made available to the public interest. This and many issues mentioned in the dissertation prove that the evaluation made in the blockchain environment is superior to the existing ones. As a result, the main purpose of this dissertation is to prove this superiority.

Heraclitus, one of the ancient philosophers, famously stated, "*The only thing that does not change is change itself*". As it is stated in this saying, change brings some innovations, and some innovations bring change itself. It should not be doubted that innovations have removed the obstacles in front of human beings throughout history. As in every field, it is inevitable that there are innovations in the functioning of the state and in the services provides. How closely public institutions and managers follow current technological advances varies regardless of time and place. However, it cannot prevent some changes, such as the internet, from being used in the public sphere, so the impact and acceptance of an innovation in the public sector, as well as being a part of this system, is a significant work for users.

In this dissertation, the advantages of blockchain technology, which is claimed to present a new way of doing business, are discussed if it is applied in a specific part of the public space., Efficiency and success of the technology-based application is crucial for public services also. Knowing where an innovation that is implemented by considering the public sector as a sector is located more in the literature is important for the efficiency and success of the technology-based applications planned to be made in the public sector from now on. For this reason, in the next

part, elements such as how a system can be thought of if the public replaces the companies at the center of the system in the sectoral innovation system model, and how a technology-based innovation offered in the public services can be positioned is discussed.

2.3. Public Sector Innovations and Its Relations with the Concept of Sectoral Innovation System, Service and Social Innovations

Library science has been of great importance for centuries in the classification and subsequent distribution of information (David-West & Angrey., 2018). A correct classification can accelerate access to information. For this reason, it is valuable to classify and correctly position an innovation made by the public in this part. In summary, what would a public-centered system theory look like if the public innovates in its business and operations? This situation is discussed. The purpose of this discussion is to examine the system dynamics of innovations in the public sector, and thus to position the dissertation within the evolutionary literature.

Joseph Alois Schumpeter (1883-1950) is regarded as one of the greatest economists of the twentieth century. His views about entrepreneurship and innovation are probably the most distinctive contribution to economics (Śledzik, 2013). Schumpeter's (1934) original theory of innovative profits emphasized the role of entrepreneurship (his term was entrepreneurial profits), and the seeking out of opportunities for novel value-generating activities which would expand (and transform) the circular flow of income. However, it did so with reference to a distinction between invention or discovery on the one hand and innovation, commercialization and entrepreneurship on the other (Cantwell, 2001) and this view of Cantwell about Schumpeter's original view acknowledges that there is a clear economic relationship with innovation and economic activities. Innovation, on the other hand, also emphasizes services such as finance, insurance, and real estate (Caiani, Russo & Gallegati, 2019), non-financial social activities (Moore, Westley & Nicholls, 2012) and public services. In this part, the discussion will be on the relationship between the public sector innovations and concepts of the sectoral innovation system, service, and social innovations. Intersection and difference points are argued in this chapter while keeping in mind these three concepts are interrelated.

2.3.1. Assessment of Public Sector Innovation as a Sectoral Innovation System

Innovation processes occur over time and are influenced by many factors and because of interactive nature of innovation, organizations or companies have to interact to realize innovation. These organizations might not only be other firms (suppliers, customers, and competitors) but also universities, research institutes, investment banks, schools, government, ministries (etc.) (Edquist, 2015). There are various system approaches. Mainly these are *National Innovation Systems* (Freeman, 1995, Dosi et.al. 1988, Nelson, 1993, & Lundvall, 1992), *Regional Innovation Systems* (Cooke, 1996), *Technological Innovation Systems* (Carlsson, 1995) and *Sectoral Innovation System* (Malerba, 2001).

For an understanding of innovation and economic growth, sectors provide a very important level of analysis. In the Orthodox literature, sectoral boundaries have been considered static and well delimited and differences in the equilibrium. However, most of the literature about systems of innovation, not much emphasis has been paid to the role of non-firms organizations, to knowledge and learning processes by firms, to the wide range of relations among the agents, to the transformation of sectors in their boundaries, actors, products, and structure (Malerba, 2003). On the other hand, systemic approach can define innovation holistically. Therefore, in this dissertation a systemic approach is followed up.

Innovation in the public sector is becoming popular among many scholars and practitioners because of the idea that innovation can contribute to improvement and quality of services as well as enhancing the problem-solving capacity of governmental organizations in dealing with societal challenges (De Vries, Bekkers & Tummers, 2016). Furthermore, public sector innovation can help governments create public policies which are more broadly based, inclusive and better targeted on citizens' needs. This creates new spaces to challenge the architecture of problems, overcome old administrative legacies and channel public resources to where they are most needed. Participatory budgeting schemes, regarded as a powerful innovation (Fostering Innovation in the Public Sector, 2017), are being used across the world, distributing opportunity more equally across society.

Public sector innovations, on the other hand, have to overcome some challenges such as bureaucratic barriers, unknown and risky nature of innovation, democratic responsibility, and political mandate to deliver public services in consistent and equal ways (Fostering Innovation in the Public Sector, 2017).

In addition to these challenges, the necessity of modeling and assessment of innovation in the public sector should be considered (OECD, 2020). As mentioned before the systemic approach to public sector innovation might be a solution, but the nature of the systemic approach contains some barriers that have to be overcome.

Sectoral innovation systems (SIS), at a glance, are firm centric systems. The design and model of the SIS mainly focus on amending the competitiveness of private firms (Malerba & Mani, 2009). Public sector within the governments, ministries, research institutes, funding agencies, universities, norms, and regulations have subsidiary roles despite having a big influence on the SIS. Therefore, if we shifted to a part of a public sector to the center of the system (e.g., a ministry or funding agency), the measurement of the isolated effect of this public body would not be easy. For the reason that, in most countries, including Turkey, the public bodies and related institutes like funding agencies, universities, and research centers have been suffering the high incidence of biasedness, it becomes impossible to assess an innovation's performance on that public body and extraction of innovation's performance becomes too risky because of the nested structures of public bodies in some countries.

Sectoral Innovation System and its knowledge base mostly is linked with the production functions of a given sector (Malerba, 2006). Public sector innovations such as e-government applications may not be directly related with a production function. It may affect another sectors or public economic enterprises' production function indirectly, but generally public innovations regulatory. Therefore, this situation makes public innovations go beyond the common SIS literature.

Finally, as Malerba points out (2006), at least four challenges exist for research in the analysis of innovation, and the evolution of industries in front of the SIS

(Malerba, 2006) and these challenges are also valid for public sector innovation system. These challenges are; *demand*, *knowledge*, *networks*, and *coevolution*. The following sub-section is dedicated to afore-mentioned challenges.

2.3.1.1. Demand

Consumer behavior plays a major role in affecting innovation (Malerba, 2006). Michael Porter (1995) emphasizes sophisticated demand in his seminal book *Competitive Advantage of Nations*. Malerba (2006) highlights the importance of knowledge asymmetries and adoptive capacities among users of a specific sector. This issue is also valid for public sector innovation, and it is more severe than any SISs which are mainly on the manufacturing sector since most public sector innovation serves to the broader part of the society and knowledge asymmetries, and capacities is vary.

2.3.1.2. Knowledge

Malerba (2006) indicates that “...*In particular, the evolutionary literature has proposed that sectors and technologies differ greatly in terms of the knowledge base and learning processes related to innovation. In some sectors, science is the force driving knowledge growth, while in others, learning by doing and cumulativeness of advancements are the major forces.*” Comparing with public sector innovation, consequences of Malerba’s challenges may not be so severe. Because Malerba’s sectors are mainly about manufacturing such as ICT and semiconductors, knowledge stocks of these sectors are homogenous in themselves, which can ease the analysis. Public sector innovations, on the other hand, can serve to cross-sectoral fields, which causes heterogeneity. The success of an innovation can decrease because of these conditions, and these conditions may complicate the analysis also.

2.3.1.3. Networks

The innovation system literature has put the role of links and relationships among various actors at the center of the analysis. In a similar vein, evolutionary theory has

stressed that, in uncertain and changing environments, networks emerge because agents are different, thus integrating complementarities in knowledge, capabilities and specialization (Malerba, 2006).

According the quantitative analysis, trust and power relationships are correlated with the network formations (Umeda *et al.*, 2015). Thus, public sector innovations are a little bit luckier than the Malerba's sectors because of holding public power.

2.3.1.4. Coevolution

The final challenge of Malerba is the dynamic analysis of innovation, and the evolution of industries. This challenge also saves the importance of the public sector innovation too. Besides, the coevolution process in the public sector may often be later than the complementary sectors, and this causes a time lag between the sectors.

2.3.2. Assessment of Public Sector Innovation as Service Innovations

Service innovations are defined as, innovations including the introduction of new services or incremental improvements of existing services (Witell *et al.*, 2016). Besides, service innovation does not need to be in the service sectors. Service innovation is intrinsically different from “product”, as it usually lacks the tangible nature of product innovations. Services may be highly tailored according to the client/customer needs and include many different stakeholders. Especially, in the knowledge-intensive sector, where service innovation plays an important role, the concept of service innovation is likely to differ radically (Durst, Mention & Poutanen, 2015) from that of a product innovation.

As Durst *et al.* (2015) indicate, service innovations take shape according to customer needs. This property of service innovation resembles public innovation because under the normal circumstance governments should supply the public needs, and innovation may take place during this supply. Moreover, service innovations usually have an intangible nature. This is also similar to public innovations, but public innovations do not have to be an intangible nature, especially municipality activities that have tangible nature.

Like service innovations, public innovations are also knowledge intensive. Norms, and regulations might be examples to this and finally service innovations are usually ICT-based innovations (Edquist, 2015), this is also similar to e-government applications of the public sector.

Finally, service innovations do not always contain a financial effort just like public to innovations that serve the public good. Hence, service innovations generally provide customers with more efficient services at the same price as in service innovations, public innovations are aimed at increasing public welfare.

2.3.3. Assessment of Public Sector Innovation as Social Innovations

Three pillars are needed to define social innovation: first, it needs to be about implemented solutions with value for society; secondly, the implementation needs to be understood as a process; and thirdly, it must be acknowledged that most implementations fail. The European Commission broadly defines social innovation as innovations that empower people and drive changes in the sense that it leads to social change that produces sustainable social inclusion. The most cited definition of social innovation is, “Social innovation is a novel solution to a social problem that is more effective, efficient, sustainable, or just than existing solutions and for which the value created accrues primarily to society as a whole rather than private individuals” (Oeij *et al.*, 2019, pp). According to these definitions, it can be concluded that public innovations are social innovations at the same time. Thus, public innovations empower the citizens’ life, and also most public innovations are free to use for citizens. However, public innovations are mostly for a specific nation unlike social innovations.

As with all doctoral studies, the aim of this dissertation is to fill a gap in the literature. As discussed in this part, there are many points that show parallels with the conceptual innovations provided by blockchain technology and microevolutionary economics. In this part, these intersections are pointed out, and the potential contributions the blockchain can make to the evolutionary economics literature on issues such as trust, transparency and democracy is discussed.

After Giovanni Dosi's article published in 1982, which has become a classic, many studies have been carried out on technological paradigm change. In spite of the fact that several decades have passed since Dosi's work, his contribution to the perspective of evolutionary economics still continues (Von tunzelmann *et al.*, 2008). With the change of the technological paradigm (Cvetanovi, Despotovi & Mladenovi, 2012), great differences arise in the way of doing business, and this change brings many radical innovations with it.

It is not known today whether blockchain technology causes a paradigm shift, but the number of those who call it disruptive technology is increasing day by day.

The following part is about blockchain technology, the current of thought, and conceptual innovations that come with it (Nowiński & Kozma, 2017).

2.4. Blockchain Technology

There is no actual use of blockchain technology in this dissertation. In the study, the variables affecting the process and the cognitive effects of face-to-face commission meetings within the R&D incentive process in traditional methods are determined, and how blockchain technology could contribute to these effects with its secure, democratic, unchangeable, and polycentric structure, these issues are determined and analyzed. Therefore, this dissertation is a hypothetical proposition. This part is reserved for the conceptual analysis of blockchain technology, and the introduction its concepts.

Certain types of technological change have widespread consequences for all sectors of an economy. The diffusion of these changes is accompanied by major changes in which institutional, and social adaptations are necessary to harmonize the new technology and the system of social management of the economy (Freeman & Dosi, 1988). Furthermore, technological change has extensive impacts on social life. For the sake of example, as Karl Marx indicates, “hand-mill creates feudal, and the steam-mill, capitalist societies” (Schumpeter, 1942, pp). Moreover, technological changes can adjust our daily life as well as our attitudes and way of doing business.

Then, one may conclude that technology is both a tool that makes the life easier and a s offer new rules of using that technology.

Innovation and technology are essential for economic growth (Verspagen, 2004) and in this sense, technological innovation is often regarded as the primary drive for long-term economic growth (Pisa & Juden, 2017). Recently, one of the promising technological innovations is the blockchain technology with its various usage areas from finance to supply chain management (Akgiray, 2019), and it is increasingly getting more attention among the latest emerging technologies. Blockchain technology contains a subset of technologies such as distributed ledger technology (DLT), cryptography, decentralized consensus algorithms, and smart contracts, all of which offer a wide variety of application areas, namely finance, insurance, voting, health, etc. (GSMA, 2017). In addition, through its persistent nature, blockchain technology promises a solution to academic misconduct (Vijay, 2019).

In this part, the focus is on the concept of blockchain. Initially, the definition, and a short history of this technology are presented. Then, the usage areas of blockchain to date and its promising applications are briefly mentioned. After that, what blockchain technology promises, and what importance it can hold in terms of social sciences are explained. In the last part, barriers in front of the diffusion of blockchain technology are mentioned.

2.4.1. Blockchain Definition, Types, and Historical Background

Each *block* in blockchain technology contains a definite part like a page in the ledger. In this *block*, there is also information about the transaction performed. These *blocks* come together to form the blockchain. For a transaction to be made within the block, it is necessary to plan with the other users. For this, all the users in the blockchain are required to approve the transaction. Once the necessary approval is obtained, the requested change may occur (Mulligan, 2017). However, both the old version of the block , and its new version are registered in the ledgers thanks to the “unalterable” structure of the blockchain (Society, 2020).This means that one can never erase the information that is created in the block. In addition, this confirmation mechanism

gives the blockchain its ever-so-called “democratic” character (Reijers, O’Brolcháin, & Haynes, 2016). In most types of the blockchain, a change may occur depending on the approval of 51% of the total number of users (Sayeed & Marco-Gisbert, 2019); therefore, a certain consensus must be established between them (Swan & de Filippi, 2017).

As can be seen in Table 2.1 the blockchain is basically divided into two main types: open and closed. In particular, the open, also known as public, blockchain is referred to as decentralized, unmanaged blockchains (Tavana et al., 2020). The best-known examples of these blockchains are *Bitcoins*. Another important public blockchain, *Ethereum* has recently come to the fore with its programmable and more volatile structure and smart contracts⁶ (Harm, Obregon & Stubbendick, 2016).

Table 2. 1. The main types of blockchain segmented by permission model (OECD, 2018)

		READ	WRITE	COMMIT	EXAMPLE
OPEN	Public permissionless	Open to anyone	Anyone	Anyone	Bitcoin, Ethereum
	Public permissioned	Open to anyone	Authorized participants	All or subset of authorized participants	Supply chain ledger for retail brand viewable by public
CLOSED	Consortium	Restricted to an authorized set of participants	Authorized participants	All or subset of authorized participants	Multiple banks operating a shared ledger
	Private permissioned “enterprise”	Fully private or restricted to a limited set of authorized nodes	Network operator only	Network operator only	External bank ledger shared between parent company and subsidiaries

⁶ “Smart contracts are programming code which stored on blockchain and automatically execute when predetermined and programmed terms and conditions are met. The advantages of smart contracts are mostly required for business relationships where it is used as an agreement between the business alliances so that they can rely on consequences without involving any intermediary. A smart contract is a legal contract between two parties in the form of programming code. The programmed agreement is unaltered and stored on distributed database which executes on the blockchain. All the transactions of the smart contract are processed by the blockchain when the conditions in the agreement are matched as there is no intermediary involved.” (Sheikh, Azmathullah and Rizwan, 2019)

The consortium blockchain, on the other hand, is a suitable blockchain for the business world. In this type of blockchain technology, which makes use of features such as deployment, governance, scalability, and data privacy, the management of the chain is carried out from a single source (Dib et al., 2018). This type of blockchain, which is decentralized, does not actually comply with the conceptual novelties brought by the blockchain technology. However, due to aforementioned features of this blockchain such as governance and data privacy, it can be preferred by the business world.

When it comes to the history of the blockchain, the first publication about blockchain, in which blockchain was conceptually mentioned, is "New Directions" that was published in 1976 (Sarmah, 2018). However, DLT, which is a sub-technology of blockchain concept, was developed in 1991 by Stuart Haber and Scott (Torta, 2020). The roots of the digital currency go back to the studies of Adam Black's "hash cash" and Wei Dai's "b-money" in 1997 (Sarmah, 2018). Bitcoin, on the other hand, was created in 2008 by Satoshi Nakamoto, an anonymous writer or a group of writers whose identity is still unknown. It is based on the article named "Bitcoin: A Peer-to-Peer Electronic Cash System" (Torta, 2020). According to another opinion, Satoshi Nakamoto, is a part of a formation called "cyberpunk" that advocates free thought and knowledge sharing that emerged in the 1990s (Fresno, 2017). As a result, considering the innovations brought by blockchain technology, it cannot be denied that it shows similarities with its possible history.

2.4.2. Blockchain Examples

As mentioned in the previous part, bitcoin is one of the well-known application areas of blockchain. However, blockchain technology has extensive usage areas like public sphere supply chain, financial services and banking, insurance, public procurement in ministries and municipalities, personal records (health, insurance, financial, identity), land title registry, benefits, entitlements and aid, contract and vendor management, energy utilities, copyrights, voting, mitigating, and identifying fraud, and streamlining interagency and cross-sector processes (World Bank, 2018 & OECD, 2018).

Current and possible uses of the blockchain is not discussed at length in this part. However, it is worth underlining that the application areas are related to the conceptual innovations brought by the blockchain. For example, the bitcoin application is a solution for unwarranted payments made to an intermediary, namely the bank, in money transfers. Moreover, blockchain implementation in public procurement may be considered as a remedy for the needed transparency. To give an example, the blockchain application for citizens' identities may be used for data quality and security. As a result, it can be said that every technological progress is a solution to a problem and blockchain application is a candidate technology to offer a solution in cases where concepts such as transparency, trust, data quality and security, and democracy lack. As a result, due to the previously mentioned unique features, blockchain can be used in many areas other than finance, and its usage areas are increasing day by day.

2.4.3. Blockchain's Elimination Strategy for the Lack of Trust, Transparency, and Democracy

2.4.3.1. Trust

Blockchain technology provides complete information about the transactions thanks to the persistent nature of the software (Zheng et.al. 2017). A ledger in the blockchain consists of all the uploaded data which cannot be deleted and adding new data has to have consensus among the users. In addition to this, the consensus mechanism of blockchain may remove the information asymmetries. All the users included in the chain should prove that the data is crucial for the chain, so the user who wants to add new data should convince others. This method can reduce the information asymmetries among the users. Finally, it eases the dissemination of knowledge via the public type of blockchain (Pwc, 2017) and thus, problems about information asymmetry can be solved by gathering experts' opinion easily since blockchain technology can provide a trust environment⁷, which is the most valuable

⁷ Blockchain technology also known as trust machine because of its ability to allow people to interact and conduct transactions even though they may not know each other or pre-existing trust-based relationship (OECD, 2018).

and coveted commodity in the digital economy and society (GBBC, 2019). In addition to this (Yeung, 2019), especially in developing countries where there is a lack of institutions for providing trust, blockchain represents a shift from trusting people to trusting math.

2.4.3.2. Transparency

Data is new oil (Flender, 2019), so it can be said that those who have the data also have a certain power supply and, as with any power source, there are likely to be many discussions and disagreements about the way it should be shared and used or the degree of its quality. As is usually the case, there may be people who want to have power and strive to become monopoly (Mosca, 2011). Today, data produced via channels such as banking transactions, social media interactions, scientific studies, and even refrigerators that connect to the internet are kept in a center. Ironically, the data produced especially through purchased goods and services can be collected without consent and be subjected to repeated sale. The main reason for this situation is that all these data produced are retained in a center and the institution or people owning the center have a monopolistic attitude on the data, which are anonymous.

The data produced by the blockchain's distributed ledger technology (DLT) can be stored in many centers (or computers) preventing the ownership of the produced data from being in a single hand (Banks & Technology, 2020). Thanks to DLT, the fact that data ownership has a distributed structure reduces doubts about the accuracy of the data and increases transparency.

2.4.3.3. Democracy

Munck (2014) argues that democracy is more than just elections. According to Munck, democracy is basically an open management system (Munck, 2016).

Thanks to the various consensus protocols⁸ in the content of the blockchain, it is possible to vote and select the data to be recorded in the block (Racsko, 2019).

⁸ Consensus protocols are Proof of Stake (PoS), Proof of Work (PoW), Proof of Elapsed Time (PoET), Proof of Capacity (PoC), Proof of Burn (PoB), and Proof of Activity (PoA) (Racsko, 2019)

Furthermore, it is possible to make choices in line with the consensus protocols determined by the community involved in the blockchain. It is a feature of blockchain technology that constitutes its democratic part.

2.4.4. Limitations of Blockchain Technology

It has been mentioned a lot that the blockchain consists of blocks, and the data contained or deleted in these blocks pass through an approval mechanism among all users. The blockchain requires substantial computing power for changes made through blocks. This situation necessitates the use of more qualified devices or a longer period of time (Zhao *et al.*, 2019). For this reason, a huge amount of electricity is consumed by blockchain users. This high consumption is a concern for the future of the blockchain, especially nowadays with increasing environmental concerns.

Secondly, the legal, institutional, and physical infrastructure of the blockchain has not yet been established. In particular, blockchain governance, there are no "public" organizations that can interfere with the way rights and assets are distributed among their members because the only structurally enabled distribution in blockchain governance is the distribution originating from interactive nodes. Moreover, there are no restrictions for large inequalities in the distribution of rights and assets, especially no obstacle to greater efficiency of individuals or companies in the system (Reijers, O'Brolcháin & Haynes, 2016).

Finally, there are some more technical barriers to the blockchain. These include cyber-attacks, network security issues, limited member capacity, and poor scalability (Brett 2018). However, some of these barriers can be overcome with the help of technological developments. For example (Jani, 2018), it is known for its ability to add more users, better network security, programmable structure, and high scalability compared to another type of blockchain, Ethereum blockchain.

Leonardo Da Vinci's word "*Simplicity is the ultimate sophistication*" is engraved on the wall of the Uffizi museum. For Da Vinci, simplicity is the key to permanence.

Despite some shortcomings, blockchain technology proposes to improve the simplest and the most basic but the most needed concepts. Today, transparency, decentralization, trust, and democracy are the most fundamental needs for everyone, and the simplest solution to meet these requirements may also be the wisest.

For this reason, it is thought that blockchain, which is one of the pillars of dissertation, has the potential to deeply affect social and economic life rather than being an ordinary technological innovation alone. From this perspective, it can be said that the blockchain proposes a new techno-economic paradigm change.

It has been mentioned in the previous part that with the widespread use of blockchain technology, it can bring many innovations in the society and in the way of doing business. However, how ready are people and society for this technology, or can this technology be accepted by the masses? The answers to these questions are discussed in the next part.

While the benefits of changing technology are mentioned on one hand, how much can be adapted to these promised benefits or the role of technological innovations in the evolution process of human beings is mentioned.

2.4.5. Blockchain Technology Recommended for Use in Turkish R&D Funds

In this section, where literature information about blockchain is given, the features and differences of blockchain technology are discussed, starting from the history of the technology. In this subsection, the details of blockchain technology, which forms the main theme of dissertation, will be discussed.

2.4.5.1. Type of Blockchain

Blockchain is a technology with a polycentric structure. Thanks to its multi-centered structure, the information in the ledgers can be kept on many servers or computers. Again, new registrations to ledgers and/or deletions are made with the common consent of the members. Thanks to these features, information written in the

blockchain can be followed by many people, and a democratic environment can be provided thanks to the consensus mechanism. If blockchain is used in public R&D funds, the diffusion of information may be greater. Because, in the current mechanism, information produced with public resources can be kept on public servers, and new inventors or proposals cannot know what is in old inventions and applications. In this way, people will be able to mature their R&D project applications and benefit from existing experiences.

On the other hand, it does not seem appropriate for the information recorded on the blockchain to be available to everyone within the scope of dissertation. Especially in terms of IPR, it would be appropriate for authorized persons to register to the ledgers and view the information in order to protect the rights of the project owners. Blockchain types are listed in Table 2.1. Accordingly, an **OPEN** blockchain is considered in dissertation. However, the records in the chain must be centrally **PUBLIC PERMISSIONED**. All publicly permitted people will be able to write to the blockchain, but only project evaluators and project owners will be able to add or delete information.

2.4.5.2. People and Their Roles

The people who will be included in the proposed Open and Permissioned Public R&D Project Evaluation Blockchain and their roles are as in Table 2.2.

As seen in Table 2.2, there are 4 different roles in the proposed blockchain model. Personnel working in the public institution that controls public funds will be able to read information about the project and process this information into ledgers. The broadest authority will be given to academicians who are project evaluators. Academicians, whose number is suggested to be between 8 and 12 people (explanations regarding these numbers are discussed in detail in the following section), have the authority to write about the project and also have the authority to commit.

The party presenting the project has the authority to read and respond to comments received on the project.

Table 2. 2. Open and Permissioned Public R&D Project Evaluation Blockchain:
People and Roles

	READ	WRITE	COMMIT
Public Officers	✓		✓
Evaluator Commissioners	✓	✓	✓
Project Owners	✓	✓	
Observers	✓		

Finally, in order for the information to reach more stakeholders, observers who are interested in the project topic and authorized by public authorities can be included in the chain.

2.4.5.3. Decision Making in Blockchain

In Blockchain, decisions can be made by full consensus or by the majority decision. In the proposed model, the form of the decision-making mechanism is left to policy makers. Accordingly, it is recommended that it be written on the chain and left to the approval of 51% or the majority in order to make a faster decision.

2.4.5.4. IPR

The polycentric and unchangeable structure of the blockchain can facilitate the protection of intellectual rights. On the other hand, in programmable blockchain types such as Ethereum, contracts can be embedded into the chain. As a result, the public, project owners and evaluators can make a contract among themselves on the etherium infrastructure to share the economic benefit obtained. It is also possible to distribute the income obtained thanks to tokenization virtually.

As a result, in this section, a framework has been drawn about the blockchain structure and its stakeholders, which are thought to replace traditional methods. In this way, a more fair, multi-stakeholder, traceable and traceable structure is proposed. Therefore, blockchain type technology which is multi-centered is useful tok for this.

2.5. A Review of Human-Machine Communication via Blockchain Technology

One of the main pillars of the dissertation is to test the effects of technology on people's choices. On the other hand, aside from the benefits of technologies, the adaptation of these technologies (in this case, blockchain technology) to social life and the evolution of routines in line with possibilities are discussed in this part.

In modern society, technology has greatly changed the way people interact with each other daily (Morin, 2020). The response of societies or age groups to major technological changes may be different. While some societies or age groups can easily adapt to technological changes, some may not be successful in it. Blockchain technology also emerges with such a technological change. The reaction of societies or age groups to a technology such as blockchain, and its tendency towards technology while using this technology can directly affect the acceptance of the technology among the masses and the success of blockchain technology (Aste, Tasca & Di Matteo, 2017). Therefore, it has become necessary to examine the effect of this on different segments of the society. Thus, one can conclude that the relationship of people from different age and gender groups with technology may differ. It is the main purpose of this subsection to examine whether the possible differences in the relationship of human communities with technology also differs.

It would not be possible for the dissertation to progress without looking at whether the communication of human with computer or machine has an effect on its decisions. For this reason, understanding the behavioral differences between human communication with machine (computer) or group decision-making within the scope of the dissertation is an essential. It is argued that the evaluation of public R&D projects based on blockchain technology is more effective and objective than the current situation. Due to its nature, project evaluation is takes place digitally with the help of blockchain technology. In this case, users must have some digital literacy. However, could this decision-making have an impact on decision makers' rationality of choosing right option? The answer to this question is important because one of the main arguments of the dissertation is that the decisions made on the blockchain are more objective and freer from the handicaps of coming together physically than

traditional ones. For this reason, this part has been prepared to examine the effects of the nature of human-machine interaction on the rationality of decision makers, and the impact of different age groups on decisions made in digital environment.

Technology in particular is not only a medium, but also a part of the communication process (Westerman *et al.*, 2020). This chapter has been prepared to relieve concerns whether this involvement makes use of technological elements as a part of the decision.

Moreover, decision-making processes are complex cognitive processes, including learning. This learning process also includes sub-processes based on personal, social and knowledge (Zhang & Zhang, 2007).

In a nutshell, the chapter is analyzing the evolutionary development of human-machine communication, and touch on socio-technical systems that examine the effects of information technologies on social life. Then, after mentioning the effects of computer-assisted communication, the effects of people's real identities or their anonymity on their decisions is discussed. Then, the positive and negative aspects of the number of decision makers on the decisions is discussed. The possible effects of these issues on the blockchain-based decision-making mechanism, which is the subject of our dissertation, is also mentioned one by one.

2.5.1. Decision Support Systems and Blockchain

Decision support systems are software designed to assist managers in their decision-making processes. In these systems, a large amount of information is classified and analyzed, resulting in helpful results in decision-making (Tripathi, 2011). It is hoped that the literature on decision support systems help us about how the blockchain technology, which is also a software, should be used in a kind of decision-making process in our dissertation. For this reason, the intersections of the decision support systems and the blockchain-based project evaluation are discussed in this part.

Today, decision-making processes have become more complicated with the development of information technologies. The increasing amount of information

raised the number of alternatives and the expected decision-making times shortened. This situation has started to strain human capacities in decision-making processes. Additionally, the quality of the decisions made is very important in such an environment (Turban, Aronson & Liang, 2003). At this point, the decision support systems literature suggests various software opportunities to managers in decision-making processes. Thus, an increase in productivity is predicted.

Decision support systems briefly list the features of these software, which are used for better and efficient decision-making processes, as follows: *faster calculation capability, improved communication and efficiency and technical support* (Loya *et al.*, 2003). The benefits listed above and promised to users with decision support systems can also be provided by the blockchain-based R&D project evaluation system. In blockchain-based project evaluation processes, commission members are able to make computer evaluations regardless of time and place. During this evaluation, they are able to benefit from the data previously entered in the notebooks, and they can access the information they need faster thanks to web search engines.

In addition, there is a relatively isolated environment in the commissions established for the selection of traditional R&D funds, at which point the commission has access to information as much as the people's memory capacity to make decisions. On the other hand, decision-makers in blockchain-based decision-making processes are equipped with more information opportunities in a self-governing environment. At this point, the literature on decision support systems also supports the efficiency of the decisions to be made in the blockchain environment.

As noted, traditional commissions have a limited membership. As is stated later in this part, there may be communication problems between the members due to hierarchical classifications or the shy character of the commission members. Furthermore, commission members may want to remain anonymous for several reasons, which can allow them to express themselves freely. However, this free environment cannot provide via traditional commission system. For this reason, blockchain technology can provide a more efficient communication environment, with the ability to remain anonymous if people wish and to communicate with more people at the same time.

Additionally, as stated in decision support systems, consultation with experts on a problem is both costly and inefficient. This also applies to the traditional R&D projects evaluation system (Turban, et al., 2003). In the traditional assessment process, commission members participate in commissions for a certain fee and by covering a certain cost from different parts of the country. However, the efficiency is not as high due to the limited participation. On the other hand, in the proposed blockchain-based evaluation system, the number of participants is high and there is no need to meet in a certain place for participation. Therefore, a decrease in costs and an increase in reliability of decisions are expected in the blockchain-based evaluation system.

Finally, unlike the traditional evaluation system, the blockchain-based evaluation system offers technical opportunities such as data storage, benefiting from internet research, and being able to log into the system at any time and evaluate.

2.5.2. Human- Machine Communication and Evolution

The relationship, compatibility, or incompatibility of human with machine or computer is a very wide and comprehensive subject and is beyond the scope of this dissertation. However, the possible impact of human communication with a machine or computer on the decision process has close relationship with the dissertation topic. For this reason, in this subsection, the evolutionary process of human-machine communication is briefly mentioned and studies on human adaptation to the new process is mentioned.

Traditionally, people are more used to learning face to face (Kemp & Grieve, 2014). For this reason, it can be said that virtual learning environments produced by online learning technologies are insufficient in the learning process. On the other hand, it should not be ignored that the psychological characteristics of every different generation of modern people are also different. As a result, it does not seem possible to explain the generation-specific learning phenomenon. The fact that modern humans are now subject to different selection pressures compared to their ancient ancestors has made them compatible with technology, and the ability to use

technology has become a new survival skill (Kock, 2009). In conclusion, although there are many sources stating that the human brain can learn face to face and is more susceptible to communication, it would not be too ambitious to say that being able to use technology is a new struggle for survival for human beings, causing them to evolve to use technological possibilities.

2.5.3. Socio-Technical Systems

The efficiency of any technical system brought to a business or institution can only increase if it is part of a larger social-technological system. It has been reported many times that deficiencies in building social capital led to system errors. Therefore, the success of technical systems within the organization is related to the involvement of human capital. Again, the interaction of technical systems brought to organizations with human capital is one of the most important factors affecting the success of this technical system (Riegelsberger, Sasse & McCarthy, 2005). It is very important for the efficiency of the system so that the system's beneficiaries trust the system.

Cryptography is a method used to make systems more reliable. By emphasizing cryptography, it offers a software infrastructure that can secure the information and documents that need to be protected in the blockchain system (Al-Hamdani, 2008). As a result, blockchain is a structure that can alleviate the concerns of the beneficiaries.

2.5.4. Variety and Anonymity

There is a positive correlation between diversity and innovation. In environments with a lot of diversity, innovation is expected to increase (Nathan & Lee, 2013). For this reason, diversity in decision-making can also positively affect the outcome of the decisions made. In spite of the fact that this polyphony increases the decision-making time, as is seen in the following parts, confidence in the decision also increases.

There has been a noticeable increase in the number of co-authors in academic articles in recent years. In addition, there is a significant increase in the number of articles

with international co-authors (Mihăilă, 2018). This shows that specialization is increasing and those who have knowledge are geographically dispersed. In such a case, it can be concluded that making a decision based on location would not be very appropriate in today's conditions. Thus, it is obvious that an electronic decision-making environment is more efficient (Turoff & Hiltz, 1982). At this point, an advantage of electronic decision-making systems over traditional methods stands out. Indeed, users may be skeptical of such a decision-making mechanism in the electronic environment with concerns of intellectual property infringement. However, with the secure unchangeable nature of blockchain technology and smart contracts features, these concerns are also prevented (Racsko, 2019 & Ishmaev et al., 2017).

The literature provides evidence that anonymity encourages high participation. In addition, it provides observations that electronic meetings make participants feel more comfortable, especially with shy characters. It is argued that the meetings in the electronic environment relax the participants with sensitive characters and provide equality among the participants (Nunamaker, et al., 1988). Moreover, it has been observed that there is less obstruction in meetings held in electronic environment compared to face-to-face ones (Jessup, Connolly & Galegher, 1990). This situation naturally provides more discussion environment and more production opportunities. Lastly, it provides evidence that the participants are more courageous in the meetings held electronically (Lehmann & Seitz, 2017). It is obvious that such an environment is more liberal and its positive effect on innovation should not be ignored.

In addition to the positive aspects of decision-making in electronic environment mentioned above, blockchain technology can also enable people to communicate in writing. Studies have shown that written communication is more detailed and careful than oral communication (Schllert & Kleiman, 2007). Again, written communication shows that especially participants with sensitive characters are more participatory during decision-making.

As a result, it is understood that discussions in electronic environments such as blockchain are more efficient, and the results may be more satisfactory. Although it is

predicted that such a decision-making process takes more time than traditional process, it is seen that the idea of distributing public resources in a fairer and more satisfactory way for all parties is superior in terms of accountability and transparency, considering that the subject of this dissertation is the distribution of public funds. Providing such an environment is a requirement for R&D funds generated from public resources. For this reason, this thesis also has a social purpose.

2.5.5. Group Decision Support System

Group decision support systems are computer-based systems that support decision-makers in structured or semi-structured tasks (Chen, 1998). Similarly, in this study, a group of decision-makers are involved in the selection of public R&D funds. From this point of view, the subject of the dissertation is parallel to the Group Decision Support Systems (GDSS). On the other hand, details of the GDSS literature are not included because, in this dissertation, the effects of individual characteristics on the group are modeled by Agent Based Simulation (ABM) methods. In this respect, the GDSS literature is used, but the dissertation determines its original method.

Decision-making within the group can have positive or negative aspects. One of its downsides is that some of the group members may be discouraged or unwilling to share their information. This situation may cause some group members to dominate the group during the decision. Thus, results such as pressure, discomfort, and poor communication may occur among group members. On the other hand, as a result of the diversity provided by decision-making within the group, an improvement was observed in the quality of the decisions (Vogel & Nunamaker, 1990).

Studies have determined the optimum group size as groups of 3 or 5 people, although some members may oppress the group (Dennis *et al.*, 1990). Again, as stated in the social psychology literature, it is found that group members can exhibit selfish behaviors during decision-making and that there is no guilt in doing so. This situation is called *diffusion of responsibility*. Again, in detailed experiments, less cooperation, and more competition were encountered among group members. However, as a result, it has been determined that such moral situations and ethical

norms emerge in the interaction between humans. It has been found that such behaviors cannot be transferred in human-machine type communication. The reason for this is that while feelings such as responsibility in human-human type of communication can be transferred to other people in the group, such a transfer cannot occur in communication between human-machine communication. It has been shown that the machine is not human and has no emotions (Kirchkamp & Strobel, 2019). As a result, while people can benefit from factors such as information sharing and diversity of being a group, since people are not physically present in the decisions made in groups in electronic environment, they can decide objectively as if they were alone at the point of transferring responsibility.

Finally, the social psychology literature shows us that there is an enormous danger. As is known, the subject of the dissertation is the evaluation of public R&D funds. In spite of the fact that the fund provider in this assessment is the public, diffusion of responsibility can have serious consequences during the assessment because R&D projects contain many risks due to their nature. In such an environment, transferring responsibility for decision-making to people with less competence on the subject may both sharpen the information asymmetry and lead to the mismanagement of public funds.

Another point concerns the difficulty or complexity of the decisions. According to the GDSS literature, if the issue to be decided is complex, decisions made in electronic environment can be made after long discussions. In addition, since the discussions in the group in the electronic environment are on the internet, there is a lot of information loading (this is called background noise), and the decisions made can lead to wrong decisions. On the other hand, it has been observed that (Carey & Kacmar, 1997) the decision taken in the GDSS is more confident due to the more discussion and consensus on the decisions taken.

2.5.6. General Data Protection Regulation (GDPR)

Although we defend the effectiveness of online decision-making processes in this subsection, we should not ignore the fact that this has many real-life consequences and responsibilities. One of these is legal liability.

As an example of these legal obligations is the General Data Protection Regulation, which entered into force in the European Union in 2016. Within the scope of this regulation, the data security of individuals is guaranteed in member countries (European Parliament & of the Council, 2016).

For this reason, data transparency specified in GDPR should be guaranteed. Regarding data transparency, the superiority of blockchain technology has been emphasized in many parts of the dissertation. As a result, although it is not possible to be preconceived in a dynamic process, as of the time of this writing, blockchain technology seems to comply with the provisions dictated by the GDPR.

In a nutshell, firstly, after briefly mentioning the relationship between decision-making processes in electronic environment and human evolution, the advantages of decision-making processes in electronic environment are underlined in this part. This is followed by the advantages of group decision-making in a higher-level electronic environment. The contributions of blockchain technology at every stage have been included in these discussions. As a result, ongoing life is a dynamic and evolving phenomenon, and human beings have to adapt to this process in line with their abilities, and it should not be forgotten that such technologies promising wide-ranging changes have wide-ranging effects on human life. It is predicted that blockchain technology also creates such a change. In this subsection, the socio-psychological and evolutionary effects of this change have been examined.

Until this part, the importance of R&D incentives, the significance of evaluating incentive applications, the place of innovations in public services, and the importance of blockchain as a new technology have been discussed. On the other hand, it has not been mentioned yet where this dissertation is located in the literature and what gap it fills.

In spite of the fact that blockchain technology is an innovation, its importance in the system has a place in this study. Therefore, due to the emphasis and importance it places on innovation and knowledge, this study hopes to find a place for itself in the evolutionary economics index. In this part, the contribution of the use of blockchain technology, in public R&D funds to evolutionary economics is discussed.

2.6. Points of Convergence Between Blockchain Technology and Evolutionary Microeconomics:

Evolutionary economics, which takes its roots from Darwin's theory of evolution, is known for prioritizing knowledge over other mainstream economics (Potts, 2014). Evolutionary economists argue that the economy is a dynamic, complex and unstable structure, just like biology (Dosi *et al.*, 2018).

In this section, the possible contributions of blockchain technology to the evolutionary economics literature with its features such as its trust environment, polycentric structure and immutability of information are mentioned.

2.6.1. Possible Contribution of Blockchain Technology to Evolutionary Economics Literature

Blockchain technology has led to conceptual changes from both technical and economic points of view (Atzori, 2017) although it seems as if it is related solely to software sector. In essence, blockchain technology contains several subset technologies such as Distributed Ledger Technology (DLT), cryptography, decentralized consensus algorithms, and smart contracts. All of these offer a wide variety of application areas, namely finance, insurance, voting, health, and so on (GSMA Association, 2017). Moreover, these subset technologies support some philosophical concepts such as democracy (De Simone *et al.*, 2019), trust (Hughes, 2017), decentralization (Swan, 2017), and transparency (Chang, Chen & Lu, 2019). Economic life is inevitably affected by these concepts once the blockchain technology finds itself in economic and social life.

This part covers how blockchain technology would affect the distribution of accepted or rejected R&D project proposals submitted to public body (Data from MOIT, one of the main public body for R&D funding in Turkey, is used in this dissertation) if the blockchain technology were used in the public administration in Turkey.

In order to evaluate an R&D project, traditional funding bodies in Turkey set a central commission consisting of academicians and representatives of different

sectors. The decision is made by this commission at a given time and location (TUBITAK, 2018). Commission members decide to reject or approve the proposed R&D projects by using their individual rationality and stock of information. This kind of scene resembles a standard economic activity. Thus, one may conclude that election of an R&D project to be funded has similarities with the daily economic life because this kind of election is simply a selection problem.

Microeconomics is basically the study of individuals' behavior in decision-making and allocation of resources (Tyagi, 2013). Macroeconomics is, on the other hand, the big picture which deals with how overall economy works, and this kind of approach is incapable about interactions among agents and their individual choices. Similarly, individual decision-making and interaction among other commission members come to the forefront in the public R&D assessments. Therefore, R&D public assessment is much more akin to the microeconomics than the macroeconomics considering the similarities between the R&D assessment system and economic activity. Agents that represent commission members in this sample act individually in order to make decisions, share information and experience during the commission meetings, defend their decisions that pretend to be fully rational. Finally, members have to protect limited resources of public funding budget to prevent any possible misallocation. Therefore, it is apparent that the selection process in R&D assessment has several intersections between the microeconomics and public administration.

Joseph Schumpeter indicated in *Capitalism, Socialism and Democracy* that “(t)he essential point to grasp is that in dealing capitalism we are dealing with an evolutionary process” (Warner, 2013). Furthermore, dealing with human society that covers all of capitalism, socialism, and democracy necessitates dealing with evolutionary process (Potts, 2000). Besides, it is assumed that agents have full relevant knowledge and are blessed with a strong rationality on the classical microeconomics (Soukup, Maitah & Svoboda, 2015). In addition to these, learning is at the core of evolutionary theory on the contrary to neoclassical economics (Nelson, 2007). Moreover, as Potts (2000) states, learning costs are negligible, and the role of institutions are neglected in the neoclassical theory. However, evolutionary microeconomics claims that agents are not capable of having full relevant knowledge

and their rationality is limited. Additionally, learning has a central role, and the position of institutions cannot be ignored in the evolutionary microeconomics (Potts, 2000). Eventually, evolutionary microeconomics seems more convenient in order to study dynamics of public R&D assessment system. Thus, the effect of blockchain technology on knowledge accumulation and dissemination, learning environment and possible effect of bounded rationality on choices, the role of institutions in the light of the blockchain technology, and the role of state are discussed under the framework of evolutionary microeconomics.

In short, this part discusses possible contributions to the evolutionary microeconomics of blockchain technology, which is assumed to be utilized in public R&D assessment system.

The organization of this part is as follows: first of all, the possible estimated effects of blockchain technology on learning, learning costs, and agent's rationality are discussed; then, the possible roles of blockchain technology on institutional organizations and changed position of state are underlined.

Decision-making process can be split into two separate periods. In the first period, decision-maker obtains a message considered to be true, and this message is processed in the decision-maker's mind. During this process, the message modifies decision-makers' beliefs, and decision-maker chooses an action accordingly. The value of information is simply the difference between these two periods (Lesourne et al, 2006). In addition to the value of information, asymmetry of knowledge and information also plays a central role (Metcalf, 1994). Consequently, the role of information on decision-making cannot be ignored, and blockchain is, on the other hand, a good medium in order to share and disseminate information. Powered by blockchain technology, bitcoin, for example, has 54.27 million users worldwide (Rudden, 2020). Moreover, blockchain provides an opportunity for sharing and protecting data more securely among the users (Liang *et al.*, 2018). This property of blockchain enables users to share information more freely, leading to the expectation that dissemination and generation of information can accelerate. Additionally, through the unmalleable nature of blockchain, all the comments, transactions,

changes, and the questions or doubts about a ledger can be visible and such a feature can be both a good source for agents and a permanent record for future decision-makers. The listed properties of blockchain can also be applied into public R&D assessment system in case blockchain technology is used in commissions. Members of commission, and project owners share relevant data or information through blockchain without feeling concerned about intellectual property. In addition to this, unlike the traditional R&D commissions, blockchain ledgers always record all the data generated during the assessment of projects, and this can ease the dissemination of data if the ledgers are public. Otherwise, the recorded data can be published by permission. In addition, users (according to use; agents or commission members) can generate new information by means of blockchain's chatting property because users can feel freer thanks to secured intellectual property rights.

Potts indicates (2000) knowledge accumulation is highly important for evolutionary microeconomics and argues that the number of possible connections can increase the stock of information. In this manner, commissions in the traditional R&D assessment have a limited number of members, but, on the other hand, the number of commission members can be increased freely with blockchain technology. This, in turn, can increase the possible accumulation and flux of connections and naturally, the stock of generated information.

Just like drawing on knowledge stock, commission members may also utilize their past experience during the decision-making process at traditional R&D assessment, and this procedure is limited with memory of commission members who are ready at the commission meeting because commission may change during the evaluation of projects, so former members' decision cannot be memorized by the new ones. However, memories and experiences of commissioners at the traditional R&D commission system may not be enough alone. On the other hand, memory capacity of blockchain is nearly unlimited since as indicated earlier, blockchain uses distributed ledger technology (DLT), and DLT takes the advantage of memory capacity of users' computers (Ansip *et al.*, no date). This unlimited memory capacity of blockchain ledgers may ease the decision-making process and can lead to a much more proper selection of proposed R&D projects. Consequently, this unlimited

memory capacity may result in more suitable project selection, and this situation may help people to find missing and/or fault information. In that way they can benefit from more accurate information when making a choice. Finally, one may conclude that economic problem is a choice problem, and if knowledge is perfect, then choice problem can be resolved (Potts, 2000). It is apparent that interrelations among information, rationality, and choices are visible. Blockchain technology, in fact, can trigger the concepts listed above one by one or all spontaneously.

The importance of information for evolutionary microeconomics, and enabler role of blockchain was stated previously, but the importance of information costs still remains unfolded. In addition to information costs, selection process has a cost as well, and a decision-maker wishes to optimize these costs. When decision-makers are exposed to an optimization cost which may lead them make less costly choice (Lesourne et al, 2006). Meanwhile, commission members have to afford the information costs concerning the assessment of R&D projects with which they are tasked, but they may have a tendency to choose less costly projects about which they generally do not have enough information. Unfortunately, this phenomenon may lead to the selection of inferior projects but the cost of selecting inferior projects is huge for the funding agent. Fortunately, the cost of cumulated information in the public blockchain is zero (Bryson et al., 2017) or negligible for public or semi- public type of blockchain because the state gives the necessary permissions to the commission members.

However, at the initial stages of project assessment, both blockchain, and traditional system may not have sufficient information stock as the ledgers of blockchain are empty. Yet, after a while by producing new information in commissions and recording new information generated by commission members, blockchain ledgers are eventually saturated with information, and the costs of information become negligible. Contrary to the assessment through blockchain, the state encounters with information costs at each traditional R&D assessment commissions.

Blockchain technology has some limitations despite the positiveness listed above. First of all, it requires a certain amount of digital literacy (ESCAP, 2018). However,

this problem may turn into a benefit because commission members who want to enter R&D assessment system through the blockchain should pay entry cost (Kwaak, Ormel & Eds, 2012). They can gain a digital literacy while building a capacity, leading to knowledge generation.

Unlike the neoclassical theory, evolutionary theory argues that agents have bounded rationality (Coad, 2007). This is also true for evolutionary microeconomics (Potts, 2000). Agents want to optimize their rationality, and this requires transparent environment. Blockchain technology provides this transparency via its unique unmalleable nature (Knezevic, 2018). This feature of blockchain can also support evolutionary microeconomics' concept. Furthermore, informational imitation can hamper agents' rationality (Lesourne, 2006), and a commission member may mimic others' decisions about a project. Therefore, the problem of rationality caused by insufficient information can be reduced by blockchain technology. This phenomenon may affect the assessment of a project both positively and negatively. Yet, there is a risk that the assessment of an R&D project funded by taxes is left to chance. Information imitations in the blockchain, however, can be reduced because of anonymous identities of commission members.

The foundations of evolutionary economics are based on Darwin's theory of evolution (Vromen, 2007). Charles Darwin (Darwin, 1859), in his pioneering book *On the Origin of Species*, emphasizes not only the importance of natural selection but also human selection. Darwin explains the importance of human selection by giving examples of the breeding of some pigeon and corn species by humans. Accordingly, the choices people make based on their needs affect the future of the species. For instance, some types of corn that can be considered the ancestor of corn today are either extinct or on the verge of extinction. Therefore, one may conclude that sequential as can be seen in Dvorak Keyboard example human choices are much more persistent, and most of the time fitted perfectly to human needs.

In regard to our subject, traditional R&D evaluation commissions within the limited participation cannot offer such a variety of choice. However, blockchain technology, which has many more participants than traditional commissions, can enable multiple

and sequential selection. Choices can sometimes be influenced by the updated information, and this kind of update can also be possible with learning during project assessment by using blockchain. Besides, an entry can be written to blockchain ledgers, if only a consensus among the members is provided. This unique property of blockchain can also promote democracy.

Evolutionary theory also emphasizes the importance of learning (Metcalf, 1994) , and learning is a social activity (Bossan, Jann & Hammerstein, 2015). Commission members, on the other hand, can socialize via chatting feature of blockchain technology (Sharma, 2018). This phenomenon can increase the learning possibilities of members of blockchain (commission members according to use) through learning by interacting.

In the previous chapters, the importance of information and interaction was discussed in terms of the quality of decisions. As Lesourne et al (2006) indicate, the information costs can decline if the bilateral interactions among agents increase, and it would be more appropriate to talk about small local markets rather than a single global market. Therefore, dividing agents into small groups can decrease the information costs. Besides, it can increase complexity, and this complexity leads to growth on knowledge (Potts, 2000). However, commission members who evaluate the R&D projects are mostly academicians and NGO (non-governmental organizations) members; investors or customers are barely involved in the commissions in the traditional R&D assessment. In addition to all the aforementioned, members cannot be found together all the time due to duration and space constraints of traditional R&D assessment commissions.

However, this is not the case for commissioners involved in blockchain who can connect to other participants and take part in the project evaluation wherever and whenever there is an internet connection. Finally, as Potts (2000) states the evolutionary microeconomics is based upon an ontology of connections, and the possibility of formal connections through blockchain is much more than traditional R&D assessment commission. This can be counted as another contribution of the blockchain to the evolutionary microeconomics.

Despite the several taxonomies of institutions proposed in the literature, Lesourne et al (2006) divide institutions into two sub-forms: one is “organic institutions” that are more visible and human oriented, and the other is “epistemic institutions” which are mental representations of agents. Cognitive states such as habits and trust fall into the latter category, and the importance of moral values such as trust has a significant place in evolutionary microeconomics (Lesourne et al. 2006). Blockchain, on the other hand, is known as the trust machine (De Filippi, Mannan & Reijers, 2020). As a result, blockchain is promising not only an innovative but also a technology-based institutional structuring.

Neo-classical economic theory is being criticized because it regards knowledge as an economic commodity with the assumption that knowledge is generic, codified, and context independent (Bleda & Del Rio, 2013). In fact, because of tacit nature of knowledge, absorption capacities of each knowledge carriers can vary, and this variation may lead to a systemic failure. Additionally, neo-classical approach assumes that market failure can occur because of better or worse data and knowledge processing. According to the evolutionary economic approach, the coordination between the actors or carriers is also important. In order to gain sustainability, evolutionary policy action should promote future growth of the knowledge by keeping coordination among the actors. Moreover, state should support the absorptive capacity of each actor or carrier and promote production of new knowledge by the way of enhancing the cognitive capacity of actors (Bach & Matt, 2005).

It is apparent that some of the systemic error problems arise from the coordination issues between the state and the agents. Blockchain technology, however, is a good candidate for solving systemic errors with its unique software infrastructure. In addition, since it is a public funding mechanism, traditional R&D assessment system tends to be prone in some cases to direct government intervention. In blockchain-based project evaluation, as stated above, multi-actor assessment is more appropriate with respect to the evolutionary theory.

In conclusion, as indicated previously, blockchain technology with its properties fit into to microevolutionary economics because aforementioned utilities of blockchain.

Moreover, blockchain is a good medium in order to test philosophical concepts such as democracy trust decentralization, and transparency. Besides, it seems obvious that blockchain technology is reinforce concepts such as society 5.0, when our social life, and its effects are discussed thoroughly.

In this last part of the literature review, the possible benefits of blockchain technology to those who benefit from it (for this study) is mentioned. The effect of R&D incentives on companies through behavioral additionalities, and then how the blockchain is contribute to these possible effects is mentioned.

2.7. Possible Behavioral Additionality Effects of Using Blockchain Technology in R&D Incentives

The concept of "additionality", which was first introduced by Buisseret et al. in 1995, briefly describes the effect of public intervention on the market. Accordingly, the extra effects of R&D expenditures, whose effects on economic growth are known, on R&D investments are gathered on the concept of "additionality"(Marino, 2021). Here, the additional effects of public intervention on firms are examined.

The "crowding-out" effect is defined as the decrease in the private sector despite the increase in public expenditures, and consequently the fact that the total public and private sector expenditures do not change (Andrade & Duarte, 2016). On the other hand, it is argued that public incentives may cause "crowding out", which argues that the firm's total R&D expenditures decrease or remain constant, and that incentives do not provide any additional benefit for the firm (Şen & Kaya, 2014). On the contrary, the private sector spending more in return for a unit of incentive provided by the public is called the "crowding-in" effect. In addition, it is stated that R&D incentives have a "crowding-in" effect, such as infrastructure investments, like roads, highways, airports and ports (Bessone, Ana & Guida, 2021). In summary, it is thought that the response of the companies to the R&D incentives provided by the public companies is much more than the incentives provided (OECD, 2020). For this reason, it is expected that more of the provided R&D incentives is spent "additionally" by private sector companies, which occupy an important place in the

agenda of policy makers. Behavioral changes in the organizational structure of the companies are important in order to make maximum use of this "additional" effect. For this reason, the concept of "additionality" becomes important as the result of using public resources to companies through R&D incentives is important for taxpayers.

The discussion centers on the impact of blockchain technology's transparency, accountability, and trust environment on companies receiving incentives, emphasizing behavioral additionality. In the last part, possible "behavioral additionality" effects are discussed if blockchain technology is used in R&D incentives.

2.7.1. Input, Output, and Behavioral Additionality

Additionality varies according to the type of outputs or inputs generated by research policies or investments. While some policy interventions can create output additionality such as enhanced productivity, strong collaborations, and patents some interventions may cause input additionality such as increasing the company's R&D expenditures.

On the other hand, behavioral changes (Kim & Song, 2007) that occur in the R&D investments of the company receiving R&D incentives are briefly defined as "behavioral additionality."

Input additionality deals with source input. In this type of additionality, the impact or consequences of incentives are not mentioned. Instead, it is looked at from criteria such as the success or impact of the projects, how much resources are transferred or how many more projects are supported (Gulbrandsen & Rasmussen, 2012). On the other hand, according to another definition (Bodas Freitas *et al.*, 2017), input additionality is defined as the increase in R&D expenditures of a firm that receives financial incentives compared to a firm that pays similar taxes and does not receive financial incentives.

The increase in R&D outputs such as the number of patents, which cannot be achieved without public incentives, is called *output additionality* (Kim, 2020).

Indicators such as the number of new products produced and the growth in the firm after the incentive are counted as outputs of output additionality.

The concepts of input and output additionality are traditional approaches used in measuring the effectiveness of policies. With the market failure approach, policy makers may want to gain advantage by providing the incentive needed by the market as input. This is called input additionality. On the other hand, policy makers show an increasing interest (Sun, 2018) in measuring additional innovation outputs, often measured in terms of business benefits such as patents and sales, which has led to the concept of output additionality.

Alternatively, measuring the success of an R&D project by its outputs and inputs is not a very accurate approach. Due to the nature of innovation, such a linear approach may not be correct. Moreover, it is not easy to establish a one-to-one relationship between outputs, inputs, and R&D incentives, especially due to the knowledge and behavior obtained by the firm (Clarysse, Wright & Mustar, 2009). As a result, the inadequacy of the linear innovation model and the new models put forward by evolutionary economics and the innovations brought by the system failure rationale (Douglas & Radicic, 2020) have revealed the need for a new concept other than input and output additionality.

Behavioral additionality, unlike input and output additionality, represents persistent changes in firm behavior after government intervention. Examples of these changes are the firm's approach to learning, developing new skills and routines, and internalizing them one-to-one (Gök & Edler, 2012). This change in the firm's R&D routines after the use of incentives makes behavioral additionality a second order additionality over others. For this reason, it is not possible to talk about a linear relationship for behavioral additionality (Freel, Liu & Rammer, 2019). This second order additionality can result in knowledge diffusion (Teirlinck & Spithoven, 2012), exchange and diffusion among other firms and institutions as a result of technological learning and innovation at the firm level.

Since it is a second-order additionality, unlike behavioral additionality input and output, the realization, speed, size, risks, learning or dissemination of knowledge of

R&D projects are taken into account rather than R&D investments or R&D performance. While presenting a neoclassical approach through the discussion of input and output additionality market failure, the concept of behavioral additionality is close to the evolutionary approach for the reasons mentioned above. Again, the possible cognitive changes that may occur in the firm after the incentive are in harmony with the evolutionist perspective (Neicu, Teirlinck & Kelchtermans, 2016). One of the cognitive consequences of behavioral additionality can be counted as its administrative effects. The fact that the company has benefited from public incentives may lead to a positive approach to R&D investments at the management level (Hsu, Horng and Hsueh, 2009). In addition, after the incentives received by the firms, improvements were observed in their openness to external knowledge and their tendency to take risks. It is observed that (Chapman & Hewitt-Dundas, 2018) the attitude of the company officials (managers) towards innovation reflects on the employees and motivates the employees for innovation. It has been reported that following the provision of public incentives, the firm is devoting more time, man and resources to innovation.

It was mentioned that there are changes in the behavior or routine of firms that have benefited from public incentives, and this is called behavioral additionality. From a systematic point of view, innovation can also result in a network of relationships. In this process, companies can establish closer relations with banks with the confidence of receiving incentives. As a result of these relations, the information asymmetry between the lending banks, and the firm may also decrease (Wu, 2017). As a result, external financing opportunities increase for companies.

Process innovation " ... is *the implementation of a production method, or significant changes in specific techniques, equipment and / or software, in order to reduce production and distribution costs, improve the quality, production or distribution of new or improved products, to increase the efficiency or flexibility of a productive activity or supply activity and to reduce the risks to the environment*" (Marier., 2019). As can be understood from the definition, companies need to change their organizational and/or behavioral structure for the improvements they have made by going beyond their normal routines. For this reason, the behavioral effect of the

incentives provided should be closely monitored and encouraged. In summary, a behavioral aspect of publicly provided R&D incentives is that they can cause process innovation within the firm. Thus, the desired benefit can be increased with incentives.

Behavioral additionality is a multi-layered concept. According to *acceleration additionally*, it is believed that public support affects companies to start projects earlier and to complete projects in a shorter time. *Scope additionally*, on the other hand, is defined as the changes in the content of the projects carried out by the company after the public intervention. The concept of *collaboration/network additionally*, on the other hand, is defined as new actors and collaborations that join the network after support as a sub-layer of scope additionality. In addition, the positive effect on the competitiveness of the firm after government incentives is called *competence additionally* (Sun, 2018).

Unlike input and output additionality, behavioral additionality is defined as a permanent change in the firm's willingness to innovate. This situation requires that the knowledge gained during innovation activities and the "learning" opportunity to be continuous and cyclical.

Behavioral additionality is defined as permanent changes that occur in company routines, as in input and output additionality, it is not possible to talk about a measurable linear relationship such as input additionality or the number of patents received (output additionality). Changes in the firm's capacity and capacity to innovate are related to the knowledge and learning produced in the process and do not progress in a straight line. For this reason, behavioral acquisitions that increase the innovation capacity of the firm after the incentive should be maximized in order to obtain more benefits from the incentives provided by using public resources and to increase social welfare. However, because these behavioral changes are difficult to measure and monitor, policy makers may ignore these effects. In such a case, policy makers can be content with monitoring more concrete indicators such as input and output additionality. In order to change this, incentives should be followed more efficiently, the knowledge produced should be recorded and network formations

should be encouraged. In the current system, such environments could not be created for companies. On the other hand, the blockchain technology proposed in this study, with its technological infrastructure, can provide many benefits, from recording knowledge to facilitating network formations. These new network formations, unlike traditional ones, will be virtual due to the structure of blockchain. In this dissertation, the impact of these virtual network formations on decisions in R&D evaluations is discussed. Moving face-to-face and known R&D evaluation commissions to a secure, multi-centered and democratic blockchain environment in a virtual environment is of course different from known social environments. The cognitive and social implications of this difference are discussed in this study. Thus, it is thought that the behavioral effects of blockchain technology is more intense.

2.7.2. Possible Contribution of Blockchain Technology onto the Behavioral Additionality Literature

It has been proven by neuroscience that we can learn through social interactions (OECD, 2010). Therefore, the presence and excess of social interaction can increase learning opportunities. It has been mentioned before that learning effect and knowledge spillovers after public incentives fall within the scope of behavioral additionality concept (Neicu, Teirlinck & Kelchtermans, 2016). In the light of this information, the intensity of social interaction is important in order to obtain higher behavioral additionality from public intervention and to increase the learning opportunities of companies and to produce knowledge.

Blockchain technology, thanks to its DLT technology, allows knowledge to be spread more. In addition, the fact that the users in the chain can be unlimited and the users can interact socially through the blockchain can improve the learning opportunities of the companies in the chain (Society, 2020). In this case, if firms registered in the blockchain network base benefit from government incentives, more consequences of behavioral additionality effect can be reached. As a result, if the R&D incentives are distributed over the blockchain, the companies within the chain are able to establish a healthier communication with each other thanks to the faster communication and trust environment, and the quality of the data is better owing to the unalterable

structure of the generated knowledge (Knezevic, 2018), and thus learning opportunities are more common. In this case, behavioral additionality from public incentives is greater.

Douglas and Radicic (2020) state that receiving public incentives increases the firm's existing network, and this is network additionality, a sub-element of behavioral additionality (Radicic & Douglas, 2020). On the other hand, it can be said that the secure and trustworthy environment of the blockchain creates a value for users (Murimi, 2019). For this reason, it can be concluded that the behavioral additionality effect provided by the networks created on the blockchain by companies that have received public incentives may be more. The secure and trustworthy environment of the blockchain creates a value for users.

Blockchain technology is known as a trust machine with its secure infrastructure (De Filippi, Mannan & Reijers, 2020). Trust is a necessary element in network formations (Thirunarayan & Anantharam, 2011) and collaborations (Tschannen-Moran, 2001). The nature, number and duration of collaborations developed by the firm after public intervention are called behavioral additionality (Soltanzadeh *et al.*, 2020). As stated above, the secure and trustworthy nature of the blockchain is a suitable medium for the development of such collaborations. There are also findings that the increase in cooperation after the incentive, and the information asymmetry between the parties of the cooperation are also reduced (Davenport, Grimes & Davies, 1998). On the other hand, the secure and unchangeable nature of the blockchain, and the ability to share existing information among all stakeholders may result in a further reduction of this information asymmetry.

Users within the blockchain can transparently access information recorded on ledgers, thanks to DLT and unalterable structure (Kurka & Pitt, 2017). At the same time, in a study conducted in Ireland and the UK, it was observed that incentives increase the accountability and transparency of companies (Bailey & Connolly, 1997). In summary, it is thought that if blockchain technology is used in the public incentive system, their accountability increases and this exacerbates the behavioral additionality effect on their firms.

Learning is an active element in the competitiveness and efficiency of firms. The improvement in these factors can have a positive effect on the increase in social welfare. For this reason, it is important to examine the effect of R&D incentives provided by using public resources of the firm-on-firm behavior. Blockchain technology, on the other hand, has a two-way behavioral effect on the company thanks to the innovations it has committed. First of all, if blockchain technology is used in the selection of public R&D incentives, the firm can directly benefit from the unique features of this technology. Secondly, it is foreseen that it may have behavioral effects on companies.

2.8. Concluding Remarks

It is observed that in traditional R&D evaluation models, there is a need to monitor the process end-to-end. It is necessary to benefit from developing technological opportunities in order to measure progress both during ex-ante and ex-post evaluations of project applications. Public sector innovations made in response to this need in the public sphere can also reinforce taxpayers' faith in the public.

Making public R&D funds more traceable, transparent and accountable is possible with blockchain, one of the existing technologies. With its features, blockchain is a candidate to meet this need, which is mentioned in public R&D funds. On the other hand, currently the decisions of these funds are made in traditional face-to-face environments. However, with the use of blockchain, there is a transition from human-human type communication to human-machine-human type communication. It is likely that there will be cognitive changes in decision-making mechanisms during this transition. The contribution of this thesis is primarily to identify the cognitive and sociological effects that occur during face-to-face evaluations. Analyzes regarding this are included in the following sections. The contribution of a blockchain evaluation to minimizing these effects is the subject of this dissertation. In this form, this thesis aims to contribute to the evolutionist economics literature with its content.

CHAPTER 3

METHODOLOGY

3.1. Introduction

This chapter has been prepared to detail the research organization of the dissertation. In this chapter, there are studies conducted to investigate the answer to the research question. The data generation stages to find the answer to the research question start with modeling studies in this dissertation. Since blockchain technology is a new technology, its usage areas are not common. In this dissertation, the use of blockchain in the selection of R&D projects is studied. For this reason, a dataset had not yet been created. The creation of these data is tried to be done with a simulation (Agent-Based Modeling). Since the simulation makes an estimate, the accuracy of this estimate was made by the experts through survey. This is described as "expert judgment" in the literature. Therefore, both quantitative and qualitative analyses methods were used in the method part.

The method used for the distribution of R&D Incentives in Turkey is commissions (panels). Members elected in these commissions decide to choose the most appropriate project. In these boards, a kind of social network is formed as a result of interactions between people. For this reason, "Social Network Analysis" methods are introduced in the first chapter in order to better examine the functioning of these boards. In this chapter, after these methods are compared, the advantages of the Agent-Based Modeling method chosen for the dissertation and why it was chosen is mentioned in the next chapter.

As mentioned at the beginning, the use of the blockchain method in R&D funds is the idea that was first put forward with this dissertation. In the Agent-Based Modeling study, the results of a survey conducted among academics who took part in

the previously mentioned commissions were digitalized. In line with these results, the relationships between agents and the environment (patches) were defined and weighted. For this reason, quantitative and qualitative methods are mentioned in the this chapter.

3.1.1. Social Network Analysis

While Social Network Analysis (SNA) was a tool used in classical sociology, it has become a method that appeals to a much wider area today with its inclusion in mathematical formulas. Thanks to SNA's ability to address networks of different sizes and its flexible application structure, it has developed so far with its formal techniques. With the increasing use of social media since the 2010s, SNA has become even more popular in social sciences (Park & Stamato, 2020).

SNA examines the relationships, perceptions, beliefs, or effects of decisions that bind a number of entities together in the overall structure. The main purpose of network analysis is (Heath, Fuller & Johnston, 2009) to accurately measure and represent these structural relationships and to explain both why they occur and what their consequences are.

3.1.1.1. The Advantages of SNA

Networks are non-hierarchical structures with common interests that come together to achieve the same goal. SNA, however, is a tool for understanding the boundaries of these network structures and network characteristics. In addition, SNA is an efficient tool for changes in behavior or characteristics within the network structure (Mikulskiene & Pitrenaite-Zileniene, 2013). Moreover, while classical individual social theory considers individualist choices, it ignores the effects of choices on other actors in the network (Rousseau, 2002). On the other hand, in SNA, the relations of the actors with each other are the first priority and personal preferences are the second.

As mentioned before, the commissions formed in the selection of R&D projects are social networks that come together for a specific purpose (choosing the best project)

and where everyone has an individual opinion, but these ideas can be developed through discussions. The subject of this dissertation is basically the development of this structure with blockchain technology. For this reason, the dynamics in this network are examined and optimum conditions are proposed. From this point of view, dissertation is basically a social network analysis.

There are many methods for network analysis. Of these; Ising model, game theory, geography models, and actor network theories are suitable methods for studying interaction (Razaque *et al.*, 2019). In this chapter, these methods are introduced.

3.1.1.2. Ising Model

The Ising model was initially introduced as a mathematical and statistical component of ferromagnetism. The model consists of a large number of magnetic moments (or spins) connected by links within a graph, network or grid. Each spin interacts with its direct neighbors, tending to align together in a common direction (Damodaran & Udayanandan, 2020). The Ising model can be used in social networking studies for two reasons. First, the decision of a node (actor) depends on the decision of neighboring nodes, as in SNA. Second, in physical systems, the ground state is the state with minimum energy. Because of this feature, it is likened to SNA (Liu, Ying & Shakkottai, 2010).

On the other hand, it is not possible to talk about an equilibrium, which is a dynamic environment (Annamalah & Paraman, 2021). As a result, the Ising Model was not used in this dissertation, since no equilibrium point can be mentioned in a dynamic process and its application in the economics literature is very limited.

3.1.1.3. Geography Model

After Feldman's seminal work in 1994, the geography of innovation came into focus in the fields of Economic Geography and Regional Sciences. This field mainly explores the importance of geographical location and distance in innovation (Scherngell, 2013). The Innovation Geography literature has also been involved in networking, including relationships and interactions.

However, the main element in networking studies is relationships, not location. Another reason for not using this model (Batty, 2016) is that relationships are always dynamic. The display of these in a certain location cannot fully reflect the final state in which they evolved.

Finally, changes are being explored in this dissertation that are likely to occur with the use of blockchain technology in R&D funds. Another benefit of using the blockchain is that unlike classical commissions, the blockchain allows individuals (commission members) to make decisions independent of time and place. For this reason, it does not seem possible to use this method in our dissertation.

3.1.1.4. Actor Network Theory

Social Network Analysis (SNA) examines the relationships and interactions within an organization or between individuals. In SNA, in social relations, nodes are relations that bind actors (Caniëls & Romijn, 2008). On the other hand, SNA is not the only way to analyze social relations. Actor Network Theory (ANT) is another method used to analyze relationships and interactions within the network (Borg, Toikka & Primmer, 2015).

ANT is a method that was put forward towards the end of the 1970s and allows for an examination between actors (human and non-human) without considering a social or technical priority. ANT is a method that argues that every actor in the social network interacts with each other. These actors can be people as well as things. In this sense, ANT is an important tool especially for measuring and analyzing communication within organizations (Bencherki, 2017). The term "Actor Network Theory" has come together from the seemingly contradictory words "actor" and "network". ANT is actually researching just that. That is, how did the actors in the network come together? (Callon, 2001) Considering this feature, although it seems to be a suitable tool for examining blockchain-based networks, which are the subject of dissertation, the ANT method naturally has some limitations.

First of all, while the ANT method explains the network formations, it falls short of explaining the power distribution among the actors. In addition, it gives equal

importance to human and non-human actors (Bencherki, 2017). This situation underestimates the importance of information due to a kind of information production and trivializes the information produced in the network (Elder-vass, no date). This point of view has parallels with the "externally available" (Aghion & Jaravel, 2015) view of the neoclassic movement.

Again, ANT approaches the actors within the organization from a homogeneous point of view. However, the capacities and capabilities of these actors are different (Islam, Mäntymäki & Turunen, 2019). Finally, giving the same value to man-made objects as humans is another part of the ANT method that has been criticized.

In conclusion, why the ANT method is not used in this dissertation in which project evaluation and network formations are examined through the block chain method, the most important object (in other words, the actor) is computer and software (blockchain) in the case of using ANT. Yet, one of the aims of this dissertation is the decisions that are already changing in front of the computer and thanks to the software. Here, it is not desirable for another object to pass in front of the person or for both to be equally effective. Because, with this dissertation, the purpose is to examine the changing decisions and their effects through changing technology.

3.1.1.5. Game Theory

The Agent Based Modeling method used in dissertation is mostly compared with the Game Theory method, which is introduced in this chapter. Nevertheless, as is seen later in the chapter, ABM is superior to Game Theory in some aspects. It seems that the ABM method serves the main pillars of the "Evolutionary Economics" literature, where this dissertation especially tries to fill a gap. The Evolutionary (dynamic) Game Theory, which is introduced in this chapter, approaches the ABM method in terms of its features, but still contains some shortcomings.

The ideas underlying the concept of Game Theory have existed throughout history. Opinions on the subject are also found in the Talmud, the Bible, and the works of Descartes and Charles Darwin. However, the most comprehensive study on the

subject was made by the mathematician Daniel Bernoulli, born in 1700. In spite of the fact that his work published as "*Bernoulli's Principles*" tries to explain the working principles of jet engines, the concept of diminishing returns is also included in the study. The 18th century English mathematician contributed to the logic of Thomas Bayes Game Theory with his work known as "*Bayes Theorem*". Nonetheless, game theory in the modern sense embodied in Austin Cournot's work titled "*research into the Mathematical Principles of the Theory of Wealth*" published in 1838. In this work, Cournot explains the *Nash Equilibrium* and made mathematical models.

For this reason, one can conclude that the concept of Game Theory, which is claimed to have been invented by *John von Neumann* and *Oskar Morgenstern* in 1944, is not a new concept. Since 1944, the mathematical side of the subject has been strengthened and it has become a tool that serves many fields (Raoof & Al-Raweshidy, 2010).

Game theory is a socio-economic phenomenon that mathematically models human interactions such as conflict and cooperation that may arise between decision-makers (players) and decision-making processes. In spite of the fact that game theory uses mathematical concepts, it can be applied to many fields (Kowitz, 1972). The basis of game theory is preference interactions. The standard setup of the theory is that players with their own set of preferences interfere with the preferences of other players. An example of game theory is the work of Schelling (1971, 1978). In a study of the effects of racist approaches (Manski, 2000) on neighborhood relations, Schelling found that racist neighbors affect the preferences of non-racist neighbors.

According to the 1965 Mancur Olson article, the problem of prisoner dilemma⁹ in a modern and democratic society with an x number of actors is based on the

⁹ "*The Prisoner's Dilemma involves two guys having been arrested by the police. Since there is not enough evidence to convict them, the police interrogator offers the following deal to each of them: If you testify that the other guy is guilty (defect), you will be set free and the other will be imprisoned for 3 years; unless he also defects, in which case you will be both imprisoned for 2 years. If you both keep your mouths shut (cooperate), each of you will serve 1 year in prison. Every prisoner knows that the same offer that was made to him, has been made to his fellow convict. Moreover, each one knows that the other knows that he knows, and so forth. This assumption about the game is called common knowledge and is a prerequisite to have a game of complete information. Without common knowledge, the behavior of the prisoners could be different....*" (Gaviotis, 2015)."

assumption that all actors are rational and individualistic actors. It has been observed that when individualist and rational actors decide on a common issue, the individuals (players) in the community selfishly try to pursue their own interests. This situation divides the community into individuals and as a result, a common problem of the group cannot be solved. This situation is called "zero contribution dissertation".

Research with game theory is insufficient to solve the zero-contribution problem. In this case, it should be taken into account that each actor is different and boundedly rational. As is explained in the next chapter, in Agent Based Modeling (ABM) method used in dissertation, players (in other words actors) are heterogeneous and unboundedly rational (Ostrom, 2000). In spite of the fact that game theory is compared with ABM, individual differences can be simulated with ABM just like in the real world.

3.1.1.6. Evolutionary Game Theory

Game theory has been criticized in some ways. One of them is bounded rationality¹⁰ and survival of the fittest, which is one of the points where evolutionary economics criticizes the orthodox view and finds it insufficient to explain. In standard game theory, the response to behavioral responses is not very fast. Moreover, in evolutionary game, players can develop strategies (Friedman, 1998). This situation does not exist in standard game theory.

In addition to these, while the identities of the actors are standard and homogeneous in classical (standard) game theory, the roles of actors can change in evolutionary game. In addition, while there is an isolated equilibria (Gintis, 2007) in classical game theory (*Nash equilibria*), there is a dynamic equilibria in evolutionary game.

Evolutionary Game Theory consists of two parts. One of them is "game" and the other is "dynamics". While the game part covers the behaviors of the participants

¹⁰ "Bounded rationality is a concept used in different fields such as economics, psychology, and computer science, among others. Many models of human behavior in the social sciences assume that humans can be reasonably approximated or described as "rational" entities that would never fail to behave in a rational way according to their preferences (Ballester and Hernandez, 2012)....." In spite of the fact that on the orthodox view all actors are rational at the time of their choices, on the evolutionary view it is not possible to be completely rational (Dawes and Thaler, 1988). In this regard, two views differ.

(players) among themselves, such as (Mohseni, 2019) agreement, conflict, cooperation, the dynamics part includes the stages of transformation, mutation and selection.

Despite all these developments in Evolutionary game theory, the evolutionary economics literature is criticized for modeling on an equilibrium, albeit dynamic (Mohseni, 2019). In addition, one aspect of evolutionary game theory has been criticized for being too dependent on individual strategies, which is touted as an advantage over a classical (standard) game theory (Budejovice *et al.*, 2019).

In traditional commission structures, this structure resembles a network structure due to reasons such as interactions and information exchange between commission members' selection of R&D projects. On the other hand, as it is stated in this chapter that the methods used in network studies in the literature have some limitations. For this reason, the Agent Based Modeling method, which is thought to be suitable for the study, was chosen as the method in this dissertation. The definition, scope and superior aspects of the ABM method is discussed in the next chapter.

3.1.2. Agent-Based Modelling

There is no exact and agreed definition of the agent. Differences in its application make it impossible to remove the concept of agent from the literature and use it.

However, from a utilitarian perspective, even in this chaotic situation, the features of the literature on which agents are agreed upon are:

- **Autonomous:** Agents are autonomous units (i.e., not controlled by a central controller) and have the ability to manipulate information to make decisions after migration. They are free to interact with other agents; this does not violate the autonomy.
- **Heterogeneity:** Variables such as age, gender, and behavior can be applied to agents one by one. At the same time, these heterogeneous groups can be grouped according to their properties.
- **Active:** Agents are active as they are not exposed to any effect in the simulation. The following active features are defined for agents.

- **Proactive/Target Oriented:** Agents have a goal in line with their behavior. (For this dissertation, agents aim to select the project to be supported)
- **Reactive/Perceptive:** Agents are designed to be affected by changes in their environment. (In this dissertation, this situation is handled with the example of the tendency of agents who have not yet decided to accept the project that most agents accept.)
- **Bounded Rationality:** The concept of “Bounded Rationality” is one of the most discussed concepts in social sciences. Accordingly, the agent equipped with full information will make the most accurate decision. However, with ABM, this situation can be changed and the learning agents can change their decisions according to the situation.
- **Interactive/Communicative:** Agents communicate with their neighbors and environment.
- **Mobility:** Agents can freely interact and roam within the simulation boundaries.
- **Adaptation/Learning:** Agents can easily switch to the new state thanks to its structure that can learn and adapt from the previous state (Crooks & Heppenstall, 2012).

Agent Based Modeling (ABM), which is relatively new to use in the field of social sciences, is based on the study of physicist Enrico Fermi in 1930 in which he examined the passage of neutrons and subatomic particles through matter. Each neutron had to be modeled individually, as it could interact with particles, scatter, or pass through other particles. Modeling the motion of neutrons was therefore a difficult task. Previous methods tried to model the behavior of neutrons all at once, but such a modeling was not accurate because each neutron could behave differently. Fermi developed a method in which each neutron can be modeled separately. This method was later developed, and agents replaced neutrons and the foundations of today's Agent Based Modeling were laid.

In 1947, scientists developed the Monte Carlo method to reflect this probabilistic behavior of neutrons. The name of the technique was inspired by the uncle of

Stanislaw Ulam, who always wanted a loan under the pretext of going to Monte Carlo. In the *Monte Carlo Method*, which is based on the article by Metropolis and Ulam in 1949, the financing of investments is based on trying to solve the problems of randomly selected numbers in areas such as natural disasters.

In the late 1960s and early 1970s, Thomas Schelling made an important contribution to the ABM method in his study of racism in the neighborhood. In his Nobel Prize-winning work, Schelling used the ABM method and found that individual racism caused a racial segregation in the whole neighborhood after a critical level (Turrel, 2016).

The ABM method is considered as a suitable method for studying complex systems in which agents act autonomously and interact with each other and affect the whole (Macal & North, 2010). For this reason, ABM basically consists of three components. These are agents, environment, agent-agent, and agent-environment interactions. Agents, each of which is independent and autonomous, can represent social actors or institutions in the system in the simulation, depending on the situation. That is, agents can replace customers, employees, companies, clusters, or countries, based on the situation. In this dissertation, agents take the place of decision makers who have different roles and individual decisions involved in the selection of R&D projects.

In the ABM method, where each agent can be modeled at different levels of learning, adaptation, communication, flexibility and adaptability, there are methods in which the cognitive states of decision-making agents can be modeled.

Perhaps the most crucial feature of ABM is its ability to model agent-environment interactions (Gómez-Cruz & Saa, 2017). This makes it a more dynamic method than other methods. Additionally, the stochastic nature of ABM is also an important feature for decision-making environments where every possibility or improbability is possible. With these features, ABM is a suitable method for modeling chaotic and dynamic structures.

Figure 3.1 shows the usage areas of ABM. Among the aforementioned usage areas, dissertation falls under the category of "Strategy of Decision-Making", which is at the highest rate of 14%.

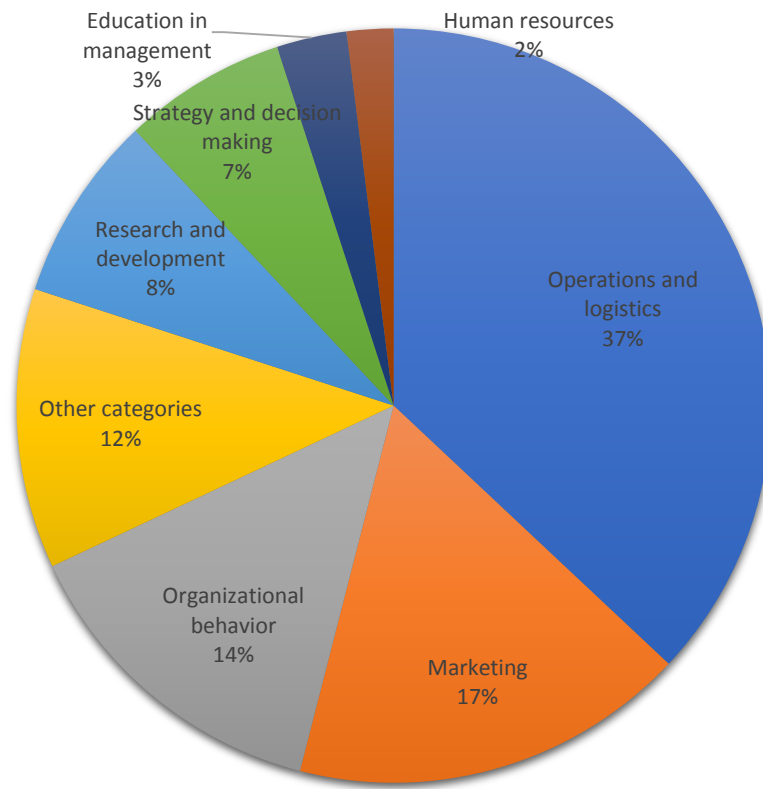


Figure 3. 1. Percentage of identified works by application area (Gómez-cruz & Saa, 2017)

3.1.2.1. The Advantages of ABM

Agent Based Modeling is a computer program in which agents interact based on a researcher-specified environment and set of rules. While these rules and constraints define predictable behavior at a micro level, interactions between agents and their environments often aggregate to create unexpected social patterns. In summary, ABM simulates the social consequences of individual behavior by specifically linking individual characters. Moreover, small changes made by individuals in a group have dramatic consequences for the whole group (Bonabeau, 2002). In this way, ABM is a useful tool for identifying basic explanatory mechanisms. It is also a successful method for investigating multi-layered situations and human behavior that cannot be easily modeled statistically and mathematically. This situation is similar to Adam Smith's invisible hand metaphor. As with the invisible hand, ABM is the method that can best model how individual preferences influence the whole among interacting individuals (Turrell, 2016).

The ABM method is a useful tool in the context of the micro and macro impact of individual choices on the combined total (Bruch & Atwell, 2015).

In this dissertation, deciding on the selection of R&D projects through a commission is discussed. This Collaborative Problem Solving (CPS) process is a challenging task. One of the most important challenges in CPS is that there is too much data and many interrelated parameters and processes (Andrews *et al.*, 2016). Therefore, it is very difficult to model such a situation. In ABM, on the other hand, since heterogeneity can be provided appropriately, interactions in this situation can be simulated.

Beyond all these features, the use of blockchain technology in the selection of R&D projects is studied. In fact, this selection is physically made by the commissions. It is discussed in this dissertation that the results are different, if this physical state is transferred to the virtual environment. However, as it is known, such a situation or a similar situation is not in question for Turkey or any other country in the world at the moment. Therefore, there is not sufficient amount of data to study this situation. Hence, other quantitative analysis methods are invalid for this dissertation. Modeling (simulation) is the most suitable method for testing such relative situations or in the absence of data. For this reason, a simulation has to be made in dissertation. Due to the aforementioned features, ABM was determined to be the most appropriate method.

3.1.2.2. Validation of Results

Despite these superior features, the ABM method also has some shortcomings. The first and most important of these methods is the validation of the simulation results. Since an imaginary future is modeled in the simulation the veracity of this data needs to be proven. The most important validation method for ABM is *expert judgment* (Bonabeau, 2002). This method is used to test whether the simulation results are correct in this dissertation. Accordingly, the existing commissions are also modeled with the ABM method and the results are shown to the experts involved in the selection of these R&D projects. In order to validate the ABM results, the results of

the survey, in which the weights of the variables used in the simulation are obtained, will be compared with the simulation results of the same scenario.

3.1.2.3. Usage Areas of ABM

ABM has many uses in fields such as physics, biology, and social sciences. This modeling method can be used in the research of civilizations that lived thousands of years ago or the market that has not yet been formed (Macal & North, 2010).

For example, remodeling archaeological sites, understanding political identity and stability, understanding national identity in nationhood, biological modeling of infectious diseases, growth of bacterial colonies, modeling alliances during World War II, economic modeling of dynamic environments, modeling vehicle traffic, electoral preferences the geographic pattern of unemployment, trade networks, and modeling of terrorist groups' social networks are some of the studies using ABM (Crooks & Heppenstall, 2012).

3.2. Overview, Design Concepts, Details, and Decision (ODD+D)

ABM is criticized that the models could not be evaluated because of poor documentation. This criticism motivated the ODD (Overview, Design Concepts, and Details) which attempts to create a standard structured format. The main purpose of ODD is to make writing and reading model descriptions easier and more efficient. In addition to this, the reproducibility of the ABM is much easier thanks to ODD protocols. Moreover, ODD is a tool for tracing all of the key features of the model through which the designer of the model can easily notice the failures of the model (Grimm *et al.*, 2010).

The ODD protocol is being prepared so that the modeling can be reproduced and understood more easily. ODD consists of 7 basic elements. All these sections have a specific purpose. On the other hand, rational choice problem in economics is a heavily studied area. In this dissertation, since there is a choice among R&D projects, the classical ODD protocol alone is not sufficient. For this reason, in this section, ODD + D (ODD + Decision), which is a more open and comprehensive version of ODD and makes ABM more standard, was introduced.

In the first chapter, "Purpose and Patterns", models and patterns are briefly described. "Entities, state variables and scales" in the second section lists the variables that represent the model. The third section, "Process overview and scheduling", gives information about the process of the model (Müller *et al.*, 2013). Theoretical and Empirical Background, on the other hand, which assumptions and hypotheses work at the system level and which assumptions and agents are involved in the decision-making phase was discussed. In the Individual Decision-Making section, which is a subsection of the Design Concepts section, the subjects and objects that affect the decision-making was discussed, and the multiple decision-making situations will be explained. In this section, where the reasoning behind the decision was stated, it was explained how the agents make their decisions. Again, if there are any that affect decision making, internal and external variables such as social norms and geographical variables were examined in this section.

Accordingly, the part related to the operation such as which agent does what when and what these variables depend on. summarized here. "7. Sub-models" and "4. The "Design Concepts" sections detail the operation of the model (Grimm *et al.*, 2010). The remaining 3 elements are "5. Initialization," "6. Input data," and "7. Sub-models" are also helpful parts for the reader to fully understand the model.

An ODD+D protocol has also been written for dissertation, and it is presented below for a clearer understanding of the model.

3.2.1. Overview Design Concepts, and Details (ODD + D) Protocol

3.2.1.1. Overview

In this section, the general outlines of the protocol are shaped.

3.2.1.1.1. Purpose

Blockchain technology promises several novelties that have not been seen before in the software sector such as unmalleable nature of the ledger that contains all transactions of the account user, unlimited or limited number of users, democratic

voting, and trustless trust. On the other hand, MOIT traditionally uses the session method, which is problematic for assessing proposed R&D projects. In this dissertation, however, how the possible decisions to be made will change is modeled if the blockchain is used in the selection of R&D projects. For example, if information asymmetry decreases between agents, the proposition that more accurate decisions are made is tried in the blockchain environment. In this way, the effect of the ledger records of the blockchain is tried to be measured. Since the blockchain or similar program does not have such a usage area, ABM attempt to simulate the possible universe.

3.2.1.1.2. Entities, State Variables, and Scales

As detailed in the Rules Section, the variables in this study are very diverse. Some of these are not used in the validation simulation, and the majority is used in the prediction of simulation. This makes agents "heterogeneous". As Çevikarslan (2017) states, ABM is capable of simulating heterogeneous agents and their interactions in their complex adaptive environments (Çevikarslan, 2017). Heterogeneous agent's variables are:

- Gender
- Behavior
- Observer Decision
- Hierarchical Power Distance
- Personality
- Individual Conflict
- Uniqueness
- Interpersonal Conflict
- Decision Duplication
- Gender Composition
- Group Size
- Majority
- Knowledge
- Group Conflict

If the agent (academic) who changed his mind in the model changes her/his decision, the color of the agent changes from white to black. In this way, under the influence of the mentioned variables, how much and in what situation the undecided academicians change their decisions. This situation has been detected.

Thus, "avoidance of responsibility" and "decision copying" seen in face-to-face commissions will be measured. As stated in Chapter 2, this does not happen in online environments. In blockchain environments, it is expected to be even less due to the unique characteristics of the technology.

3.2.1.1.3. Process Overview and Scheduling

The decision-making process consists of two intertwined phases. In the "Individual Decision-Making Phase", each agent has a preliminary assessment of the project according to their characteristics. This evaluation is mostly affected by the "Observer Decision" variable.

It is the note of the ignition observer about the project in the evaluation of R&D projects. After this stage, decision making continues individually. The internal accounting of the decision maker can be affected by the discussions between the decision makers depending on the character types and conflicts in the "Rules" section.

As a result of all these intertwined processes, a binary decision is made for the project as “yes” or “no”.

3.2.1.1.4. Design Concepts

3.2.1.1.5. Theoretical and Empirical Background

Decision making processes are complex processes with many variables. It depends on many variables that are directly or inversely proportional to each other. Especially in the economics literature, the decision-making processes regarding the purchase of

products and goods are even more complex. On the other hand, the fact that the result is binary in the evaluation of R&D projects relatively simplifies the process. However, the process that brings results goes through complex steps as mentioned before. For example, the first variable in individual decision making is the gender variable.

Expert judgment method via using survey is used to weigh the effects of these variables and sub-models in the result. The assumptions that emerged after the “Expert Judgment” application is used exactly.

Variables have been determined as a result of an extensive literature review, and these variables are specific to the decision-making processes of the selection of R&D projects.

3.2.1.1.6. Individual Decision Making

Variables that affect individual decision making used in the model:

- Gender
- Behavior
- Observer Score
- Power Distance
- Personality
- Individual Conflict
- Uniqueness
- Interpersonal Conflict

The basic rationality in individual decision-making is to be successful as a result of the R&D project, in which MOIT R&D assessment system has not clear about the criteria of “success”. According to some decision makers, the success criteria is the completion of the project, while for others, the product created as a result of the R&D project can create added value.

Decision makers act in accordance with the above variables rather than success criteria. However, due to the uncertain nature of R&D projects, uncertainty may continue in the decision made until the last moment.

3.2.1.1.7. Learning

In this dissertation, where decision making is handled in two stages, the decision made individually may change during the group decision making stage. In this model, which has a complex structure, the factors affecting decision making should be weighed by the variables that emerge because of expert judgment.

3.2.1.1.8. Individual Sensing

Decision-making of R&D projects differs within the broad decision-making literature. The decision to support projects is a binary decision, unlike the decision to make the most rational investment (the decision-making literature is heavily concentrated in this area). In addition to having only two outputs, the high risk of success in the decision made (due to the nature of R&D projects) is another factor that affects decision making.

As a result, variables suitable for the evaluation of R&D projects are determined by making use of all the literature.

The decision making modeled in this dissertation is a group decision. Therefore, personal decision-making dynamics alone are not sufficient to understand the results. For this reason, the Group Decision-Making literature is also examined. The variables that are suitable for the situation are decision duplication, gender composition, group size, majority, knowledge stock and group conflict.

3.2.1.1.9. Individual Prediction

Decision-makers benefit from external variables such as observer score, uniqueness and knowledge stock during decision making, apart from individual variables (such as gender, personality).

In the decision-making process, external (observer score, uniqueness, and knowledge stock) and internal (gender, personality, and personal conflict) variables are effective for the group to predict rational choice.

3.2.1.1.10. Interaction

The agents, who are the natural members of the committee at the same time, interact with each other directly during assessment of project proposals and interactions are mostly dependent on the previously mentioned endogenous variables. For example, the interaction may vary according to the personality characteristics of the decision-making committee member.

Variables such as interpersonal conflict can affect the interaction. However, more concrete, and data-dependent external variables such as the observer decision directly affect the result.

3.2.1.1.11. Collectiveness

In the decision-making process, individuals can be grouped depending on certain criteria in our model. The clusters of expert decision makers, which are also mentioned in the literature, have a superior effect on the outcome. In addition, there may be a conflict between the "yes" supporters and the "no" parties during decision making. If a majority is achieved within the group, the effect of the majority on the result should be high.

3.2.1.1.12. Heterogeneity

Considering the variables used in the model, it can be said that decision-makers are heterogeneous. Despite these differences, a majority can be achieved under certain conditions, e.g., when some of the agents have unique information. In the case where the majority is formed, the majority of agents who have not yet made a decision tend to follow their decision.

3.2.1.1.13. Stochasticity

In order to validate the simulations, the results obtained from the survey data according to the specific scenarios and the results in which the same scenario was simulated were compared.

3.2.1.2. Details

3.2.1.2.1. Implementation Details

After the specified variables are weighed, first a design is made on the visual of the simulation. The El-Farol Bar Problem layout from the Netlogo library is used for this design. Accordingly, all agents (human-shaped white, red, blue, and yellow objects in the design) in the decision stage are in the decision stage in the green part. Determined in line with audience and application reports. Two different situations are simulated simultaneously. Accordingly, if the audience and application reports give a definite positive or negative opinion, these situations cannot be simulated in the red patch, and if the audience and application reports do not make a definite judgment, these situations can be simulated in the gray patch. This method is preferred because the probability of an undecided academician to change his decision despite a definite judgment and the possibility of an undecided academician to change his decision in cases where there is no final judgment, and these cases are also determined statistically by the data at hand. At the end of each tick, the number of academics who changed their minds is recorded.

3.2.1.2.2. Implementation Details

3.2.1.2.3. Initialization

At the initial moment ($t = 0$) all agents are at the same distance from the binary conclusion about the project proposal. The result is reached depending on the rules specified in the Rules Section, the weights of these rules and the interactions between the agents.

3.2.1.2.4. Input Data

During the validation phase, the model is validated by expert judgment method.

3.2.2. Netlogo

Agent-based modeling can be done with almost all known computer software. Agent-based modeling can be studied even using the well-known Microsoft Excel.,

Besides, general programming languages such as Python, C++, Java and C can also be used for Agent based modeling. In addition, mathematics programs such as MATLAB and Mathematica can also be used for ABM (Macal & North, 2017).

On the other hand, Netlogo software developed in Northwestern University's Center for Connected Learning and Computer-Based Modeling is used in this dissertation. In the selection of this program, features such as the fact that the program is free, the use of this program by developers working with ABM, its flexible structure, simple-to-understand interface and the presence of graphics explaining the model are taken into consideration (Andrews et al., 2016).

As a result, version 6.1.1 of Netlogo program (Figure 3.2) developed by Uri Wilensky in 1999 is used in this dissertation. Netlogo is preferred because it is free and has many blocks and information about the codes and the program.

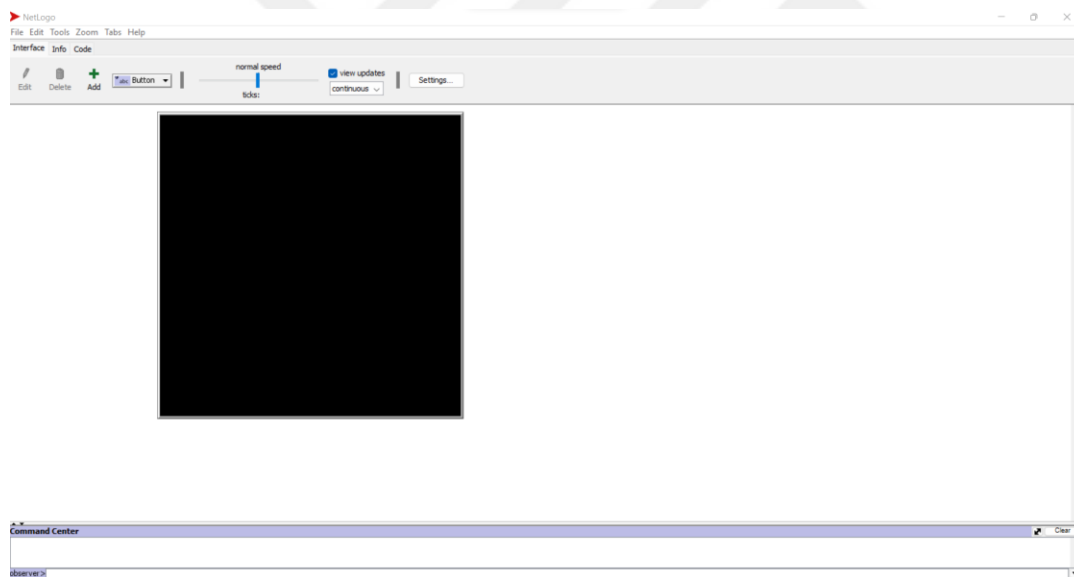


Figure 3. 2. Interface of Netlogo version 6.1.1 Software

3.2.3. Foundations of Research Method: Quantitative vs. Qualitative Research Strategies

3.2.3.1. Research

A research strategy is a systematic action plan made by the researcher to find the answer to the research question. During research, the researcher tries to understand

the essence of the research topic and to define and communicate it (Bryman, 2012). For this reason, it tries to establish a relationship with the subject by determining one of two research strategies, qualitative and quantitative, according to the reality and situation of the research subject.

In quantitative analysis, the researcher collects data to confirm or falsify their own hypothesis (Guba, 1990), and the researcher excludes themselves from this data collection process, in qualitative analysis, he/she collects context-dependent data to understand the research subject and interprets the reality of this data. In other words, research facts are independent of both theories and values (Corbin & Strauss, 2008). As a result, the quantitative research strategy aims to establish a relationship between the subject to be explained (dependent variable) and the factors to explain (independent variables) by quantifying the answer to the research question with numerical data, and thus to explain it (Hathaway, 1995). On the other hand, qualitative research strategy aims to describe and explain the relationships between social entities in order to understand their approaches (Corbin & Strauss, 2008).

3.2.3.2. The Reason for the Combination of Qualitative and Quantitative Analysis (Mixed Method)

In this dissertation, changes that may occur in decision-making mechanisms and ultimately in decisions in the case of the use of blockchain technology, which promises a paradigm shift are examined in the R&D funds of public institutions. This issue has many dimensions. First of all, it makes inferences on the relative effects of using the blockchain in the public sphere. For this reason, first of all, it is necessary to examine the social effects of this issue with its stakeholders and to discuss its "real" meaning. To put it more clearly, an innovation made in the public sphere and possible changes in the routines of the public should be examined. The other point is, as stated in the previous section, data is produced by determining the variables in Agent Based Modeling (Simulation). That is, it is mandatory to confirm the accuracy of the results. In this respect, a kind of "expert judgement" is made by comparing the "surveys" and the results of the first analysis with the actual ones. For example, the ages of the decision makers in the commission formed in the selection of R&D projects are simulated in the ABM program.

As a result, in this dissertation, surveys are used in two ways. The first of these is to determine whether such an innovation in the public sphere affects the internal dynamics of the public; that is, whether such an innovation is needed. The other issue is to verify the simulation results. A new validation process has been designed to validate the simulation results, as can be seen in the Analysis Chapter.

3.2.3.3. Validation of ABM Results

In this dissertation, the effect of blockchain technology in determining public R&D centers and funds is being studied. Blockchain is not currently being used in public sector. Therefore, this dissertation based on a simulation model is a prediction study. In order to determine the accuracy of the estimation, it is necessary to know how precisely the current state of the model is estimated within certain rules (See the Rules Section). For this reason, the determination of the selection of R&D centers incentives were repeated with the ABM retrospectively. For example, the commission members of company X, for which the R&D center decision will be made, review observer reports and application files based on the dynamics of the commission members, such as individual characteristics, hierarchical power distance, and group conflicts. To validate the simulation process, the experiment is repeated 100 times and the simulation results are cross-checked with the actual results. This is done for many scenarios in which when all commission members either change of decision and not change. The results of the experiments are discussed in more detail in the results section.

For the public R&D centers incentive program carried out by the Ministry of Industry and Technology, the questionnaire in Appendix B was sent to the academicians, sector and Ministry representatives (1776 people) who have been involved in the program since 2008. According to the results, weighting is done in the simulation.

3.3. Conclusion

In this doctoral dissertation, the possible effects that may occur with the application of an innovation to the public sector are evaluated together with the optimization of

the evaluation process of public R&D projects. While doing this, qualitative and quantitative analysis methods are used together. As such an application of blockchain technology does not exist, an uncertain future is simulated by the ABM method. On the other hand, since the validation and calibration of the first results obtained after the simulation is required, the "expert judgement" method is provided through survey. The results obtained are evaluated and the simulation is done again, and the closest results are tried to be modeled.

As a result, the effects of concepts such as secure environment, multi-participant platform, democracy, polycentricity and reliable data that blockchain promises to offer on the decision-making processes of R&D projects are discussed. Finally, some policy recommendations is presented to distribute public resources more equitably, to make public R&D projects of researchers more efficient, to direct researchers to appropriate public R&D projects, and as a result to improve the expected results from public R&D projects.

CHAPTER 4

DATA, RULES, AND MODEL OF DISSERTATION

4.1. Data

In dissertation, data regarding the support for R&D and Design Centers carried out within the scope of the Law on Supporting Research, Development and Design Activities of the Ministry of Industry and Technology (Law No. 5746) are used.

In the first phase of the dissertation, the data on the R&D and Design Centers are used with the permission of the executive institution, the General Directorate of R&D Incentives.

Tax deductions and exemptions are provided to companies that are entitled to be R&D and Design Centers within the scope of Law No. 5746. Details on these incentives and exemptions are available in the relevant part of the study. The data used in dissertation are data on the support of R&D Centers that have been carried out since 2009. Design Centers support, which came into force with the Law amendment made in 2016, is not included in this study because it is a relatively new incentive.

Within the scope of the Law No. 5746 on Supporting Research, Development and Design Activities, which entered into force in 2009, private sector companies that meet certain conditions are given the title of R&D Center and these companies can benefit from incentives and supports (Gazete, 2008).

In this context, the following data regarding the R&D Centers commissions for the years 2008-2022 are obtained from the Ministry:

- Number of supported and equity-funded projects of the company applying for the document

- The number of cooperation of the company applying for the document
- The number of events (congress, symposium and fair) of the company applying for the document
- Intellectual and industrial assets of the company applying for the document
- Total number of R&D personnel (including the number of postgraduate and doctoral personnel separately)
- Doctoral graduation year of the observer visiting the company on site
- The title of the academician visiting the company on site
- The university of observer, who visited the company on site
- Interests of the observer visiting the company on site
- Interests of the academician in the commission
- The total number of publications of the academician in the commission
- The total number of patents of the academician in the commission
- The period after the graduation of the academician in the commission from the doctorate
- The title of the academician in the commission
- University of the academician in the commission
- Interests of the sector representative in the commission

Applications for incentives can be made on the website of the Ministry (agtm.sanayi.gov.tr). Firms send the necessary documents through the site and fill out the application forms. Afterwards, the observer assigned by the Ministry prepares a report about the applicant company. In the light of the information in this report and the data submitted by the company in the application, the commission consisting of 2 academicians, 1 Representative of the Ministry of Treasury and Finance, 1 Official of Non-Governmental Organization and 1 Representative of the Ministry decides on the condition that the company benefit from the support and incentives, with the condition of majority of votes. As a result of the decision given as Yes or No, the company receives a certificate and starts to benefit from the incentives.

Although the data provided from MoIT includes all the above elements, it is both personal data and applied by changing it in the analysis (for example, since the total number of personnel with doctoral degrees is related to the size of the applicant

company, the total number of personnel with a doctorate is used by dividing the number of personnel with a doctorate into the total number of R&D personnel) in Appendix C. It was used as in.

Incentive for R&D centers has been given by MoIT since 2008. However, according to the verbal statement taken from the Ministry officials, the Ministry was able to switch to the website system where applications are received in 2016. The works and transactions carried out between 2009-2016 are available as printed documents in the archives of the Ministry. For this reason, it is not possible to make an analysis of the data before 2016. Moreover, because of the comprehensive Law amendment made in 2016, the conditions required for obtaining the R&D Center certificate were changed. This is another reason for using data from 2016 and beyond.

Figure 4.1 shows the number of R&D centers over the years. The years 2016-2018 used in the analyzes coincide with the years when the R&D center applications were high, and the interest was intense.

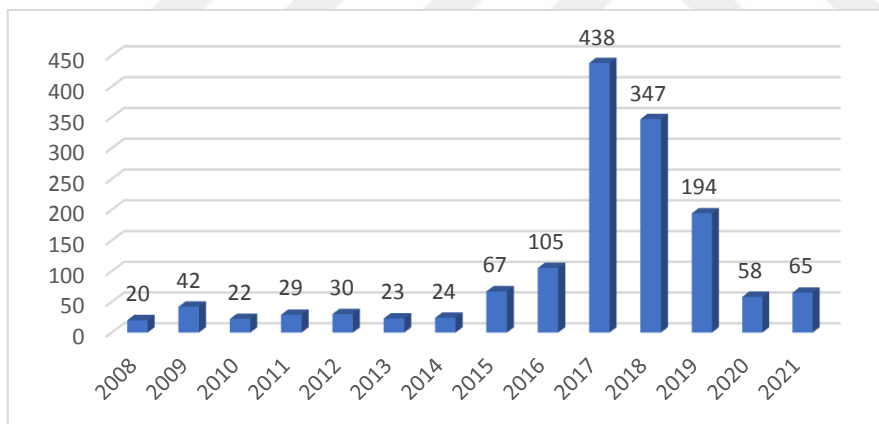


Figure 4. 1. Number of companies that have been given public R&D Center certificate by years in Turkey

However, with the COVID-19 pandemic, remote working and meetings have become widespread in the Ministry, as in many applications. For this reason, data between 2018, the year the pandemic started, and 2016, when the legal amendment was made, were used. Figure 4.2 shows the R&D center application acceptance rates. The fact that the application and acceptance rates used in dissertation have similar curves between the years 2016-2018 is another factor in using these years.

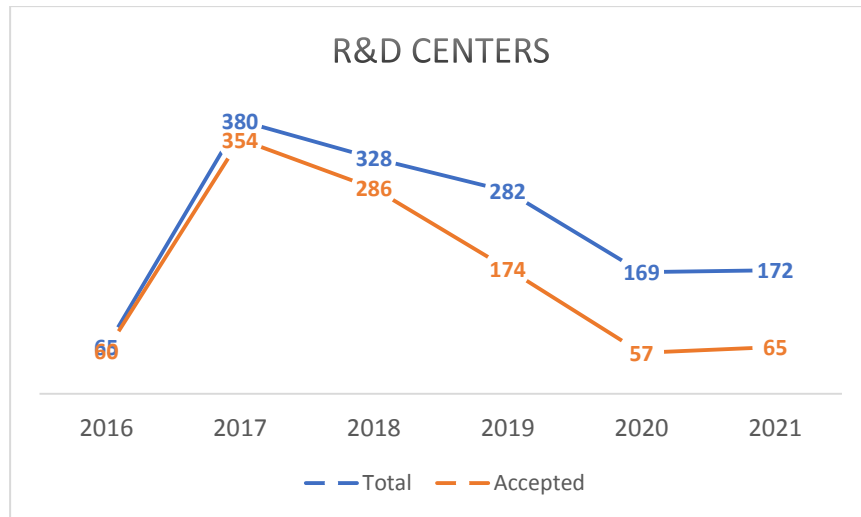


Figure 4. 2. R&D center document applications and acceptance rates between 2016-2021 in Turkey

Between 2016-2018, 773 applications were made for R&D centers. While 700 of the applications were accepted, 73 of them were rejected. The sectoral distribution of these companies is shown in the Figure 4.2

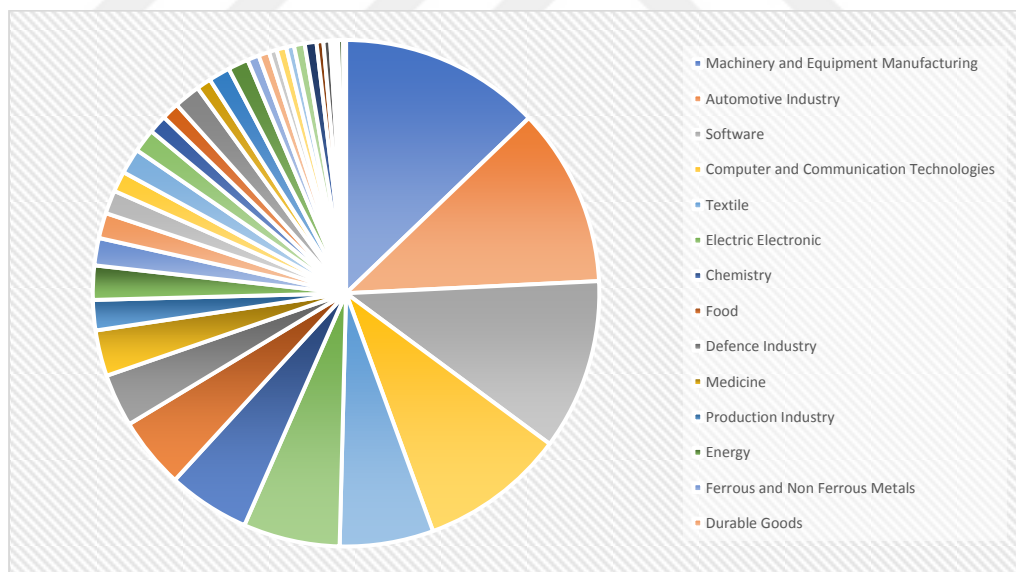


Figure 4. 3. Sectoral Distribution of Firms That Have Applied For R&D Center Certificate Between 2016-2018

In the dissertation, with the limited data permission given by the Ministry of Industry and Technology, permission was granted for 100 applications for 2016-2018. While 50 of the 100 applications were rejected, the rest were accepted. The sectoral

distribution of the companies with the data used in the dissertation is given in Figure 4.4

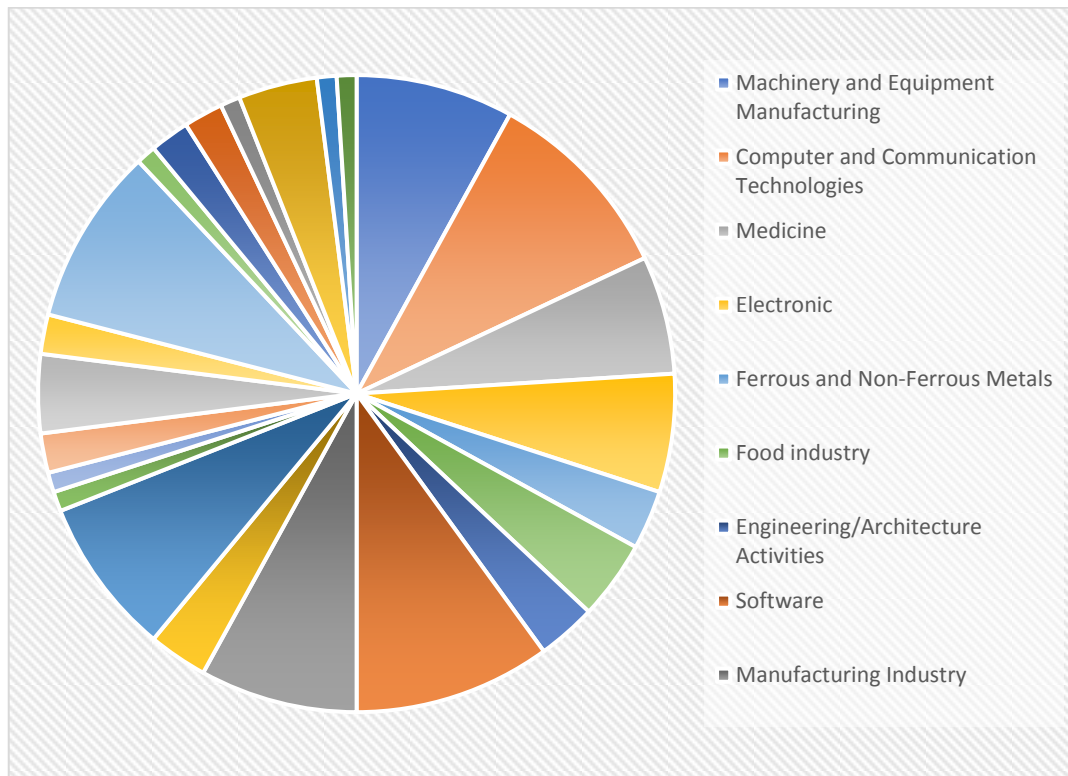


Figure 4. 4. Sectoral Distribution of Firms Applying for R&D Center Certificate and Using Data in Dissertation Between 2016-2018

According to the Yamane equation (Louangrath, 2018), which determines the minimum sample size based on the population size (for 95% confidence level), the minimum sample size is calculated as 20 .

$$n = \frac{N}{1+N (\alpha^2)}$$

In this formula, N represents the total observers, while α represents the margin of error in the 95% confidence interval, that is, 5%.

The number of 100 samples used in the dissertation more than meets this requirement. Besides, the sectoral distribution of the companies whose data are used in the dissertation is in harmony. (See Figure 4.3 with Figure 4.4)

4.2. Rules and Model of Dissertation

Decision-making is the process of choosing the most suitable one among the alternatives. On the other hand, while decision-taking describes a moment, it is a process (Saha, 2017). For this reason, this term is used because the steps leading to the final decision are modeled in dissertation.

Decision-making is a complex process by nature (Ekenberg, Danielson & Boman, 1997). Moreover, it is obvious that decision-making processes have an interdisciplinary aspect that includes many disciplines and has been studied extensively (Tyran *et al.*, 1988). Due to this interdisciplinary nature of the decision-making, it was essential to apply a multidisciplinary methodology in a study on this subject.

Decision-making processes are extensively studied in the economics literature. However, while these studies focus on customer behavior, which is the natural area of interest of economics, the decision-making processes regarding the evaluation of R&D projects discussed in this dissertation are a binary process. From this point of view, it is relatively easy.

In the literature review, it has been stated both in the relevant literature and this dissertation that the decision-making processes have two-stages. Accordingly, decision-making processes are examined in two stages as individual and group decision-making in relation to each other and circularly. In the decision-making processes of R&D projects, a two-stage decision-making process is modeled since project information is shared in advance, and the commission members come to the commissions to take decisions together with a certain knowledge about the project and an initial decision.

Although the contribution of the dissertation to evolutionary economics is discussed in the literature chapter, it is imported to note that the study can also contribute to the "behavioral economics" literature since factors such as psychological biases, limited cognitive resources, and care about other values such as fairness are taken into account in the model (Miller and Amit, 2016).

In this chapter, the rules affecting individual and group decision-making processes and their effects on the final decision are examined.

As can be seen in Figure 4.5, the decision-making process modeled in dissertation consists of intricate and nested parameters. In this section, the rules of decision-making processes and the relations of these rules with other rules and final decision are discussed.

The effect of the rules on each other and the result of decision-making is determined as a result of "expert judgment" negotiations. Accordingly, the weighting of the rules in mathematical modeling is given based on the common opinion of the experienced commission members.

In order to make the complexity of the decision-making stages mentioned below to be somewhat understandable, Rules A, B, C, etc. for individual decision making. Rules for group decision making are 1,2,3 etc. named as

In addition, in order to understand the complex structure of decision making, figures about the relations of the rules with each other are drawn (see Figures 4.5-11). The colors of these lines are unique to rule.

Moreover, under each rule, a table and the relationship between the rules are explained.

4.2.1. Individual Decision-Making Phase

4.2.1.1. Rule A (Gender)

Individually, women tend to take more risks than men (Ertac and Gurdal, 2019). It can be concluded that women commission members are more likely to accept public R&D projects than men (Bromiley and Rau, 2017)., since R&D processes involve a high level of risk.

In accordance with Rule A, "Female commissioners tend to be more accepting than male members".

The other rules and relations that Rule A affects are as follows (Table 4.1):

- Gender naturally changes the gender composition among commissioners. As a result, gender (Rule A) is related to gender composition (Rule 2).
- Gender (Rule A) also affects the difference between the current competencies of the project to be evaluated and the level of success desired by the commission members. Accordingly, this gap in female commission members is inversely proportional gender (Rule A) is inversely proportional to the gap (Rule B2).
- It can be deduced that individual conflict is less due to the high rate of women commissioners accepting projects. As a result, gender rule (Rule A) is inversely proportional to individual conflict rule (Rule F).
- The determined stance of the female commission members help to form a consensus according to their density within the group. Therefore, gender (Rule A) is related to majority rule (Rule 4).

Table 4. 1. The Relationship Between Rule A and Other Rules

Directly Proportional		
Inversely Proportional	Rule B2	Rule F
Related	Rule 2	Rule 4

4.2.1.2. Rule B (Behavior)

The economic problem is basically a choice problem. For this reason, the science of economics has developed in terms of customer preferences and the factors affecting these choices. Commission members tend to believe that they make the most rational decisions, which is the most problematic issue of economic literature. Since the survey in the analysis section was conducted with the "random sampling" method, it is assumed that it includes all "behavior" types. Therefore, this rule was included in the analysis.

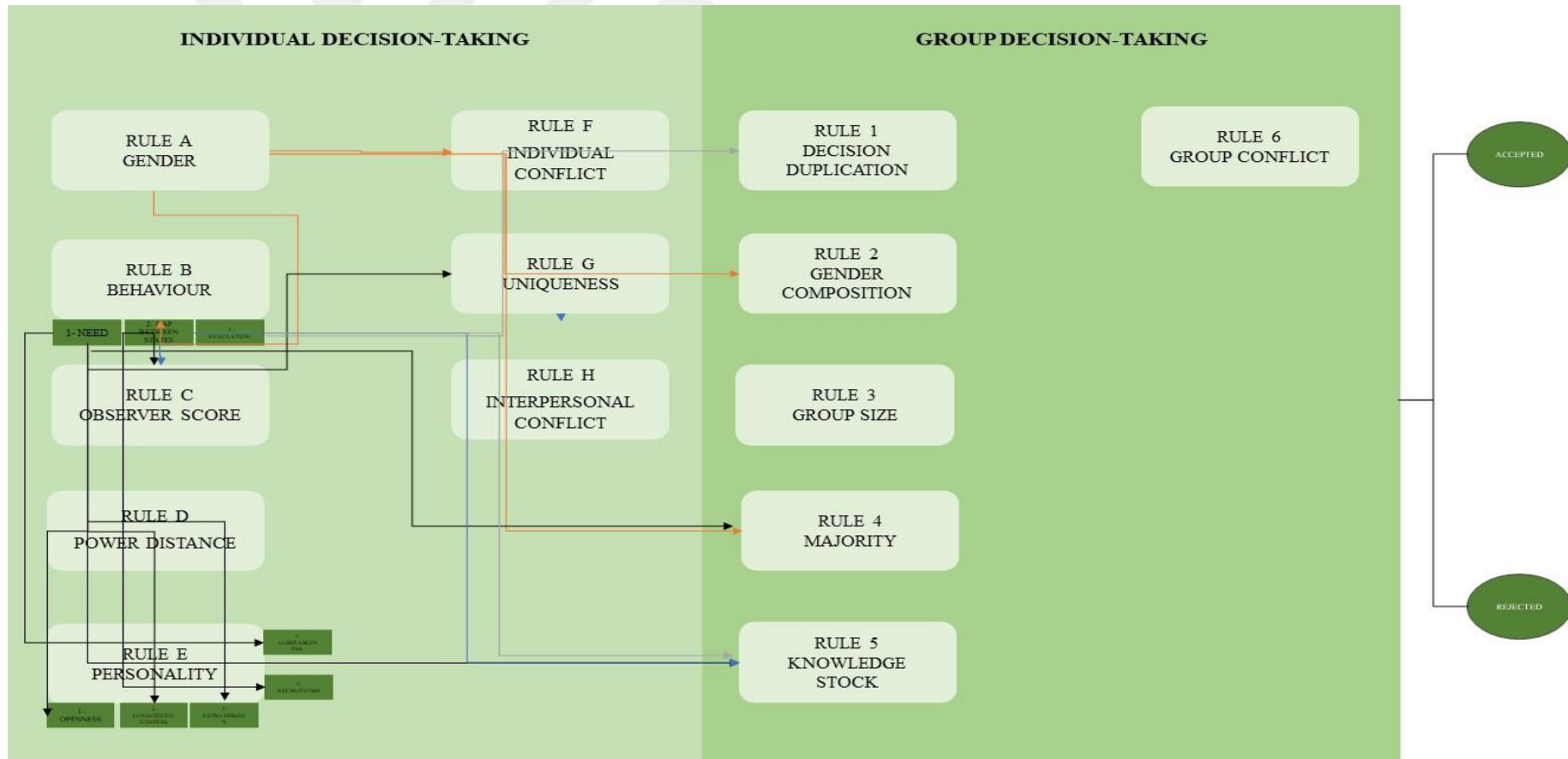


Figure 4. 5. Decision-Making Rules of Dissertation Part I

In Roozmand et al.'s (2011) study of customer behavior, customer behavior during preference is examined in five sections. These are; need, recognition, information search, evaluation of alternatives, purchase and post-purchase behaviors (Roozmand *et al.*, 2011) . In this dissertation, these behaviors are used. However, selection of information search R&D projects are considered as a separate rule since it is a very knowledge-intensive process. Again, since the main subject of this dissertation is selection, the purchase or post-purchase processes are not included.

4.2.1.2.1. Rule B1 (Need)

The decision-making process begins with the identification of the need (Roozmand *et al.*, 2011). Accordingly, the decision-making process of the commission members begins with the need for this project. Considering the other rules in this dissertation, the need is directly proportional to the knowledge level of the commission members (Rule 5). Finally, if one or more of the commission members is an expert on the subject and has a unique knowledge on this subject, they determine the need.

In addition, the score of observers who examines the project on site is directly proportional to the determination of the need (Rule C). The need for the project is also related to the character of the commission member such as openness, conscientiousness, extraversion, agreeableness, and neuroticism (Rules E1, E2, E3, E4, and E5).

If one or more of the commission members is an expert on the subject and has a unique knowledge on this subject, they determine the need for uniqueness (Rule G). Finally, the need for a matter decided by the majority (Rule 4) is directly proportional to that decision (see Table 4.2).

Table 4. 2. The Relationship Between Rule B2 and Other Rules

Directly Proportional		
Inversely Proportional	Rule C	Rule 5
Related		

4.2.1.2.2. Rule B2 (The Gap)

The gap, on the other hand, refers to the difference between the status of the current project's qualifications and the situation required for acceptance in the minds of the commissioner (Roosmand *et al.*, 2011). This situation is inversely proportional to the observer score (Table 4.3). The higher the observer's score in (Rule C), the lower the gap. Knowledge accumulation (Rule 5) is also inversely proportional to this gap (Rule B2).

Table 4. 3. The Relationship Between Rule B2 and Other Rules

Directly Proportional		
Inversely Proportional	Rule C	Rule 5
Related		

4.2.1.2.3. Rule B3 (The Evaluation of Alternatives)

The evaluation of the project according to alternative projects is also a behavior. This behavior is related to decision duplication rule (Rule 1) I. In addition, it is directly proportional to the total knowledge possessed as seen in Table 4.4 (Rule 5).

Table 4. 4. The Relationship Between Rule B3 and Other Rules

Directly Proportional		
Inversely Proportional		
Related	Rule I	Rule 5

This rule could not be included in the analysis because the discussions during the commission were not known.

4.2.1.3. Rule C (Observer Score)

In the evaluation of the TUBITAK projects and R&D Centers Selection discussed in this dissertation, before the commission evaluation, the observers visit the company

to evaluate the submitted project on site. As a result of the examination made after this visit, they prepare a report to inform the commission.

This report is very significant in both individual and group decisions of the commission members. Determining the need for observer score is directly proportional to need rule (Rule B1). The higher the score, the greater the need (Rule B1). The difference between the desired and the current situation is inversely proportional to the score. The higher the score, the smaller the gap (Rule B2). Again, while determining the alternatives, the score is related to evaluation of alternatives rule (Rule B3). Naturally, the written report has an impact on personality types. Accordingly, openness is directly proportional to conscientiousness rule (Rule E2), agreeableness (Rule E4) and neuroticism (Rule E5).

Inter-personal conflict rule (Rule H) as seen in Table 4.5 is inversely proportional to the score, because this score is the lead to resolution of disputes. In addition, although it is related to character traits, it is also related to decision repetition (Rule 1).

Table 4. 5. The Relationship Between Rule C and Other Rules

Directly Proportional	Rule B1	Rule E1, E2, E4, E5
Inversely Proportional	Rule B2	Rule H
Related	Rule B3	Rule 1

4.2.1.4. Rule D (Hierarchical Power Distance)

The hierarchical power distance rule is only used in the validation of the current commission because there are only academics in the current commission structure. There is a hierarchical power difference between these academics due to both the university they come from and the title difference, such as Professor, Associate Professor. However, there is no need for this variable the identities are anonymous in the block-chained model.

When determining the hierarchical power distance, a number was determined by multiplying the titles of the commission members and the THE (Times Higher Education) scores of the university they come from.

This rule is directly related to character traits (Rule E1, E2, E3, E4, and E5). For example, Openness (Rule E1), one of the character types used in this dissertation, is not expected to be related to hierarchical power distance (Rule D). On the other hand, agreeable commission members (Rule E4) are expected to be influenced by the powerholders. For this reason, observer score rule (Rule D) and openness (Rule E4) are directly proportional.

Similarly, there is a high probability that individuals with labile neuroticism is directly proportional to neuroticism (Rule E5) and power distance rules. On the contrary, extraverted (Rule E3) commission members who give importance to all kinds of ideas do not have a relationship with agreeableness (Rule E3) and power distance (Rule D).

People with power and status are thought to dictate their own decisions due to their inherent instincts to establish superiority, thus reducing the disagreements among the commission members. Therefore, power distance (Rule D) is inversely proportional to individual (Rule F) and interpersonal conflict (Rule H) rules.

Similarly, the importance of unique knowledge decreases as the power difference between the commission members increases, although they do not have a unique idea about the project being discussed. Therefore, power distance (Rule D) is inversely proportional to uniqueness (Rule G) and group conflict rules (Rule 6).

As a natural result of power asymmetry, copying of ideas also increases. Therefore, power distance (Rule D) is directly proportional to decision duplication rule (Rule 1). Table 4.6 briefly discusses the relations of this rule. Figure 4.6 shows the final states of the relationships introduced up to this stage. The impact of each new decision is added to similar patterns.

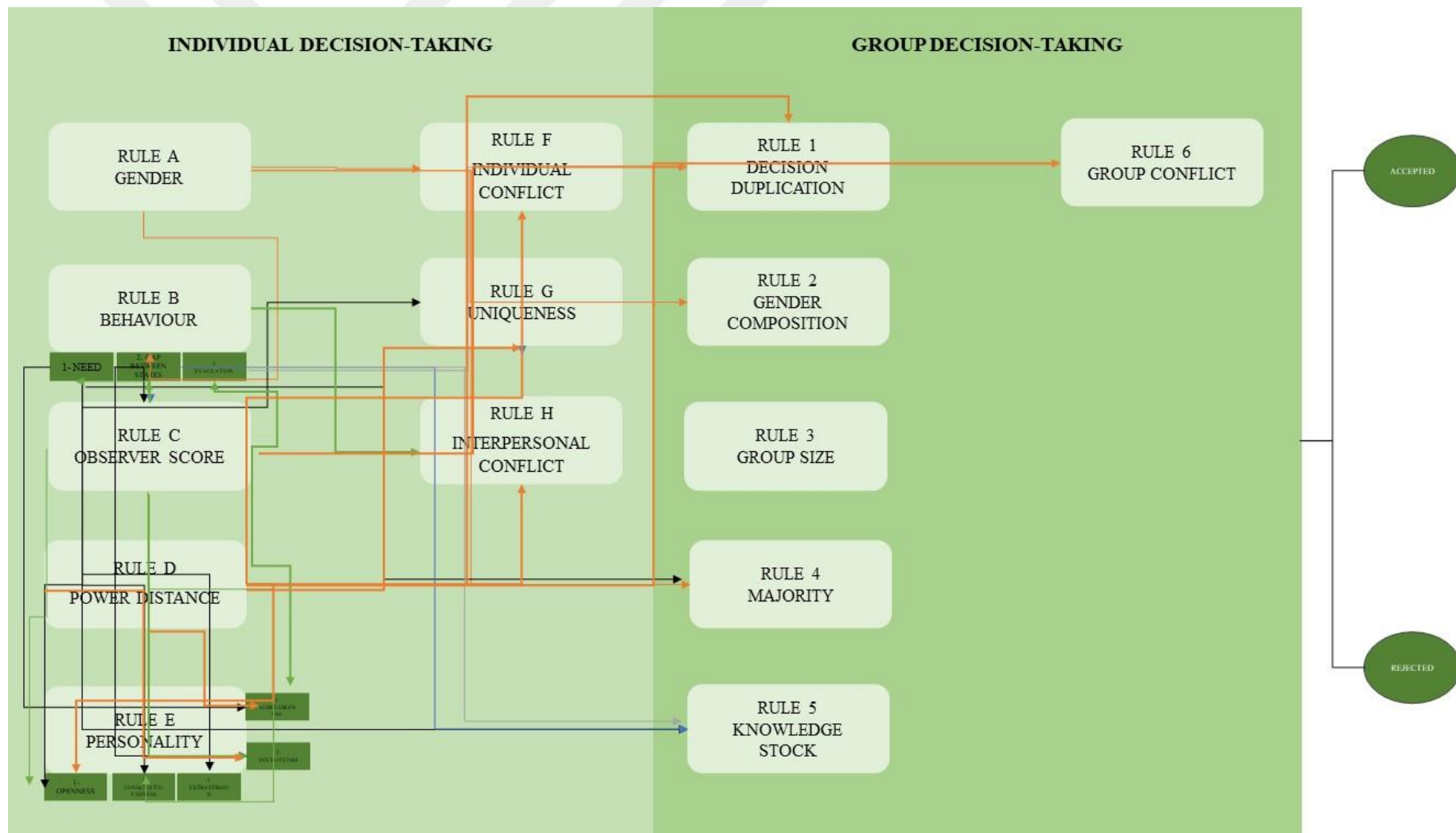


Figure 4. 6. Decision-Making Rules of Dissertation Part II

Table 4. 6. The Relationship Between Rule D and Other Rules

Directly Proportional	Rule E1, E4, and E5	Rule 1		
Inversely Proportional	Rule F	Rule H	Rule G	Rule 6
Related				

4.2.1.5. Rule E (Personality)

Undoubtedly, the influence of character traits on decision-making processes is undeniable. For this reason, personality is naturally in a relationship with almost all variables.

In order to validate the model, we build in the dissertation, the previous commissions in which R&D projects are evaluated and remodeled. If similar results are obtained, the consequences of making a decision in the blockchain environment are predicted. As can be expected, character trait rules is not used in validation tests since there is no data on the character traits of the commission members who have made their decisions.

4.2.1.5.1. Rule E1 (Openness)

Open people are people who are more open to new ideas than the other personality types (Roosmand *et al.*, 2011). For this reason, openness (Rule E1) is more likely to follow other ideas. Therefore, openness (Rule E1) is directly proportional to decision duplication rule (Rule 1). Openness is also associated with uniqueness (Rule G) and knowledge stock (Rule 5) rules because it respects knowledge. Table 4.7 covers all possible connections about openness rule. As can be seen from the table, the relationship of this character trait with other rules is limited compared to other rules. However, openness to other ideas is an important parameter for the innovation literature. Accordingly, respect for new ideas and thoughts increases the possibility of innovation.

Table 4. 7. The Relationship Between Rule E1 and Other Rules

Directly Proportional	Rule 1	
Inversely Proportional		
Related	Rule G	Rule 5

4.2.1.5.2. Rule E2 (Conscientiousness)

Conscientious people can be portrayed as disciplined, accountable, and determined (Roosmand et al., 2011). As mentioned before, observer score is directly proportional to observer score (Rule C) and conscientiousness (Rule E2) rules. Since they are accountable individuals, the decision of a project that has been more reviewed is important for them. Due to their stable traits, they can reduce individual conflicts. Therefore, conscientiousness is inversely proportional to individual conflict rule (Rule F). However, their determination increases interpersonal and intergroup conflict, so conscientiousness (Rule E2) is inversely proportional to interpersonal (Rule H) and group conflict rules (Rule 6). Table 4.8, 4.9, and 4.10 summarize the connections about rules.

Table 4. 8. The Relationship Between Rule E2 and Other Rules

Directly Proportional	Rule C		
Inversely Proportional	Rule F	Rule H	Rule 6
Related			

4.2.1.5.3. Rule E3 (Extraversion)

Extraverted people are chatty, devoted, and impassioned. In addition, extraversion is associated with status (Roosmand *et al.*, 2011).

As can be seen from the definition, extraverted people are directly related to power distance. Therefore, as the power distance increases, the extraverted people are more affected, so they are both directly proportional to extraversion rule (Rule E3) and

power distance (Rule D). In addition, the number of extraverted (Rule E3) commissioners also influences the majority (Rule 4). Naturally, this situation also increases the decision duplication rates, as a result, extraversion rule (Rule E3) is directly proportional to decision duplication rule (Rule 1). Finally, extraversion rule (Rule E3) is inversely proportional to interpersonal (Rule H) and group conflict rules (Rule 6), as the increase in the extraverted commission member reduces the conflicts between groups and individuals.

Table 4. 9. The Relationship Between Rule E3 and Other Rules

Directly Proportional	Rule D	Rule 4	Rule 1
Inversely Proportional	Rule H	Rule 6	
Related			

4.2.1.5.4. Rule E4 (Agreeableness)

Agreeableness, on the other hand, depicts softhearted, trusting, and good-natured people. These people are socially compatible people (Roosmand *et al.*, 2011).

It can be thought that since agreeable people are compatible, they avoid conflicts. In this case, agreeableness rule (Rule E4) is inversely proportional to rules; interpersonal (Rule H) and group conflict (Rule 6). On the other hand, agreeableness is directly proportional to decision duplication (Rule 1) and majority (Rule 4) rules.

Table 4. 10. The Relationship Between Rule E4 and Other Rules

Directly Proportional	Rule 1	Rule 4	
Inversely Proportional	Rule H	Rule 6	
Related			

4.2.1.5.5. Rule E5 (Neuroticism)

Neuroticism is used to describe individuals who are emotionally pessimistic, unstable and depressed (Roosmand *et al.*, 2011).

It is seen that neuroticism may be directly proportional to all conflicts (individual (Rule F), interpersonal (Rule H) and group conflicts (Rule 6)). However, neuroticism is thought to be (Rule E5) inversely proportional to the factors that require stability and adaptation (decision duplication (Rule 1) and majority (Rule 4)).

Table 4. 11. The Relationship Between Rule E5 and Other Rules

Directly Proportional	Rule F	Rule H	Rule 6
Inversely Proportional	Rule 1	Rule 4	
Related			

4.2.1.6. Rule F (Individual Conflict)

Individual conflict can be a character trait, or it can be an instantaneous situation specific to the situation encountered (Wu and Sekiguchi, 2020). Since people in this situation are in doubt, they do not take risks and adapt to the majority. Therefore, individual conflict (Rule F) is directly proportional to majority (Rule 4) and decision duplication (Rule 1), and neuroticism (Rule E5) is directly proportional to individual conflict since it is a balanced problem.

In addition, it can be considered that individual conflict increases dissonance at all levels (individual (Rule F), interpersonal (Rule H), and group conflicts (Rule 6)).

Table 4.11 and 4.12 summarizes the connections between Rule F and E.

Table 4. 12. The Relationship Between Rule F and Other Rules

Directly Proportional	Rule 4	Rule 1	Rule H, 6
Inversely Proportional			
Related			

4.2.1.7. Rule G (Uniqueness)

Scientific development demands more specialization and diverse knowledge with increasing enthusiasm. This situation is also reflected in the number of co-authors in scientific articles (Zhang *et al.*, 2018). Again, different expertise is needed in solving complex problems. This uniqueness is also occasionally encountered in the selection of R&D projects. The expertise needed may lead to the emergence of different groupings within the commission, or it may also cause a consensus on the opinion of the commission member who has other expertise (Van Veen, Kudesia and Heinimann, 2020). As a result, if the project subject and the information of the commission members match, the perception of the need for the project may be affected positively.

So uniqueness rule (Rule G) is related to need rule (Rule B1). Similarly, if there is a lot of unique information, the gap between the need and the project is also relevant. Personality traits may also be related to the difference of unique knowledge. Therefore, uniqueness rule and character traits rules (Rule E1, E2, E3, E4, and E5) are directly proportional.

Specializations promote team formations, as a result, uniqueness (Rule G) is directly proportional to interpersonal conflict (Rule E) and majority rules (Rule 4) The decision copying rule (Rule 1) showing majority (Rule 4) compliance, these are directly proportional.

Finally, uniqueness (Rule G) is directly proportional to knowledge stock (Rule 5) as it increases the marginal knowledge of the general commission.

Moreover, it is known that specialized knowledge increases group formation among commission members, which causes uniqueness to be directly proportional (Table 4.13) to group size (Rule 3) and group conflict rules (Rule 6). This rule is also very related to the hierarchical power relationship rule. As a result of the analysis, it was observed that there was a knowledge-based hierarchy in R&D commissions. This rule lies at the basis of this hierarchy.

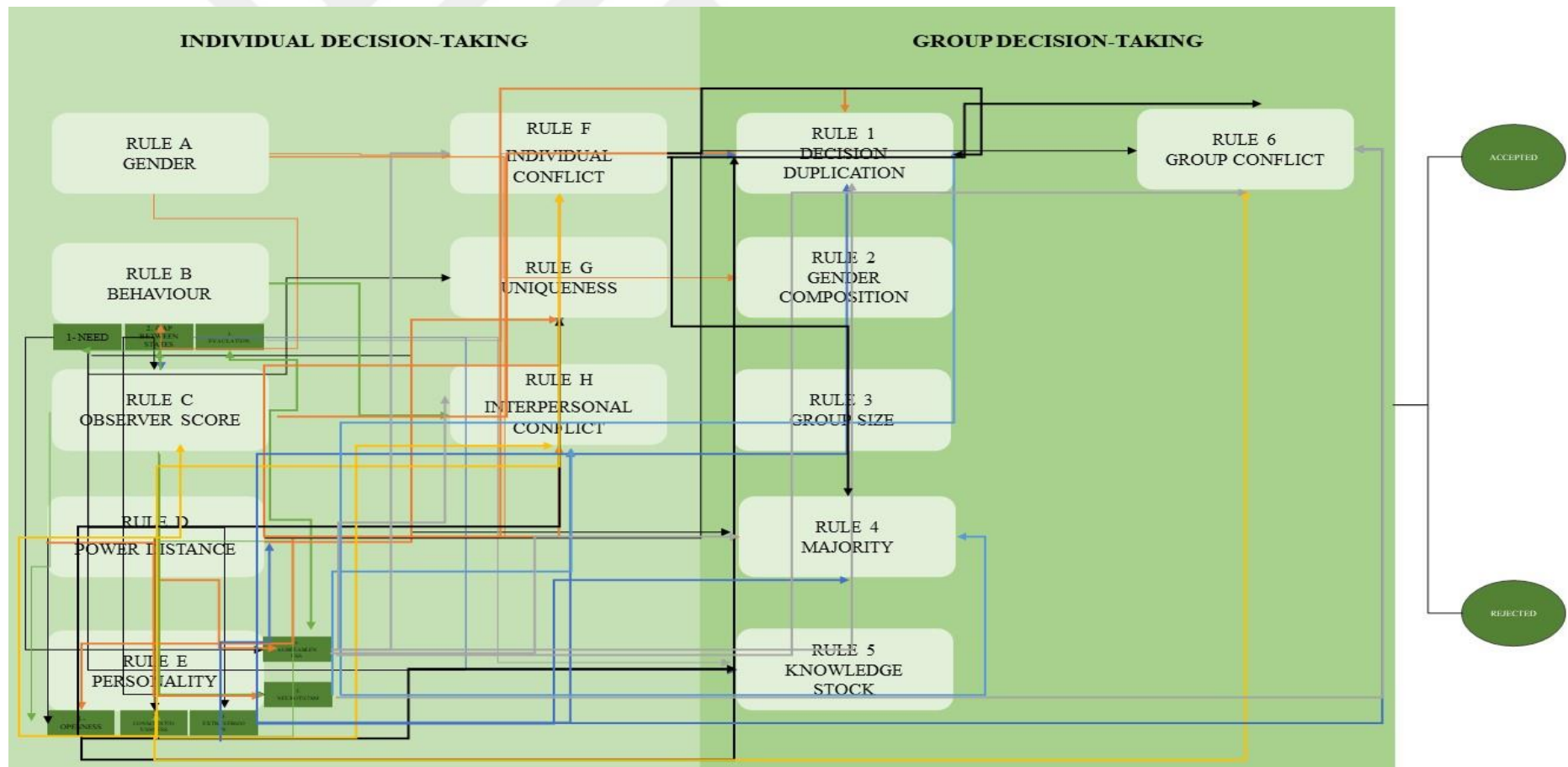


Figure 4. 7. Decision-Making Rules of Dissertation Part III

Table 4. 13. The Relationship Between Rule G and Other Rules

Directly Proportional	Rule E1, E2,E3,E4	Rule H	Rule 4	Rule 1	Rule 5	Rule 3	Rule 6
Inversely Proportional							
Related	Rule B1						

4.2.1.8. Rule H (Interpersonal Conflict)

Depending on the number of people, conflicts may occur between like-minded subgroups within the commission (Martinho *et al.*, 2015). It can be predicted that this situation has an impact on the group's decision-making.

As discussed in personality types, inter-personal conflict (Rule H) is inversely proportional to openness (Rule E1), conscientiousness (Rule E2), extraversion (Rule E3), and agreeableness (Rule E4), while it is directly proportional to neuroticism (Rule E5). Individual conflicts are a predictable result in the individual conflict rule (Rule F) grouping dimension. On the other hand, having a leader in the commission (power distance rule (Rule D)) is inversely proportional to interpersonal conflict (Rule H) as it resolves the conflict between people.

Finally, having a observer report (whether it is positive or negative) (Rule C) is inversely proportional to interpersonal conflicts (Rule H). Table 4.14 is also indicates the aforementioned effects.

Table 4. 14. The Relationship Between Rule H and Other Rules

Directly Proportional	Rule E5		
Inversely Proportional	Rule E1 E2, E3, E4	Rule D	Rule C
Related	Rule B1		

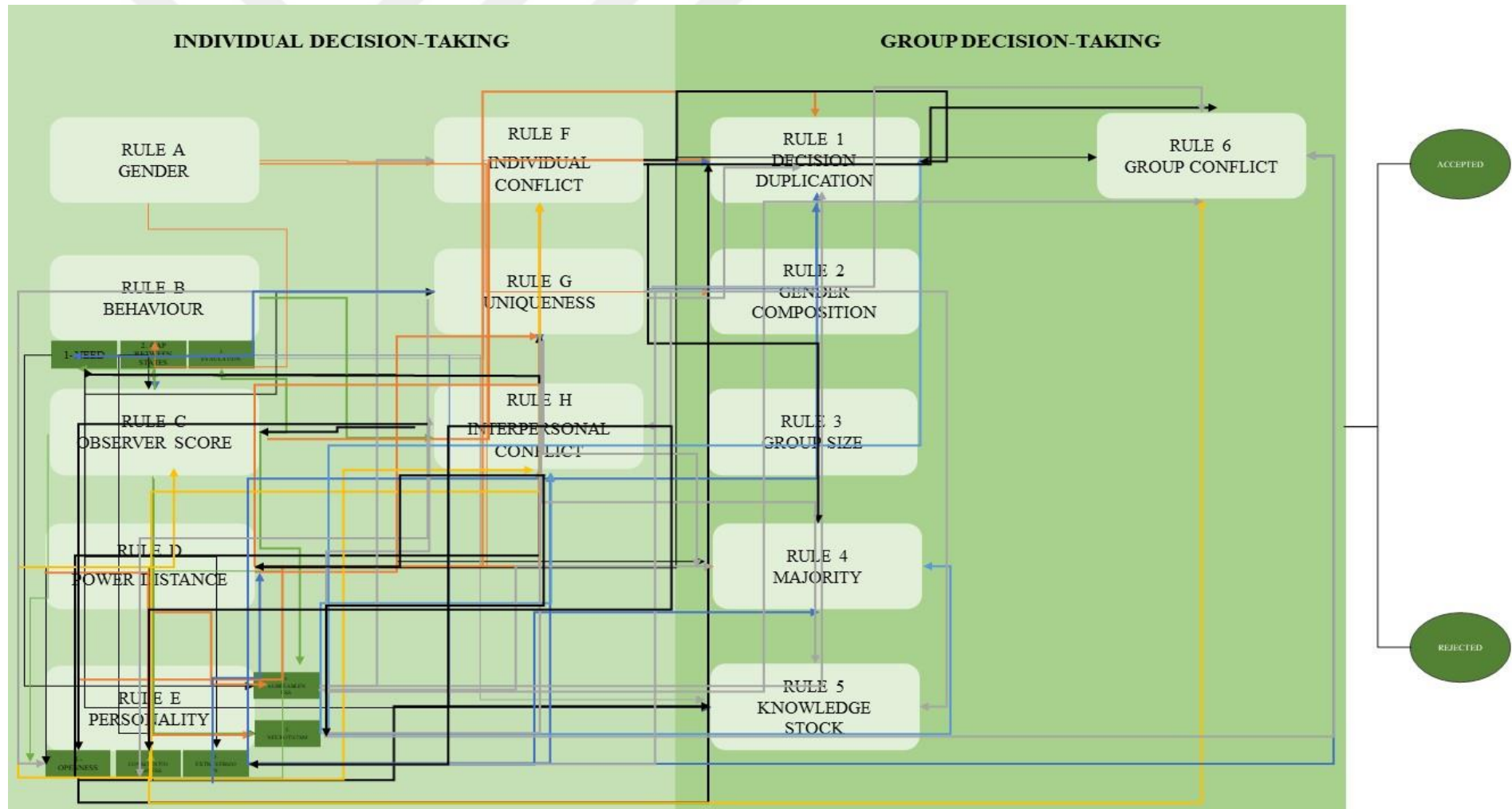


Figure 4. 8. Decision-Making Rules of Dissertation Part IV

4.2.2. Group Decision-Making Phase

It is stated at the beginning of the section that decision-making consists of two stages. Contrary to Figure 4.8, it is not possible to make a clear distinction between these processes. At the end of this cyclical and dynamic decision-making process, the community (commission for this dissertation) can come to a decision. Although this decision is a binary decision for this dissertation, individual and group decision-making processes affect each other until the last moment. In order to facilitate the modeling of the decision-making processes, which are currently quite complex, decision-making is discussed in two stages in this dissertation.

In the group decision making part, which is the second part of the decision-making process, information exchange and bargaining within the group naturally has an impact on the final decision, so this section discusses the rules regarding the group.

4.2.2.1. Rule 1 (Decision Duplication)

Some group members are more likely to approve the decisions of the majority (Ertac and Gurdal, 2019). Particularly in the section where group decision making in the digital environment is discussed, this dissertation is also likely to transfer the responsibility of the members (Kirchkamp and Strobel, 2019).

The most visible relationship of Rule 1, called Decision duplication, is with majority (Rule 4). Similarly, it can cause an increase in group sizes within the group (Rule 1 is directly proportional to Rule 3). There may be other group members whose decisions are copied by the group members, as well as this observer, so decision duplication (Rule 1) is directly proportional to observer score (Rule C).

Decision duplication is related to the fact that some of the commission members can influence others. Accordingly, power asymmetry increases this situation. Therefore, decision duplication (Rule 1) is directly proportional to power distance rule (Rule D). It should not be overlooked that not being original or being influenced can be a personality trait. Therefore, it is directly proportional to openness (Rule E1),

extraversion (Rule E3) and agreeableness (Rule E4), but it is inversely proportional to neuroticism Rule E5.

Finally, it can be thought that an indecisive individual can adapt other decisions to stay in the safe zone (i.e., decision duplication (Rule 1) is directly proportional to individual conflict rule (Rule F)). Similarly, the members who intend to implement other decisions follow the people who are more prone to the subject and have original knowledge (i.e., decision duplication (Rule 1) and uniqueness (Rule G) are directly proportional) (Table 4.15).

Table 4. 15. The Relationship Between Rule 1 and Other Rules

Directly Proportional	Rule 4	Rule 3	Rule C	Rule D	Rule E1,E3, and E4	Rule F	Rule G
Inversely Proportional	Rule E5						
Related							

4.2.2.2. Rule 2 (Gender Composition)

Lamiraud & Vranceanu (2018) observed in their study that risk-making tendency is less in groups where women are the majority, compared to other group compositions (Lamiraud & Vranceanu, 2018). Although it has been reported that women take more risks in their individual decisions (Bromiley and Rau, 2017), this situation changes to the opposite when they consider the majority within the group. As a result, in relation to the number of commission members (Rule 3), gender composition (Rule 2) is also related to gender (Rule A).

Table 4.16 summarizes the relation network of gender composition. In Figure 4.9, the relationships up to this stage are schematized. Accordingly, there are many factors that affect the outcome during group decision-making. When the decisions made at the individual decision stage are combined with the dynamics within the group, a very chaotic appearance emerges.

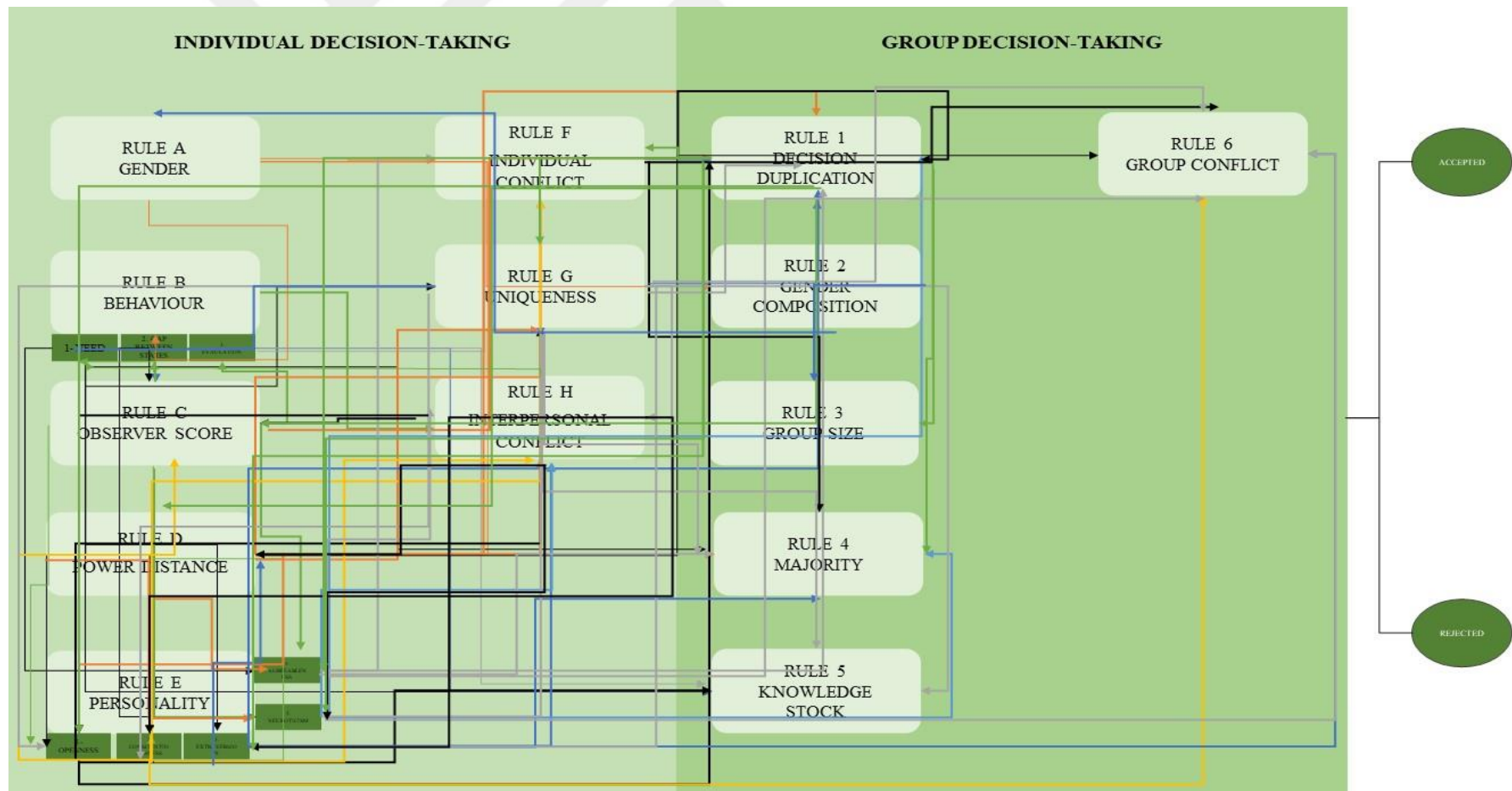


Figure 4. 9. Decision-Making Rules of Dissertation Part V

Table 4. 16. The Relationship Between Rule 2 and Other Rules

Directly Proportional		
Inversely Proportional		
Related	Rule A	Rule 3

4.2.2.3. Rule 3 (Group Size)

The commission, by whom R&D projects in Turkey are evaluated, usually consists of five members. It is suggested that this number can be increased as desired by using blockchain technology in this dissertation. However, how can this change as the number of commission members (group size) increases? Shadmehr (2015) sought the answer to this question in his study.

Accordingly, he concluded that small groups (for our study, this number was determined as 5 commissioners) were more collegial, while large groups decided more individually as the group size increased (Shadmehr, 2015). Table 4.17 briefly mentions these effects.

Table 4. 17. The Relationship Between Rule 3 and Other Rules

Directly Proportional	Rule G	Rule 1
Inversely Proportional		
Related	Rule 2	

4.2.2.4. Rule 4 (Majority)

Until this section, all the rules related to the majority rule are as in Table 4.18

Table 4. 18. The Relationship Between Rule 4 And Other Rules

Directly Proportional	Rule E3, E4	Rule F	Rule G	Rule 1
Inversely Proportional	Rule E5			
Related	Rule A	Rule B1		

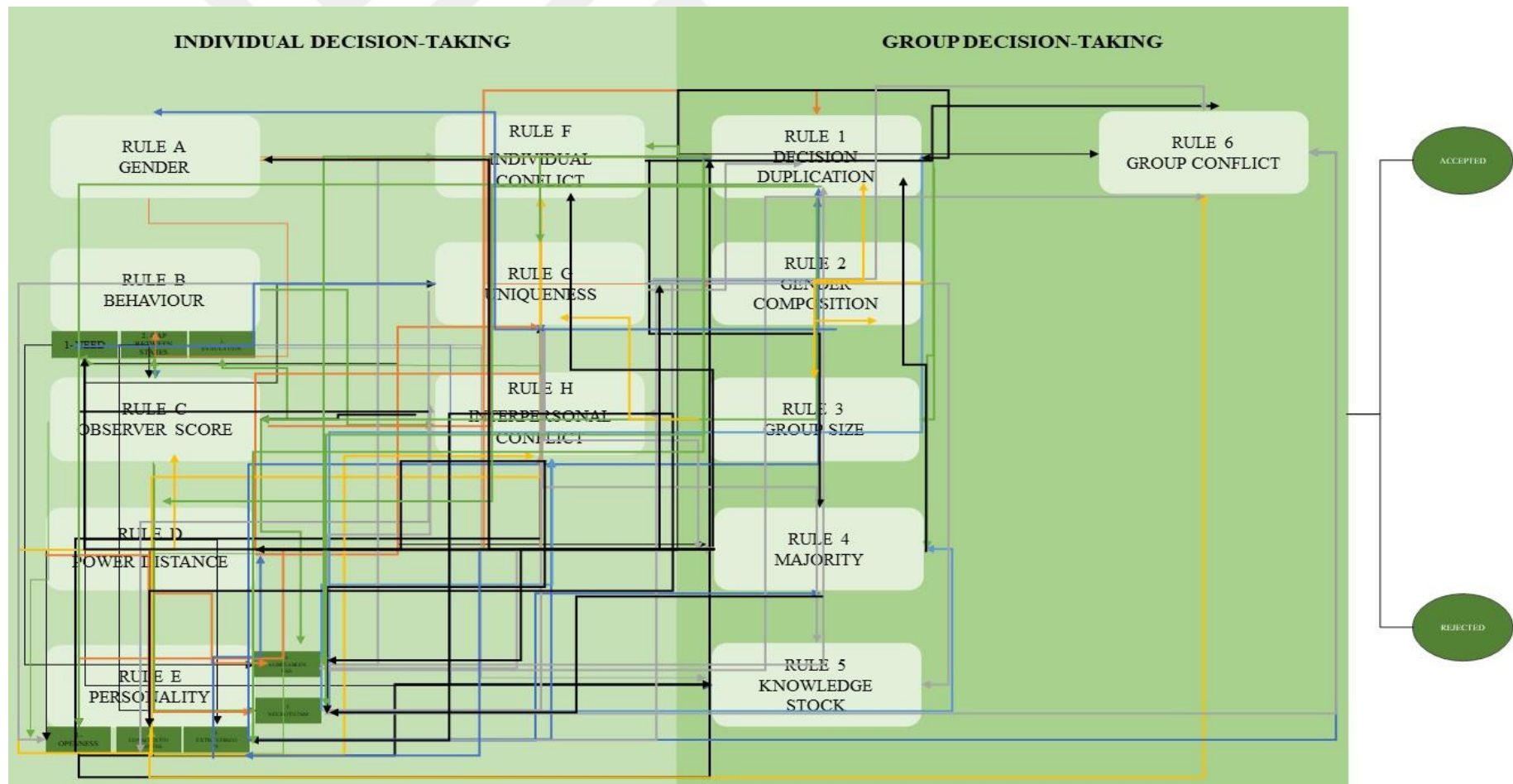


Figure 4. 10. Decision-Making Rules of Dissertation Part VI

4.2.2.5. Rule 5 (Knowledge Stock)

It is not possible to measure individually owned knowledge with current facilities. However, the relationship of knowledge with variables such as education period and experience are obvious. For the stock of information in this rule, each commissioner was accepted equally without any discussion. It is also a predictable result that the increase in the stock of information in the commission complicates the acceptance conditions. Therefore, knowledge stock rule (Rule 5) and the gap rule (Rule B2) are inversely proportional. In addition, it can be predicted that increasing the number of groups increases knowledge (knowledge stock (Rule 5. Moreover, it is directly proportional to group size rule (Rule 3)). The necessity of the project (Rule B1) can also be understood by the abundance of available information. All kinds of disputes can increase knowledge as it increases discussion and research (knowledge stock (Rule 5), individual (Rule F), interpersonal (Rule H), and group conflicts rules (Rule 6)). On the other hand, having a lot of unique knowledge (Rule G) naturally increases your knowledge (Rule 5). Table 4.19 below summarizes these effects.

Table 4. 19. The relationship between Rule 5 and other rules.

Directly Proportional	Rule B1	Rule G	Rule F	Rule H	Rule 3	Rule 6
Inversely Proportional	Rule B2					
Related	Rule B3	Rule E1				

4.2.2.6. Rule 6 (Group Conflict)

In this section, where the conflicts between the smaller groups within the group are indicated, the relationship between the rules is demonstrated in the Table 4.20.

Table 4. 20. The Relationship Between Rule 6 and Other Rules

Directly Proportional	Rule G	Rule H	Rule 5
Inversely Proportional	Rule D	Rule E2, E3, E4, E5	
Related			

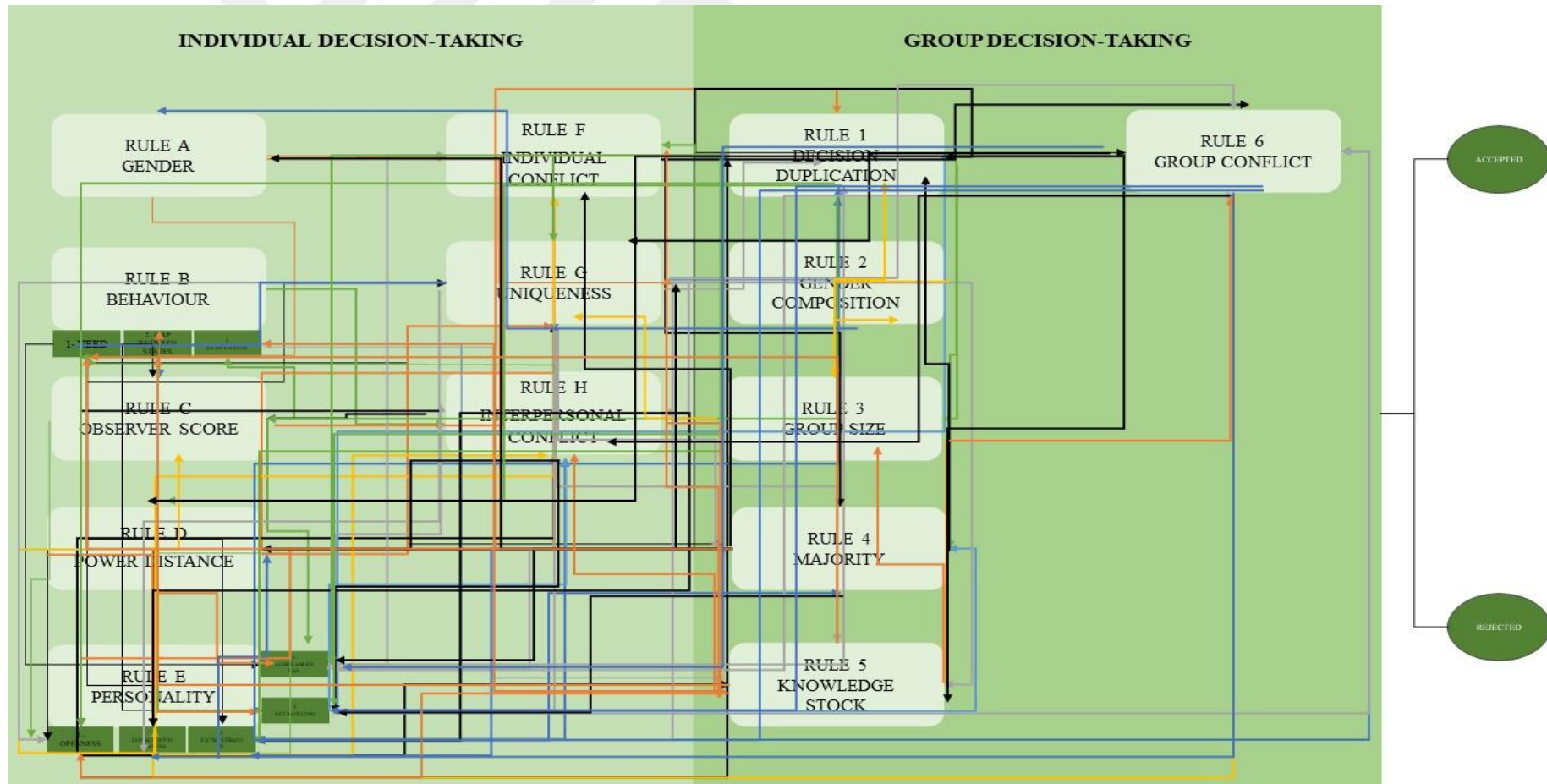


Figure 4. 11. Decision-Making Rules of Dissertation Part VII

CHAPTER 5

ANALYSES

5.1. Introduction

The qualitative and quantitative methods use in the analysis section are summarized in Figure 5.1. Accordingly, firstly, Iterative Dichotomies 3 (ID3) and entropy analyzes are carried out on the variables obtained from the Ministry of Industry and Technology (except as "own calculations" in Table 5.9). Thereupon, a survey (1st Survey) is designed with the academicians in the commissions to determine the variables that have the most impact on the R&D center decision, and when the results are compared, it is observed that the order of importance of some variables differed between the analyses. This result led to the need for further and in-depth analysis. The data set received from the Ministry was expanded as a result of the studies (own calculations) made in the meantime.

In the second stage of the analyses, the expanded data set was analyzed again using the Matlab 2022b Classification Learner program. As a result of this analysis, the results are tried to be predicted in the light of the available numerical data. As a result of this analysis, it is concluded that cognitive and social effects affected the discussions held in the commission. Variables are analyzed in order of importance using MRMR (Maximum Relevancy Minimum Redundancy) and Tobit analysis methods, which are carried out in parallel with this analysis, and the results are compared. MRMR and Tobit analyzes point out the existence of a hierarchical power relationship among the commission members.

As a result of the quantitative analyzes performed at this stage, it is concluded that there are cognitive and social effects in the decision-making process of the commission members. At this stage, a second survey (2nd Survey) is designed. In

line with the results obtained as a result of the analyses, possible social and cognitive effects are reflected in the survey questions. The data obtained as a result of the survey was digitalized and simulated with Agent-Based Modeling (ABM).

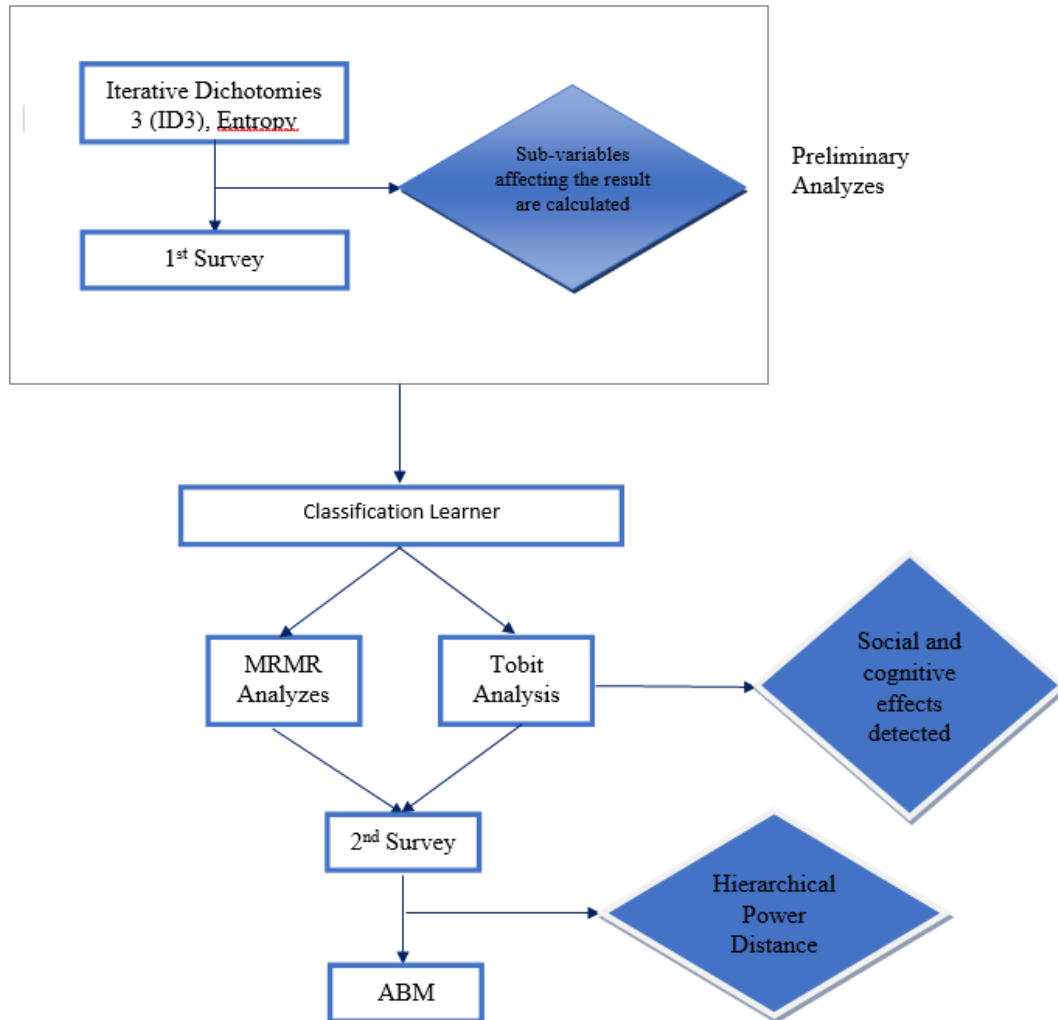


Figure 5. 1. Analysis Flow Chart

As a result, the existence of cognitive and social effects in decision-making processes has been proven. It was concluded that the hierarchical power relationship was the most dominant variable among these effects.

5.2. Preliminary Analyses

Agent Based Modeling (ABM) is used as a method in this dissertation. Features and details of ABM can be found in the relevant chapter. under the Analysis Chapter.

Accordingly, ABM's features are autonomous, heterogeneous, active (proactive/target oriented, reactive/perceptive, bounded rationality, interactive/communicative, mobility and adaptation/learning). With these features, it has been chosen as a suitable method for blockchain-based decision making. On the other hand, in this Chapter, a preliminary analysis is carried out using Machine Learning algorithms. The aim of this study is to verify the results of the analysis studies that will be done intensively in the next chapter, to test the general results from the variables used and to use the current entropy application in the thesis.

The purpose of Machine Learning (ML) is to build computer programs that can learn. With this method, the computer program, which is run with past data, can predict a similar future with little or no data (Ayodele, 2014). Moreover, the data used in ML algorithms can be continuous, binary or categorical. Decision tree algorithms (DT), in which a set of values with both numeric and yes/no answers are branched according to a threshold value, on the other hand, are among the most used ML algorithms. There are several Types of DT algorithms (Abdulazeez, 2021) such as Iterative Dichotomies 3 (ID3), Successor of ID3 (C4.5), Classification And Regression Tree(CART), Chi-squared Automatic Interaction Detector(CHAID), Multivariate Adaptive Regression Splines (MARS), Generalized, Unbiased, Interaction Detection and Estimation (GUIDE), Conditional Inference Trees (CTREE), Classification Rule with Unbiased Interaction Selection and Estimation (CRUISE), Quick, Unbiased and Efficient Statistical Tree (QUEST).

The example of DT (ID3), in which the decision to play golf in the open air is made according to the weather conditions, is shown in Table 5.1 (Al-sagheer and Al-haboobi, 2020)

Table 5. 1. Weather Data Set (Al-sagheer and Al-haboobi, 2020)

Outlook	Temp	Humidity	Windy	Play Golf
Rain	Hot	High	False	No
Rain	Hot	High	True	No
Overcast	Hot	High	False	Yes

Table 5.1. (continued)

Sunny	Mild	High	False	Yes
Sunny	Cool	Normal	True	No
Overcast	Cool	Normal	True	Yes
Rain	Mild	High	False	No

The entropy of the data is calculated for the formation of new branches in the DT. Entropy calculates the effect of that dataset on the final decision. Accordingly, it can be calculated how effective the dataset is on the final decision or whether it is/is not. The formula for entropy calculation is as follows (Al-sagheer and Al-haboobi, 2020). $E(S) = \sum_{i=1}^c -P_i \log_2 P_i$ $P_i = P_i$ is the ratio of S belonging to class i.

The DT (ID3) version of the decision-making processes of the R&D centers carried out by the Ministry of Industry and Technology can be seen in Table 5.2.

As can be seen in Table 5.2, the structure of the data we have conforms to the Machine Learning Decision Tree (ID3) structure. In addition, since a blockchain decision-making is not currently used, either simulations or ML algorithms would be used to design a future. Simulation method is chosen as the method of dissertation. An algorithm trained with the ML method can predict the future appropriately. For this reason, a combination of Agent Based Modeling (ABM) and Machine Learning (ML) methods is used in this dissertation.

The features of ABM are enumerated in the paragraph above. However, as can be seen in Table 4.2 in the data obtained from the Ministry of Industry and Technology, no data suitable for the characteristics of ABM such as autonomous and heterogeneous structure could be obtained. To give an example, although the commission members can decide of their own free will, as indicated in the data in Table 5.2 all the commission members gave either a yes or no decision for result. No contrary decision has been made. This situation violates the heterogeneity feature of ABM. Due to these reasons, the validation phase was carried out using Python, which is the general coding language used for ML as it is easier and more convenient, instead of the specialized Netlogo software language for ABM, which is also used as a method.

5.3. Results

Each iteration of the Iterative Dichotomiser 3 (ID3) algorithm used in the decision tree experiment makes an entropy calculation according to the formula. According to this account, the decision tree branches. There is no branching in the parts where the entropy is 0, so it is concluded that this part has no effect on the decision. The entropy calculated in each iteration finds how much information can be obtained from that variable (Ogheneovo and Nlerum, 2020). It can be concluded that more results can be obtained from a variable with a lower entropy.

In the study, the opinions of the observer and the commission members, academics, the Representative of the Ministry of Treasury and Finance, and the Ministry personnel's decision have no effect on the final decision; That is, its entropy is equal to 0.

After the coding on Python, it was calculated that the most influential variable on the support decision is the number of personnel with a doctorate specified in the company's application file. This is followed by the total Intellectual Property Rights (IPR) and the number of articles owned by the company with a high entropy difference. In the third place in importance, there is a surplus of personnel with a master's degree. The fourth place is shared by the number of R&D projects supported by the company by other public institutions and organizations and the abundance of training opportunities it offers to its personnel during the application period. Moreover, the surplus of other unsupported R&D projects of the company ranks fifth. The factor that has the least effect on the decision is the number of collaborations with other R&D centers and universities.

As a result, the impact of individual decisions of the commission members could not be measured, as a unanimous policy was followed in incentive decisions in the data provided by MOIT. Since the first original data of the MOIT contains the detailed application form content of the companies applying for the incentive, the effect of the information in this form on the incentive decision was measured, and it was calculated that the highest impact was on the density of the qualified human resources of the applicant company.

Table 5. 2. R&D Centers Data Set in DT ID3 Format

Sector	# of Projects Supported	# of Projects Unsupported	# of Collaboration	# of Activity	# of IPR and article	# of Employee	# of Employee (Msc)	# of Employee (PhD)	Observer 1 Decision	Observer 2 Decision	Academician1	Academician2	Representative of Ministry of Treasure	Sector Representative	Head of Department	Result
Machinery and Equipment Manufacturing	4	7	7	3	1	19	1	0	No	No	No	No	No	No	No	NO
Computer and Communication Technologies	4	3	6	10	9	19	1	0	No	No	No	No	N/A	No	No	NO
Software	0	8	4	24	0	45	3	1	No	No	No	No	No	No	No	NO
Manufacturing Industry	2	5	17	17	0	22	1	0	No	No	No	No	N/A	No	No	NO
Automotive Supply Industry	0	4	0	0	0	19	0	0	Yes	No	No	No	N/A	No	No	NO
Banking and finance	0	7	2	44	5	19	6	1	No	Yes	No	No	No	No	No	NO
Software	1	5	9	5	0	27	6	0	No	No	No	No	No	No	No	NO
Media and Communication	0	6	27	18	2	24	8	0	No	Yes	No	No	N/A	No	No	NO
Manufacturing Industry	0	10	8	15	0	31	2	0	No	Yes	No	No	N/A	No	No	NO
Tire-Plastic-Rubber	0	10	12	26	61	21	1	0	Yes	No	No	No	No	No	No	NO
Software	1	46	26	149	29	30	11	9	Yes	Yes	Yes	Yes	Yes	Yes	Yes	YES
Agriculture	2	40	8	47	10	57	0	1	Yes	Yes	Yes	Yes	N/A	Yes	Yes	YES
Textile	2	16	59	55	10	27	1	0	Yes	Yes	Yes	Yes	N/A	Yes	Yes	YES
Food industry	2	9	45	48	0	20	9	0	No	Yes	Yes	Yes	N/A	Yes	Yes	YES
Medicine	0	15	47	0	0	66	0	10	Yes	Yes	Yes	Yes	Yes	Yes	Yes	YES
Transport and Logistics	0	7	6	0	0	20	1	1	Yes	No	Yes	Yes	N/A	Yes	Yes	YES
Defense Industry	4	1	0	2	0	20	1	1	No	Yes	Yes	Yes	Yes	Yes	Yes	YES
Agriculture	0	12	10	5	0	29	2	0	Yes	Yes	Yes	Yes	Yes	Yes	Yes	YES
Durable Goods	7	8	5	5	6	39	19	8	Yes	Yes	Yes	Yes	N/A	Yes	Yes	YES
Paper and Paper Products	0	8	7	17	0	20	4	0	Yes	Yes	Yes	Yes	Yes	Yes	Yes	YES
Textile	2	17	20	12	0	20	3	0	Yes	Yes	Yes	Yes	N/A	Yes	Yes	YES
Chemistry	2	9	45	48	0	20	9	0	Yes	Yes	Yes	Yes	N/A	Yes	Yes	YES
Electronic	0	4	1	2	0	19	0	0	Yes	Yes	Yes	Yes	N/A	Yes	Yes	YES

5.4. Results from Machine Learning

Each iteration of the Iterative Dichotomiser 3 (ID3) algorithm used in the Decision Tree experiment makes an entropy calculation according to the formula. According to this account, the Decision Tree branches. There is no branching in the parts where the entropy is 0, so it is concluded that this part has no effect on the decision. The entropy calculated in each iteration finds how much information can be obtained from that variable. Accordingly, it can be concluded that more results can be obtained from a variable with a lower entropy (Ogheneovo and Nlerum, 2020).

In the study, the opinions of the Observer and the commission members, academics, the Representative of the Ministry of Treasury and Finance, and decision of Head Department of Department have no effect on the final decision; that is, its entropy is equal to 0.

After the coding on Python, it was calculated that the most influential variable on the support decision is the number of personnel with a doctorate specified in the company's application file. This is followed by the total Intellectual Property Rights (IPR) and the number of articles owned by the company with a high entropy difference. In the third place in importance, there is a surplus of personnel with a master's degree. The fourth place is shared by the number of R&D projects supported by the company by other public institutions and organizations and the abundance of training opportunities it offers to its personnel during the application period. Moreover, the surplus of other unsupported R&D projects of the company ranks fifth. The factor that has the least effect on the decision is the number of collaborations with other R&D centers and universities.

5.5. First Survey

In order to compare with the calculations made on the algorithm, a survey was conducted with the commission members who have participated in the selection of R&D Centers at least once since 2009. The aim of this survey¹¹ is to determine

¹¹ Research conducted within and/or outside of the Middle East Technical University that requires obtaining data from human participants will not allow any foreseeable ethical problems. The Middle

which main and sub-variables are more dominant on decision making. At the same time, these variables are used as inputs in the ML algorithm. If these variables are repeated.

- Application File
 - The number of Projects
 - The number of Supported Projects (number of supported projects in public institutions and organizations)
 - The Number of Unsupported Projects (number of R&D projects with the company's own resources)
 - The number of Collaborations (the sum of collaborations between universities, other R&D Centers)
 - The number of Activity (the sum of education, congress and conference attendance)
 - Total number of IPR and article
 - Total R&D personnel
 - Number of personnel with PhD
 - Number of personnel with Msc
- Observers' Decision (Expresses the decision of the observer making the application)
 - Graduation from PhD (as years)
 - Title (Dr. Assoc. Dr. or Prof.)
 - Rank of University (according to the Times Higher Education Index (THE))
- Committee Member Academician
 - Gender
 - Knowledge Stock
 - Number of publishing
 - Number of patents
 - Hierarchical Power Distance

East Technical University Human Research Ethics Committee (IAEK) was formed to evaluate whether it was designed in such a way that. The survey carried out within the scope of dissertation was made based on the permission of İAEK dated 15/02/2022 and numbered 286220816. (See Appendix A)

- Graduation from PhD (as years)
- Title (Dr. Assoc. Dr. or Prof.)
- Rank of University (according to the Times Higher Education Index (THE))
- Committee Member Representative of Ministry of Treasure
- Committee Member Sector Representative
- Committee Head of Department

Within the scope of the survey, the contact information of 1755 commission members who took part in the decision of the R&D centers at least once were determined, and the survey link was sent to them via e-mail. 96 people responded to this survey. This amount is enough for %95 accuracy.

5.6. First Survey 's Results

Unlike the decision tree algorithm results, the survey participants reported the most important factor in their decisions as the reports from the observer. The company's application report ranks second in importance. In the qualitative analyzes, the most important variable in the positive decision was found to be the human resource of the company (especially the most important variable, the number of personnel with a doctorate). In the survey results, the most important criterion among the application report variables is the number of projects carried out by the company.

5.7. Analysis on the Importance of Commission

Companies applying for incentives given to R&D Centers subject to dissertation undergo a 3-stage evaluation (See Figure 5.2). Accordingly, the firm first fills out an "Application Form" in a certain format.

The data in this form provides a preliminary assessment of the company for the observers and commission members.

After the application report is sent to the institution where the evaluation is made, at least two academicians visit the firm as observers. Their selection depends on the

activities of the firm and the contents of the projects (Ministry of Science and Technology, 2017).

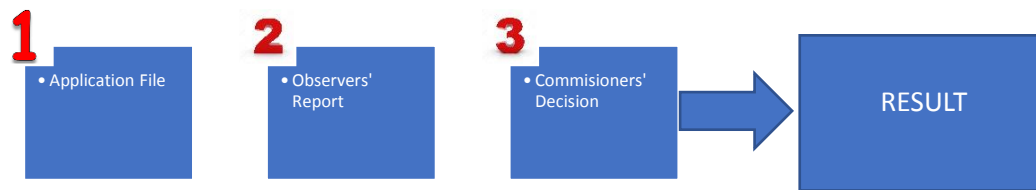


Figure 5. 2. The application process of R&D and Design Center's Application

During the visit, the observer examines the projects in the application file of company application file and the physical condition of the center and writes a report. At the end of the report, it states whether the company meets the necessary conditions to become a R&D or Design Center. The result of the report is either yes or no in a binary format.

The company's application report comes before the final decision makers of the committee, which includes 2 academicians, 1 non-governmental organization representative, 1 ministry representative, these members will have made a preliminary decision on these reports before the commission members meet. On the decision day, the company makes a presentation that includes the elements in the application reports (projects, attended events, personnel qualifications, training given to personnel, developments specific to IPR). After this presentation, the commission members make a decision on the acceptance or rejection of the application. After this presentation, the last stage “Group Decision Making” stage takes places whether application rejected or accepted.

Also, the effects of the last processes on the final decision are analyzed for the accuracy and importance of the study. This subsection deals with these analyses.

For the first analysis, the data containing the application reports of the companies, the views of the observer and commission members are taken from the Ministry of Industry and Technology, which is the authorized institution. Within the scope of the analysis at this stage of the dissertation, Trials were conducted to examine the effect of the sub-stages in the application process shown in Figure 6.1 on the decision to

support individually or collectively. Trials are made with Matlab R2022b Classification Learner. Classification Learner is a software that allows choosing the best statistical method among many methods. In this software, some of the data is reserved for testing. The separated test data shows how accurately the outcome (the binary decision of yes/no for the dissertation) can be predicted with the best method. In addition, with the Machine Learning algorithms (Kotsiantis, Zaharakis and Pintelas, 2006; Chamorro-Atalaya *et al.*, 2021) , the computer tries to predict the results with the data reserved for the training.

Although the application form and observer reports have a proportional weight in EU funds, the decision of the commission has a great influence on the final decision in all the supports programs examined (European Commission, 2014). However, the observer reports submitted to commission are used only for consultation for the R&D and Design incentives given by the Ministry. In other words, the members of the commission can make their decisions regardless of these reports. For this reason, commission dynamics are worth studying.

Each process mentioned in Figure 6.1 also has some sub-processes. To give an example, the application reports of the companies show the number of projects supported by other public institutions, collaborations with other institutions per researcher (these are domestic and foreign institutions, including universities, other R&D centers), the total number of researchers, and IPR activity per researcher.

Finally, the effect of the above-mentioned variables on the final decision is analyzed in this Chapter. As test method, "*Maximum Relevance Minimum Redundancy (MRMR)*" values in Matlab R2022b Classification Learner software are checked.

MRMR can provide the prediction accuracy by eliminating irrelevant features, accelerating the model training and prediction speed, reducing the monitoring and maintenance workload for feature data pipeline, and supplying better model interpretation and diagnosis capability (Zhao, Anand and Wang, 2019). As a result, MRMR allows researchers to determine the most important variable among variables and sub-variables.

5.7.1. Trial 1

In the first attempt, the actual situation in Figure 5.3 is studied with machine learning.

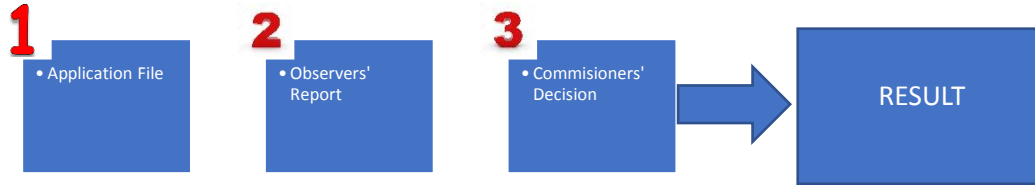


Figure 5.3. The Application Process Of R&D And Design Center's Application

As predicted, the computer found the model above with 100% accuracy. The studied models and their estimated percentages are given in Figure 5.4¹²

Sort by: Model Number		
1	Tree	Accuracy (Validation): 100.0%
Last change: Fine Tree 15/15 features		
2.1	Tree	Accuracy (Validation): 100.0%
Last change: Fine Tree 15/15 features		
2.2	Tree	Accuracy (Validation): 100.0%
Last change: Medium Tree 15/15 features		
2.3	Tree	Accuracy (Validation): 100.0%
Last change: Coarse Tree 15/15 features		
2.4	KNN	Accuracy (Validation): 96.0%
Last change: Fine KNN 15/15 features		
2.5	KNN	Accuracy (Validation): 98.0%
Last change: Medium KNN 15/15 features		
2.6	KNN	Accuracy (Validation): 50.0%
Last change: Coarse KNN 15/15 features		
2.7	KNN	Accuracy (Validation): 98.0%
Last change: Cosine KNN 15/15 features		

Figure 5.4. Statistical models and percentages of accuracy for Trial 1

The reason for this margin of truth is that, as stated, the final decision was made by the commission. The applications that the commission said yes were accepted, while those that voted against were rejected. For this reason, the accuracy is 100%.

Moreover, when the feature ranking is examined by MRMR analysis, naturally, the opinion of the academician is the most influential variable. Table 5.3 shows MRMR results for Trial 1.

¹² In the study, the "Fine Tree" model will be taken as a basis in terms of being a unity of practice and resembling the decision tree of the project decision process.

Table 5. 3. Feature importance scores sorted using MRMR algorithm.

Features	MRMR
Commission Member Academician's Decision	0.6931
Total Number of Activity	0.5783

5.7.2. Trial 2

In this trial, commission data and phase is omitted and a situation like Figure 5.5 is analyzed.



Figure 5. 5. The Application Process Of R&D and Design Center's Application

If there was a situation like Figure 5.5, Matlab R2022b Classification Learner application could predict the application result with the accuracy in Figure 5.6.

In this trial, Medium KNN and Coarse Gaussian SVM methods estimated correctly with the highest rate of 84%, while the SVM Kernell method was found to be correct with the lowest rate of 48%.

3.1 Tree	Accuracy (Validation): 78.0%
Last change: Fine Tree	10/10 features
3.2 Tree	Accuracy (Validation): 78.0%
Last change: Medium Tree	10/10 features
3.3 Tree	Accuracy (Validation): 74.0%
Last change: Coarse Tree	10/10 features
3.4 Linear Discriminant	Accuracy (Validation): 76.0%
Last change: Linear Discriminant	10/10 features
3.5 Quadratic Discriminant	Failed
Last change: Quadratic Discriminant	10/10 features
3.6 Logistic Regression	Accuracy (Validation): 70.0%
Last change: Logistic Regression	10/10 features
3.7 Naive Bayes	Failed
Last change: Gaussian Naive Bayes	10/10 features
3.8 Naive Bayes	Accuracy (Validation): 60.0%
Last change: Kernel Naive Bayes	10/10 features
3.9 SVM	Accuracy (Validation): 78.0%
Last change: Linear SVM	10/10 features
3.10 SVM	Accuracy (Validation): 74.0%
Last change: Quadratic SVM	10/10 features
3.11 SVM	Accuracy (Validation): 74.0%
Last change: Cubic SVM	10/10 features
3.12 SVM	Accuracy (Validation): 66.0%
Last change: Fine Gaussian SVM	10/10 features

Figure 5. 6. Statistical Models and Percentages of Accuracy for Trial 2

Looking at the Fine Tree method in terms of application unity, it is seen that the accuracy drops to 78%. Accordingly, the program found the results of 11 applications in total out of 50 test data to be incorrect (see Figure 5.7).

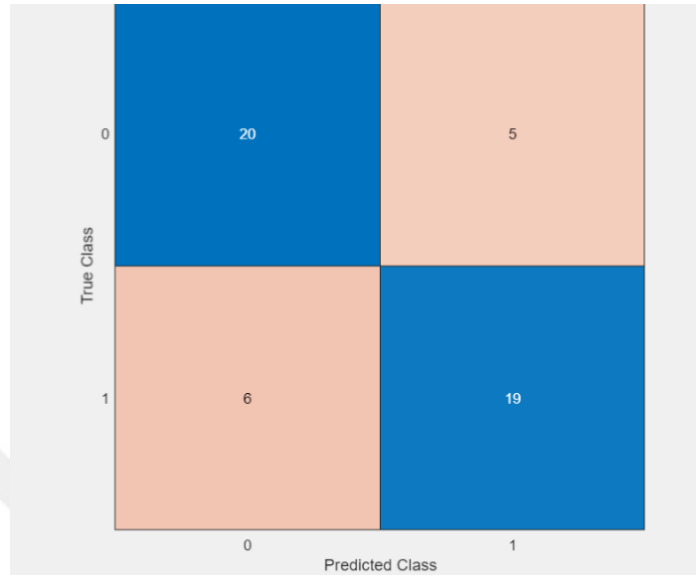


Figure 5. 7. Confusion Matrix of Trial 2

The order of importance of the features according to the MRMR algorithm is as follows for Trial 2 in Table 5.7.

Table 5. 4. Feature Importance Scores Sorted Using MRMR Algorithm

Features	MRMR
Observer Decision	0.2262
Total Number of Supported Projects Divided by Total Researcher	0.0914
Total Number of IPR Activity Divided by Total Researcher	0.0260
Total PhD Holder Researcher Divided by Total Researcher	0.0082
Total Number of Unsupported Projects Divided by Total Researcher	0.0049
Total Number of Researcher	0.005

Accordingly, it is seen that the decision of the observer who makes the on-site examination of the company applying for incentives is the most influential variable on the final decision.

5.7.3. Trial 3

Considering the effect of the "Application Report" presented by the companies in the decision of the R&D and Design Center support (Figure 5.8), the impact of the report on the final decision decreases dramatically. Accordingly, while the highest estimation is with 56% (Fine KNN), this rate drops to 48% (Coarse KNN).

In this trial, commission data is omitted and a situation like Figure 5.8 is analyzed.

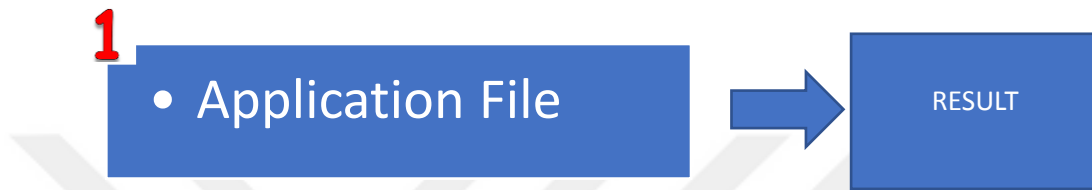


Figure 5. 8. The Application Process of R&D and Design Center's Application

According to the "Fine Tree" method, which is common among all trials, this rate is 52% (Figure 5.9).

1 Tree	Accuracy (Validation): 52.0%
ast change: Fine Tree	8/8 features
2.1 Tree	Accuracy (Validation): 52.0%
ast change: Fine Tree	8/8 features
2.2 Tree	Accuracy (Validation): 52.0%
ast change: Medium Tree	8/8 features
2.3 Tree	Accuracy (Validation): 52.0%
ast change: Coarse Tree	8/8 features
2.4 KNN	Accuracy (Validation): 46.0%
ast change: Fine KNN	8/8 features
2.5 KNN	Accuracy (Validation): 56.0%
ast change: Medium KNN	8/8 features
2.6 KNN	Accuracy (Validation): 48.0%
ast change: Coarse KNN	8/8 features
2.7 KNN	Accuracy (Validation): 56.0%
ast change: Cosine KNN	8/8 features
2.8 KNN	Accuracy (Validation): 56.0%
ast change: Cubic KNN	8/8 features
2.9 KNN	Accuracy (Validation): 56.0%
ast change: Weighted KNN	8/8 features

Figure 5. 9. Statistical models and percentages of accuracy for Trial 3

Looking at the confusion matrix, the number of errors for 50 applications is 24 (Figure 5.10).

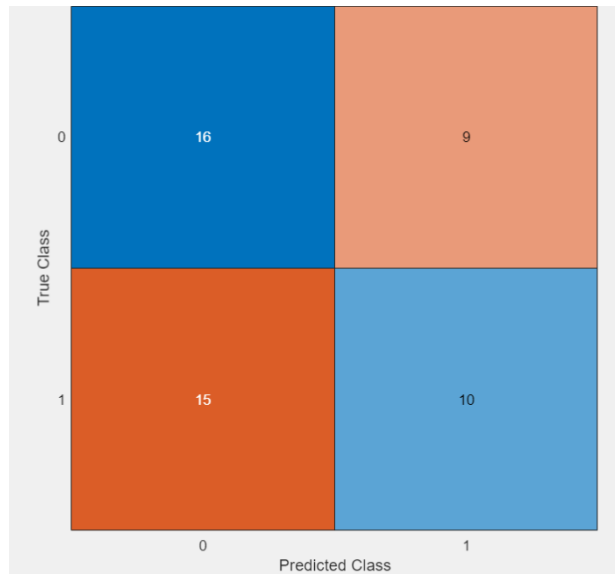


Figure 5. 10. Confusion matrix of Trial 3

The MOIT requests some quantitative data from companies in their R&D and Design Center applications. The order of importance (MRMR) of these data is shown in Table 5.5.

Table 5. 5. Feature Importance Scores Sorted Using MRMR Algorithm

Features	MRMR
Total Number of Supported Projects Divided by Total Researcher	0.0638
Total Number of Researcher	0.0277
Total Number of IPR Activity Divided by Total Researcher	0.0035
Total PhD Holder Researcher Divided by Total Researcher	0.0012
Total Number of Unsupported Projects Divided by Total Researcher	0.008

Table 5.5 is in agreement with the tables in other trials. Accordingly, the company's ability to do a project seems to be the most influential feature on the decision to be accepted for the application. In addition, the number of researchers in the center is another important feature in the decision-making process.

Thirdly, it is important for decision makers to translate the results of R&D and Design activities of the company into patents, design registrations, publications, or articles.

Another issue that the decision-making commission members attach importance to is the employment rate of doctoral graduate personnel who are seen as the source of academic knowledge within the applicant company.

5.7.4. Trial 4

In the absence of a company's application report, machine learning can estimate 100% as the commission phase is the last and most effective phase in decision making, as stated in Trial 1 (Figure 5.11).

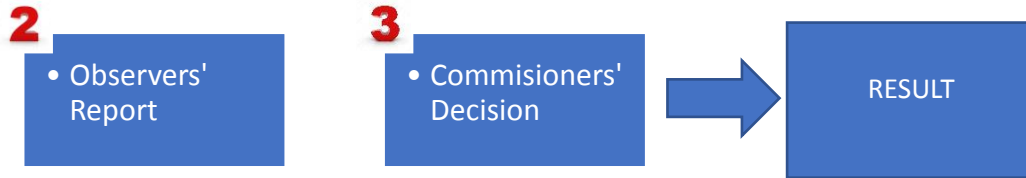


Figure 5. 11. The Application Process of R&D And Design Center's Application

As a result, according to the MRMR algorithm, the sub-variables of the commissions are statistically significant.

5.7.5. Trial 5

In this fifth experiment, where only the effect of observer decisions on the final decision is examined (Figure 5.12), the effect of observer opinions on the final decision varies by minimum 50% and maximum 86% according to the methods.

If any of the Kernel Naive Bayes, Medium KNN, Coarse KNN, Cosine KNN, Fine Gaussian SVM, Coarse Gaussian SVM and Logistic Regression Kernel methods are used, the machine can predict the result with 86% accuracy with this data.

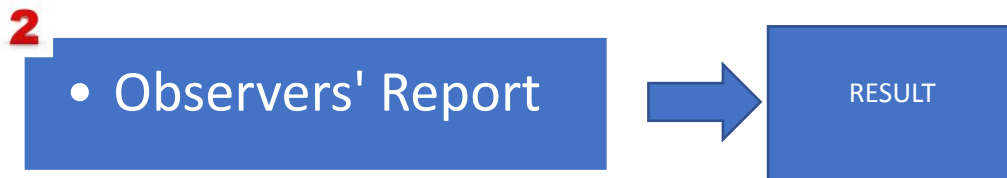


Figure 5. 12. The Application Process Of R&D and Design Center's Application

Out of 50 real applications, the machine guessed 10 incorrectly, with only the observer reports. (Figure 5.13) Accordingly this amount of incorrect guess proves the effect of cognitive effects of hierarchical power distance. Because of this hierarchical power distance effect is worth to study.

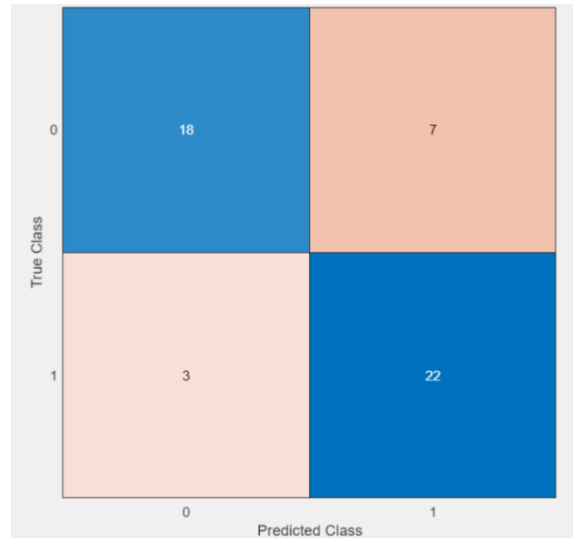


Figure 5. 13. Confusion matrix of Trial 5

As a result, it is revealed that the opinions of the observer academics are of great importance in the decisions of the commission members. Observers' reports have a greater impact on the final decision than the application report.

5.7.6. Trial 6

Finally, when only the commission data and the final decision are compared, the machine can estimate the result with 100% accuracy. This result is an expected result when looked at previous trials. This situation also supports our proposition in dissertation.

In this dissertation, we are trying to move the decision-making environment to the blockchain environment. These trials also show that commission dynamics are worth studying (Figure 5.14). As indicated before commission has extensive power on final decision.

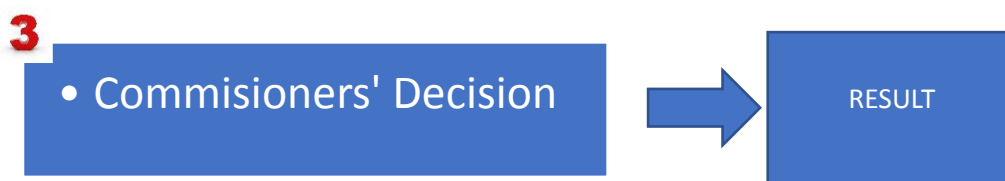


Figure 5. 14. The Application Process of R&D and Design Center's Application

Decision making is a dynamic process. In this process, abstract concepts such as the character traits of the decision makers have an impact on the final decision, as well as factors such as the decision makers' experiences, knowledge, and hierarchical positions.

Decision-making dynamics will be detailed in the next section by considering intangible and tangible elements. Title and time since doctoral graduation can be given as examples of concrete variables. Abstractly, hierarchical power distance and character traits can be given as examples.

In this section, the effects of quantitative data on the final decision are analyzed. Accordingly, the compatibility (sector match) of the commission member and the applicant company, commissioners' total number of publications, the time passed from doctorate graduation date, their title, the Times Higher Education (THE) ranking of the university they work at, the total number of patents they hold (in the Table 5.6 the digitization methods of these variables are determined), and the factor of influence on the final decision of the commissions are analyzed.

Table 5. 6. Numerical Data and Definitions of Academics Who Are Members of the Decision-Making Commission

Feature	Value	Description	Details
Sector match	No (0)	If decision maker's interests do not match with applicant's sector	In case of sectoral harmony, it is thought that the knowledge mismatch between the applicant and the evaluator will be less.
	Yes (1)	If decision maker's interests match with applicant's sector	
Total number of Publications	Numeric value	If it is high, it will be more effective	The total number of publications represents the numerical evaluation of the decision maker's general knowledge

Table 5.6. (continued)

Graduation from PhD	Numeric value (years)	If it is high, it will be more effective	The time taken from doctoral graduation represents the experience and knowledge of the decision maker
Title	Prof. (3)	The higher the title, the higher the numerical value given	Hierarchical power distance digitized
	Assoc. Prof. (2)		
	Dr. (1)		
Times Higher Education (THE) ranking of the university	Numeric value	If it is low, it will be more effective	It is thought that academics who are decision-making commission members working at more reputable universities are ahead of the hierarchical power distance
Total number of patents	Numeric value	If it is high, it will be more effective	The total number of patents represents the numerical evaluation of the decision maker's general knowledge

As a result of the analysis done with Matlab R2022b Classification Learner software, the accuracy rate of the commission on the final decision was 61% compared to the Fine Tree method (While the Logistic Regression Kernel method predicted the highest rate with 63% accuracy, the Boosted Tree and Medium Neural Network methods were able to predict with 48% accuracy).

Accordingly, as a of the result of analyses done with 100 commissions' final decisions given in in Figure 5.15. As seen in this Figure below the machine can correctly predict 61 of 100 decisions.

Finally, commissions' decisions can be predicted with a maximum 63% accuracy rate. using numerical data available. Considering the remaining 37% variance, group decision-making dynamics, turning points on group members' decisions, and

conditions of influence are worth studying. These dynamics will be studied in the next part of the dissertation. Within these dynamics, especially in the case of decision-making in a face-to-face environment, effects such as hierarchical power distance will not be in a block-chain decision-making environment., How much the final decisions change in a more democratic and original decision-making environment is also discussed.

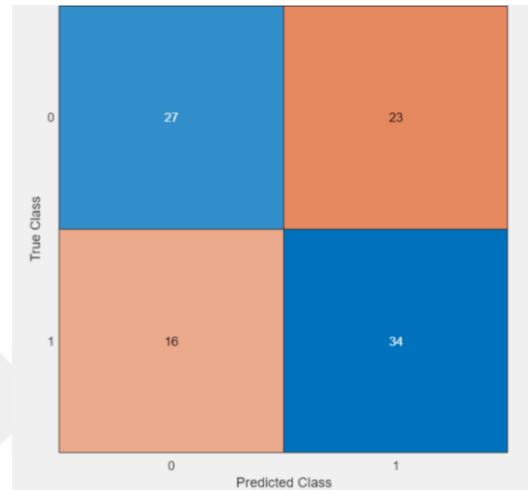


Figure 5. 15. Confusion matrix of Trial 7

Table 5.7 shows which variable is most effective on the decision by using the MRMR algorithm. Accordingly, it is observed that the most influential feature is the title of decision-making academics. This situation is in parallel with our study. Dissertation proposes that the "Hierarchical Power Distance", which consists of components such as the title and university, of the decision-making commission members in the blockchain environment will not have an effect. Since there is a human-machine type communication in the blockchain decision-making environment, it is assumed that there will be no hierarchical power distance effect. The analyzes have proven that in the current commission structure, decision makers are affected by the hierarchical power distance effect.

Table 5. 7. Feature Importance Scores Sorted Using MRMR Algorithm

Features	MRMR
Title	0.0156
Number of publications	0.0074

Table 5.7. (continued)

Number of patents	0.0010
Sectoral match	0.00007

In addition, other variables (such as number of publications and patents) are the second and third important variables. This situation shows the importance of information in decision making. Blockchain, on the other hand, offers to provide better quality information to decision makers at the decision-making stage, thanks to its immutable structure. This result agrees with the propositions made by dissertation.

5.8. Tobit Analysis and Comparison with Other Analysis

In the application report with the Iterative Dichotomiser 3 (ID3) method in the previous sections:

- The number of Projects
 - The number of Supported Projects (number of supported projects in public institutions and organizations)
 - The Number of Unsupported Projects (number of R&D Projects with the company's own resources)
- The number of Collaborations (the sum of collaborations between universities, other R&D Centers)
- The number of Activity (the sum of education, congress and conference attendance)
- Total number of IPR and article
- Total R&D personnel
 - Number of personnel with PhD
 - Number of personnel with MSc

included in the observer report with variables such as:

- Observers' Decision (Expresses the decision of the observer making the application)
- o Graduation from PhD (as years)

- o Title (Dr. Assoc. Dr. or Prof.)
- o Rank of University (according to the Times Higher Education Index (THE))

the effect of the variables on the commission decision is made by calculating entropy.

After this analysis, the effect of the observer's decision on the final decision has been calculated as limited. The effect of the number of doctorate and master's personnel included in the application report and the total number of R&D personnel on the decision is relatively high. Again, it has been calculated that the multiplicity of IPRs such as patents and registrations included in the application report have an impact on the decision.

A survey conducted with among 1755 people follows the preliminary analysis, it was asked which of the above-mentioned variables were effective in the decision of the commission, and it is stated that unlike the ID3 study, observer reports were more prominent. In the application report, on the other hand, the most important factor is stated as "excessive number of R&D projects".

This discrepancy between these qualitative and quantitative analyzes has led to the need for a second qualitative analysis.

For this reason, another comprehensive qualitative analysis is conducted within the scope of the Matlab "Classification Learner" program.

As a result of the analysis, it is found that the most important of the evaluation stages consisting of 3 consecutive steps during the R&D incentive application is the commission stage (Figure 5.16).

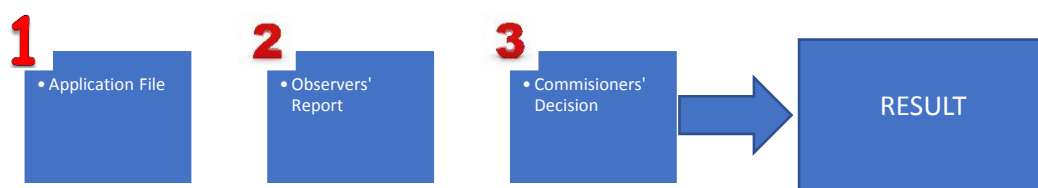


Figure 5. 16. The Application Process of R&D and Design Center's Application

It has been observed that the result of the "Classification Learner" method, in which all mathematical estimation methods are used, can be estimated at a rate of 63% at most, from the data coming from the first 2 stages.

Again, as a result of the Maximum Relevance Minimum Redundancy (MRMR) analysis (see Table 5.8), conducted within the program, the number of the total supported R&D projects is calculated as the first 2 important variables, similar to the results of the first survey.

Table 5. 8. Feature importance scores sorted using MRMR algorithm

Features	MRMR
Observer Decision	0.2262
Total Number of Supported Projects Divided by Total Researcher	0.0914
Total Number of IPR Activity Divided by Total Researcher	0.0260
Total PhD Holder Researcher Divided by Total Researcher	0.0082
Total Number of Unsupported Projects Divided by Total Researcher	0.0049
Total Number of Researcher	0.005

On the other hand, the number of doctorates and patents in the company are calculated as the third and fourth important variables, similar to the entropy calculation with MRMR analysis.

These similarities and differences between the results of two qualitative and one quantitative analysis revealed the need for validation of the results. For this reason, in this section, the results of the regression analysis performed with the "Tobit" method will be compared with the results of the previous 3 analyzes and all 4 analyzes will be evaluated.

5.8.1. Overview

Within the scope of the analysis, the data obtained from the Ministry of Industry (MoIT) and Technology and the variables created by using these data are used. Accordingly, 27 variables are used for the data of 100 R&D Centers determination

commission. These variables are abbreviated for use in Tobit analysis, these variables and their properties are listed in Table 6.7 and all data found in the analyzes are included in Appendix. C.

As with dissertation, the outcome of many strategic decisions is yes or no. In the *probit* and *logit* methods, which are used statistically, the probability of realization of the binary result with the data in hand is calculated (Amore and Murtinu, 2021). The *Tobit* method, which is a specialized type of the *probit* method, is used when there is a lot of data clustered around a certain number (0 and 1 for dissertation) and there is censored data that is not in the analysis but can affect the result of the analysis. An example of a concert where tickets were sold out long ago can be given to embody the latter situation. The number of ticketed spectators is not enough to measure the observer's interest in the concert (McDonald and Moffitt, 1980). The number of spectators who want to buy a ticket but cannot find a ticket is the censored data in this case.

There is a similar situation with dissertation, where the result is also binary. The cognitive effects that are investigated in the dissertation, the decision change points that he could not convert into data during the commission, and many numerical data that could not be obtained are censored variables that affect the result. For this reason, the Tobit method is preferred in this part of the analysis.

Stata v10 is used in Tobit analysis. The codes of the analysis and the content of "do file" are included in Appendix D. On the code page in question, there are codes for the analyzes performed and tests for the accuracy of the analysis. The accuracy of the analyzes and the suitability of the method used were tried to be validated with these tests.

Table 5. 9. Variable Descriptions Used in Tobit

Nr	Variable Name	Description	Data Source
1	sppro	Number of R&D projects supported by public funds of the applicant company	MOIT database
2	unsppro	Number of R&D projects funded by the applicant company with its own resources	MOIT database

Table 5.9. (continued)

3	coll	Total number of R&D personnel of the applicant company divided by the number of collaborations with other R&D centers and universities	MOIT database
4	act	The number of workshops and conferences attended by the applicant firm's R&D personnel divided by the total R&D personnel	MOIT database
5	ipr	The number of IPRs received by the applicant company divided by the total R&D personnel	MOIT database
6	emp	Number of R&D personnel of the applicant company	MOIT database
7	mscemp	Ratio of graduate (including students) R&D personnel of the applicant company to total personnel	MOIT database
8	phdemp	Ratio of PhD holder (including students) R&D personnel of the applicant company to total personnel	MOIT database
9	obs ¹³	Decision of the observer academic 0 no 1 yes	MOIT database
10	smatch	Compatibility of the field of study of the observer academic with the field of activity of the applicant company, 0 no 1 yes	Own calculation
11	phd	The observer refers to the time elapsed between the academician's doctoral graduation and the year he/she made the examination (years)	Own calculations
12	rank	Times Higher Education (THE) ranking of the university to which the observer academic is assigned during the review	Own calculations
13	acmsmatch	Compatibility of the work area of the academic member of the commission with the R&D projects of the applicant company	Own calculations
14	acpub	The total number of publications of the academician who is a member of the commission (only articles)	Avesis
15	acpat	Number of registered patents of the academician who is a member of the commission	Avesis
16	acphd	The period from the doctoral graduation of the academician who is a member of the commission to the year the application is made (years)	Own calculations
17	acrank	THE ranking of the university that the academic member of the commission is a member of in the year the evaluation is made	Own calculations
18	decision (dependent variable)	The status of the company's application after all examinations, 0 no 1 yes	MOIT database

5.8.2. Analysis

As stated, Tobit analysis is a type that includes the effect of the data that is distributed between the maximum and minimum two variables but cannot be

¹³ Observer and commission member academicians are 2 people for each application. The data of both observer academicians are used in the analyses. obs1 defines the first observer, while obs2 defines the other one. Therefore, the variables obs, smatch, phd, rank are included in the analyzes for 2 commissioners, and the variables acmsmatch, acpub, acpat, acphd, acrank are included in the analyzes separately for two academics who were members of the commission.

included in the analysis (as in the example of the concert example, where the supply does not meet the demand). For this reason, the analysis is done by putting limits (censored) on the maximum and minimum values. This censoring is applied to the highest and lowest values (left and right censored) in the analysis.

In the Tobit method of dissertation, the data are analyzed as right and left censored. For right censored analyzes, the u1 code is used as the highest 1 (yes) code for the decision dependent variable, and the 11(0) code is used for the left censored analyzes as the lowest 0 (no) code is used for the left censored analyzes (code). Appendix D for details and do file can be viewed).

Table 5.10 is obtained as a result of the right censored Tobit analysis. As a result of the analysis, the available data could be estimated at a rate of approximately 55% (R^2).

As seen in Table 5.10, unsppro, coll, ipr, phdemp, phd1, smatch2, phd2, acpub, acpat1, acrank1, and acpat2 variables are found to have a negative effect on the decision. Contrary to the analyzes in the previous section, it is noteworthy that the number of R&D projects (without support) (unppro), cooperation (coll), IPR (ipr) and doctoral personnel (phdemp) of the applicant company is calculated negatively in the Tobit method. On the other hand, it is a predictable result that the viewers are experts in their field (smatch2), their experience (phd2) is high, the number of publications (acpub) and the number of patents (acpat1 and acpat2) of the academics taking part in the commission negatively affect them. The expectations of the observer and commission members may be high, which can negatively affect the result.

On the other hand, the fact that the observer's decisions (obs1 and obs2) are the variables with the most significant effect on the result is also compatible with MRMR analysis. As stated in the relevant section, the observer decision was found to be significant and important in the MRMR analyses. On the other hand, as stated in the policy recommendation section, it is recommended to increase the effectiveness of audience reports on the final decision.

Table 5. 10. Right Censored Tobit Analysis Results

Tobit regression

Number of obs = 95

LR chi2(26) = 108.45

Prob > chi2 = 0.0000

Log likelihood = -44.568521

Pseudo R2 = 0.5489

decision	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
sppro	.0949456	.0418818	2.27	0.027	.0113936	.1784976
unsppro	-.0324087	.0133983	-2.42	0.018	-.0591376	-.0056798
coll	-.1022792	.0986181	-1.04	0.303	-.299017	.0944586
act	.0165735	.0388092	0.43	0.671	-.0608487	.0939958
ipr	-.2605547	.1314064	-1.98	0.051	-.5227032	.0015939
emp	.0034614	.0073394	0.47	0.639	-.0111802	.0181031
mscemp	1.249324	.7184822	1.74	0.087	-.1840083	2.682657
phdemp	-1.328388	1.847926	-0.72	0.475	-5.014899	2.358123
obs1	.5738977	.1553921	3.69	0.000	.263899	.8838965
smatch1	.0809853	.1596202	0.51	0.614	-.2374483	.3994188
phd1	-.0045527	.0111316	-0.41	0.684	-.0267597	.0176542
rank1	.000119	.0000489	2.43	0.018	.0000215	.0002165
obs2	.828626	.1666003	4.97	0.000	.4962674	1.160985
smatch2	-.1080353	.1004066	-1.08	0.286	-.308341	.0922704
phd2	-.0138439	.0110452	-1.25	0.214	-.0358785	.0081906
rank2	.0000419	.0000407	1.03	0.306	-.0000392	.0001231
acmsmatch1	.1072678	.1762531	0.61	0.545	-.2443475	.4588832
acpub1	-.0004686	.0010427	-0.45	0.655	-.0025488	.0016116
acpat1	-.0096324	.0841398	-0.11	0.909	-.1774868	.158222
acphd1	.0001067	.011184	0.01	0.992	-.0222047	.0224181
acrank1	-2.63e-06	.0000642	-0.04	0.967	-.0001308	.0001255
acmsmatch2	.2074502	.1470268	1.41	0.163	-.0858603	.5007606
acphd2	.0037982	.0016995	2.23	0.029	.0004078	.0071886
acpat2	-.0033761	.0244228	-0.14	0.890	-.0520983	.0453461
acpub2	.0152972	.0113546	1.35	0.182	-.0073547	.037949
acrank2	.0000851	.0000467	1.82	0.073	-8.11e-06	.0001783
_cons	-.9214754	.4384045	-2.10	0.039	-1.796068	-.0468824
/sigma	.4317713	.0495937			.3328346	.5307081

The fact that the knowledge and experience of the commission members (acpat, acphd and acrank) is significant proves the existence of the "hierarchical power distance" effect, the effect of which is examined in the next section.

As can be seen in Table 5.11, results similar to the left censored are obtained when the right censored Tobit analysis is performed. In this analysis, where the R^2 ratio is slightly higher, similarly in the left censored, observer decisions (obs1 and obs2) were calculated as the most influential variable on the final decision. The fact that the number of collaborations (coll) and the number of personnel with doctorate degrees (phdemp) from the application report is significant and high is also in line with the previous analyses. Therefore, the left censored Tobit method is compatible with previous analyses. On the other hand, the fact that the data at hand can predict the result at the rate of 63% is fully compatible with the machine learning results made within the scope of the Matlab Classification Learner program.

5.8.3. Results

As a result, Tobit analysis was found to be compatible with Matlab Classification Learner and MRMR analysis. The importance of the number of supported projects (sppro) and the number of personnel with doctorate (phdemp) determined in the ID3 analysis in the decision is also significant in the Tobit analyzes. As a result of the fact that the concrete data available in the Classification Learner analysis could predict the commission decision by 63%, it was found exactly the same in the Tobit (left censored) analysis. Again, the "hierarchical power distance" effect, which was determined in MRMR analyzes, was confirmed by the fact that the experience, knowledge and THE ranking of the university (acpub, acphd, acpat and acrank) variables of the academic member of the commission were significant in the Tobit analysis.

Table 5. 11. Left Censored Tobit Analysis Results

Tobit regression	Number of obs = 95
	LR chi2(26) = 126.84
	Prob > chi2 = 0.0000
Log likelihood = -36.579948	Pseudo R2 = 0.6342

decision	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
sppro	.0484447	.0241509	2.01	0.049	.0002649	.0966245
unsppro	-.0054717	.0092754	-0.59	0.557	-.0239756	.0130321
coll	.0728019	.0859995	0.85	0.400	-.0987625	.2443663
act	-.0749336	.0748023	-1.00	0.320	-.22416	.0742929
ipr	-.542592	.2528037	-2.15	0.035	-1.046922	-.0382624

Table 5.11. (continued)

emp	.0023683	.0055449	0.43	0.671	-.0086934	.01343
mscemp	.3560689	.5498527	0.65	0.519	-.7408572	1.452995
phdemp	.391295	1.162747	0.34	0.737	-1.928323	2.710913
obs1	.6476264	.1718452	3.77	0.000	.3048047	.9904481
smatch1	-.0561778	.148087	-0.38	0.706	-.3516034	.2392478
phd1	-.0085911	.008874	-0.97	0.336	-.0262943	.0091121
rank1	.0000444	.000034	1.31	0.196	-.0000234	.0001121
obs2	.9859364	.1662711	5.93	0.000	.6542345	1.317638
smatch2	-.081409	.1017275	-0.80	0.426	-.2843498	.1215318
phd2	-.0183128	.0110909	-1.65	0.103	-.0404385	.0038129
rank2	.0000248	.0000356	0.70	0.489	-.0000462	.0000958
acmsmatch1	.0029842	.1739758	0.02	0.986	-.3440879	.3500563
acpub1	.0005085	.0009278	0.55	0.585	-.0013423	.0023594
acpat1	-.017343	.2580893	-0.07	0.947	-.532217	.497531
acphd1	-.0050779	.0080217	-0.63	0.529	-.0210807	.0109249
acrank1	.000026	.0000502	0.52	0.606	-.0000741	.000126
acmsmatch2	.2090856	.1514478	1.38	0.172	-.0930445	.5112156
acphd2	.0004437	.0010693	0.41	0.679	-.0016895	.002577
acpat2	.0155391	.0308132	0.50	0.616	-.0459316	.0770097
acpub2	.0177104	.0086478	2.05	0.044	.0004585	.0349624
acrank2	.0000492	.0000318	1.55	0.126	-.0000141	.0001126
cons	-1.135662	.3497053	-3.25	0.002	-1.833305	-.4380189
/sigma	.3768354	.0410437			.2949555	.4587154

In summary, it has been determined that cognitive effects are also important in R&D commissions, apart from countable data and variables, and the "hierarchical power distance" effect that occurs during face-to-face commissions is of great importance on the final decision. In the next section, the importance of cognitive and hierarchical power distance effects in face-to-face commissions in the decision was determined by analysis methods. For this reason, it has been proven that decisions can be made away from these effects in secure online environments such as blockchain and it is also worth studying academically.

5.9. Decision-Making Dynamics

Until this part, studies on how important face-to-face commissions are in the selection decision of R&D centers are covered. In this part of dissertation, the roles

that emerge during group decision making and the effects of these roles on the decision will be introduced. This last part consists of two stages. In the first part, a survey study conducted among academicians who took part in decision-making is explained. In this survey study, how often and in what situations academics changed their decisions was examined. This survey is a second study that was conducted at a different time from the previous survey. Accordingly, the roles that emerge during the decision making and the effects of the roles on the final decision are weighted. The values obtained from here will be used in the last stage of "Agent Based Modeling". In the survey study, it is observed that there is a hierarchical difference between the decision-makers and this affects the final decision. In this study, a democratic tool is proposed in group decision making in the blockchain environment, where decision makers cannot delegate their responsibilities to other group members and can make decisions individually within the chain. Accordingly, the "hierarchical power distance" effect in the modeling is reset and the blockchain environment's cognitive effects are tested. In the absence of this effect, how the decisions change is observed.

5.10. Group Decision-Making Dynamics Survey

During face-to-face group decision making, the decisions of group members (academicians in this dissertation) are not always linear. The academician, who comes to the place and time of the commission by reading the information in the application file and the observer reports written as a result of the on-site examination of the applicant, comes to the commission with a certain dependence. On the other hand, in case of hesitation about the project applying for incentives, the academician may be affected by the discussions within the group and may approve a different decision than the initial one. Meanwhile academicians can change their initial decisions. As have been mentioned previously, the degree and extent of the impact depend on many variables. A survey¹⁴ study was conducted in order to convert one of these, "hierarchical power distance", which is likely to occur among academicians,

¹⁴ Research conducted within and/or outside of the Middle East Technical University that requires obtaining data from human participants will not allow any foreseeable ethical problems. The Middle East Technical University Human Research Ethics Committee (IAEK) was formed to evaluate whether it was designed in such a way that. The survey carried out within the scope of dissertation was made based on the permission of İAEK dated 15/02/2022 and numbered 286220816. (See Appendix A)

into a numerical value, and then model it with "agent-based modeling". Since blockchain technology has not yet been used in the public R&D fund system, there is no on data to analyze the effect of this technology on the funding system. For this reason, in this dissertation data were generated through simulation methods. For this reason, the following questionnaire is sent via e-mail to 3642 academicians registered in the academic pool of the Ministry of Industry and Technology, General Directorate of R&D Incentives, who have taken part in the commissions to which they are included in the R&D Centers incentive system by applying before or are likely to take part. An e-mail containing the survey link was sent to 3642 e-mail addresses registered in the ministry system. An automatic e-mail was sent from 67 of 3642 addresses stating that the e-mail did not reach. In this section, the survey and its results are discussed.

5.10.1. Overview

According to the Turkish Higher Education Institution (YÖK) December 2022 data, there are 97,709 academics in the country. Of the academics, 33,232 are Professors, 21,672 are Associate Professors, and 42,805 are doctor lecturers 888 (YÖK, Yüksek Öğretim Bilgi Sistemi, 2022). However, since the General Directorate of R&D incentives gives R&D center certificates to companies operating in the field of production and software in Turkey, they cannot work with academicians in all branches whose numbers are given above. There are a total of 21,309 academicians working in the faculties of architecture, computer and informatics, architecture and design, engineering, pharmacy, medicine and education that meet this requirement.

However, only 3642 of these academics registered their work by registering in the Ministry's system. 3642 is chosen as the universe because each of the 3642 people had the probability of working on the commissions at an equal rate (probability-based sampling) (Stuart and Murthy, 1969).

5.10.2. Sample Overview

In order for the academicians who are members of the commission to take part in the commissions where the R&D Centers are selected, they must be registered on the

web portal of the Ministry. According to their areas of expertise, commission members are selected from this portal and invited to the commission. For this reason, every registered academic has an equal chance of being a commission member. The sample used in the dissertation is determined as the academicians registered in this portal.

The distribution of the academicians in the sample according to their fields of specialization is given in Figure 5.17 Since the manufacturing industry is prioritized in the R&D Centers incentive program of the Ministry of Industry and Technology, most academics from engineering faculties are naturally invited to the commissions.

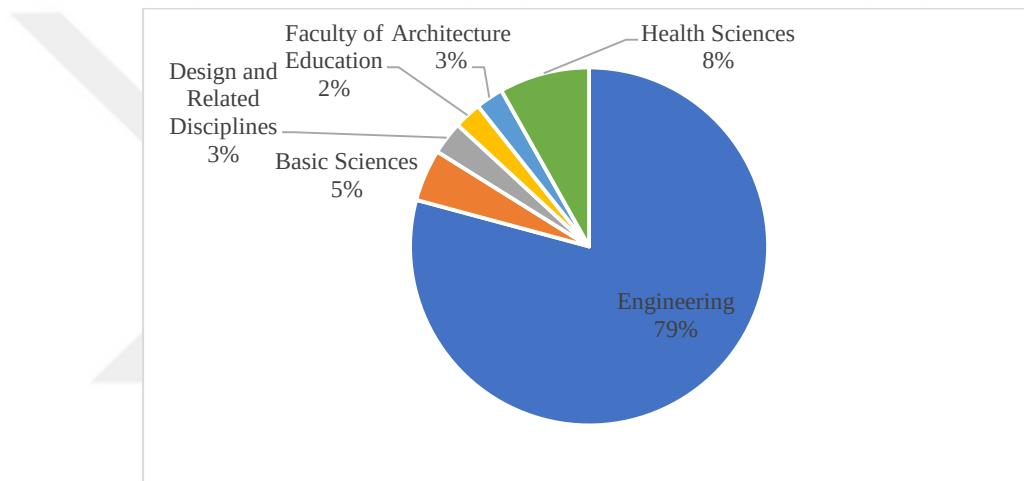


Figure 5. 17. Distribution of Academicians' Assigned/To Be Assigned to Commissions of R&D Centers by Field of Expertise

On the other hand, in dissertation, an analysis is not made according to the differences in the fields of expertise. This is because in the commissions where the applications are evaluated, the applications of the companies operating in the same field as the academicians' fields of expertise are evaluated in accordance with the relevant legislation. As a result, there is no power asymmetry between the fields of expertise. However, the analysis of a specialized expertise within the main areas of expertise is made in the "Agent Based Modeling" part of the dissertation. For example, if the applicant company operates in the field of electronic engineering, the commission that will evaluate it is composed of electronic engineering academicians. Information about this is available in the database of the Ministry. However, if the

company has projects in the field of "power electronics", which is a sub-branch of electronic engineering, there may not be an evaluator in the field of "power electronics" in the commission. The reason for this is that there are no sub-diffractions in the academician pool of the Ministry. In order to measure the effect of "unique knowledge" on decisions within the group, there are questions related to this in the questionnaire. This open questionnaire is tried to be closed with the ABM analysis afterwards.

The distribution of the sample according to their titles is shown in Figure 5.18 below. This distribution is also compatible with the distribution of the population responding to the survey.

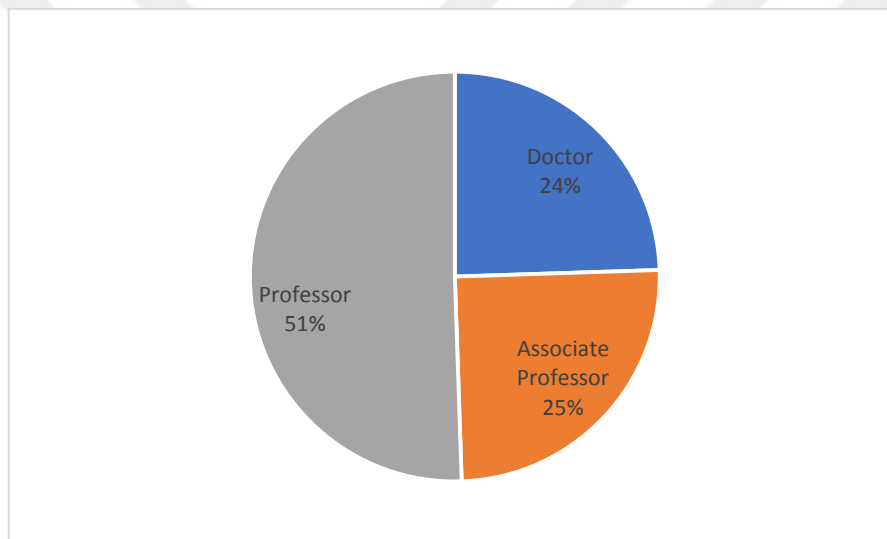


Figure 5. 18. Distribution of Academicians' Assigned/To Be Assigned to Commissions of R&D Centers by Field of Expertise

5.10.3. Survey Results

According to the probabilistic sampling method, the population surveyed should have an equal probability of reaching this survey (Martínez-Mesa *et al.*, 2016). For this reason, a questionnaire is sent to the e-mails in the Ministry database. Therefore, our sample is 3642 people, which is the number of people to whom e-mail is sent. Since e-mail never reaches 67 people for technical reasons, the exact sample is 3575. The sample is not chosen randomly, the academicians in the database are randomly enrolled. Since this database is used in the study and the participation of the

academicians in this study is equal, the method of the survey study is determined as "simple random sampling" (Stuart and Murthy, 1969), which is the purest sub-method of probabilistic sampling.

Out of 3575 academicians, 105 academicians completed the entire questionnaire and 115 completed halves of the survey.

For finite sample size, as in the study, sample size is calculated with the following formula.

$$Finte\ population = n' = \frac{n}{1 + \frac{z^2 \hat{p}(1-\hat{p})}{\epsilon^2 N}}$$

z is the z score

ε is the margin of error

N is the population size

ĥ is the population proportion.

For 3575 samples, the margin of error is determined as 9.47%, and the number calculated with this value and representing the whole with 95% confidence level is calculated as 105. This number is the same as the number of people who responded to the survey. For this reason, 95% of our survey respondents represent the whole. The questions asked to the academicians during the survey and their answers and results are as follows. The academicians are asked questions measuring a situation that is mostly encountered and their reactions to it. Since a numerical modeling will be made on the responses, a 5-point Likert scale is used to quantify the severity of the response. Since the study is conducted in Turkey, the language of the questionnaire is Turkish (Appendix B)

Q1) Your age?

- ☐ 25-29
- ☐ 30-34
- ☐ 35-39
- ☐ 40-44
- ☐ 45-49
- ☐ 50-54

- 55-59
- 60-64
- 65-69

Result:

The age distribution of respondents is shown in Figure 5.19 Accordingly, the highest number of participants was between the ages of 40-44 and 50-54. This range seems natural. It is estimated that there will be fewer academicians at young ages in Turkey, where it takes a long time to get a title. In addition, digital literacy was predicted to decrease with age due to the fact that the survey is conducted online, which confirms this result.

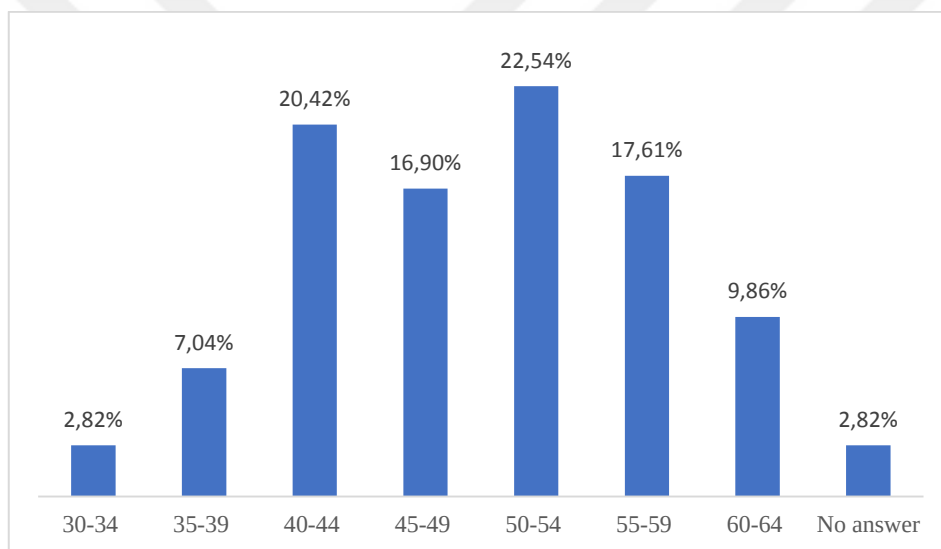


Figure 5. 19. Age Distribution of Survey Participants

Q2) Your title?

- Dr.
- Assoc. Dr.
- Prof. Dr.

Result:

Title distributions of respondents Figure 5.20 is also shown. This distribution shows similar pattern with the Figure 6.19 where the sample distribution is shown. This

result is important because the "hierarchical power distance" from the title will be tested in the dissertation. In case of a mismatch between the sample and the questionnaire, it was necessary to repeat the questionnaire for some titles.

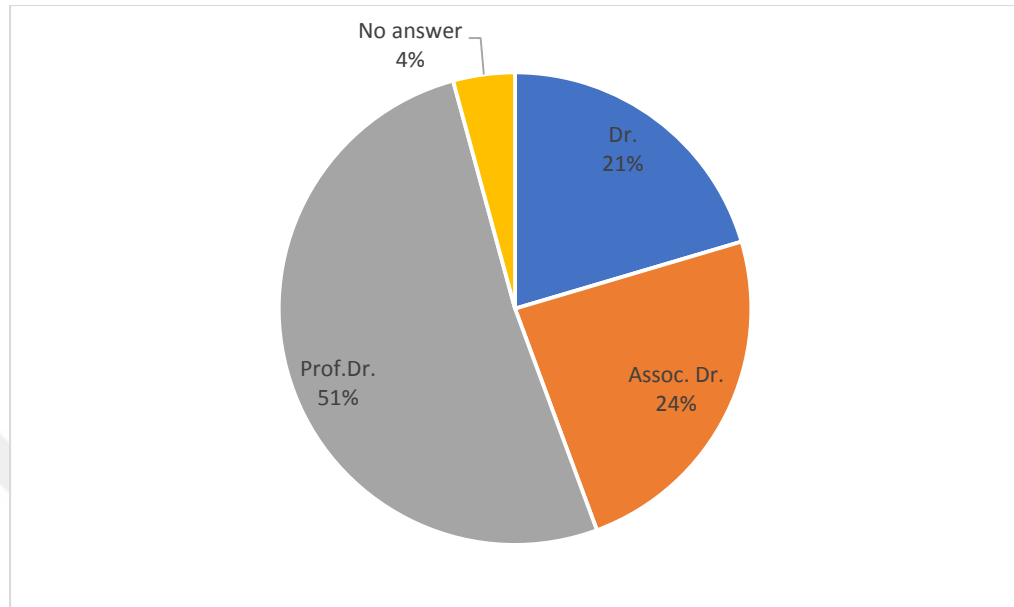


Figure 5. 20. Title Distribution of Survey Participants

Explanation:

In this part of the questionnaire, there is an explanation for the respondents. This is like the description:

"Decision-making consists of 2 stages. These are individual and group decision-making stages. In this thesis study, in which the factors affecting the document decision of the R&D Centers evaluated within the scope of the Law No. 5746 are studied, the committee member during the individual decision-making, the observer (2 academics) reports and the application process. In the application report, the number of researchers, doctoral and graduate personnel of the company, the events attended, the symposiums, the trainings given to the personnel, the number of articles, publications and patents are decisive. The other determining factor is the negative results. By looking at these two factors, the commission member who participates in the commission during the commission has a certain decision in mind (individual decision-making phase).

In this study, this situation is divided into two.

These are;

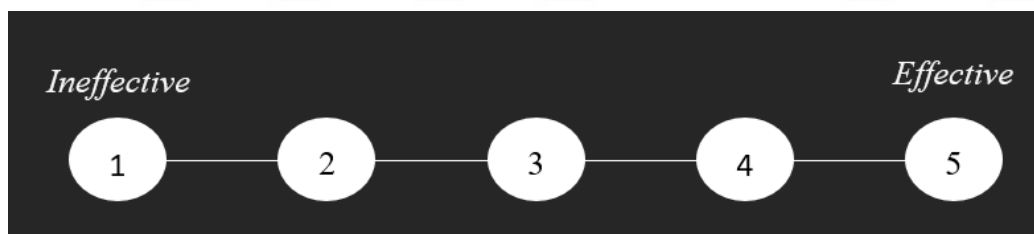
SCENARIO 1 (STABILITY: Individual decision was made before the commission meeting)

SCENARIO 2 (UNCERTAINTY: The individual decision has not yet been made before the commission meeting).

Accordingly, the same questions are asked to the participants twice according to the certainty and uncertainty in the scenarios.

Q3) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- **1 academician who is not an expert on the subject.**



Explanation:

Despite the fact that the academician had a positive or negative definite opinion about the application in the reports and files examined by the academician before the commission, 111 people answered the question about a commission member giving the opposite opinion of this decision. The figure shows the proportions of those who responded to this. Accordingly, there were 82 respondents who stated that the opposing view who is not expert of the applicant projects would not change their decision. There are 21 people who stated that they would create a hesitation. The Likert score for this question is calculated as 1,378378378. The percentage rate

calculated according to the Blackboard calculation method is 9.6% (Murray, 2017) (The formulas for the rate calculation calculated with the Blackboard method are as follows). In other words, there is a possibility that 1 out of every 10 academicians who encounter this situation will change their decision.

$$\text{Maximum Possible Points} = \text{Total Number of Responses} \times \text{Maximum Percent}$$

(1)

$$\text{Maximum Possible Points} = 111 \times 100 \% = 111,000$$

Table 5. 12. Distribution of answers to this question

	Count	Percent	Product
Strongly Effective	2	100	200
Effective	1	75	75
Neither Effective or In effective	5	50	250
Ineffective	21	25	525
Strongly Ineffective	82	0	0
	111	Sum Total	1050

$$9,6\% = \frac{\text{Sum of Total Products}}{\text{Maximum Total Points}} \times \frac{100}{1}$$

(2)

$$\text{Percentage} = \frac{1.050}{111.000} \times \frac{100}{1}$$

Table 5.12 contains the data used in the weight calculation. Figure 5.21 summarizes the answers given to this question during the survey. These calculations are the basis of Agent-Based Modelling calculations. Commission member academicians decision making behavior are simulated via using calculations on Table 5.12. These calculations may not be done by hand, that is why Netlogo software was used. This software is capable of simulating this kind of stochastic and dynamic environment.

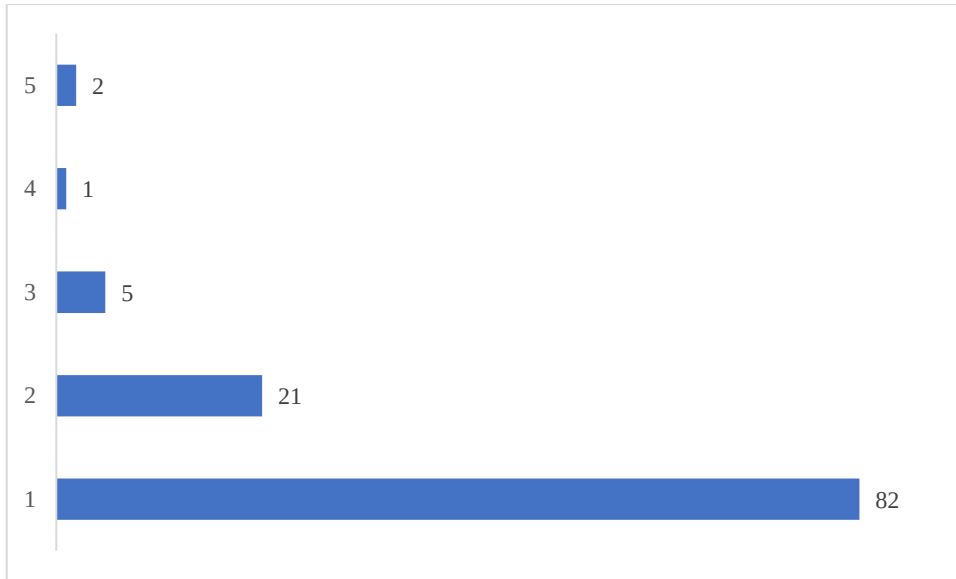
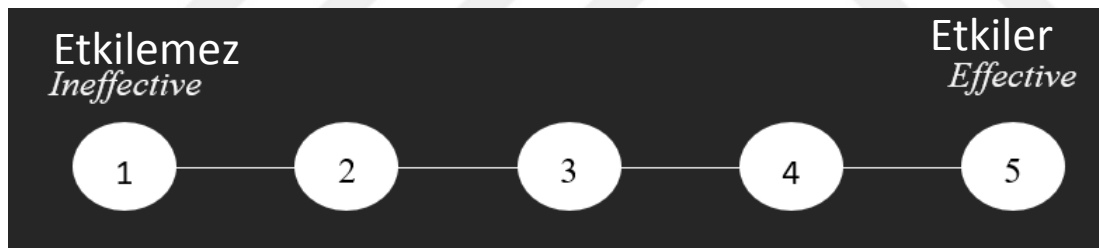


Figure 5. 21. Graph Regarding the Case of a Dissenting Decision Despite a Final Decision Before the Commission

Q4) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- **2 academicians who are not an expert on the subject**



Explanation:

111 people answered this question (for details Figure 5.22). In this question, which examines the change of decision in the event that there are 2 academics who say the opposite of a definite situation, although they are not experts on the subject, it is observed that if the majority decides in the opposite direction, the person questions his final decision and hesitation increases. In this case, it is observed that a cognitive situation such as the majority decision in an information-intensive situation begins to take precedence over information. This is an indication that hierarchical relationships are beginning to take shape, although it also depends on the character traits of the

respondents. The Likert score for this question is found to be 1.531531532. In this situation, the probability of the remaining academicians to change his mind is 13%.

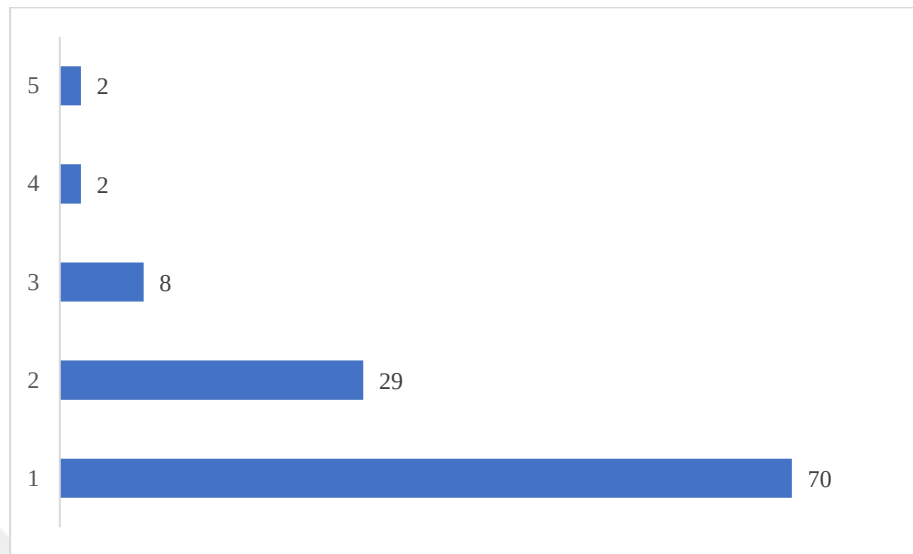
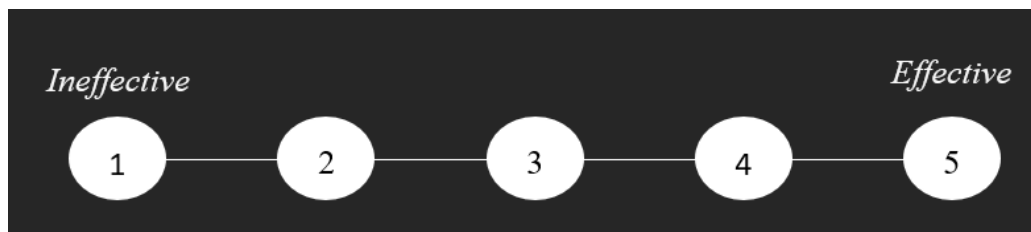


Figure 5. 22. Graph of Majority's Opposition Despite a Final Decision Situation

Q5) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- *1 academician who is not an expert on the subject and*
- *1 academician who is an expert on the subject you know from the social sphere.*



Explanation and Result:

110 people answered this question, in which the effect of both majority and knowledge was tried to be measured Figure 5.23. Although it was observed that the academicians tried to stick to their initial ideas in the situation shown in Figure 5.22, in a situation like the one in the question, it was observed that the majority marked "3" indicating indecision and pushed the evaluation towards insolvency. In this case, if a natural leader emerges in the commission, it is obvious that the commission

members will approve his decision. In such a scenario, it is observed that a knowledge-based valuation has been abandoned and a "hierarchical power"-based evaluation has been passed. At the beginning of this scenario, without forgetting how determined the decision maker is in his own rationality, this Figure has proven how effective cognitive roles are on group decision making. Although the application and observer reports say the opposite, in the case where 1 academician who is an expert in his field and 1 academician who is known from the social environment are of the opposite opinion, the indecision of the academician who is expected to decide is also reflected in the Likert calculation. According to this, the Likert score is 2.618181818 (considering 3 indecisiveness) and the probability of changing his decision is 40%.

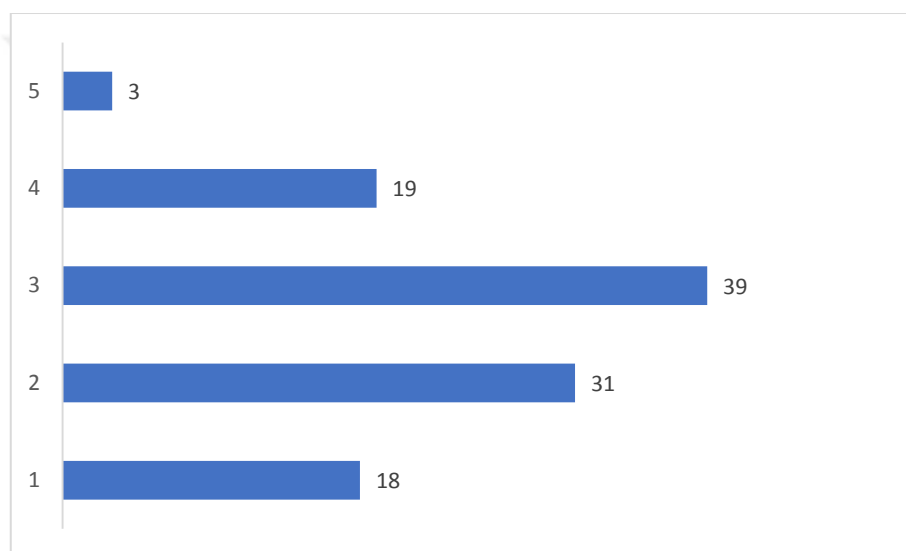
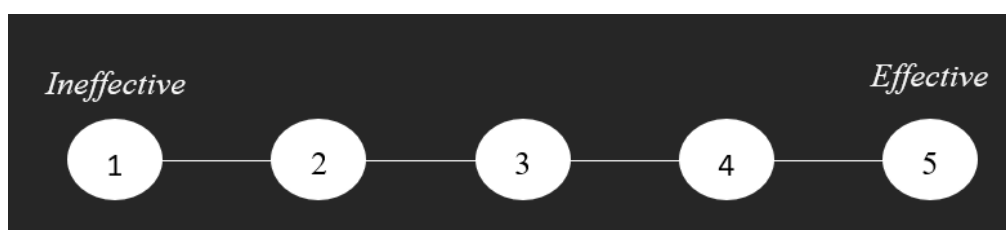


Figure 5. 23. Graph Regarding the Opposite Decisions of Experts and Non-Experts on the Subject

Q6) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- 1 academician who is not an expert on the subject and
- 1 academician you know from the social circle



Explanation and Result:

110 people answered this question, most of which were tried to be measured, with 1 academician who was acquainted with from the social environment. In this question, in which the effect of "cognitive distance", which is important for network studies (Nooteboom *et al.*, 2005), is tried to be measured, a situation different from question 5 has emerged. In this question, where the influence of the majority is still seen, it is seen that academicians prefer knowledge to trust based on social proximity in the evaluation of R&D projects. As seen in Figure 5.24, it can be concluded that the number of those who definitely changed their mind (those who marked 5 and 4 in the question) decreased compared to the other questions, and that the academician reacted to the decision made by his/her friend. The negative effect of the dissenting opinion of the academician, who is not an expert on the subject, was also reflected in the Likert score. In this case, the Likert score is 1.690909091 and the probability of changing the decision is 17 %. In this question, where both trust and knowledge-based network formations are tested, it is observed that the hierarchical formation based on knowledge is more effective than the one based on trust. Likewise, in a similar question in which an undecided academician was asked against the opinion of 2 academicians who are experts in their field, the fact that the rate of those who changed their minds and the Likert score was higher than in this question proves this situation.

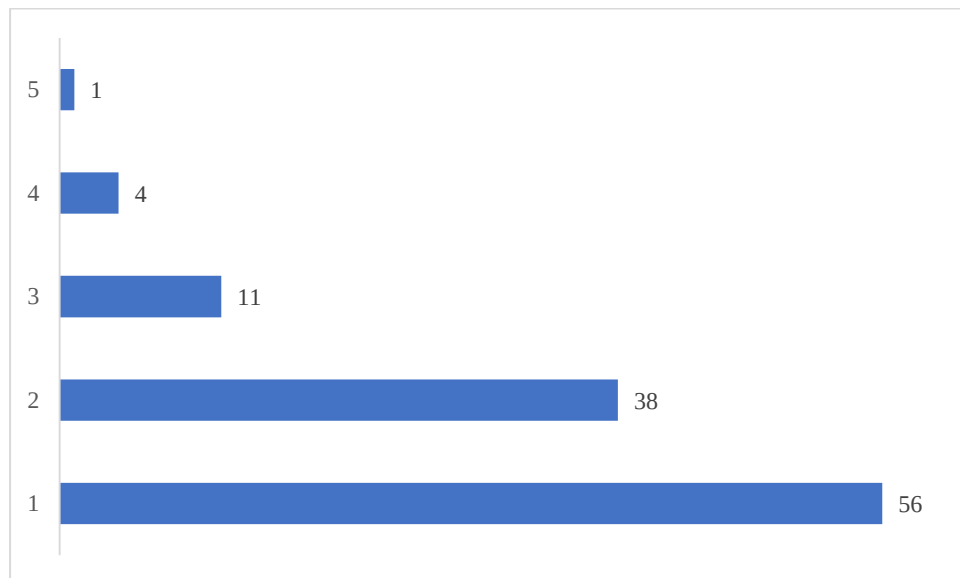
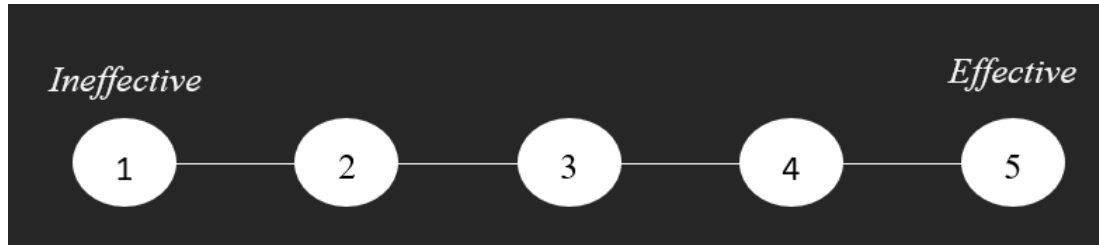


Figure 5. 24. Graph Showing the Effect of Social Closeness and Majority

Q7) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- 1 academician you know from the social circle



Explanation and Result:

In this question, the effect of trust originating from social proximity on decision makers is evaluated. According to this, the decision maker decides after the academician with whom he/she has a friendship relationship states the opposite decision. In this case, the decision of the decision maker is the stage that will determine the majority. When Q7 (this question) is compared with Q3 (Figure 5.21), it is clearly observed that the friendship relationship has an impact on the academician's decision. Surprisingly, unlike Q3, no one ticked to change my decision with certainty (those who marked 5 on the chart). Respondents may not have ticked "1" to indicate that social intimacy has no effect at all. On the other hand, the effect of social intimacy can also be observed from the number of those marking 3 (indecision state) and 4. In this question, in which social intimacy is measured alone, the Likert score is 1.518181818, and the rate of change of decision is 13%. It should be noted that this rate is 4 points higher than the question in which the non-expert academician expressed the opposite opinion. This is a testament to the influence of social networks on decision-making (please refer the Figure 5.25).

As seen in Figure 5.25, commission member academics overwhelmingly answered this question as ineffective

On the other hand, there is a group, albeit small in number, who state that social closeness also affects their decisions. Stating that social closeness is effective, even if only a little, is a clear indication that the survey was filled out sincerely.

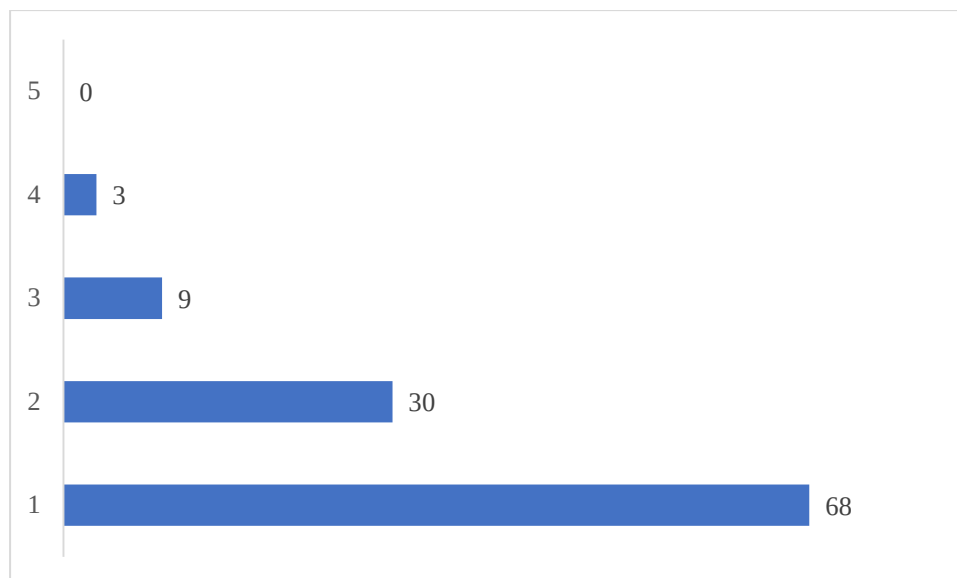
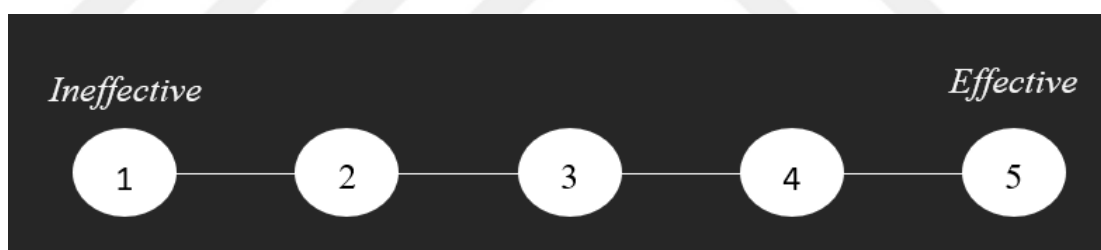


Figure 5. 25. Graph Showing the Effect of Social Closeness

Q8) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- *2 academicians you know from the social circle*



Explanation and Result:

In this question, in which the influence of the social environment is increased, it is observed that the decision of two academics from the social environment, in the opposite direction of the observer and application reports, have a great impact on the determination of the academician. According to Q6, in which non-expert and social acquaintances are tested, the academician is more undecided on this question. This is another proof that there is social influence in group decision-making mechanisms. Accordingly, despite the fact that the available data say otherwise, it proves that the majority and social proximity tempts the decision maker. Figure... these comments

are proving. As a result, the influence of the social network and the majority is also reflected in the indecision rates. The Likert score for this question is 1.727272727, and the rate of change of decision is 18%. Figure 5.26 shows the results aforementioned.

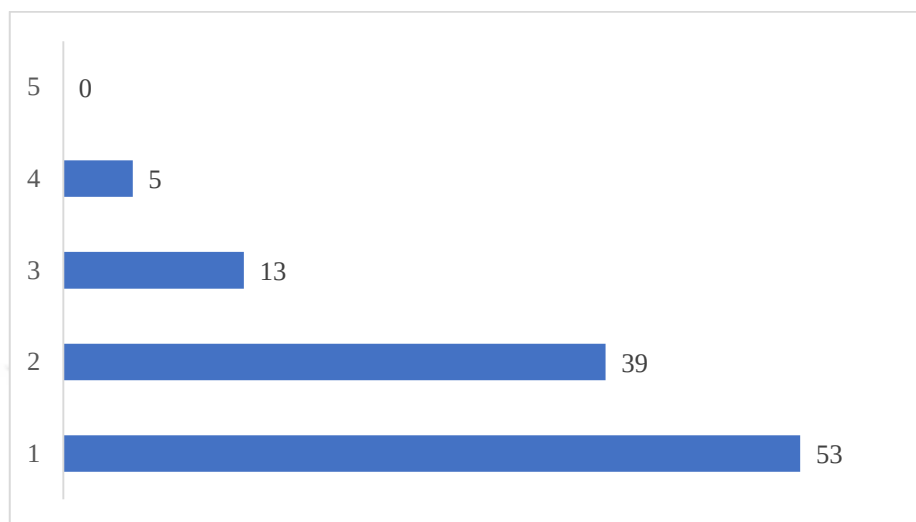


Figure 5. 26. Graph Showing the Effect of Social Closeness and Majority

Q9) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- *1 academician who is an expert on the subject you know from the academic community*



Explanation and Result:

Before the commission meeting, many documents are brought to the attention of the commission members for their decision. The information from the observer and application reports makes it much easier to decide for the application. Academicians who examine the applicant company on site are selected in line with the company's

field of activity. In scenario 1, the application and observer reports about the firm's decision give a definite opinion. In Scenario 1, in such a case, the factors that affect the decision at the commission stage are investigated. In Q9, despite the conditions of scenario 1, you were asked what your decision would be if an academician who is a member of the commission, who you know is an expert in his field, stated a decision to the contrary. The answers given to this are observed in the figure. It is seen that the rate of academics who marked my decision as "I definitely will not change my decision" for the first time in Q9 has decreased so much. From this result, it is seen that the application and observer reports did not have a great impact on the decision of the commission. From this result, it is clear that the impact of the application and observer stages on the final decision is very limited. Therefore, it shows that these two processes are a waste of time and resources.

The high rate of undecided (those who ticked 3) in Figure 5.27 shows that there is a hierarchy within the group in the group decision-making phase, as in Q5. In such cases, for some reason, the person at the top of the hierarchy (in this case, an expert academician) can decide on behalf of the group. Despite the contrary data, the fact that one expert in the commission thinks differently brings the commission members closer to indecision. In this question, the Likert score is 2.845454545, and the rate of change of decision is 46%.

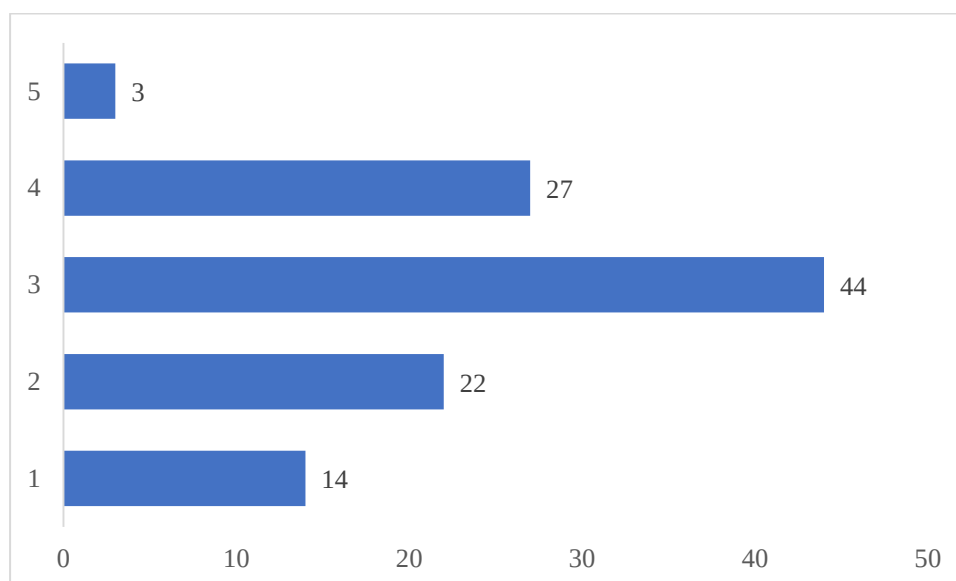
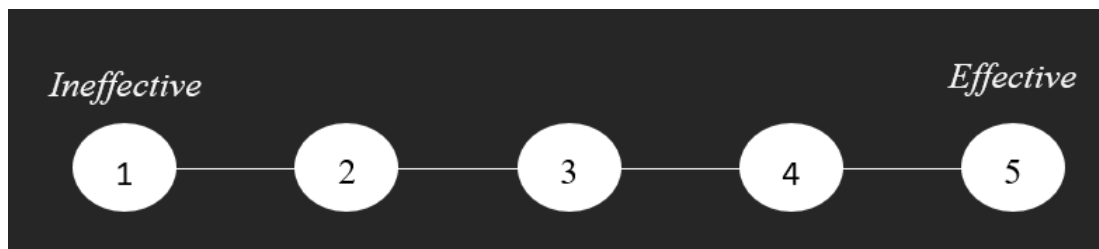


Figure 5. 27. Graph Regarding the Opposite Decisions of Expert

Q10) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- **2 academicians who is an expert on the subject you know from the academic community**



Explanation and Result:

It is seen that a situation parallel to the situation in Q9 continues to increase in Q10, when the effect of two academicians who are experts in the subject expressing their opinions contrary to the current situation is measured. As it can be seen in the figure, it is seen that the academician changed his decision. In addition, it is seen in Figure 6.27 that the undecideds start to change their decisions. As a result, as stated in Q9, it is clear that the commission stage is the only decisive stage on the decision. In addition, it shows that a knowledge-based hierarchy can change everything. In addition, it is seen that commission members prefer concrete discussions to soft information (application and observer reports). Despite the certainty of the available data, this question also draws attention to how effective the commission was in its support decision. The effect of 2 academics, who are known to be experts in their fields but whose accuracy was not clear during the commission, on the third academician, who is the decision maker, is devastating. The Likert score for this question is 3.372727273 and the rate of change of decision is 59% (see Figure 5.28).

The answers given to the questions mentioned in Figure 5.28 prove that there is a knowledge-based hierarchy among the commission members. In response to this question, commission member academics transfer the decision-making power to the leader whom they deem superior in terms of knowledge.

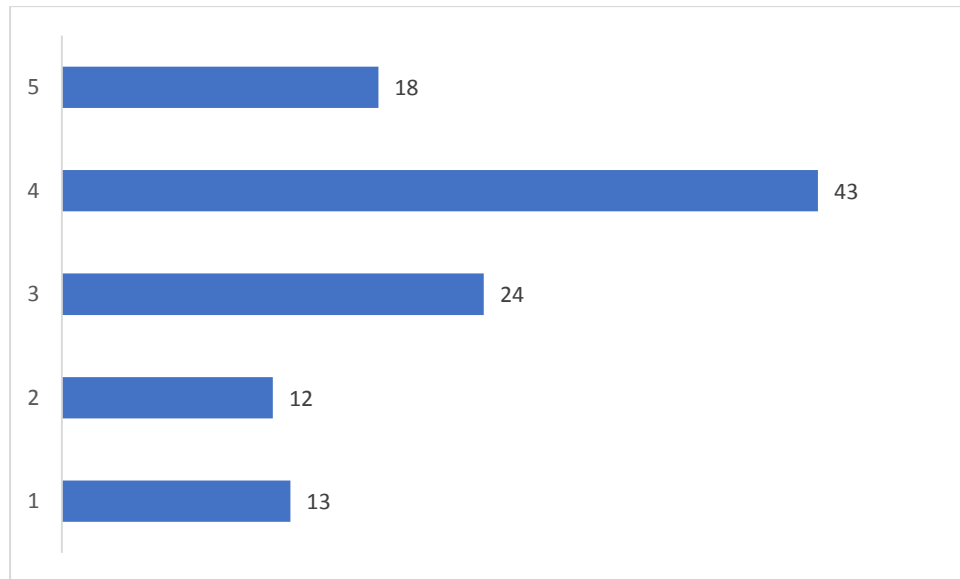


Figure 5. 28. Graph Regarding the Opposite Decisions of Experts

Q11) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- 1 academician who is an expert on the subject you know from the academic community
- 1 academician you know from the social circle



Explanation and Result:

In Q11, the effect of an expert and an academician from the social circle making the opposite decision is seen. The results in Q11 show similar results (see Figure 5.26 and Figure 5.29) with the case where only an expert in the field decides otherwise and the academic is the second decision maker. Accordingly, the effect of being an expert in the field is more than the effect of social proximity and majority. Although the effect of majority and social proximity is limited compared to the effect of expertise, it is too high to be ignored. The Likert score for this question is 2.7000 and the rate of change of decision is 43%.

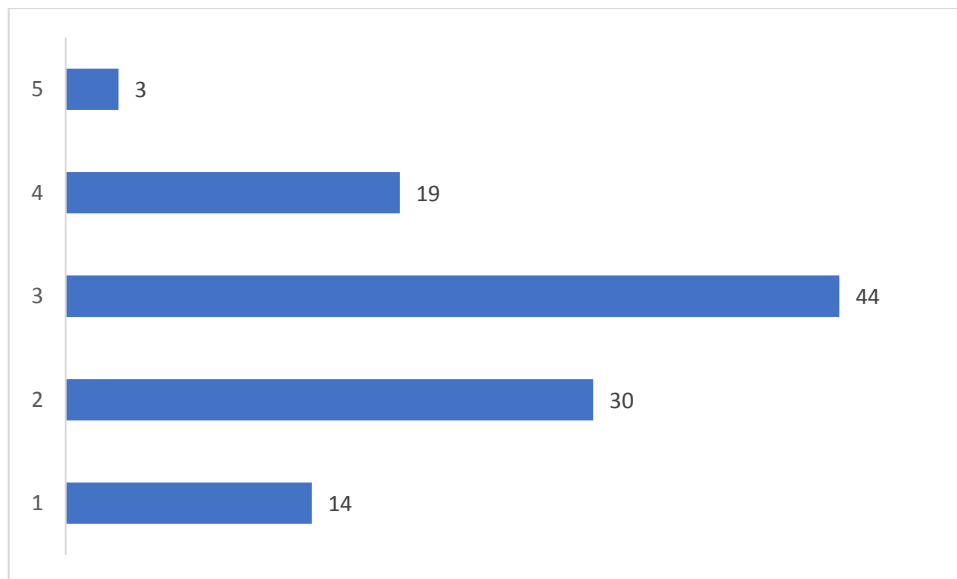


Figure 5. 29. Shows the Opposite Decision of 2 Academicians, Experts in their Fields and Socially Known

In Scenario 2, which describes the situation where there is no definite judgment about the outcome as a result of the observer and application reports, the relations between the commission members are more intense than in Scenario 1. However, especially in R&D commissions, where an informed evaluation is made, an approach that is far from scientific study methodology is important both in the fair distribution of funds and in terms of directing companies and researchers to different areas other than their knowledge in order to receive funds. In the second part of the questionnaire, the same questions are asked as in Scenario 1, and the dynamics of the respondents in case of uncertainty are studied.

Q12) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- 1 academician who is not an expert on the subject



Explanation:

The same question was asked in Q3 for Scenario 1, which shows the answers given by the academics to the opposing academic who an expert in the field is not. Figure 5.20 and Figure 5.30 in the current Scenario show parallelism with each other. As a result, it is seen that academicians show the same reactions in case of uncertainty. Even in the moment of uncertainty, confidence in the decision of an academic who is not an expert in the field is low. The Likert score calculated for this situation is 1.481132075, and the rate of change of decision is 12%. It was stated that a similar question was asked in Q3, about which there was a more stable and definite opinion. As stated, expertise becomes more important when there is no definitive conclusion from the results of the audience and application files. Accordingly, in cases where there is no definite opinion about the undecided academician, he/she tends to trust the academician who is knowledgeable about the subject more and transfer the right to decide to him/her. On the other hand, it is not thought that such a behavior would be desirable for someone who is expected to express decisions and opinions in the commission. The study argues that the right to decide cannot be transferred through a human-machine-human type of communication.

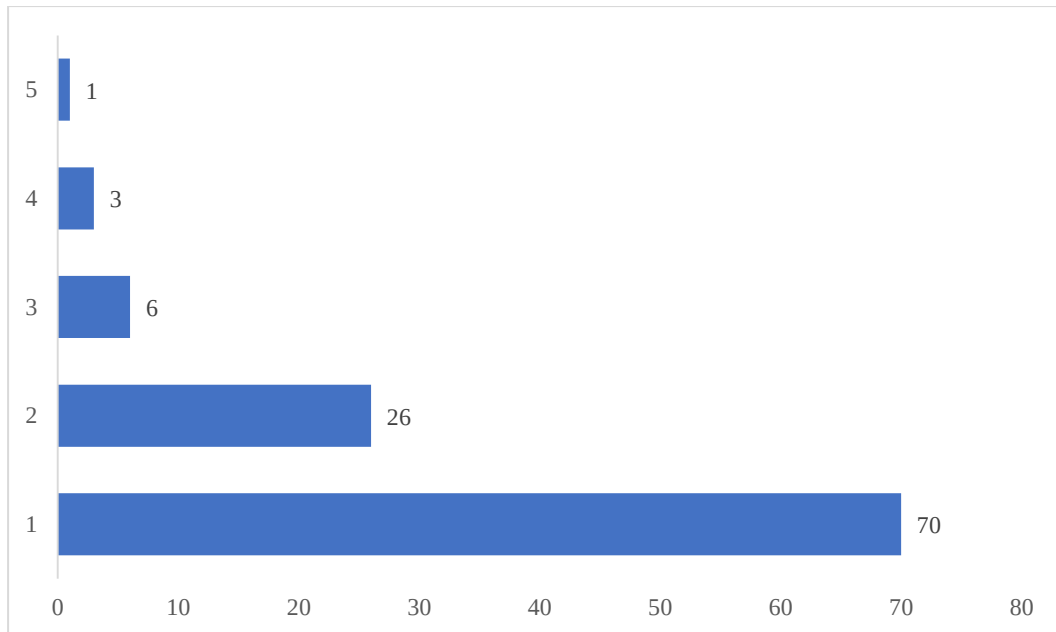


Figure 5. 30. Graph Regarding the Case of a Dissenting Decision Despite a Final Decision Before the Commission

Q13) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- 2 academicians who are not an expert on the subject



Explanation:

Similarly, this question shows similar features with Q4. The effect of the majority is also seen in Q13. It is observed that academics do not change their own decisions even in uncertain environments. In the indefinite moment, it is understood that the academics protect their ideas before the commission. The indecision rate increases with the influence of the majority. Accordingly, the Likert score is 1.632075472, and the rate of change of decision is 16%. Figure 5.31 indicates the results

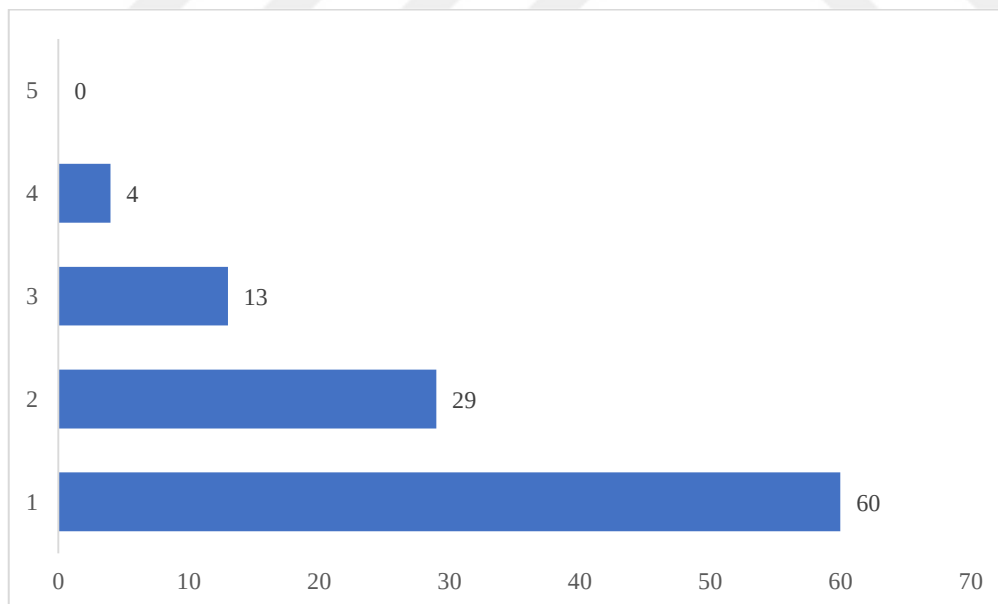
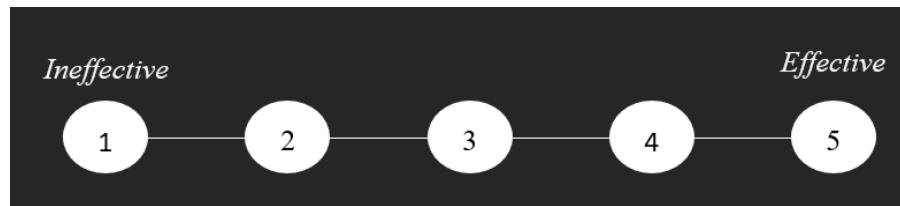


Figure 5. 31. Graph of Majority's Opposition Despite a Final Decision Situation

Q14) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- 1 academician who is not an expert on the subject and
- 1 academician who is an expert on the subject you know from the academic community



Explanation and Result:

The same pattern in Q5 is seen in Q14 as well. The precision of the pre-commission data appears to be the same with slight differences in both scenarios. In this case, the commission did not disregard the reports presented, but only according to the reactions of the other academics in the commission and in the order of decision making (the effect of the majority is observed to act. The results so far also confirm the suggestions of dissertation. This result shows that academics mostly delegate responsibility in one direction in face-to-face group decision making. Similarly, relationships within the group are also important in face-to-face meetings. The academic superiority of the decision maker is also evident in Scenario 2, where an unstable environment is portrayed. Accordingly, the Likert score is 2,716981132, the probability of changing a decision is 43% (Figure 5.32).

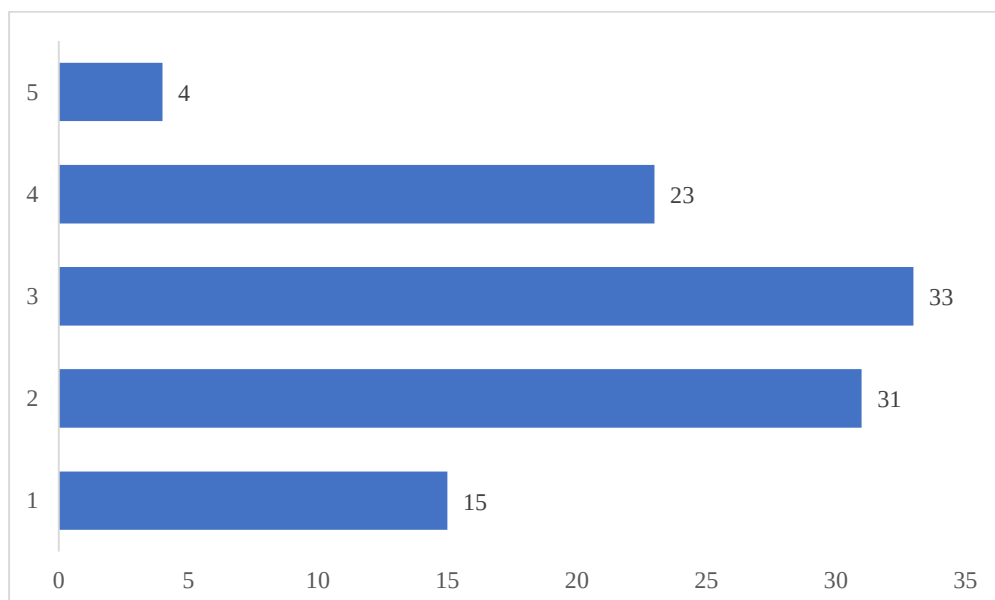


Figure 5. 32. Graph Regarding the Opposite Decisions of Experts and Non-Experts on the Subject

Q15) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- 1 academician who is not an expert on the subject and
- 1 academician you know from the social circle



Explanation and Result:

The answers of the academicians in this question, in which the determination of the academician, whose turn is to be an expert in an uncertain environment and to make a decision after two academics who are known from the social environment, are measured, differs greatly from the Q5, which is similar. In this question, where the application and observer reports leave the decision to the commission, a situation that requires expertise seems to be perceived by the academicians as a sign of the opposite. When Figure 5.35 and Figure 5.23 in Q5 are examined, it is clear that the academics who participated in the voting showed a reaction to the votes cast. Accordingly, in situations where decisions are made in an uncertain environment, it is seen that social proximity and ignorance have a negative effect on other decision makers. Accordingly, the academician, whose turn it is to make a decision, feels distrust in such a scenario and makes opposite decision. In this case, the Likert score is 1.838095238 and the rate of change of decision is 21%.

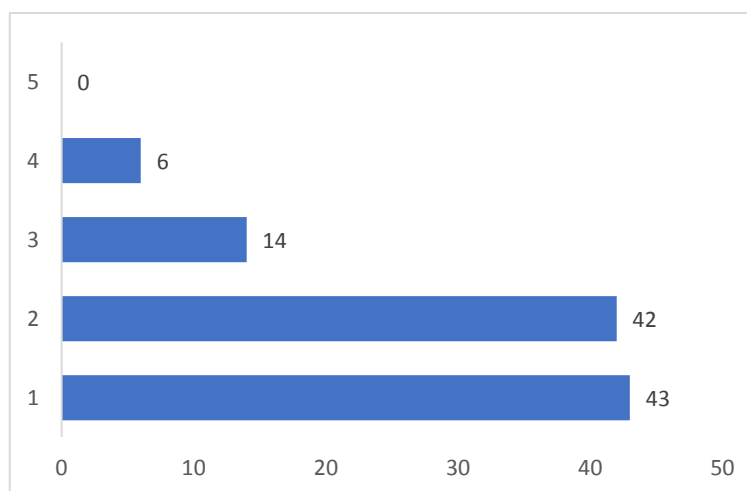
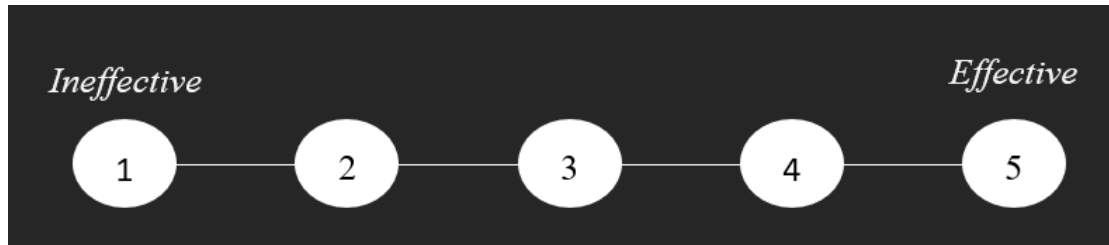


Figure 5. 33. Graph Showing the Effect of Social Closeness and Majority

Q16) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- 1 academician you know from the social circle



Explanation and Result:

It is observed once again that the question asked for Scenario 1 (Q7), where the decision is clearer in Q17, in which the social proximity relationship is evaluated, produces similar results. Accordingly, the impact of the observer and the application report on the result is very limited. In addition, the effect of social intimacy is negligible in such groups where knowledge is important. The Likert score of this question is 1.628571429 and the rate of change of decision is 16%.

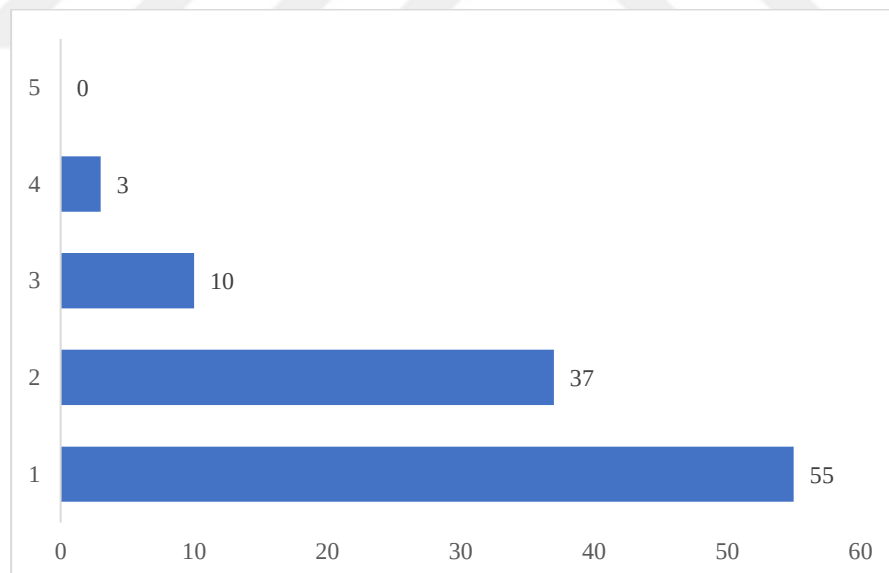
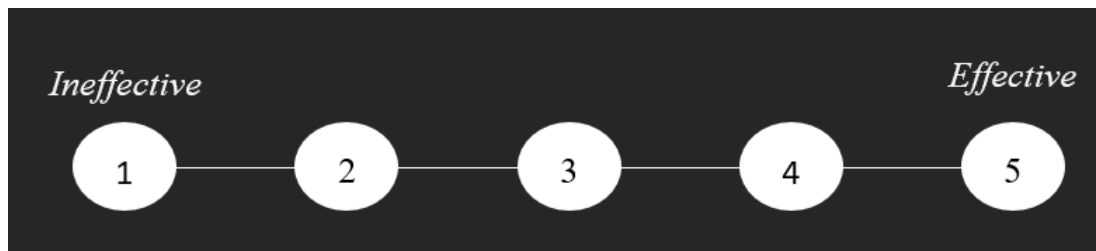


Figure 5. 34. Graph Showing the Effect of Social Closeness

Q17) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- 2 academicians you know from the social circle



Explanation and Result:

Similar results to Q8 in Scenario 1 are obtained in this question as well. Accordingly, the fact that the decision is specific or uncertain in one direction does not seem to have an effect on the decision of the commission members. Accordingly, policy makers should develop policies so that observer and application reports have a weight in the evaluation. As a result, the Likert score is 1.885714286 and the rate of change of decision is 22%. Figure 5.35 summarizes the results.

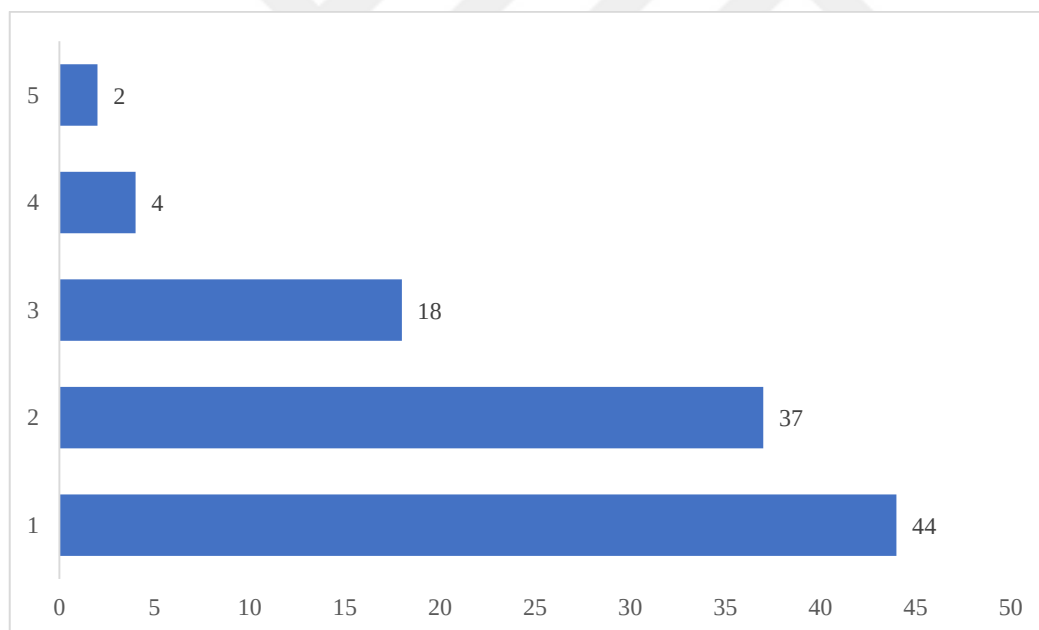
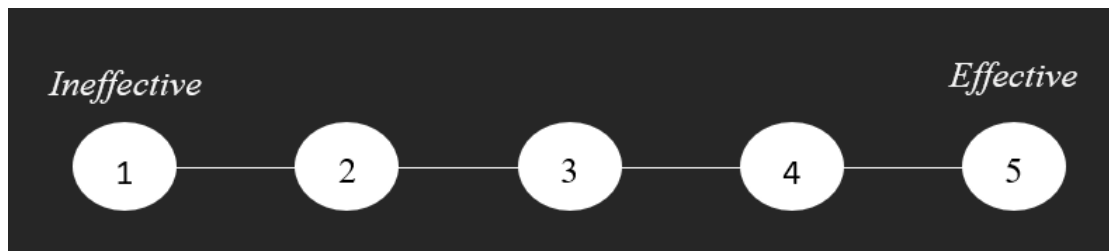


Figure 5. 35. Graph Showing the Effect of Social Closeness and Majority

Q18) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- **1 academician who is an expert on the subject you know from the academic community**



Explanation and Result:

The effect of Scenario 2, which is an ambiguous environment, can be observed in this question, in which the decision of the second academician, who made a decision after an expert academician, is examined in an uncertain environment. Accordingly, it is observed that the academicians approved the decision of the academician who had knowledge about the application subject in an uncertain environment. In Scenario 2, the effect of unique knowledge is more effective than in Scenario 1. Accordingly, the Likert score is 2.923809524 and the rate of change of decision is 48% (Figure 5.36).

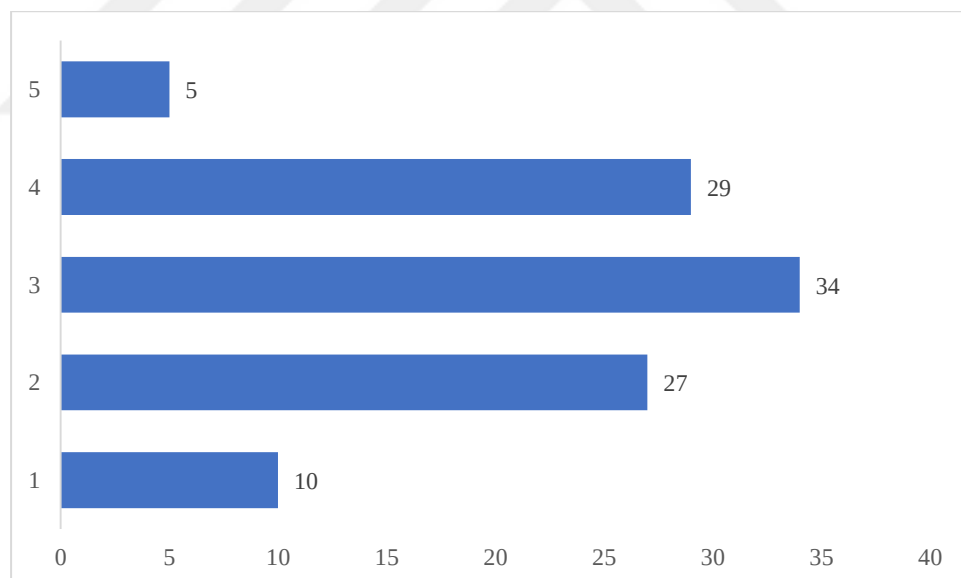
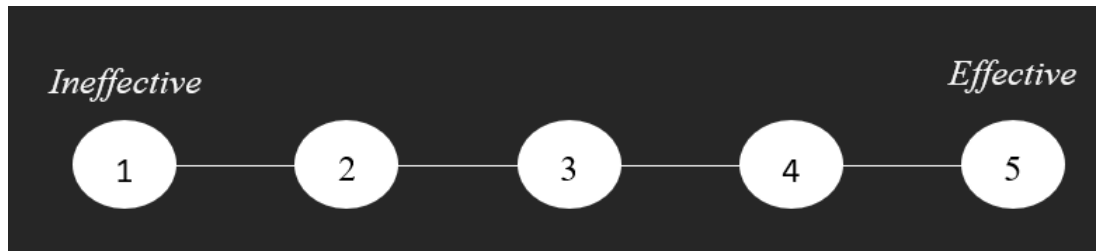


Figure 5. 36. Graph Regarding the Opposite Decisions of Expert

Q19) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- **2 academicians who is an expert on the subject you know from the academic community**



Explanation and Result:

In this question, in which uncertain environments in which two experts decide in one direction compared to the previous question are measured, it is observed that expertise is very effective on the decision. According to Q10 of Scenario 1, academics voting in uncertain environments are more subject to experts in their decisions (Figure 5.36). In this scenario where indecision prevails, the opinion of academics who are experts in their fields is decisive. Likert score 3,580952381, the probability of changing the decision is 65%.

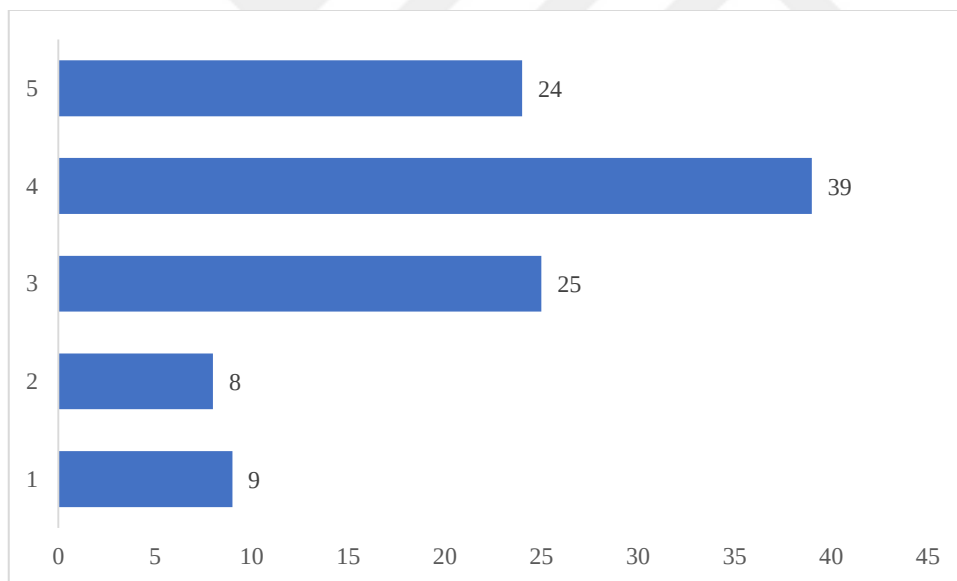
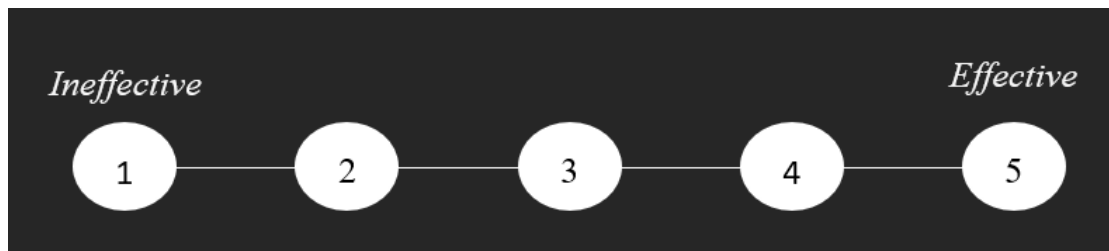


Figure 5. 37. Graph Regarding the Opposite Decisions of Experts

Q20) Does the following member(s) of the commission have a dissenting opinion with you, affect your decision?

- 1 academician who is an expert on the subject you know from the academic community
- 1 academician you know from the social circle



Explanation and Result:

Finally, in this question, where the decisions of the decision-maker academician are examined in an uncertain environment after two academics who experts in their fields are and close to the social environment, a different pattern is observed, as can be seen in Figure 5.38 in Q11. Accordingly, the influence of majority and expertise is greater in uncertain environments than in situations that give a definite opinion. The Likert score of this question is 2.942857143, the probability of changing the decision is 49%.

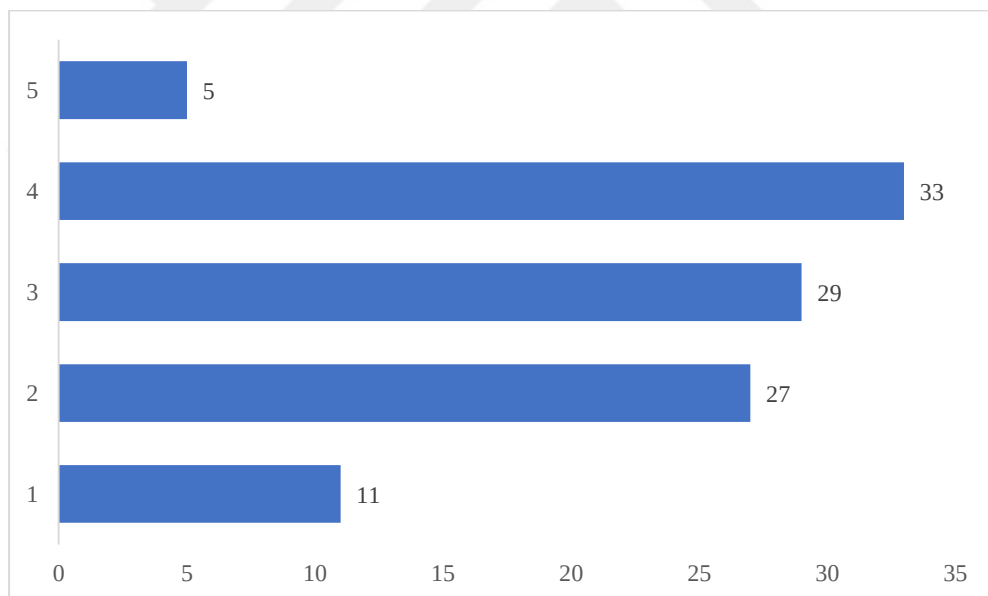


Figure 5. 38. Shows the Opposite Decision of 2 Academicians, Experts in their Fields and Socially Known

5.10.4. Overall Results

In the conclusion part, the results obtained as a result of the survey carried out so far have been examined. These results are listed in this final section.

1. In the event of an ambiguous situation in which the commission members could not reach a clear decision as a result of the examination of the application and observer reports, the academics who are familiar with the social environment and who are not experts in the subject of the application, who have clarified their decisions before the decision-maker academic, have a negative effect on the decision of the final decision-making academician. In other words, the academician makes a decision in the opposite direction of the decision of the academicians who made their decisions before him.

2. The impact of the observer and application reports on the final commission decision is limited. This result is also compatible with analytical results made with machine learning.

3. Decisions are made as a result of social interactions within the commission itself, without being affected by the observer and application reports.

4. The effect of social intimacy on R&D projects is limited compared to those who have no knowledge about the subject (unique knowledge).

The following table (Table 5.13) represents the analyzes and results made in this section.

Table 5. 13. Possibilities of Decision Makers to Change Decisions According to Scenarios and Situations

SCENARIO 1			SCENARIO 2		
Graphical Display	Probability	Question Nr.	Graphical Display	Probability	Question Nr.
	9.6%	3		12%	12
	13%	4		16%	13
	40%	5		43%	14
	17%	6		21%	15

Table 5.13. (continued)

	13%	7		16%	16
	18%	8		22%	17
	46%	9		49%	18
	59%	10		65%	19
	43%	11		49%	20
Explanation					
	This figure represents the decision-maker who is not an expert on the subject				
	This figure represents the expert decision-maker				
	This figure represents the decision-maker whose turn it is to make a decision and the other decision-maker who has social affinity				
	This figure represents the decision maker				

5. In cases where the commission members are undecided, the hierarchically leading commissioner assumes the leadership role and the other commission members follow the leader's decision.

6. A knowledge-based hierarchy is effective in the evaluation of R&D projects.

7. In commissions where knowledge-based hierarchy is formed, the effect of the information coming from the observer and application reports is even more limited compared to other commissions.

8. In cases where the observer and application reports do not give a clear opinion about the project subject to the application, the opinion of the expert commission member academician comes to the fore in the commission.

5.11. Agent-Based Modelling Analysis and Results

Until this stage of the dissertation, analyzes have been made to show the effect of the sub-processes up to the commission process and the face-to-face commissions on the decision-making of the R&D Centers. Accordingly, in the "entropy" calculations made in the Python environment (See Chapter 5 made using the ID3 algorithm), the observer evaluations made before the commission and the application report have been calculated to have a limited effect on the result. Apart from that, it has been proven that the mathematical and statistical methods used with the "Classification Learner" made in the Matlab environment can only calculate the support decision with a precision between 84 and 48% at the most. According to this, it was possible to approach the result as much as a coin toss. These results show how effective the social interaction in face-to-face commissions is on the final decision.

At this stage, the "hierarchical power distance" effect is modeled on an agent basis using the NetLogo program. As stated in the related section, "agent-based modeling" is a social environment where both agents (dissertation academics) and the environment (the "stable situation" in which the application and observer reports suggest a definite decision and the "stable situation that they do not suggest") in a dynamic environment can have a direct impact on each other's outcome. can model networks close to reality?

The application process consists of 3 stages. These are the submission of the application report, the observer reports, and the decision of the commission. In the analysis of the data for the first two stages, the decisiveness of the commission's decision emerges, as also conveyed in the relevant sections. Accordingly, although there are contrary opinions, the commission may decide in a different direction. It is an undeniable fact that there is social interaction in face-to-face commissions. However, the possible distribution of roles within the commission is not known exactly. For this reason, a survey study was conducted among the academicians, members of the commission, in order to model these role distributions. The results obtained from this study were digitized and the environment was simulated with the agent-based modeling method.

On the other hand, the research question of dissertation is "What is the effect of the blockchain on the decision-making process of R&D centers/projects? Dissertation claims that this effect is not observed in non-face-to-face decision-making processes, and in meetings held via online or teleconference (although a group seems to come together), decisions are taken alone due to the nature of the environment. It proposes that decisions can be taken more individually and freely thanks to blockchains secure, unchangeable, democratic, and online environment. Such a comparison is not possible at the moment, as the blockchain does not currently have an application to be used from the decisions of R&D incentives. The aim is to show the effect of the "hierarchical power distance" effect on the results.

In this section, the possibilities of decision-making academics who have taken part in the commissions before, according to the situations shown in the Table 5.14, were collected through the survey method and these results were placed in the model as rules. These situations are prepared according to certain scenarios. Accordingly, it is the turn of the decision (white human figure) to decide according to the past status of the commission (red or gray patches). In the scenarios, the indecisive (white human figure) academic tries to make a decision under his background knowledge and social interaction. These decisions are made under the pressure of other members' knowledge on the subject or not, a friendly relationship independent of the subject, and the majority's decision to the contrary.

Table 5. 14. Probabilities of Changing the Decision Obtained as a Result of the Survey

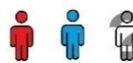
SCENARIO 1				SCENARIO 2		
Graphical Display		Probability	Question Nr.	Graphical Display	Probability	Question Nr.
		9.6%	3		12%	12
		13%	4		16%	13
		40%	5		43%	14
		17%	6		21%	15

Table 5.14. (continued)

  	13%	7	  	16%	16
  	18%	8	  	22%	17
  	46%	9	  	49%	18
  	59%	10	  	65%	19
  	43%	11	  	49%	20
Explanation					
	This figure represents the decision-maker who is not an expert on the subject				
	This figure represents the expert decision-maker				
	This figure represents the decision-maker whose turn it is to make a decision and the other decision-maker who has social affinity				
	This figure represents the decision-changers				
	This figure represents the decision maker				

5.11.1. Hierarchical Power Distance

It is mentioned in Chapter 4 that decision making is a complex situation with many components. In this part of the dissertation, the effect of "hierarchical power distance" on the decision is modeled. In order to model decision making with all its components, sufficient data could not be accessed within the scope of dissertation. In addition, since there is no data on behavior (Rule C), individual, interpersonal, group conflicts, and group size (Rule F, H, 6, and 3) variables, they could not be used in the simulation. However, the following variables are modeled under the title "hierarchical power distance".

Information on gender and gender composition (Rule A and 2) is not included in the study since it was found to be an ineffective variable in the preliminary studies.

Observer Score (Rule B)

The views of the viewers on the projects in the R&D center applied for were processed in the modeling environment (from NetLogo terminology to patches). Accordingly, if the observer reports have a definite opinion with the application (it should definitely be accepted or not), it is shown with a red patch, and if there is no definite opinion, it is shown with a gray patch (see Figure 5.39). The green patch represents the initial stage of the commission.

In agent-based modeling studies, unlike other simulation software, agents (turtle in NetLogo terminology) can interact both with themselves and with their environments. For example, if a traffic simulation is to be made, drivers' acceleration and braking behaviors (agent or turtle behavior) can be coded, while whether the road is wet or dry (patch behavior) can be coded. In this way, it is possible to simulate how many vehicles can accumulate in which situations at intersections.

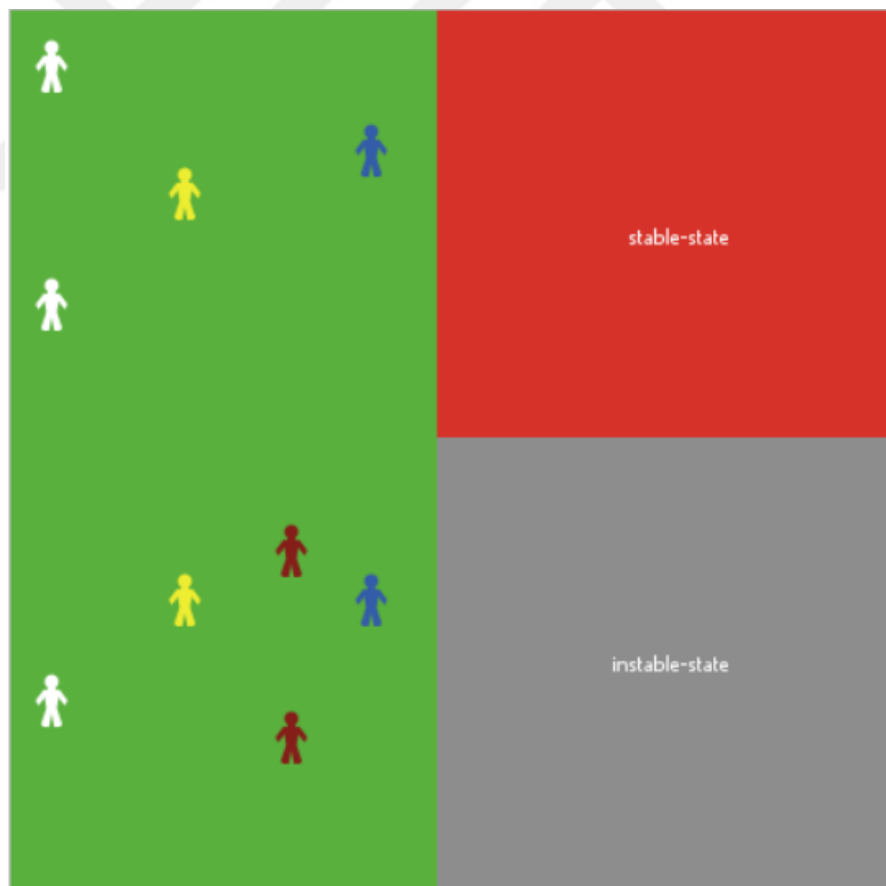


Figure 5. 39. NetLogo Image. The Green Part Represents Academics Awaiting Appointment, The Red Part Represents Patches With A Final Judgment On The Application And The Gray Part For No Final Judgment

Power Distance (Rule D)

The Power Distance rule has been extended to include hierarchical power distance.

Personality (Rule E)

In the study, a survey was conducted with all academics who took part in the selection of R&D Centers and the evaluation of projects. It is assumed that each character trait will be an academican in the sample determined as random. For this reason, it is predicted that the effect of character traits is reflected in the survey results.

Additionally, the yellow human figure shown in Figure 5.40, evaluates the effect of the trust relationship on the decision. The effects of trust and social intimacy on character traits are discussed in the relevant section. In the simulation, the yellow human figure is used for this purpose.

Uniqueness (Rule G)

In this variable in which the effect of specialized knowledge is measured, this situation is depicted in the plot of the dissertation (see Figure 6.34) with a blue human figure.

Majority (Rule 4)

Table 5.14 lists the decision-making sequences and the possibilities of changing the decision regarding the sequences. Accordingly, the influence of the majority is also included in the probability of change of decision.

Overview

The interface of the simulation is as shown in Figure 5.39. Accordingly, it is possible to divide the simulation interface into two parts. On the left are the command buttons and on the right are the representation of the simulation. Interface, Info and Code

sections are respectively; The interface is the representation in the picture, the info part is where the details about the code are written, and the code part is where the actual coding is done.

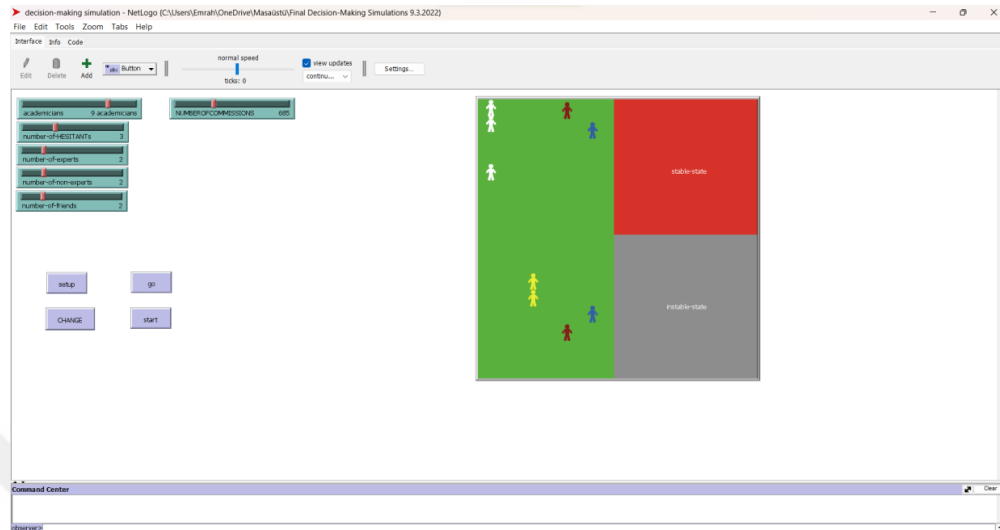


Figure 5. 40. Decision Change Simulation Interface

In the command interface of the simulation, there are total academicians, academicians who are in the decision-making stage, HESITANTS (white human figure), expert (blue human figure) and non-expert (red human figure) academicians, and academicians who have a friendship relationship with the academic who is in the decision-making order (yellow human figure). There are sliders to determine their number.

The number of these yellow, white, blue and red human figures is regulated so that they cannot exceed the total number of academics. Otherwise, a warning appears in the "Command Center" as in Figure 5.41. These sliders are available so that the numbers can be determined manually during the control stages. In the analysis of model studies, these numbers (excluding the total number of academicians) are determined randomly. The "NUMBER OF COMMISSIONS" slider represents the number of R&D Centers and commissions where their projects are evaluated. This number can be determined at the desired rate. According to this number, the simulation performs the previously mentioned probability calculations over and over in each iteration. In the simulation, the hierarchical power distance effect can be modeled for two different states (stable and instable states) at the same time.

Therefore, in each iteration ("tick" in NetLogo terminology), two commissions are simulated with different combinations. Therefore, multiplying the number on the "NUMBER OF COMMISSIONS" slider by 2. For example, "NUMBER OF COMMISSIONS" when it is requested to calculate the number of changes of decision for 500 commissions, this number actually corresponds to 1000 real commissions.

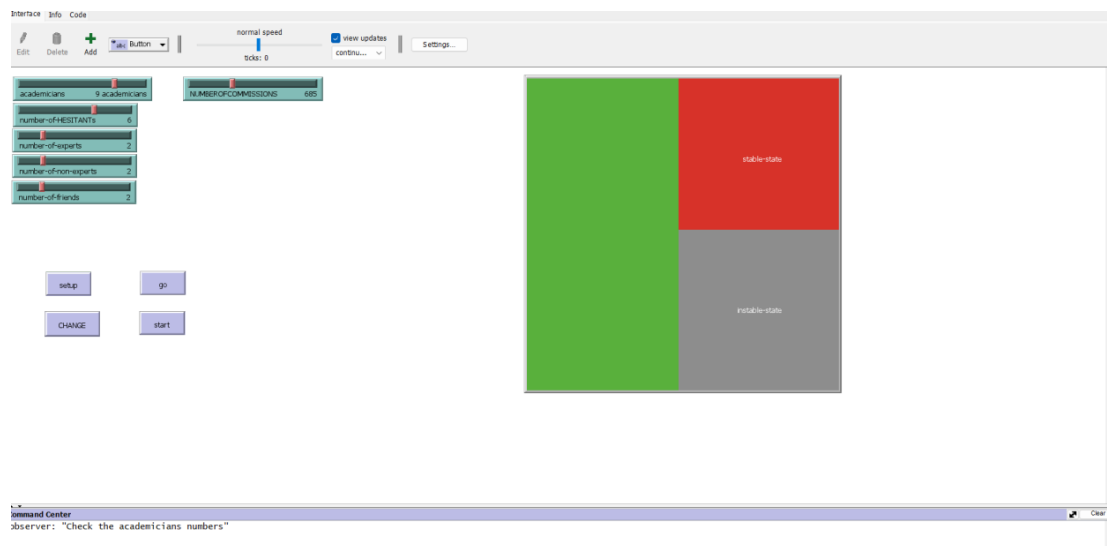


Figure 5. 41. Control of Total Number of Academicians

The "Setup" button is an indispensable command button on almost all NetLogo models. When this button is pressed, academics wait in the green patch, which is the waiting area according to their roles. (see Figure 5.42).

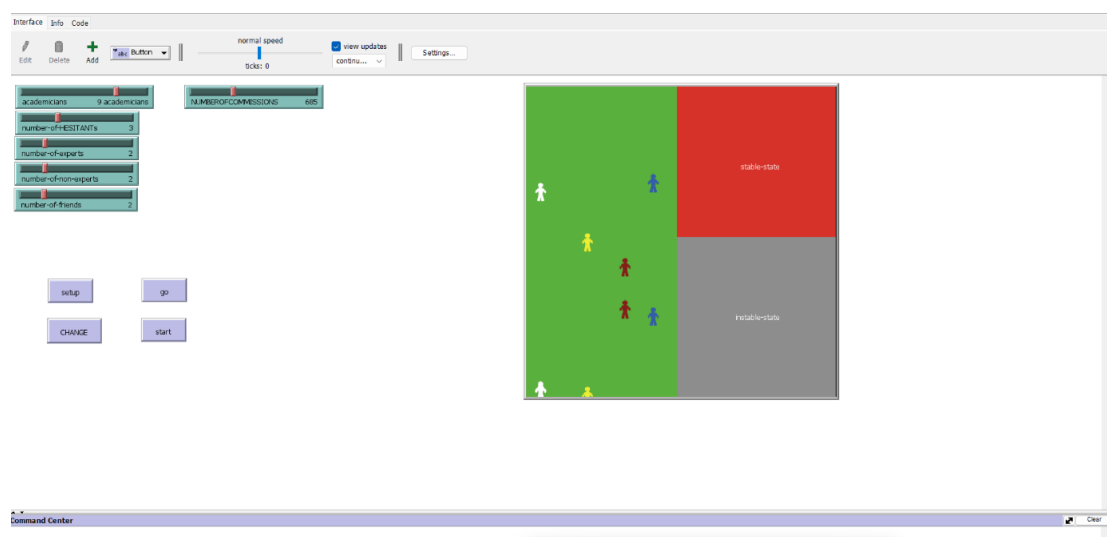


Figure 5. 42. The Status of Academics in the Waiting Area (Green Patch) After the Setup Command

With the "go" command, academics are randomly distributed in stable-state (red patch) or instable-state (gray patch) according to their roles. During the dispersal phase, there must be at least 1 white (HESITANTs) human figure on the red and gray patches. White human red or gray patch can have 2 human like Figure 5.43, 5.43 or 3 human can be randomly assigned as in Figure 5.44.

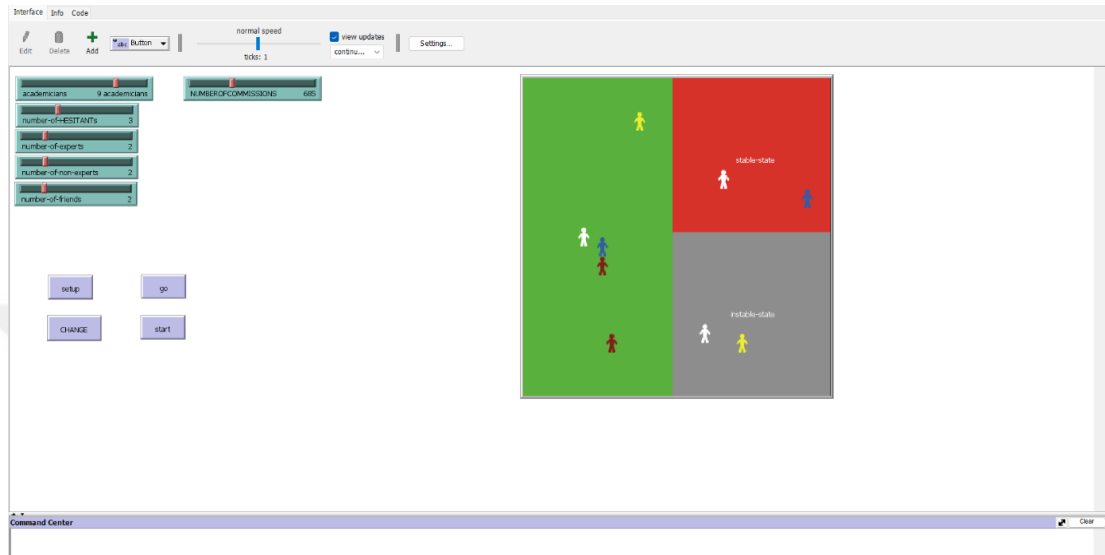


Figure 5. 43. Random Event Patterns over Stable and Instable States 1

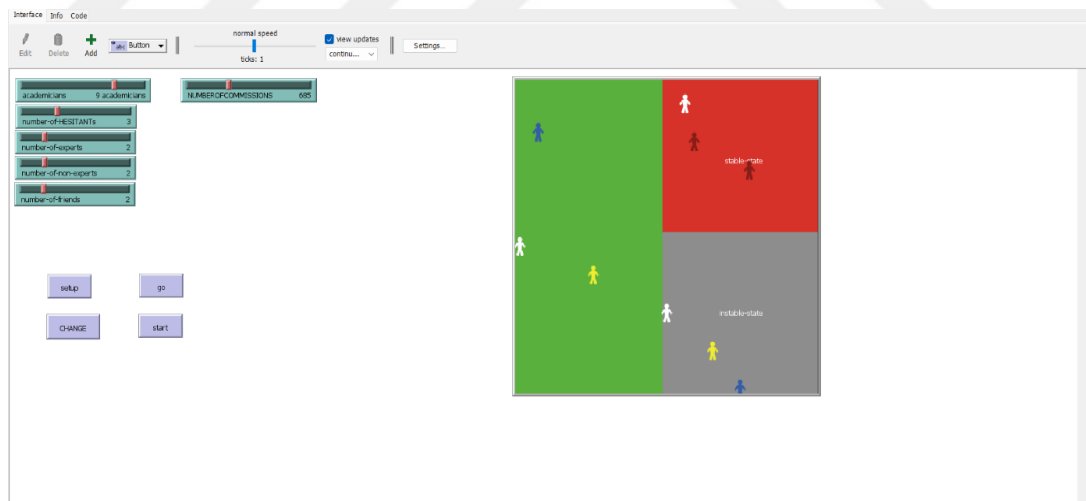


Figure 5. 44. Random Event Patterns over Stable and Instable States 2

As shown in Figures 5.43 and 5.44, one of the most important features of ABM is that it is stochastic. Accordingly, a stochastic model is the most suitable model for modeling human behavior. Because although the possibilities show certainty, impossibilities are also possible in real life. ABM can also indicate the possibility of impossibility.

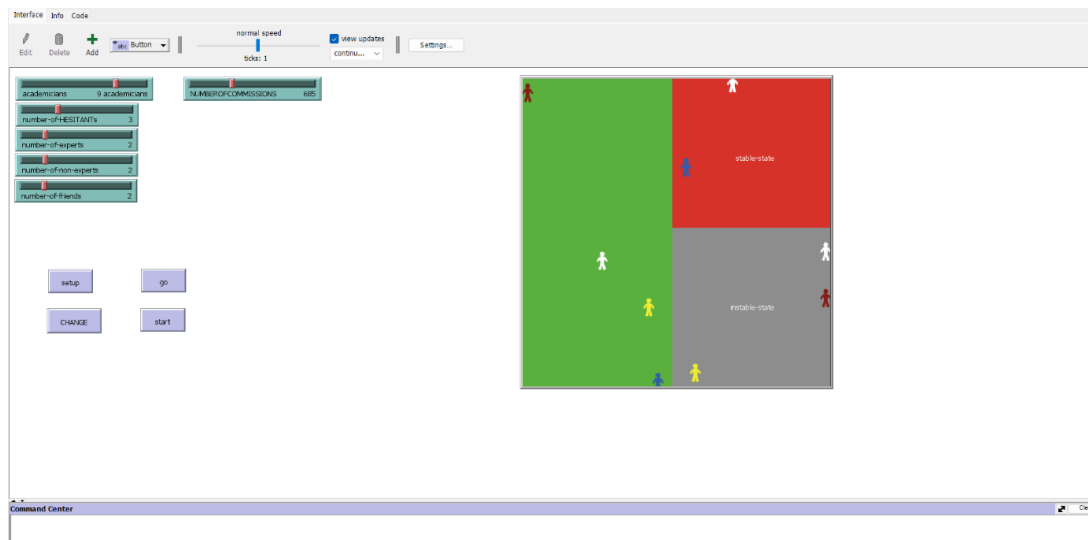


Figure 5. 45. Random Event Patterns Over Stable and Instable States 3

The "Change" command is a command created specifically for this simulation. Accordingly, when the "Change" command is activated, white human(s) (HESITANTS) turn black according to the probability calculations in the Figure 5.45. Its change to black color means that it decides the opposite of the positive or negative decision about the R&D center or its projects before coming to the commission face-to-face with the effect of "hierarchical power distance" (All codes are available in Appendix E).

Table 5. 15. Probabilities of Changing the Decision Used in Simulation

SCENARIO 1			SCENARIO 2		
Graphical Display	Probability	Question Nr.	Graphical Display	Probability	Question Nr.
	9.6%	3		12%	12
	13%	4		16%	13
	40%	5		43%	14
	17%	6		21%	15
	13%	7		16%	16

Table 5.15. (continued)

	18%	8		22%	17
	46%	9		49%	18
	59%	10		65%	19
	43%	11		49%	20
Explanation					
	This figure represents the decision-maker who is not an expert on the subject				
	This figure represents the expert decision-maker				
	This figure represents the decision-maker whose turn it is to make a decision and the other decision-maker who has social affinity				
	This figure represents the decision-changers				
	This figure represents the decision maker				

As can be seen in Table 5.15, the academician (white person) whose turn it is to make a decision in the red area (stable state) in the upper left picture met with 1 academician who is an expert in his field. This means that although the application and observer report clearly express a positive or negative opinion (because it is in the red area), we know that he is an expert in his field in the face-to-face commission, but we do not know whether he has worked specifically for this application, whether he has read the observer and application reports (blue). human) expresses the opposite of this view (blue human is negative if application and observer reports are positive or vice versa). In such a case, when the "Change" button is pressed when the white man's fate is wondered, the simulation finds the equivalent of this situation in the Table 5.16. According to this situation in Table 6.14, there is a 46% probability

that the white man changes his decision. The simulation randomly determines a number between 0-100 and if this number is between 0 and 46 ([0 46]), the white person turns into a black person (change of decision) in the "after" part. As a result, in this case, white has turned to black.

Table 5.16 is simulated when the gray colored area of the same column is taken into account, where the observer and the application report do not give a precise result about the application. Accordingly, the white person who has to make a decision is again the last decision maker this time and there is two academics one who disagrees with him/her and is not an expert on the subject of the application (red person) and the other one is a friend of him/her. According to the Table 6.14 of this situation, white people change their mind with a 21% probability. As a matter of fact, when the "Change" button is pressed, the white person remains white.

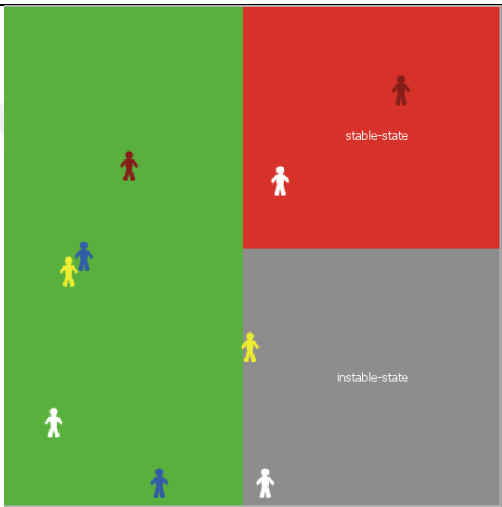
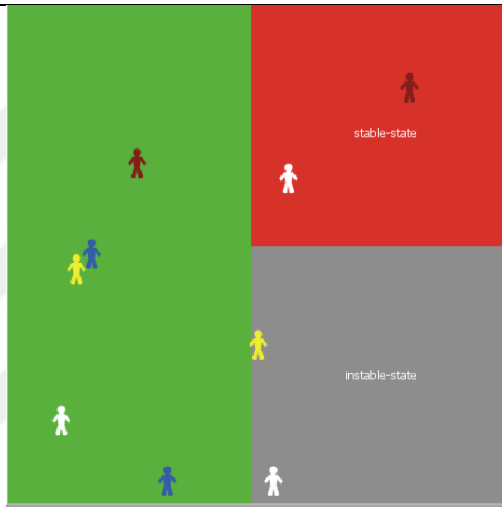
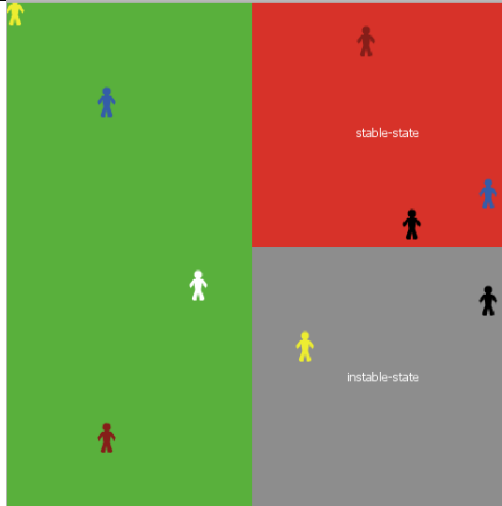
Looking at the second row, on the red (stable state) patch, there are two academicians, who are not experts in their fields and are friends, who have decided to the contrary with their own opinion. Accordingly, the probability of changing a decision is 17%. When there is a white and blue person on the gray patch, the probability of the undecided white person to agree with an expert academic is 49%. When the "Change" command is given, it is seen that neither the red nor the whites in the gray area are black. It is noteworthy that there is no change, especially in the gray area. However, "agent based modeling", which is used in modeling the complex structure of life, shows its difference just in this case. As a result, although the probability decreases each time, a coin can come up 3 times in a coin toss.

Table 5. 16. Decision Change States for Different Arrays 1



As can be seen in Table 5.17, the undecided academician (HESITANT) who enters the decision-making area (grey and red patch) stochastically changes or does not change his decision. The situation of the academic who changed his/her decision turns from white to black. The decision change situation is completely calculated with the ratios obtained from the scenarios, and the academics who change their decision transfer the responsibility of decision making.

Table 5. 17. Decision Change States for Different Arrays 2

Before	After
	
	

5.11.2. Results

The data used in the dissertation includes a total of 773 commissions, as stated in the data section. For this reason, 773 commissions will be simulated in this simulation,

which is essentially a data-based estimation study. Validation of this result is not possible, as the available data does not include how many people changed their minds during the commission or the estimates in the commissions. In order to do this, the author had to personally enter all the commissions and take notes, which is both impossible and would require decades of teamwork. In this case, there is no other choice but to respect the probability calculations in the Table 6.13, calculated as a result of the answers given by the academicians in the survey results.

It has been mentioned that HESITANTS (white people) who are in the decision-making stage make random decisions at a certain rate according to the situations and the plot. Accordingly, while it can change its decision for the same plot (while turning into black), sometimes it may not. The simulation was designed in this way in order to approach the randomness of life. For example, when a white person encounters 2 blues in the gray area, they may turn black in one iteration, while the other may not turn despite the high rate. Thus, the character traits of the decision makers specified in the Rules section are reflected in the result.

For this reason, the rates of turning black that will be the subject of the analyzes in this section will always vary. In order to prevent this and make it statistically significant, the experiments were repeated 100 times.

The results are as in Table 5.18 The table gives the number of academics who changed their decision for 774 commissions that used the data in dissertation. In order for these numbers to be meaningful, 100 trials were conducted. It should not be forgotten that the total number of people varies between 2,322 and 1,548 when it is considered that in each commission 2 people in some cases and one out of 3 people (white people) change their decision.

According to the table, the median value is calculated as 229, the mean value is 228.06, and the standard deviation is 12,48829.

Thus, it can be concluded that 30 academicians copy the decisions of others in every 100 evaluations.

Table 5. 18. Number of Persons Who Changed Decisions in Commissions

Attempt	Result	Attempt	Result	Attempt	Result	Attempt	Result
1	222	26	229	51	226	76	235
2	218	27	228	52	214	77	231
3	222	28	203	53	228	78	216
4	239	29	216	54	242	79	246
5	212	30	212	55	249	80	207
6	243	31	219	56	249	81	229
7	243	32	237	57	220	82	240
8	264	33	216	58	208	83	234
9	222	34	229	59	213	84	238
10	221	35	233	60	204	85	238
11	230	36	234	61	227	86	203
12	231	37	235	62	231	87	263
13	231	38	228	63	233	88	254
14	221	39	219	64	234	89	239
15	234	40	201	65	216	90	217
16	226	41	240	66	236	91	224
17	223	42	223	67	230	92	230
18	208	43	237	68	215	93	223
19	234	44	228	69	247	94	239
20	232	45	243	70	235	95	223
21	232	46	202	71	233	96	231
22	227	47	236	72	239	97	230
23	232	48	223	73	225	98	246
24	218	49	239	74	217	99	230
25	219	50	223	75	215	100	217

The number of decision changers for each 774 commissions is shown in the simulation as in Figure 5.46.



Figure 5. 46. Result of Analysis Shows that 222 Academics Changed Their Decisions in 774 Commissions

The following results can be obtained from the analysis of the simulation results.

1. The knowledge and experience of all decision makers cannot be fully utilized in the face-to-face decision-making phase.
2. In face-to-face decision sessions, a relationship based on trust and hierarchy is formed between decision makers for a short time.
3. Decision makers cannot bear the costs of decision making and avoid decision making responsibility.
4. There is a definite power relationship between decision makers during face-to-face decision making. This hierarchy is in the form of knowledge, majority and social proximity, from strong to weak in R&D projects.
5. It is recommended to change the decision-making environment according to the content of the decision to be made. Accordingly, if the subject to be decided is more knowledge-based (such as the evaluation of R&D projects), it is recommended to do it in environments such as blockchain, and if an emotion-based decision is to be made, it is recommended to be made face-to-face with the decision makers.
6. In the evaluation of R&D projects, it has been revealed within the scope of dissertation that issues such as resource time consuming, preparation of the application file and on-site visit of the applicant company have little effect on the support decision.
7. For resources to be used more effectively, it should be made mandatory for the audience report to have an impact on the final decision (such as percentage contribution).
8. It is revealed that 30% of the academicians do not fulfill their responsibilities.
9. It has been determined that academics who changed their decisions mostly did so because of their trust in information. However, it is not known how much they investigated the source of the trust felt while making this decision.

10. It is important to what extent academics who change their decisions irrationally after face-to-face commissions will stick to this new decision.

11. There is a risk that post-commission academics will change their research fields if they change their decisions and adapt their interests and research to this new field.

12. As a result of this change, information and time losses may occur as the academician tends to a new field.

As a result of the studies, the effect of social interactions in the commission on the result of the commission has been revealed. Accordingly, a role distribution among the members (academics) emerges in the discussions within the commission. This psychological effect is due to the weight of decision making. In the commissions, which are a scientific advisory board, decision-making academics transfer the social effects and the decision-making authority given to them by public institutions to the strongest as a result of the power relations within the commission. Contrary to what is desired, being strong does not always mean having knowledge about the subject in commissions. Moreover, while trying to benefit from the knowledge and experience of all the commission members at the highest level, the commission members transfer this right granted and expected to them. Based on this result, it is important to take policy actions to regulate the commission structure and relations. The final section discusses these policy recommendations.

With the Agent-Based Modeling method, which is the last analysis method of dissertation, possible decision changes in the face-to-face commission that have been carried out in the past are simulated. The results of the survey conducted with the academicians who took part in the commissions were made numerical and the model was coded. However, there is no established method regarding the validation and robustness of the ABM method. With the trials in this section, it will be tried whether the model is suitable for the usual flow of work.

5.11.3. Expertise Level

The effect of many of the variables affecting decision making was discussed in the previous section with the Agent-Based Modeling method. However, the effect of the

level of expertise, which is not included in the literature but is thought to be important to study, is discussed in this section.

Although it is difficult to measure, the level of expertise on the subject that a decision-making academician is expected to decide is important for other decision-making academics who are considering delegating decision-making power. Accordingly, the academic who thinks to follow the decision of the expert academic (the person in blue color in Netlogo simulation) may tend to trust him according to the level of expertise of the "expert scholar (the person in blue color in the Netlogo simulation)" while doing so. This situation can be decisive in his "decision copying".

In order to measure this situation, a separate question is not asked in the questionnaire in which behavioral patterns are digitized. Accordingly, in the survey, the academicians accepted that the expert was "fully" expert on the project for which the expert was asked to examine in questions about expertise. However, in the real situation, the level of expertise of the people may not be like this, a level of expertise has been added to the model as seen in Figure 5.47 to harmonize this.



Figure 5. 47. Netlogo Model Including Expertise Levels

In the updated model, the scenarios shown in Table 5.19 are rearranged according to their level of expertise. For example, in the scenario marked in red in Table 6.17 where application and observer reports are important, the probability of an undecided academic to change his decision is 46%. In this data, it is accepted that the expert

academician is at the 10/10 level of expertise. If the expert academician's level of expertise is determined to be 5/10 with a slider added to the new model in the Figure 6.47, the probability of an undecided academician to change his/her decision under the same conditions drops to 23%.

Based on the fact that Netlogo is a stochastic simulation program, it may not always be possible to be around the possibilities in Table 5.19 in the new model, which is organized according to expertise levels. To give an example, if the audience and the application reports do not make a final judgment about the project under consideration, and the subject expert and both academics have given a decision in one direction, the probability of the final decision maker expected to change is 65%. In the new model, this probability drops to 7% by reducing the expertise level to "1". As can be seen in Figure 5.47, the undecided academic (white person) does not change his mind in this case.

Table 5. 19. Probabilities of Changing the Decision Obtained as a Result of the Survey

SCENARIO 1			SCENARIO 2		
Graphical Display	Probability	Question Nr.	Graphical Display	Probability	Question Nr.
	9.6%	3		12%	12
	13%	4		16%	13
	40%	5		43%	14
	17%	6		21%	15
	13%	7		16%	16
	18%	8		22%	17
	46%	9		49%	18
	59%	10		65%	19

Table 5.19. (continued)

  	43%	11	  	49%	20
Explanation					
	This figure represents the decision-maker who is not an expert on the subject				
	This figure represents the expert decision-maker				
	This figure represents the decision-maker whose turn it is to make a decision and the other decision-maker who has social affinity				
	This figure represents the decision-changers				
	This figure represents the decision maker				

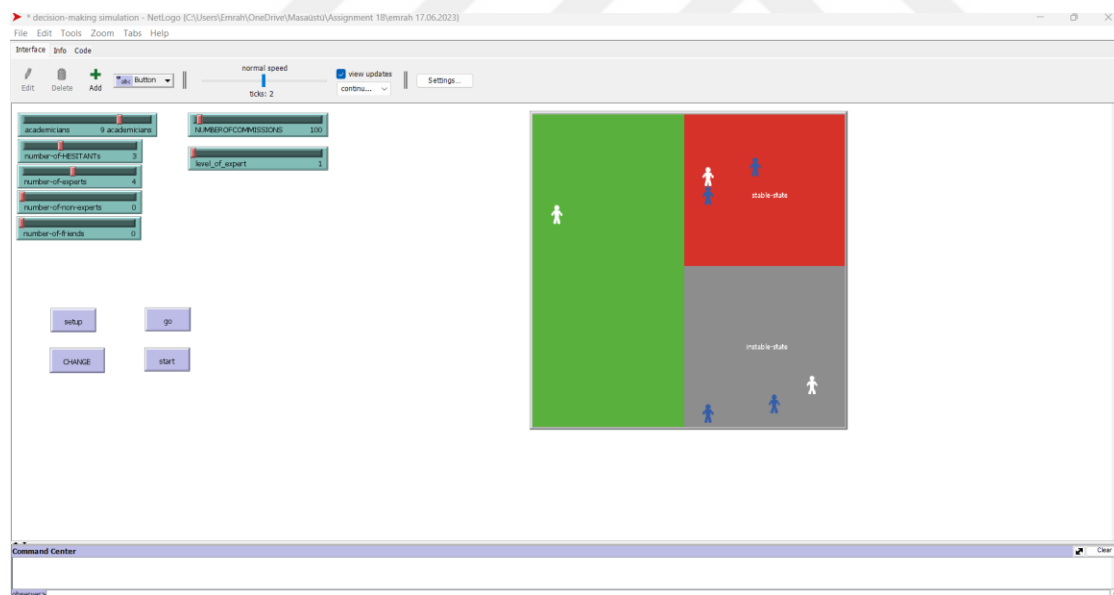


Figure 5. 48. Expertise Level Change Status

On the other hand, as can be seen in Figure 5.48 and 5.49, the academician, who encountered an academic who was not an expert in his field in the gray area and had a very low probability of changing his decision, changed his decision. This is one of the best examples of ABM's stochastic operation.

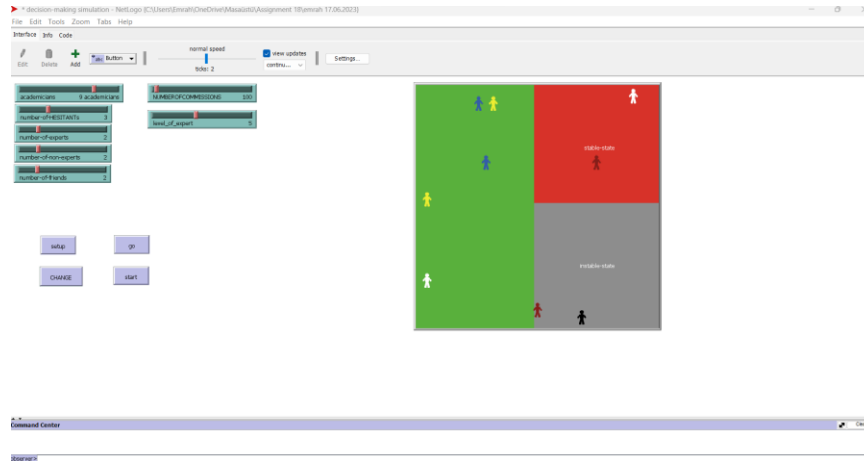


Figure 5. 49. New Model Arranged by Expertise Levels

5.11.4. Analysis Results Including Expertise Level

When simulations were performed at 10 and 5 expertise levels for 774 commissions with data, the academicians who changed their minds in 774 commissions are shown in Table 5.20. In cases where the level of expertise is reduced from 10 to 5, it is expected that the probability of changing their decision will decrease by 50%, while this ratio shows a distribution below 50% in some cases and much higher in others, as seen in the Table. This is due to the stochastic nature of the Agent-Based Modeling method. It should be noted again that with this feature, ABM is the most accurate model for modeling social networks. Because, unlike other linear models, ABM is more effective in modeling dynamic processes. In the ABM, it is shown that low probability is also a possibility and should not be ignored. In this state, ABM was chosen as the most suitable method for dissertation in which social dynamics are designed.

Table 5. 20. Number of Persons Who Changed Decisions in Commissions

Attempt	Result (10 Expertise Level)	Result (5 Expertise Level)	Attempt	Result (10 Expertise Level)	Result (5 Expertise Level)
1	222	135	26	229	149
2	218	138	27	228	161
3	222	124	28	203	137
4	239	150	29	216	139
5	212	159	30	212	169
6	243	142	31	219	148
7	243	132	32	237	138

Table 5.20. (continued)

8	264	132	33	216	146
9	222	144	34	229	151
10	221	137	35	233	143
11	230	104	36	234	130
12	231	130	37	235	146
13	231	147	38	228	148
14	221	137	39	219	149
15	234	127	40	201	149
16	226	138	41	240	128
17	223	143	42	223	140
18	208	134	43	237	138
19	234	137	44	228	142
20	232	154	45	243	149
21	232	148	46	202	149
22	227	150	47	236	154
23	232	144	48	223	144
24	218	151	49	239	144
25	219	147	50	223	145

5.12. Robustness Tests

There are commission results in the data obtained from the Ministry of Industry and Technology, but there is no data on the dynamics within the commission and the movements in the decisions of the academicians who are the members of the commission. Currently, it does not seem possible to obtain such data. Dissertation, on the other hand, envisions a blockchain future without cognitive effects in face-to-face decision making. For this reason, the effects of cognitive states on decision changes were studied with the survey and simulation data. For this reason, the ABM method, which has been approved by the literature, was preferred, as it gives the closest result to the dynamic decision-making process.

On the other hand, ABM provides stochastic data. For this reason, the results are distributed around a certain data. Under these conditions, a healthy method for robustness tests of the analyzes has not been specified in the literature. For this reason, the test setup whose results are written in Table 6.17 has been designed. For this reason, this test was designed due to the stochastic feature of the ABM, although the probability of changing decisions according to the scenarios is coded.

According to the test, the probability of changing the decision specified in the Table 5.21 was reworked by keeping the other conditions constant. (see Figure 5.50) For example, in red and gray scenarios, the probability of changing the decision of the expert academician (blue person) and then the decision maker (white person) was 46% and 49%, respectively, while the robustness test results were measured as 48%. In the whole analysis, white, yellow, blue and red people are randomly distributed to the white and red scenarios and stochastically change their decisions according to the probabilities specified in the Table 5.21. Robustness tests, on the other hand, confirm these results.

Table 5. 21. Netlogo Robustness Tests Results

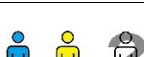
SCENARIO 1		SCENARIO 2		Test Results
Graphical Display	Probability	Graphical Display	Probability	Probability
	9.6%		12%	9%
	13%		16%	15%
	40%		43%	40%
	17%		21%	22%
	13%		16%	20%
	18%		22%	18%
	46%		49%	48%
	59%		65%	61%
	43%		49%	42%
Explanation				
	This figure represents the decision-maker who is not an expert on the subject			

Table 5.21 (continued)

	This figure represents the expert decision-maker
	This figure represents the decision-maker whose turn it is to make a decision and the other decision-maker who has social affinity
	This figure represents the decision-changers
	This figure represents the decision maker

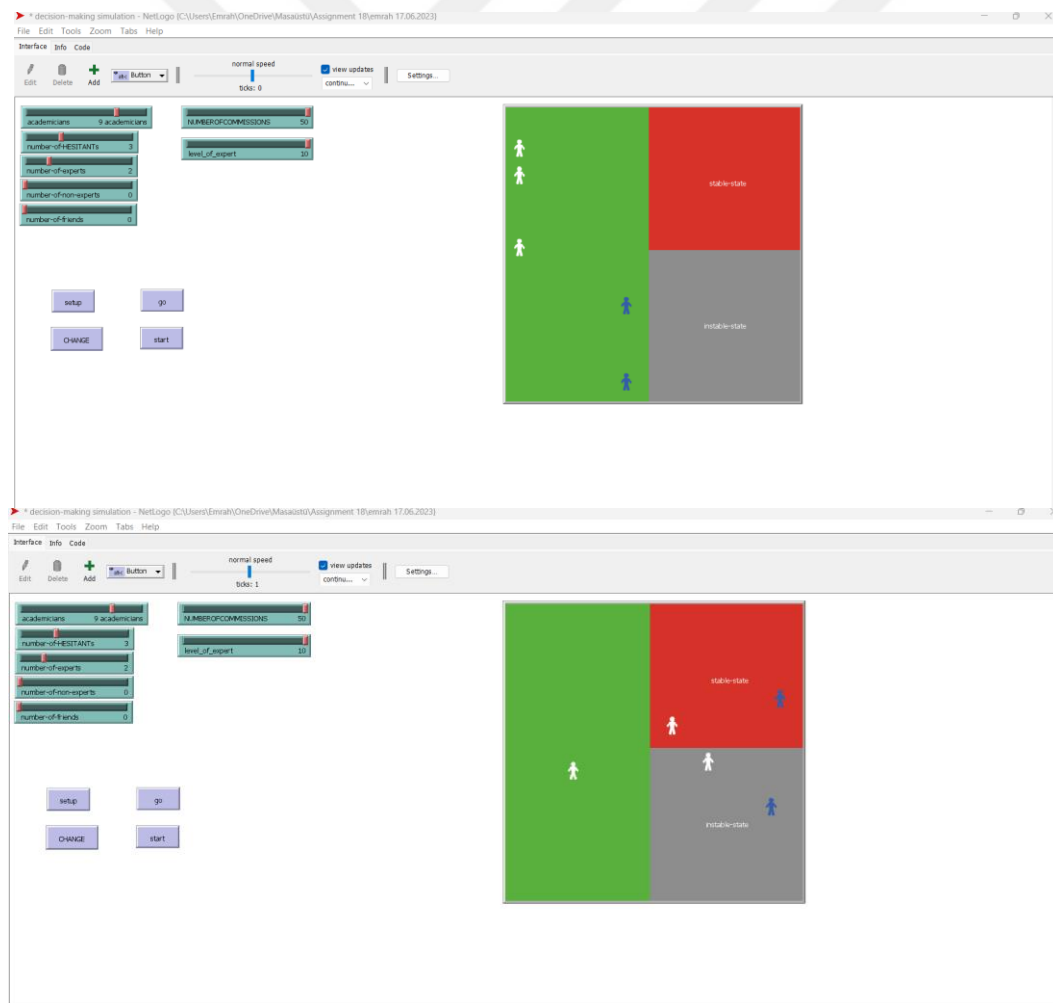


Figure 5. 50. Robustness Tester

5.13. Concluding Remarks

As a result of the analysis, it was determined that the commission stage was the most effective phase of the evaluation during the evaluation of R&D Centers. It is also observed that the available data are insufficient to predict the decision of the evaluation of the application. It was determined that the effect of numerical data on the final decision was limited, and social and cognitive effects among the commission members were also effective in the decision. As a result of the analysis, it was found that the hierarchical power relationship was more effective than the others among these social and cognitive effects. It has been found that the knowledge-based trust relationship is the most important element in the hierarchy.

CHAPTER 6

POLICY RECOMMENDATIONS

In this dissertation, in which the effect of hierarchical power relationship in the selection of public R&D funds is investigated, it is discussed that reducing the hierarchical power relationship with blockchain technology and making fund distribution more transparent and accountable due to the features of blockchain. The study clearly bears the responsibility of the fund created by the contributions of the data payers. In this section, the results obtained as a requirement of this responsibility are discussed in the form of policy recommendations.

Considering the studies carried out up to this stage, it has been concluded that the main aim is to determine the supports provided by the public institutions that provide R&D incentives, and that the commissions are not authorized to make extraordinary decisions, especially in the processes that start with the application and end with face-to-face commissions. In addition, it is necessary to benefit from technological opportunities in order to classify, distribute and reuse valuable information produced in R&D projects where public resources are distributed more effectively with the responsibility that it is the common property of the public. In order to achieve this, effective policy actions ¹⁵ should be taken.

While dissertation basically discusses the differences between traditional methods and decision making on the blockchain, it actually examines the effects of technological developments on business habits. While discussing the conveniences of current and ongoing technological innovations and the shortcomings of existing methods, policy recommendations recommended for institutions in Turkey, in

¹⁵ According to OECD, effective policy actions should include elements such as clear objectives, causal theory, legal structure of the implementation process, committed officials, supportive interests groups to no undermining of changing socioeconomic conditions (Diehl, 1985).

particular R&D incentives, are discussed in this section. As a result of studies on R&D incentive processes in parallel, it has been found that the most important deficiency is on accountability and transparency. For this reason, the most basic policy proposal is on transparency and accountability.

The main policy goal is to distribute the public resources used in R&D projects in a more effective, accountable, and transparent manner, and to take measures so that the valuable information produced can be reused by the public.

The policy objectives set out in this section are tools developed to fulfill the main policy objective. While some of the helpful suggestions emerged as a result of the analysis, some of them were inspired by the superiority of blockchain technology over similar technologies. On the other hand, some policy suggestions were put forward due to the fact that institutions responsible for R&D incentives in Turkey did not have a study on this issue. To give an example, the proposal for a more transparent incentive system is the publication of public institutions that offer R&D incentives to private companies in Turkey.

It is recommended that such an aim has not been found in the strategy documents, which are mentioned or not published, or in the impact analysis reports. Naturally, since there is no written document, there is no reference to it. The figure presents seven policy recommendations necessary to achieve the main objective.

6.1. Enhancing Transparency and Accountability

R&D projects inherently involve high risk. Accordingly, the expectation of generating income from the results of R&D projects is mostly to be neglected. Instead, indicators that are relatively abstract and can achieve success in the long run, such as the production of new knowledge or skills, can be used in the success of projects. In addition, since the success of R&D projects is difficult to follow, the gains obtained from trial-and-error studies that pushed a project that was shown as unsuccessful to failure can contribute to another R&D project as an experience. As a result, measuring R&D projects with traditional methods will not give accurate

results. On the other hand, as a requirement of the social state, governments should be able to account for the expenditures made to those who pay taxes. Since this will not be easy for R&D projects, ledger-based technologies such as blockchain can make accountability even easier. In addition, if the multi-center structure of the blockchain is integrated into the R&D project system, transparency will be provided very easily. In the light of this information, the policy proposal is as follows (see Figure 6.1).

Transparency and accountability are always important since the resources provided to companies that qualify to become R&D Centers are provided by the public from taxes. This proposition should not be understood as meaning that the current situation is not transparent. Because it is a requirement of the social state to always create more transparent and more accountable environments in the public sphere.

2.4.3. As stated in the section, blockchain is a technology that can be used to create a more transparent and accountable public system.

Policy Recommendation 1 R&D incentives made with the resources of taxpayers should be made more transparent and accountable by utilizing the elements of technology.

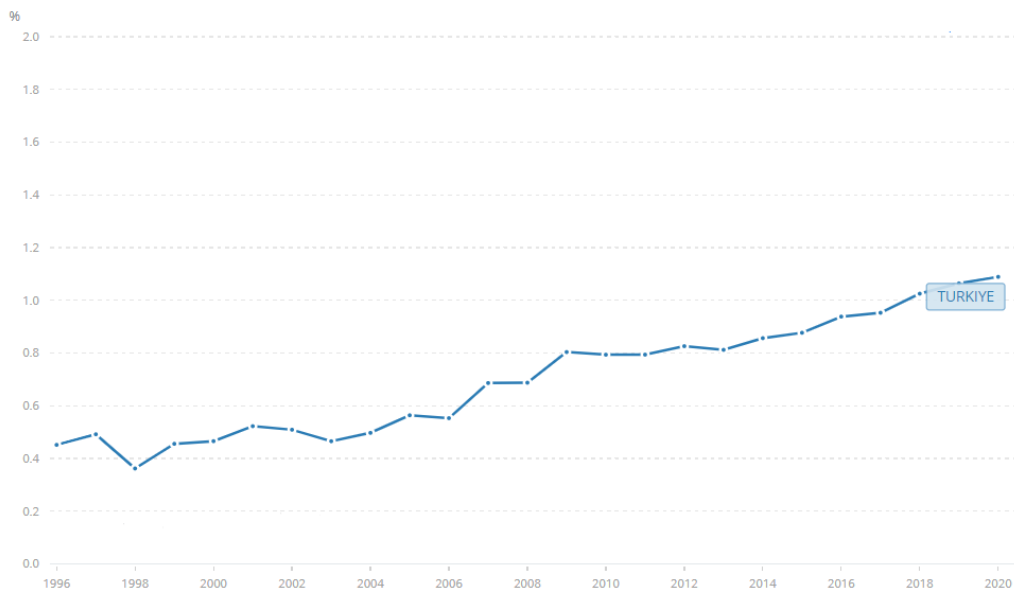


Figure 6. 1. Turkey's R&D Expenditures Over the Years

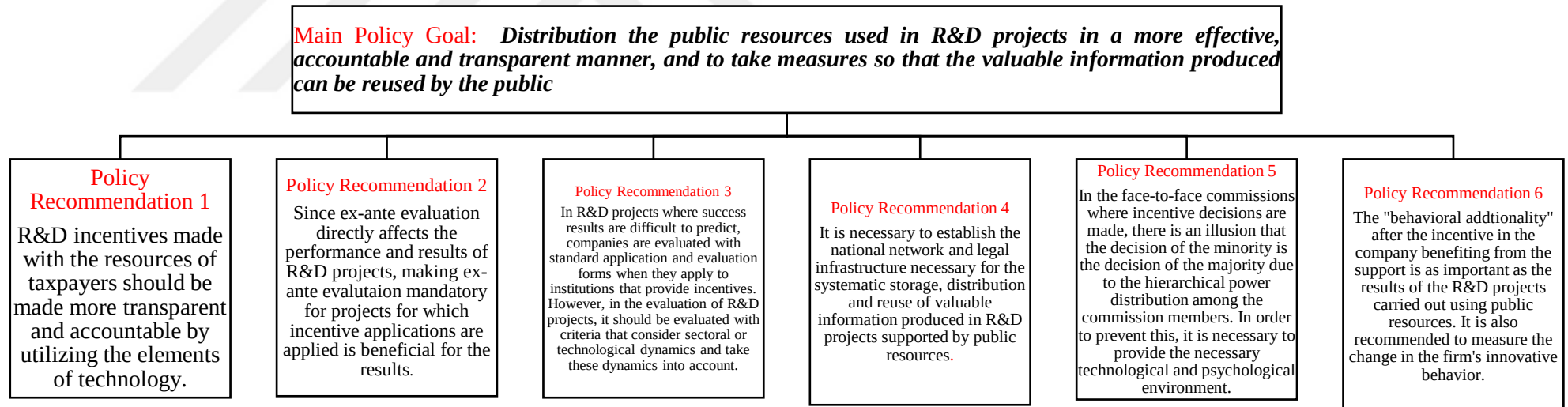


Figure 6. 2. Policy Recommendations Proposed to Achieve the Main Policy Goal

As can be seen in Figure 6.2, although it has been somewhat stable in recent years, an R&D culture has been forming in Turkey over the years. The increase in the R&D expenditures in the figure in GDP (GERD) should also be perceived as an indicator of this formation. On the other hand, it is important that these expenditures, which are made within limited means, can be explained to taxpayers in an accountable and transparent manner.

Although the impact assessment law has been enacted in order to monitor the incentives effectively in Turkey, this law is insufficient for R&D incentives due to its aforementioned features. Impact assessment law alone is not sufficient for the realization of this policy proposal. For this, two policy tools are recommended. Accordingly, it is recommended to establish a central statistical unit responsible for collecting data, matching it for other projects, and monitoring the projects afterwards. Currently, institutions such as the Ministry of Industry and Technology, KOSGEB, TUBITAK provide R&D incentives. In addition to these, the units responsible for the distribution of EU funds (IPA) in 3 different ministries also provide R&D incentives. Moreover, the authority to give R&D incentives to institutions such as the Ministry of Agriculture and Forestry, if they wish, is given by the relevant law (Law No. 5746 on Supporting R&D and Design Activities). The transparency and accountability of the incentives given in such a chaotic environment is very important considering that the resources are very limited. For this, the use of blockchain technology, which stands out with its secure, multi-centered and unchangeable structure, is recommended as a second policy tool.

6.2. Ex-Ante Evaluation Before Application

As stated in Section 2.2, Ex-Ante project evaluation has a great contribution to R&D projects to achieve the desired results. However, as mentioned in the previous section, it is important that records are accessible in order to create a more transparent and accountable process. Keeping the evaluations made during ex-ante project evaluation in a multi-centered and unchangeable blockchain environment will also affect the outcome of the project.

Financing institutions play a major role in the financing of companies' R&D projects. However, there may be situations that do not benefit the companies. The

"information asymmetry" between funders and funders is one of the barriers to supporting R&D projects. Accordingly, the applicant may be blindly attached to the project and may demand an amount above its value, while the funder who does not have a good grasp of the content of the project may set a price below its value. In order to avoid this problem, meeting with a common achievement with feasibility reports that can appeal to the knowledge of both parties can convince the parties (Ugur and Trushin, 2022). Similarly, in order to establish a more effective relationship between public institutions and those who request support in public R&D funds of projects, and to prevent a possible mistake at the beginning of the project, it is presented as another policy proposal to conduct ex-ante evaluations by independent institutions before the application. Accordingly, making such an evaluation will prevent loss of money and time. In addition, an analysis made at the very beginning of the process will be able to prevent problems that will grow like a snowball in the future from the very beginning. Accordingly, the second policy proposal is as follows:

Policy Recommendation 2 Since ex-ante evaluation directly affects the performance and results of R&D projects, making ex-ante evaluation mandatory for projects for which incentive applications are applied is beneficial for the results.

Inevitably there will be a cost if such analysis is done by independent organizations. The sharing of this cost by incentive institutions and bidders will be included in our policy proposal as a policy tool. The existence of such independent organizations specialized in R&D projects will contribute to the project culture in the country, and a competence in this sense will also increase the country's participation in applications to EU funds such as Horizon 2020.

6.3. Avoiding Standard Evaluation Criteria

The third policy proposal is about the standardization of the evaluation criteria of R&D projects. The examinations showed that (although the commissions are selected according to the project areas), there is no sectoral and/or technological distinction in either the project application forms or the observer evaluation reports. Such a macro

approach may ignore sectoral dynamics. To give an example, in our MRMR analyzes carried out, it was found that the number of R&D personnel with doctoral degrees is considered important by the decision makers. However, there is a sectoral variation in the number of graduates in Turkey. According to the data of the Council of Higher Education, the number of doctoral graduates in all departments is 8857 as of the end of 2020-2021. When YÖK statistics are examined closely, there are great differences especially between engineering branches. To give an example, as of the end of 2021, although the Department of Computer Engineering is a relatively new branch of engineering, a total of 164 people graduated, while 39 people graduated from Metallurgy and Materials Engineering (YÖK, 2021). Naturally, this situation is also reflected in the labor market. While there is no problem with the supply of PhD personnel in some branches, some do. This situation is also reflected in the employment structure in the companies whose project application is from the areas where the personnel supply is low. This involuntary situation leads to unfair competition on behalf of one party in the evaluation criteria. Similarly, as can be seen in the Figure 6.3 where the European Union Intellectual Property Office (EUIPO) data is listed (European Patent Office , 2016), the number of patents is high in some NACE codes, while the number of patents is lower as a requirement of some jobs (for example, Defense Industry). As can be seen in the 5th section where the analysis results are shared, in the MRMR analyzes made, it is striking that the patent is an important criterion. Claiming the patent for every industry as a result of one-size-fits-all policies results in unfair competition as can be seen.

As can be understood from the discussions, it is the creation of sectoral specialized R&D project evaluation and monitoring sets in order to fulfill this policy proposal. In this way, a fairer evaluation process will be possible, and a balance will be achieved between sectors that attract more investment and sectors that do not.

Policy Recommendation 3 In R&D projects where success results are difficult to predict, companies are evaluated with standard application and evaluation forms when they apply to institutions that provide incentives. However, in the evaluation of R&D projects, it should be evaluated with criteria that consider sectoral or technological dynamics and take these dynamics into account.

NACE code	NACE description	Patents/ 1000 employees
28.24	Manufacture of power-driven hand tools	109.74
77.40	Leasing of intellectual property and similar products, except copyrighted works	69.23
21.10	Manufacture of basic pharmaceutical products	27.57
20.59	Manufacture of other chemical products n.e.c.	19.08
72.11	Research and experimental development on biotechnology	15.64
26.70	Manufacture of optical instruments and photographic equipment	13.67
26.51	Manufacture of instruments and appliances for measuring, testing and navigation	13.35
27.51	Manufacture of electric domestic appliances	13.12
28.91	Manufacture of machinery for metallurgy	12.33
26.60	Manufacture of irradiation, electromedical and electrotherapeutic equipment	12.26
28.94	Manufacture of machinery for textile, apparel and leather production	9.84
72.19	Other research and experimental development on natural sciences and engineering	9.65
24.45	Other non-ferrous metal production	9.56
26.30	Manufacture of communication equipment	9.35
26.11	Manufacture of electronic components	8.51
06.20	Extraction of natural gas	8.51
30.99	Manufacture of other transport equipment n.e.c.	7.99
20.11	Manufacture of industrial gases	7.77
28.95	Manufacture of machinery for paper and paperboard production	7.58
30.40	Manufacture of military fighting vehicles	7.58

Figure 6. 3. Patent Statistics by NACE Codes (EUIPO, 2016)

In order to make a policy proposal that considers sectoral or technological dynamics, first of all, the data of past R&D project applications should be gathered from all support institutions. As a second step, by looking at the distribution of R&D projects, it will be evaluated whether sectoral or technological dynamics will be taken into account. Depending on the results of the evaluation, a distinction should be made about what is considered in the application and audience reports of companies that can receive incentives or apply and not receive incentives in order to determine the sectoral or technological dynamics. At the end of the criteria evaluation, new criteria set should be studied. The new criteria set should be reused on past applicants who have been successful in the application processes and those who have not. The new criteria should be put into use if they meet the sectoral or technological dynamics.

6.4. National R&D Data Network

Public institutions are used in the evaluation of R&D projects. These opportunities are not only limited to financial opportunities, in addition, labor is also spent.

Considering the R&D project applying for incentives as a question, the observer and commission reports created using public resources provide us with unique information about the answer to the question. The importance of the knowledge obtained from this process is understood even more. On the other hand, as mentioned before, many public institutions in Turkey distribute R&D incentives. Since there is no effective communication network between institutions, similar projects, even the same projects, are assessed and sometimes supported by different institutions. For this reason, the creation of a National Project Network is presented as a policy proposal to record the knowledge produced during the evaluation processes of R&D projects and to prevent similar projects from being supported repeatedly. A secure and highly centralized technology such as blockchain is a suitable tool (as stated in section 2.4.1) for building this network.

The policy recommendation for the network proposal is as follows:

Policy Recommendation 4 It is necessary to establish the national network and legal infrastructure necessary for the systematic storage, distribution and reuse of valuable information produced in R&D projects supported by public resources.

The opportunities provided by the National Project Network will also serve as a tool for the realization of the policy. The tools of policy proposal are grouped under four headings. These are briefly, demand, knowledge, networks and evaluation.

Demand: Other companies that may be interested in these projects can be found from the imprint information of the projects included in the National Network. In this way, a cooperation opportunity on the network structure can be started between the two companies.

Knowledge: Since the information produced after the project evaluation and finalization phase will be stored in this blockchain-based network, taking into account the IPR, it can be passed on to third parties by voting within the chain if necessary. The IPR rights of the information produced in R&D projects are always a problematic issue. Since all the information in this tool is already registered in the blockchain and recorded on many computers, and it is clear in the ledgers who recorded these records, these records can be used in case of any conflict.

Network: This national network will have existing project owners. When other demanding companies mentioned in the demand part are included in this network, a full business network will emerge.

Coevolution: In this blockchain-based network, there will be no IPR thanks to the trust environment brought by the blockchain. In this case, companies that accept the chain participation specification can be included, and new projects can be made with the gains obtained from the projects.

6.5. Avoiding Disclaimer

“There is no expedient to which a man will not go to avoid the labor of thinking.”

Jashua Reynolds

The main premise of dissertation is that people are overwhelmed by the weight of decision making and delegate that responsibility to others. In this situation, which is encountered in face-to-face meetings, people tend to transfer the "right to decide" given to them as a result of psychological factors to those who hold the psychological superiority (hierarchical power distance) within the group. In the analysis studies (as a result of ABM analysis in section 5), it is observed that the decision makers in the group mostly delegate these rights to the relatively more knowledgeable people in the group (although they are not sure that they are more knowledgeable). It was determined that he gave this right to his friends, then to the majority, respectively. The analyzes have also proved that this transfer process is not to be underestimated. Accordingly, the next policy proposal is:

Policy Recommendation 5: In the face-to-face commissions where incentive decisions are made, there is an illusion that the decision of the minority is the decision of the majority due to the hierarchical power distribution among the commission members. In order to prevent this, it is necessary to provide the necessary technological and psychological environment.

Public institutions may delegate the decision-making power from time to time. While doing this, the principles of accountability, consultation with experts and transparency are taken into consideration. R&D commissions act with similar

motivations. Accordingly, within the scope of the principle of accountability, it delegates the decision to the commissions, has a command of the subject thanks to the commissions formed from experts on each subject, and makes these commissions through face-to-face discussions within the scope of the transparency principle. However, despite all these moral aims, it has been proven within the scope of this dissertation that the commission members transferred the power given to them to others without much difficulty.

In order to prevent this, our first suggestion as a policy tool is to make commissions in more free expression environments such as blockchain rather than face-to-face. In this way, since there is no human-to-human communication, there will be no hierarchical power distance effect. In this way, the intended "collective intelligence" can be accessed more efficiently. As the second tool, as suggested by the psychology literature, the highest efficiency is obtained in commissions of at least 8 and at most 12 people without making collective decisions. However, traditionally commissions consist of a maximum of 5 people. There are several reasons for this. First and foremost, every extra person creates a cost, secondly, the difficulty of having so many people in the same place at the same time, and lastly, the risk of prolonging the commissions. However, in making a blockchain-based decision, these costs will be reduced, there will be the opportunity to make decisions independent of time and place, and people will have the opportunity to participate in the discussions whenever they want.

Due to the fact that R&D projects contain more unique information by nature and policy makers are aware of their risky nature, the tolerance of taxpayers or supervisors can be high for the expenditures made here. On the other hand, transparency and accountability are much more important in commissions where relatively more transparency is desired, such as in public tenders. For this reason, "live broadcast" tenders have been held recently in order to ensure and maintain justice. Broadcasting the tender live on television does not mean that the hierarchical power distance effect is not effective on the decision. In fact, with this method, anyone who turns on the television is only given the right to access the information in the broadcast. This situation is already available in blockchain with distributed

ledger technology. Transparency, multi-centralization, trust and clear recording of the discussion over the decision are required to avoid fully off-topic influences. By using the blockchain system in such a sensitive area, all the conditions mentioned can be achieved from a single source. This policy tool is the most important and top priority recommendation in this chapter.

6.6. Measuring Behavioral Additionalities

It is mentioned in the relevant section (section 2.7) that R&D incentives are defined as "behavioral additionality", which is the permanent change in the company's R&D innovation culture. Even if the incentives are interrupted, the company's willingness to continue its R&D and innovation projects is important for the country's interests. In addition, subsidizing the R&D investments that the company plans to make with its own resources with incentives and public resources is important for the efficient use of limited resources in terms of creating a "crowding-out" effect.

It has been mentioned in the previous sections that impact analysis studies can be made easier and information-based thanks to the unchangeable ledger structure of the blockchain technology. This feature of blockchain also emerges as a useful technology in terms of measuring the behavioral effects of R&D incentives. Thanks to the multi-center ledgers of the blockchain, the changes in the R&D culture of the company that receives incentives can be observed from different perspectives. In addition, more effective policies and impact analyzes can be made thanks to the fact that the information on the ledger can be deleted or written by voting by the members in the chain. Based on this information, the final policy recommendation is as follows.

Policy Recommendation 6: The behavioral additionality"after the incentive in the company benefiting from the support is as important as the results of the R&D projects carried out using public resources. It is also recommended to measure the change in the firm's innovative behavior.

The Ministry of Industry and Technology carries out impact analysis studies that have been made compulsory by the Impact Analysis Law for its institutions and

programs. Even a unit was established in the Ministry for the studies carried out. However, unfortunately, there is no public report on the work of this unit. In terms of contributing to these studies, measuring the effect of "behavioral additionality" as stated in Chapter 2 is recommended as a policy tool. Accordingly, the company's pace of making new projects, the expansion of the scope of the projects, the increase in the number of collaborations and the R&D project budgets are the new generation indicators used to measure the behavioral impact. As a result of an impact analysis study including these indicators, the permanence of the R&D culture in the company after the incentive will be measured. Thus, both the unwarranted use of public resources will be prevented and an established R&D culture will be formed within the country. With the long-term effect of these changes, the possibility of producing value-added products and services will increase.

All policy recommendations, details, tools, and activities presented so far are demonstrated in Table 6.1.

Table 6.1 contains 10 policy recommendations under 6 main headings. In order to realize these sub-recommendations, there are policy actions for the relevant public institutions and organizations.

In the final and last part of the dissertation, there is a conclusion section where all the literature, analysis studies and the gains obtained from the policy recommendations made as a result of these are included. This section also mentions the obstacles to completion of the study in later stages. In addition, the section containing advanced analysis stages, which were not carried out within the scope of this study but are thought to take the study further if carried out by the author, is also included in this section. For example, if "semi-structured interviews", which could not be completed within the period of this study, are conducted with a similar study, better quality data obtained from the survey study can be obtained. As a result, the results of simulation studies can be more clear and precise. However, the study can still provide precise data in its current form. Because it is thought that the academicians who conducted the survey answered the survey sincerely.

Table 6. 1. Policy Implications: Policy Tools and Key Activities for Each Policy Recommendations

- ***Policy Recommendation 1: R&D incentives made with the resources of taxpayers should be made more transparent and accountable by utilizing the elements of technology.***

Policy Aims to Clarify the Purpose of Recommendation: With this policy, to make R&D processes more transparent and accountable, where success criteria are not clear, and to raise R&D awareness in public administrators and ultimately throughout the country.

Key Policy Tools to Achieve Policy Recommendations	Key Activities/Tasks to Realize Policy Tools
1.1. An institution should be established above the institutions that provide R&D incentives, where data are collected, and upper policy decisions are made. 1.2. Blockchain technology should be included in the National R&D fund system for healthier data tracking and the distribution and re-creation of the valuable information obtained.	1.1.1 Re-functionalization of the Science and Technology Supreme Council 1.1.2 Bringing together the possibilities and data of ministries and affiliates 1.2.1 Preparing the R&D project inventory of the supporting institutions. 1.2.2 Inclusion of all data in the blockchain system. 1.2.3 Determining the institutions, organizations and persons to be included in the chain and making authorizations

Table 6.1 Policy Implications: Policy Tools and Key Activities for Each Policy Recommendations (cont'd)

- ***Policy Recommendation 2:*** *Since ex-ante evaluation directly affects the performance and results of R&D projects, making ex-ante evaluation mandatory for projects for which incentive applications are applied is beneficial for the results.*

Policy Aims to Clarify the Purpose of Recommendation: The policy proposal aims to evaluate projects at a certain maturity level.

Key Policy Tools to Achieve Policy Recommendations	Key Activities/Tasks to Realize Policy Tools
2.1 Authorized independent pre-assessment bodies need to be established to assess the suitability of projects and evaluate them with the right policy proposal.	2.1.1 Determine the sectoral maximum conditions that the project proposal must meet in order to be evaluated. 2.1.2 Determine the conditions that must be met by organizations that will make ex-ante project assessments. 2.1.3 Authorize companies to conduct independent ex-ante project evaluations 2.1.4 Determine success criteria of accredited organizations 2.1.5 Organize periodic inspections of authorized bodies

Table 6.1 Policy Implications: Policy Tools and Key Activities for Each Policy Recommendations (cont'd)

- **Policy Recommendation 3:** *In R&D projects where success results are difficult to predict, companies are evaluated with standard application and evaluation forms when they apply to institutions that provide incentives. However, in the evaluation of R&D projects, it should be evaluated with criteria that consider sectoral or technological dynamics and take these dynamics into account.*

Policy Aims to Clarify the Purpose of Recommendation: With the policy proposal, it is aimed to make a fairer evaluation by considering the sectoral or technological dynamics.

Key Policy Tools to Achieve Policy Recommendations	Key Activities/Tasks to Realize Policy Tools
3.1 Making evaluation sets that take into account sectoral or technological dynamics.	3.1.1 Decide whether sectoral or technological dynamics take precedence. 3.1.2 According to the prioritization studies given, extract the variables that affect the decision between the companies that receive support and those that do not.

Table 6.1 Policy Implications: Policy Tools and Key Activities for Each Policy Recommendations

- ***Policy Recommendation 4: It is necessary to establish the national network and legal infrastructure necessary for the systematic storage, distribution and reuse of valuable information produced in R&D projects supported by public resources.***

Policy Aims to Clarify the Purpose of Recommendation: With the policy proposal, it is aimed to follow up, store and reuse data from a single source by establishing a National R&D network.

Key Policy Tools to Achieve Policy Recommendations	Key Activities/Tasks to Realize Policy Tools
4.1 To create a demand environment for projects by displaying project results on a platform (such as Ethereum) that can prevent IPR problems experienced in R&D projects.	4.1.1 Secure IPR by creating smart contracts on Ethereum (a blockchain-like program) 4.1.2 Collect R&D requests from smart contract providers 4.1.3 Bring project and requesters together
4.2 Recording the information produced during the project evaluation and finalization phase	4.2.1 Record objections, successes and failures on the Ethereum chain at every step of R&D projects 4.2.2 Give tokens to the owners of the generated knowledge as much as the knowledge they produce 4.2.3 Bring together those who accept the terms of the smart contract with the right holders
4.3 Establishing a business network between the project owners and the institutions and individuals requesting the project outputs.	4.3.1 Create an IPR-secured network with smart contracts
4.4 Creating added value by re-evaluating the results of the concluded R&D projects	4.4.1 Bring together claimants and beneficiaries dealing with information circulating in the network

Table 6.1 Policy Implications: Policy Tools and Key Activities for Each Policy Recommendations (cont'd)

- **Policy Recommendation 5** *In the face-to-face commissions where incentive decisions are made, there is an illusion that the decision of the minority is the decision of the majority due to the hierarchical power distribution among the commission members. In order to prevent this, it is necessary to provide the necessary technological and psychological environment.*

Policy Aims to Clarify the Purpose of Recommendation: The aim of this proposal is to create more democratic and rational decision-making environments.

Key Policy Tools to Achieve Policy Recommendations	Key Activities/Tasks to Realize Policy Tools
5.1 With the amendment to be made in the public procurement law, it is recommended that public tenders be made in the blockchain environment.	5.1.1 Create the legal legislation of the Public Procurement Law 5.1.2 Plan the necessary arrangements in blockchain technology. 5.1.3 Move the sealed bid method to the blockchain environment. 5.1.4 Secure decisions with blockchain stamp enforcement

Table 6.1 Policy Implications: Policy Tools and Key Activities for Each Policy Recommendations (cont'd)

- **Policy Recommendation 6** *The Behavioral additionality"after the incentive in the company benefiting from the support is as important as the results of the R&D projects carried out using public resources. It is also recommended to measure the change in the firm's innovative behavior.*

Policy Aims to Clarify the Purpose of Recommendation: Creating an R&D culture in companies after R&D incentives.

Key Policy Tools to Achieve Policy Recommendations	Key Activities/Tasks to Realize Policy Tools
6.1 Determining the R&D incentive of the company towards R&D and permanent changes after the incentive.	6.1.1 Establish impact analysis units in incentive institutions. 6.1.2 Identify variables that will measure changes in the institutional capabilities of firms benefiting from the incentive. 6.1.3 Measure the impact of the incentive on the corporate culture

CHAPTER 7

RESULTS AND LIMITATIONS AND DIRECTION FOR FURTHER RESEARCH

7.1. Results

As Darwin stated in his notes in his book *The Origin*, the most important driving force for man to come from his/her ancestors in Africa to his/her present level is the "gradual and continuous acquisition of mental power" (Tattersall, 2008). One of the most important works of human beings, who follow their curiosity and needs with the effect of this power, is "technology". Every success achieved with technology reveals other works, obstacles, and new ways of doing business in front of human beings. Human nature adapts to these social, cultural, and economic changes. Those who do not might be excluded by Darwin's "survival of the fittest" principle. This acceptance naturally brings the question to mind, "how?". What kind of process does a man go through while adapting and what changes.

During this dissertation, the writing process of which included the COVID-19 pandemic, there were many technological developments and the way of doing business was changing. With the restrictions imposed by the COVID-19 pandemic, the face-to-face meetings were held online. At the same time, blockchain technology was increasing its popularity day by day. Many new application areas were being considered for this technology with its safe, democratic and polycentricity, and much academic research are conducted on this subject. These developments have been decisive in the determination of dissertation. In this thesis, the role of blockchain technology in the selection of R&D projects, its effects on decision-making processes and the benefits of using blockchain in Turkey's R&D incentive system were investigated.

As a result of the analysis carried out within the scope of the study, some improvement areas are identified, as detailed in the following sections. Accordingly, it is concluded that public R&D funds, in which resources collected from taxpayers are used, should be accountable and transparent. Ensuring accountability and transparency becomes accessible through technological means. In this sense, blockchain technology is a good tool with its features. During the evaluation of R&D Centers, very valuable information can be produced as discussions between both the audience and the commission members. This generated information can be used to make new evaluations fairer and can also be beneficial for the country's Science, Technology and Innovation ecosystem. In addition, a central evaluation model is used in the evaluation of R&D Centers. This model can ignore sector-specific dynamics, as detailed in the relevant section. For this reason, studies should be conducted on original models that include sector-specific dynamics. On the other hand, in order to better examine the sector-specific dynamics, field expert academics are appointed to the evaluation commissions of R&D Centers using public resources. However, analyzes conducted within the scope of dissertation have shown that, under the influence of hierarchical power distance, the knowledge and experience of field expert academics cannot be fully utilized due to cognitive effects. Finally, the most important input of dissertation is the data obtained from the Ministry of Industry and Technology. Although this data is very high quality and detailed, it needs to be validated with qualitative methods, that is, supported by semi-structured interviews. This method could not be studied within the scope of this study, but it is recommended to do so.

The following results are obtained from the quantitative and qualitative analyzes such as literature research conducted within the scope of Dissertation, ID3, Classification Learner, MRMR, Tobit and ABM analyzes, and 2 surveys conducted among academicians who took part in R&D commissions:

7.1.1. Transparency

Developing technology shows its effect in public administration and finance as well as in many areas of social life. The transparency of their governments' policies is also

related to the technology boom. Even in China, one of the world's most populous and relatively closed societies, they have devised practices and new policies to gain access to their laws and policies in the last two decades. This unprecedented situation in China's history is the product of an effort to demonstrate its democratic transparency. In addition, openness and transparency are a prerequisite for transnational companies to minimize their costs of doing business and therefore invest (Relly and Sabharwal, 2009). For this reason, countries invest in openness and transparency to attract these investments to their countries.

In the OECD's 2022 annual report titled Raising the Bar in Tax Transparency, Turkey received the "partially compliant" grade in tax transparency in the general grading. The inadequacy of Turkey's domestic and international information collection and reporting was influential in this note (OECD, 2022).

It is also important that the results of the Public R&D Funds, in which the revenues collected from taxpayers are distributed, are transparently and openly disclosed to all stakeholders. Blockchain technology is an effective mechanism, thanks to its features, to increase efficiency in R&D projects supported by resources obtained from taxpayers, to record and reuse the produced information, and to monitor the outputs obtained after incentives in order to turn them into a value chain, and for transparency and accountability.

7.1.2. Expertise and Knowledge Stock

In the study, in which multi-criteria decision making suggests improvement in the evaluation of the R&D projects decided by the group members, in which the project applications coming to the National Science Foundation of China are evaluated by multiple experts, it has been determined that the expertise level of the decision-making academics has a direct effect on the decision (Liu *et al.*, 2017). The results of Tobit analysis made in Dissertation also support this result. According to this as a result of the Tobit analysis, it is observed that the probability of the applications being eliminated increases as the expertise of the observers and academicians increases.

From a different point of view, ID3 and MRMR analyzes have determined that the applicant company has done more R&D projects and has a high number of highly educated human resources, which increases the likelihood of the application being accepted. These analyzes revealed that there is an information asymmetry between the evaluators and the evaluators. It is thought that it would be beneficial for the company to switch to a more effective information management system in order to increase its capacity and capability before the application. It has been concluded that blockchain technology can provide this infrastructure to companies with its unchangeable ledger structure.

In addition, in another study in which R&D projects were investigated using AHP and Fuzzy TOPSIS methods, it was found that the number of expert personnel, the availability of laboratory and testing facilities and the strength of the software infrastructure of the applicant company contributed positively to R&D project applications (Kiraz *et al.*, 2018). These results are directly related to the results found in dissertation.

In the entropy, MRMR and Tobit analyzes, it was determined that the excess number of staff with doctoral degrees and supported or unsupported projects increased the probability of the applications to be accepted. These results are directly or indirectly supported by the study using AHP and Fuzzy TOPSIS. Kiraz *et al.* while emphasizing the importance of expert personnel in their study, it has been determined that doctoral and graduate personnel are important in dissertation. In addition, laboratory, test and software infrastructure indirectly affects the number of R&D projects. For this reason, the two studies are consistent.

On the other hand, there are differences in the priority of some variables between the entropy, MRMR and Tobit analyzes used. It has been determined that there are differences in the data obtained from the Ministry of Industry and Technology during the dissertation, in the data of companies with R&D Centers. This situation has resulted in the fact that different variables are effective on the result in entropy calculations, MRMR and Tobit analyzes. To give an example, the most important factor in entropy calculation is the excess of the number of personnel with doctorate

degrees, while the excess of the projects carried out in the Tobit study is found. It is natural to obtain these results from these data, which are collected without any discrimination in the sectors to which the companies apply. On the other hand, the existence of these results does not change the fact that these variables are the factors that are considered in the acquisition of incentives. However, at this point, some companies are naturally advantageous while others are disadvantaged. For example, while it is not a problem to find personnel with a doctorate for the pharmacy sector, this situation can be a problem in the software sector. While increasing the number of projects in terms of the duration and budget of the projects is not a problem for the software sector, this may be a problem for the pharmacy sector this time. For this reason, it has been concluded that a sectoral evaluation method should be used in the public R&D incentive system and that "one-size-fits-all" policies should be avoided. Since this situation will bring tracking and classification costs on the public side, it is thought that blockchain technology can be a solution to this problem with its multi-center structure.

7.1.3. Data

Data improves the lives of its people in many ways. Quality data is essential for effective decision making (Mary Kay Rizzolo, 2022). In addition, data is the most important input in obtaining appropriate results in analysis and in solving problems. There are many advantages of storing data in multiple centers with security. Accordingly, it provides access to accurate and high-quality data in multi-center data centers without intermediaries or obtaining permission from a central structure. Naturally, this increases accountability and transparency. Faster and more effective solutions can be produced with the information obtained from data that is not in a central authority. Verification of the results obtained with the data obtained from the multimedia can also be more effective. This fast, secure, and efficient environment also reduces time-dependent costs as a result.

Many public institutions in Turkey provide incentives within the framework of their authorities. These cash and in-kind incentives are both kept in the public institution's own database, and data sharing between institutions, including public institutions that

are in close contact, is limited. Again, the data quality and diversity of the Ministry of Industry and Technology data used in dissertation is low. In these incentives, where public resources are used, data should be kept at the national level and multi-center simultaneously. For this reason, it has been concluded that the necessity of using a multi-center structure such as blockchain. In this sense, blockchain is a technology that can meet this need in the best way, with the ability to monitor data instantly and to change or add it with a multiple approval mechanism.

7.1.4. Hierarchical Power-Distance

There is no study in the literature on the effect of hierarchical power distance between decision makers in group decision-making environments where R&D incentives are decided. However, in a study of multi-member decision-making groups, Li et al. It has been concluded that the individual decisions of the group leaders and the collective decision of the group largely agree (Li, Li and Kou, 2021). This result raises doubts about the independence of the group's decision. It is not a desirable result in terms of democracy that the leader's decisions and the group's decisions are in harmony. On the other hand, there is no leader mechanism in group meetings where R&D projects are evaluated. On the contrary, it is more desirable that everyone contributes to their knowledge and makes suggestions in this group work. Dissertation, on the other hand, emerged as a result of a knowledge-based leadership consisting of academicians and other academics trusting the leader's decision and transferring the responsibility of decision making to him/her.

Although there are many studies on the effect of the leaders' decisions on the joint decision (Ejimabo, 2015), there is no study on the effect of the leader in the R&D incentive evaluation, where there is no official leader and it is not thought to exist.

As a result of the analysis results and ABM simulations, it was concluded that a superior leader emerged among the other commission members hierarchically in face-to-face commissions and the final decision for incentives could be given through the views of this leader. This situation may lead to wrong results in the decision of R&D incentives where polyphony and expertise are important. In the

public sector where resources are limited, this situation may need to be prevented in face-to-face commissions in order for the incentives to be more efficient and the results to be more positive. For this reason, it has been concluded that incentive decisions are made through a secure online platform such as blockchain in order to negotiate online and to record the information, comments and opinions produced during the discussions.

7.2. Limitations

This thesis has a number of limitations resulting mainly from the change in data structure over time and lack of data. Those limitations are provided in the relevant chapters or sections of the thesis. However, a summary of them is presented as follows.

Limitation due to Data Held on Different Platforms: In the data provided by the Ministry of Industry and Technology, it has been declared that data for some years are not available in excel files, while some are kept on the online platform. For this reason, it has been studied with limited data of years that can be shared.

Limitations Arising from the Data Requested from the Applicant Companies and From the Observer/Commission Member Academicians: There have been many changes in the data requested from companies and academicians during the application. These changes were also decisive and restrictive in the analyzes.

Limitations Due to Survey Method: During the dissertation, 2 different surveys were conducted among the academicians who mostly participated in the R&D Center selection processes. In these studies, their participation in the survey was not at the desired level. Particularly, there was a need for high participation in the determination of the decision-making points of the academicians of the ABM simulation, but it was not at the desired level. However, the respondents' responses to the survey questions and the quality of the data were above expectations.

Direction for Further Research: Although many studies have been conducted on R&D incentives, there are not many studies on the human factor in making incentive

decisions. It is recommended to focus more on the person at the center of the evaluation, apart from the studies that focus on the content and deficiencies of the incentive. It is hoped that other researchers, who will follow the path opened by this study, will conduct more comprehensive studies with richer data sets.

In addition, while there are many studies focusing on the economic impact of technological progress, it is thought that it is equally important to increase the number of studies focusing on possible changes in the way people do business as a result of technological progress. It is thought that it would be valuable to diversify this study in this axis, in which the effect of technological progress on human beings is addressed in environments where people are at the center.

Finally, in this study, the data on the cognitive factors affecting the decisions of the academicians in the process leading to the decision were obtained by the survey method. On the other hand, obtaining higher quality and unbiased data directly affects the simulation results. For this reason, it is recommended to use face-to-face semi-structured interviews in order to validate the quantitative analysis results instead of questionnaires as a data collection tool in future studies.

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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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15 ŞUBAT 2022

Konu : Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi : İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Prof. Dr. Erkan ERDİL

Danışmanlığınızı yürüttüğünüz in "Türkiye'de Kamu Ar-Ge Projelerinin Değerlendirme Sistemine Blok-Zincir Teknolojisinin Uygulanması" başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **0128-ODTÜİAEK-2022** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Prof.Dr. Mine MISIRLISOY
İAEK Başkan

B. SURVEY QUESTIONS

Informational Text

Sayın hocam

Orta Doğu Teknik Üniversitesi Bilim ve Teknoloji Politikaları Çalışmaları bölümünde doktora çalışmalarını yürütmekteyim. Çalışma başlığım “Türkiye’de Kamu Ar-Ge Projelerinin Değerlendirme Sistemine Blok-Zincir Teknolojisinin Uygulanması”dır. Bu çalışma kapsamında, hali hazırda kamu fonlarının seçiminde kullanılmayan, ancak kullanılması durumunda blok-zincir teknolojisinin kararlar üzerine etkisi modellenenecektir.

Bu modelleme çalışması aynı zamanda bir tahmin çalışması da olacağı için modelde kullanılan değişkenlerin doğal durum ile uyumu için “uzman değerlendirmesine” ihtiyaç duyulmaktadır. Bu sebeple, grup karar verme esnasında, karar vermeye etki eden/edebilecek dinamikleri belirlemek üzere bu anket çalışması hazırlanmıştır. Burada vereceğiniz kıymetli veriler ile makul bir gelecek modellenerek tahmin edilmeye çalışılacaktır.

Araştırma sırasında sizden alınacak bilgiler gizli tutulacak ve sadece araştırma amaçlı kullanılacaktır. Bu araştırmaya katılmama hakkınız bulunmaktadır. Aynı zamanda çalışmaya katıldıktan sonra çalışmadan çıkabilirsiniz. Anket ile ilgili sorularınız için benimle irtibata geçebilirsiniz.

Emrah KORAMAN

Dear sir

I am carrying out my doctoral studies in the Department of Science and Technology Policy Studies at Middle East Technical University. My working title is "Application of Block-Chain Technology to the Evaluation System of Public R&D Projects in Turkey". Within the scope of this study, the effect of block-chain technology on decisions, which is not currently used in the selection of public funds, but if used, will be modeled.

Since this modeling study will also be a prediction study, "expert evaluation" is needed to ensure that the variables used in the model are compatible with the natural situation. For this reason, this survey study was prepared to determine the dynamics that affect/may affect decision-making during group decision-making. A reasonable future will be tried to be modeled and predicted with the valuable data you provide here.

The information collected from you during the research will be kept confidential and will be used only for research purposes. You have the right not to participate in this research. You can also leave the study after participating in the study. You can contact me for your questions about the survey.

Emrah KORAMAN

Q 1) Yaşınız

- ☐ 25-29
- ☐ 30-34
- ☐ 35-39
- ☐ 40-44
- ☐ 45-49
- ☐ 50-54
- ☐ 55-59
- ☐ 60-64
- ☐ 65-69

Q 2) Unvanınız?

- ☐ Dr. Öğretim Üyesi
- ☐ Doç.Dr.
- ☐ Prof. Dr.

Statement

Karar verme 2 aşamadan oluşmaktadır. Bunlar; **bireysel** ve **grup** karar verme aşamalarıdır.

5746 sayılı Kanun kapsamında değerlendirilen Ar-Ge Merkezlerinin belge kararına etki eden unsurların çalışıldığı bu tez çalışmasında, komisyon üyesi bireysel karar verme sırasında, izleyici (2 akademisyen) raporları ve başvuru dosyasından gelen bilgilerden faydalanmaktadır.

Başvuru raporunda, firmanın araştırmacı, doktoralı ve yüksek lisanslı personel sayısı, katılım sağlanan etkinlik, sempozyumlar, personele verdirilen eğitimler, makale, yayın, patent sayıları karar verici olarak belirleyici olmaktadır.

Merkez adayını yerinde inceleyen akademisyenlerin, firma hakkında olumlu ya da olumsuz sonuçları da diğer belirleyici unsurdur.

Bu iki unsura bakarak komisyon zamanı komisyona katılım sağlayan komisyon üyesinin **aklında (bireysel karar verme aşaması)** belli bir karar bulunmaktadır.

Bu çalışmada bu durum ikiye ayrılmıştır.

Bunlar;

SENARYO 1 (KARARLILIK: Komisyon toplantısı öncesi bireysel karar oluşmuş)

SENARYO 2 (BELİRSİZLİK: Komisyon toplantısı öncesi bireysel karar henüz oluşmamış)

Bu iki duruma göre soruları yanıtlamanız beklenmektedir.

Sağ üst köşede yer alan insan ikonları komisyondakileri temsil etmektedir.

Soru işareti ile ifade edilen insan ikonu karar verme sırası gelen **sizi** temsil etmektedir.

Kırmızı insan ikonu kararını vermiş (olumlu ya da olumsuz) **konusunda uzman olmadığını bildiğiniz kişi(leri)yi**

Sarı dolgulu insan ikonu kararını vermiş (olumlu ya da olumsuz) **sosyal çevreden tanıdığınız kişi(leri)yi**

Mavi dolgulu insan ikonu ise kararını belirtmiş (olumlu ya da olumsuz) akademik

olarak tanıdığınız ve **konunun uzmanı kişi(leri)**yi temsil etmektedir.

Q 1) Your age

☐ 25-29

☐ 30-34

☐ 35-39

☐ 40-44

☐ 45-49

☐ 50-54

☐ 55-59

☐ 60-64

☐ 65-69

Q 2) Your title?

☐ Dr. Lecturer

☐ Assoc.Prof.Dr.

☐ Prof. Dr.

Statement

Decision making consists of 2 stages. These; **individual** and **group** decision making stages.

In this thesis study, in which the factors affecting the document decision of R&D Centers evaluated within the scope of Law No. 5746 are studied, the commission member benefits from the audience (2 academicians) reports and the information from the application file during individual decision-making.

In the application report, the number of researchers, doctoral and master's degree personnel of the company, the events attended, symposiums, training provided to the personnel, the number of articles, publications and patents are decisive.

Another determining factor is the positive or negative conclusions about the company made by the academicians who examine the center candidate on site.

Considering these two elements, the commission member who participates in the commission has a certain decision **in mind (individual decision-making phase)**.

In this study, this situation is divided into two.

These;

SCENARIO 1 (DETERMINATION: Individual decision was formed before the commission meeting)

SCENARIO 2 (UNCERTAINTY: Individual decision has not yet been formed before the commission meeting)

You are expected to answer the questions according to these two situations.

The human icons in the upper right corner represent those on the commission.

The human icon represented by a question mark represents **you**, whose turn it is to make a decision.

The **red** person icon represents the person(s) you know is not an expert on the subject who has made their decision (positive or negative).

The **yellow** filled human icon represents the person(s) you know from the social circle who has made their decision (positive or negative).

The **blue** filled human icon represents the person(s) you know academically and who is an expert on the subject, who has expressed their decision (positive or negative).

NOTE: English version of below questions are kept in the dissertation at Section 5.10.

Q 3)

**SENARYO 1 (KARARLILIK)**



SORU 1

Komisyonunda aşağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

☐ Konunun uzmanı olmayan 1 akademisyen

Etkilemez 1 2 3 4 5 6 7 Etkiler

Q 4)

**SENARYO 1 (KARARLILIK)**



SORU 2

Komisyonunda aşağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

☐ Konunun uzmanı olmayan 2 akademisyen

Etkilemez 1 2 3 4 5 6 7 Etkiler

Q 5)

**SENARYO 1 (KARARLILIK)**



SÖRÜ 3

Komisyonda ařağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

☐ Konunun uzmanı olmayan 1 akademisyen
☐ Akademik çevreden tanıdığınız konunun uzmanı 1 akademisyen ve

Etkilemez Etkiler

1 2 3 4 5 6 7

Q 6)

**SENARYO 1 (KARARLILIK)**



SÖRÜ 4

Komisyonda ařağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

☐ Konunun uzmanı olmayan 1 akademisyen ve
☐ Sosyal çevreden tanıdığınız 1 akademisyen

Etkilemez Etkiler

1 2 3 4 5 6 7

Q 7)

**SENARYO 1 (KARARLILIK)**



SORU 5

Komisyonunda aşağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

☐ Sosyal çevrenizden tanıdığınız 1 akademisyen

Etkilemez 1 2 3 4 5 6 7 Etkiler

Q 8)

**SENARYO 1 (KARARLILIK)**



SORU 6

Komisyonunda aşağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

☐ Sosyal çevrenizden tanıdığınız 2 akademisyen

Etkilemez 1 2 3 4 5 6 7 Etkiler

Q 9)

**SENARYO 1 (KARARLILIK)**



SORU 7

Komisyonunda aşağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

☐ Akademik çevreden tanıdığınız konunun uzmanı 1 akademisyen

Etkilemez 1 2 3 4 5 6 7 Etkiler

Q 10)

**SENARYO 1 (KARARLILIK)**



SORU 8

Komisyonunda aşağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

☐ Akademik çevreden tanıdığınız konunun uzmanı 2 akademisyen

Etkilemez 1 2 3 4 5 6 7 Etkiler

Q 11)

**SENARYO 1 (KARARLILIK)**



SORU 9

Komisyonunda aşağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

☐ Akademik çevreden tanıdığınız konunun uzmanı 1 akademisyen ve
☐ Sosyal çevrenizden tanıdığınız 1 akademisyen

Etkilemez Etkiler

1 2 3 4 5 6 7

Q 12)

**SENARYO 2 (BELİRSİZLİK)**



SORU 1

Komisyonunda aşağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

☐ Konunun uzmanı olmayan 1 akademisyen

Etkilemez Etkiler

1 2 3 4 5 6 7

Q 13)



SENARYO 2 (BELİRSİZLİK)



SORU 2

Komisyonunda aşağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

☐ Konunun uzmanı olmayan 2 akademisyen

Etkilemez

1

2

3

4

5

6

7

Etkiler

Q 14)



SENARYO 2 (BELİRSİZLİK)



SORU 3

Komisyonunda aşağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

☐ Konunun uzmanı olmayan 1 akademisyen

☐ Akademik çevreden tanıdığınız konunun uzmanı 1 akademisyen

Etkilemez

1

2

3

4

5

6

7

Etkiler

Q 15)



SENARYO 2 (BELİRSİZLİK)



SORU 4

Komisyonunda aşağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

- ☐ Konunun uzmanı olmayan 1 akademisyen ve
- ☐ Sosyal çevreden tanıdığınız 1 akademisyen

Etkilemez



Etkiler

Q 16)



SENARYO 2 (BELİRSİZLİK)



SORU 5

Komisyonunda aşağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

- ☐ Sosyal çevrenizden tanıdığınız 1 akademisyen

Etkilemez



Etkiler

Q 17)



SENARYO 2 (BELİRSİZLİK)



SORU 6

Komisyonunda aşağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

☐ Sosyal çevrenizden tanıdığınız 2 akademisyen

Etkilemez 1 2 3 4 5 6 7 Etkiler

Q 18)



SENARYO 2 (BELİRSİZLİK)



SORU 7

Komisyonunda aşağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

☐ Akademik çevreden tanıdığınız konunun uzmanı 1 akademisyen

Etkilemez 1 2 3 4 5 6 7 Etkiler

Q 19)



SENARYO 2 (BELİRSİZLİK)



SORU 8

Komisyonunda aşağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

☐ Akademik çevreden tanıdığınız konunun uzmanı 2 akademisyen

Etkilemez



Etkiler

Q 20)



SENARYO 2 (BELİRSİZLİK)



SORU 9

Komisyonunda aşağıdaki üyenin/üyelerin sizinle karşıt görüşte olması kararınızı etkiler mi?

☐ Akademik çevreden tanıdığınız konunun uzmanı 1 akademisyen ve
☐ Sosyal çevrenizden tanıdığınız 1 akademisyen

Etkilemez



Etkiler

C. DATA USED IN ANALYSIS

N	s	unsp pro	coll	act	ipr	em p	mscemp	phdemp	ob s1	smatc h1	ph d1	ran k1	ob s2	smatc h2	ph d2	ran k2	acmsmat ch1	acpu b1	acpa t1	aeph d1	acran k1	acmsmat ch2	aeph d2	acpa t2	acpu b2	acran k2	DECTSI ON
1	4	7	0.36842105263 1579	0.15789473684 2105	0.05263157894 73684	19	0.05263157894 73684	0	0	1	6	310 4	0	1	17	147 7	1	223	0	19	1196	1	19	20	0	3302	0
2	6	21	0	2	0	41	0.24390243902 439	0.02439024390 2439	1	1	3	162 6	0	1	17	650	1	290	0	10	1304	0	40	0	19	810	0
3	4	3	0.375	0.625	0.5625	19	0.0625	0	0	1	13	997	0	1	27	844	1	90	0	11	4933	1	20	0	12	659	0
4	0	8	0.09677419354 83871	0.48387096774 1935	0.09677419354 83871	19	0.06451612903 22581	0	0	1	31	659	0	1	13	119 6	1	235	0	18	810	1	187	0	15	1671	0
5	4	14	0	0	0	22	0.09756097560 97561	0	0	1	6	145 3	0	0	11	132 8	1	74	0	14	3518	1	67	0	27	1045	0
6	0	4	0.10526315789 4737	0.36842105263 1579	0	19	0	0	0	0	6	172 7	1	0	4	162 6	0	1	0	14	2058	1	4	0	2	1895	0
7	1	10	0	0.34146341463 4146	0.09756097560 97561	30	0	0	0	1	10	146 3	0	0	9	151 3	0	86	0	16	1196	0	73	0	16	2984	0
8	2	23	0	0	0	20	0.1	0.1	1	1	15	351 8	1	1	12	316 3	1	142	0	20	1196	1	68	0	8	1941	0
9	0	6	0.42857142857 1429	19	2.9	21	0.71428571428 5714	0	0	0	9	997	0	0	11	673	0	31	0	30	659	0	30	0	8	1142	0
10	0	8	0.08888888888 88889	0.53333333333 3333	0	45	0.06666666666 66667	0.02222222222 2222	0	1	18	109 4	0	1	3	205 8	1	45	0	17	1678	0	89	0	5	1328	0
11	2	5	0.77272727272 7273	0.77272727272 7273	0	22	0.04545454545 45455	0	0	0	10	162 6	0	0	6	132 8	1	190	0	32	1196	1	51	0	22	2270	0
12	0	4	0	0	0	19	0.06451612903 22581	0	1	1	15	720	0	0	10	844	1	40	0	16	3221	1	57	0	20	1463	0
13	1	1	0.08571428571 42857	0.02857142857 14286	0	35	0.02857142857 14286	0	0	1	4	202 3	0	1	7	162 4	1	63	0	12	3214	0	1	0	14	2058	0
14	0	6	1875,00	1.43	0.25	16	0	0	1	1	11	432 6	0	1	17	810	1	57	0	14	1788	1	96	0	10	5829	0
15	0	12	0.42857142857 1429	1.46	0	58	0.31034482758 6207	0.12068965517 2414	1	1	5	182 7	1	0	16	844	0	20	0	36	596	0	73	0	13	1142	0
16	5	18	0.17142857142 8571	0.57142857142 8571	2	35	0.17142857142 8571	0.02857142857 14286	1	1	23	844	1	1	15	223 1	1	103	0	17	3643	0	20	0	14	3208	0
17	0	6	0.2	4.5	0	20	0.1	0	0	1	4	133 1	0	1	2	178 8	1	79	0	21	844	1	68	0	24	2231	0
18	0	7	0.10526315789 4737	3	0.26315789473 6842	19	0.31578947368 4211	0.02439024390 2439	0	0	11	104 5	1	0	14	161 4	0	68	0	13	1348	0	18	0	24	650	0
19	0	14	0.04545454545 45455	0.36363636363 6364	0.04545454545 45455	22	0.04545454545 45455	0	0	1	18	844	0	1	23	661 5	1	31	0	21	844	1	96	0	14	3221	0
20	0	8	0.28571428571 4286	0.82352941176 4706	0	17	0.05882352941 17647	0	1	0	13	997	1	1	7	162 6	0	12	0	9	5881	0	76	0	11	1722	0
21	1	7	0.125	0.16666666666 6667	0.25	24	0	0	0	1	12	167 7	0	1	11	121 4	1	190	0	32	1196	1	45	0	23	3104	0
22	1	5	0.33333333333 3333	0.18518518518 5185	0	27	0.22222222222 2222	0	0	0	7	167 7	0	0	11	493 3	1	28	0	13	1238	1	28	6	3	2856	0
23	0	6	1125,00	0.66666666666 6667	0.07407407407 40741	24	0.29629629629 6296	0	0	0	21	853 5	1	0	24	268 5	0	49	0	16	650	0	18	0	7	659	0
24	0	10	0.26	0.48	0	31	0.06	0	0	0	16	104 5	1	0	11	330 2	0	1	0	14	2058	0	68	0	8	1941	0
25	3	5	0.57142857142 8571	1	2.9	21	0.04761904761 90476	0	1	0	15	650	0	0	20	162 6	0	46	3	10	1992	1	122	0	10	5673	0
26	8	11	0.86666666666 6667	5	0.96666666666 6667	30	0.36666666666 6667	0.3	1	0	22	199 2	1	1	22	167 8	1	126	0	8	997	1	120	0	25	1992	1
27	2	40	0.14035087719 2982	0.82456140350 8772	0.17543859649 1228	57	0	0.01754385964 91228	1		26	659	1	1	7	913	1	198	0	32	659	1	54	0	14	1582	1
28	2	16	2.18	2	0.37037037037 037	27	0.03703703703 7037	0	1	1	7	119 6	1	1	7	158 2	1	78	0	22	810	1	64	0	20	1788	1
29	2	9	4.8	5	0	20	0.45	0	0	1	12	538 7	1	1	15	237 3	1	30	0	15	3518	1	51	0	8	3748	1

C. DATA USED IN ANALYSIS (cont')

N	s	unsp pro	coll	act	ipr	em p	mscomp	phdemp	ob s1	smatc h1	ph d1	ran k1	ob s2	smatc h2	ph d2	ran k2	acmsmat ch1	acpu b1	acpa t1	acph d1	acran k1	acmsmat ch2	acph d2	acpa t2	acpu b2	acran k2	DECISI ON
30	0	15	0.7833333333333333	0	0	66	0	0.15151515151515152	1	1	8	1671	1	0	10	3518	0	78	0	16	1351	1	200	0	12	1196	1
31	0	7	0.3	0	0	20	0.05	0.05	1	0	3	1727	0	0	10	1701	0	42	0	21	1992	0	52	0	16	1238	1
32	9	11	0.45	0.2222222222222222	0.05	20	0.1	0.05	1	1	5	2373	1	1	15	2231	1	64	0	17	1671	1	37	0	26	652	1
33	4	1	0	0.1	0	20	0.05	0.05	0	0	9	652	1	1	5	1782	0	18	0	29	6615	0	4	0	30	720	1
34	0	12	0.344827586206897	0.5	0	29	0.0689655172413793	0	1	1	23	652	1	1	6	1852	1	194	0	26	652	1	45	0	12	1331	1
35	0	16	0.16	0.06	0	31	0.06	0	1	1	20	4326	1	1	12	810	1	64	0	20	1788	1	51	0	9	1196	1
36	7	8	0.128205128205128	0.128205128205128	0.153846153846154	39	0.487179487179487	0.205128205128205	1	0	10	1328	1	0	7	1772	0	88	0	21	2845	0	5	0	10	2941	1
37	0	8	0.35	0.85	0	20	0.2	0	1	0	17	2972	1	0	17	673	0	253	0	26	1328	0	57	0	16	5461	1
38	0	6	0.0612244897959184	0.122448979591837	0	49	0.0408163265306122	0	1	1	8	1677	1	1	18	1175	1	99	1	13	3220	1	63	0	9	650	1
39	2	18	0.3	0.384615384615385	0.102564102564103	39	0.0256410256410256	0	1	1	16	1827	1	1	27	1648	1	20	0	19	3302	0	75	2	16	1463	1
40	2	17	1	0.6	0	20	0.15	0	1	1	8	1214	1	1	12	810	1	51	0	9	1196	1	64	0	20	1788	1
41	2	9	4.6	5	0	20	0.45	0	1	1	23	8362	1	0	11	1677	1	68	0	35	913	1	395	1	15	997	1
42	2	9	0.714285714285714	0	0	21	0.0952380952380952	0	1	1	24	1211	1	0	11	1677	1	63	0	17	1895	1	139	1	30	1772	1
43	0	4	0.0526315789473684	0.105263157894737	0	19	0	0	1	1	16	844	1	1	10	637	1	63	0	14	4446	1	80	1	12	5461	1
44	9	11	0.428571428571429	0.238095238095238	0.142857142857143	21	0.0952380952380952	0	1	1	5	3221	1	1	19	1196	1	40	0	6	2058	1	67	0	10	1196	1
45	2	7	0.142857142857143	0.178571428571429	0	28	0.107142857142857	0	1	0	7	1196	1	0	8	1856	0	223	0	19	1196	0	36	0	12	844	1
46	5	2	0.25	0	0	16	0.125	0	1	0	8	997	1	1	6	3518	0	44	0	27	650	0	52	0	16	2685	1
47	2	7	0.476190476190476	0.0476190476190476	0	21	0.238095238095238	0	1	1	20	7873	1	1	16	1214	1	1	0	20	2373	1	28	6	3	2856	1
48	3	26	0.310344827586207	0.172413793103448	0	29	0.379310344827586	0.137931034482759	1	0	20	1211	1	0	10	4333	0	68	0	16	650	0	62	0	12	1677	1
49	3	7	0.0285714285714286	0	0.114285714285714	35	0.0857142857142857	0	1	1	8	4329	1	1	9	1196	1	109	0	8	1124	1	88	0	13	1196	1
50	0	16	0.45	1	0.05	20	0.15	0.05	1	1	10	1938	1	1	13	1142	1	47	0	15	1463	1	13	0	8	6224	1
51	0	12	0	0.1111111111	0	18	0	0	1	1	12	3969	0	5	0	3104	1	20	0	21	3643	1	67	0	14	1407	0
52	0	6	0.21875	0.1875	0	32	0	0	0	1	6	1463	0	0	17	1045	1	43	0	16	3921	1	37	0	18	532	0
53	1	16	1	0.941176471	0.058823529	17	0.117647059	0.058823529	0	1	12	1624	0	0	20	1626	1	71	0	24	841	1	103	0	28	1782	0
54	0	5	0.666666667	0.611111111	0	19	0	0	0	0	19	841	0	1	6	1682	1	134	0	19	1274	1	101	0	23	1722	0
55	1	1	0.085714286	0.028571429	0	35	0.028571429	0	0	1	4	2023	0	1	7	1624	1	63	0	12	3214	0	1	0	14	2058	0
56	0	8	0	0	0.15	20	0.1	0	1	1	17	532	0	1	18	720	1	62	0	20	652	0	36	0	12	844	0
57	0	14	0.206896552	0.379310345	0.172413793	29	0	0	0	1	6	1214	0	1	12	1142	1	95	0	9	1938	1	257	5	22	913	0
58	0	12	0.333333333	0.285714286	0	21	0.142857143	0	0	1	9	1196	0	1	12	2058	1	45	0	19	841	0	40	0	15	1142	0

C. DATA USED IN ANALYSIS (cont')

N	s	unsp pro	coll	act	ipr	em p	mscomp	phdemp	ob s1	smatc h1	ph d1	ran k1	ob s2	smatc h2	ph d2	ran k2	acmsmat ch1	acpu b1	acpa t1	acph d1	acran k1	acmsmat ch2	acph d2	acpa t2	acpu b2	acran k2	DECISI ON
59	0	11	0.227272727	5	0	22	0	0	0	1	9	997	1	0	12	495 5	1	259	0	25	913	0	69	0	19	841	0
60	0	4	0.058823529	0.444444444	0	17	0.111111111	0	0	0	18	506 2	0	1	18	836 2	1	49	0	22	841	0	23	0	14	659	0
61	2	14	0.111111111	0.222222222	0	18	0.111111111	0	1	1	13	172 2	0	1	9	532	1	66	0	19	1274	0	38	0	22	5573	0
62	0	8	0.5	2.333.333.333	0.222222222	18	0.111111111	0	1	0	16	841	0	0	5	322 0	0	112	0	15	841	0	36	0	12	6615	0
63	1	1	0.085714286	0.028571429	0	35	0.028571429	0	0	1	4	202 3	0	1	7	162 4	1	63	0	12	3214	1	1	0	14	2058	0
64	1	5	0.333333333	0.185185185	0	27	0.222222222	0	0	0	7	167 7	0	0	11	493 3	1	28	0	13	1238	1	28	6	3	2856	0
65	0	8	0.00	0.833333333	0.111111111	18	0	0	0	1	7	177 2	1	1	6	661 5	0	35	0	13	1914	0	3	0	13	532	0
66	2	10	0.136363636	0.454545455	0.363636364	22	0.181818182	0	0	1	10	191 4	0	1	9	119 6	0	6	0	11	1624	0	46	0	11	2916	0
67	3	22	0.44	0.68	0.52	25	0	0	1	0	10	844	1	1	18	146 3	1	40	0	16	3221	1	45	0	19	3220	0
68	0	11	1	2	0.117647059	17	0.058823529	0	1	0	20	379 5	0	0	10	199 2	0	45	0	19	532	0	25	0	9	841	0
69	0	7	0.411764706	3	0.037037037	17	0.058823529	0	0	0	24	841	0	0	15	532	1	253	6	26	841	1	77	0	18	5037	0
70	0	4	4	0.368421053	0	19	0.105263158	0	1	1	18	506 2	0	1	10	191 4	0	75	0	12	673	1	91	0	8	1914	0
71	0	5	0	0.125	0.0625	16	0.0625	0	0	0	11	841	0	0	19	178 8	0	102	0	20	841	0	64	0	14	4446	0
72	0	9	0.041666667	0.416666667	0.416666667	24	0.25	0	1	0	26	673	1	0	23	648	0	67	1	26	659	0	81	0	19	841	0
73	0	2	0.315789474	0.315789474	0.473684211	19	0	0	0	1	6	661 5	0	0	13	127 4	0	28	0	15	1274	0	34	0	10	3302	0
74	0	10	0.258064516	0.483870968	0	31	0.064516129	0	0	0	16	104 5	1	0	11	330 2	0	1	0	14	2058	0	68	0	8	1941	0
75	0	10	0.571428571	1	2.9	21	0.047619048	0	1	0	15	650	0	0	20	162 6	1	46	3	10	1992	1	122	0	10	5673	0
76	4	35	0.083333333	0.638297872	0.966666667	47	0.042553191	0.3	1	1	18	432 6	1	1	5	178 8	1	28	0	7	2005	1	257	5	22	913	1
77	1	16	0.176470588	0	0.175438596	17	0.235294118	0.01754386	1	1	41	102 42	1	1	23	167 1	1	235	0	18	810	1	73	0	21	7017	1
78	0	9	0.529411765	0.235294118	0	17	0.117647059	0	1	0	16	168 1	1	0	6	817 0	0	45	0	24	648	0	31	0	19	5905	1
79	0	12	0.27	0.16	0.03	37	0.22	0	1	1	22	374 8	1	1	20	432 6	1	28	0	7	2005	1	78	0	22	810	1
80	1	14	0.136363636	0.045454545	0	22	0.181818182	0.045454545	1	1	13	130 4	1	1	21	320 8	1	132	0	23	1328	1	200	0	38	4662	1
81	1	6	0.233333333	0.166666667	0	30	0	0.033333333	1	0	10	582 9	1	0	7	648	1	74	0	14	3518	0	39	7	8	1463	1
82	0	17	0.45	0.671052632	0.184210526	76	0.236842105	0.026315789	1	1	16	506 2	1	1	10	993 3	0	25	0	5	3236	1	18	0	8	1582	1
83	0	7	0.2	0.12	0	25	0	0	1	0	5	310 4	1	1	17	532	1	39	0	12	2755	1	50	0	13	1219	1
84	0	9	0.277777778	0.388888889	0	18	0.222222222	0	1	0	15	841	1	0	13	127 4	0	17	0	42	1142	1	159	0	21	1328	1
85	0	15	0.269230769	0.153846154	0	26	0.192307692	0	1	1	9	205 8	1	1	4	132 8	0	35	0	13	1914	1	44	0	6	1407	1
86	6	39	0.421052632	0.526315789	0.947368421	19	0.315789474	0.105263158	1	1	5	237 3	1	1	21	351 8	1	72	0	21	1326	1	73	0	21	7017	1
87	1	7	2	0	0	18	0	0	1	1	24	132 8	1	0	10	433 3	1	95	0	16	2231	1	103	0	17	3643	1

C. DATA USED IN ANALYSIS (cont')

N	s	unsp pro	coll	act	ipr	em p	mscomp	phdemp	ob s1	smatc h1	ph d1	ran k1	ob s2	smatc h2	ph d2	ran k2	acmsmat ch1	acpu b1	acpa t1	acph d1	acran k1	acmsmat ch2	acph d2	acpa t2	acpu b2	acran k2	DECISI ON
88	1 0	22	0.344827586	0.137931034	0	29	0.025641026	0	1	0	19	462 3	1	1	28	913	0	134	0	19	1274	0	75	0	16	1463	1
89	0	5	0.414634146	0.12195122	0	41	0.12195122	0	0	0	8	330 2	1	0	3	310 4	0	8	0	1	720	1	126	0	12	3214	1
90	0	12	0	0.05	0	20	0.2	0	0	0	14	104 5	1	0	4	503 7	0	117	0	19	591	0	92	1	16	2373	1
91	4	19	0.255813953	0.325581395	0	43	0.069767442	0	1	1	15	113 1	1	1	16	230 3	1	134	0	19	1274	0	103	1	4	6726	1
92	0	10	0.428571429	0.428571429	0	21	0.142857143	0	1	1	4	162 4	1	1	12	121 4	1	100	0	19	1914	1	98	0	12	1274	1
93	0	14	0.512820513	0.128205128	0	39	0.025641026	0	1	1	20	810	1	1	13	178 8	1	37	0	18	4326	1	68	0	30	1196	1
94	5	3	0.294117647	0.588235294	0	17	0.117647059	0.117647059	1	1	22	227 0	1	1	8	374 8	0	6	0	20	1938	0	97	0	9	1463	1
95	0	7	0.269230769	0.153846154	0	26	0.153846154	0	1	1	27	172 2	1	1	22	114 2	1	98	0	18	2426	1	115	0	36	648	1
96	1	15	0.076923077	0	0.051282051	39	0.179487179	0.076923077	1	0	5	202 3	1	1	8	205 8	1	34	0	22	1722	0	106	0	16	8170	1
97	3	9	0.045454545	0	0	22	0	0	1	1	12	127 4	0	0	5	310 4	1	38	0	18	2005	1	126	0	12	3214	1
98	0	7	0.2	0.05	0	20	0.05	0	1	0	11	167 7	1	0	8	177 2	1	56	0	20	659	1	31	0	7	4446	1
99	9	11	0.428571429	0.238095238	0.142857143	21	0.095238095	0	1	1	5	322 1	1	1	19	119 6	1	40	0	6	2058	1	67	0	10	1196	1
100	1 0	22	0.344827586	0.137931034	0	29	0.025641026	0	1	0	19	462 3	1	1	28	913	0	134	0	19	1274	0	75	0	16	1463	1

D. DO FILE OF TOBIT ANALYSIS

```
set memory 500M
set maxvar 32000
/*****H1*****/
*****
Hypothesis 1: Decision of R&D support is possitively related with
company apllication and observer report, observer's background and
decision of observers
describe
/*Contains data
  obs:      100
  vars:      27
  size:      5,200 (99.9% of memory free)
sum
/* My dependent variable is DECISION this is the result of R&D
application.
/* sppro total supported (by public bodies) project number divided
by total R&D personnel
/* unsppro total R&D projects number divided by total R&D personnel
/* coll total colleborations among other institutions such as other
R&D centers, Universities etc. divided bu total R&D personel
/* act total number activities such as seminars, conferences divided
by total R&D personnel
/* ipt total IPR ativies divided by total R&D personnel
/* emp total R&D personel number
/* mscomp total R&D personel number with Msc divided by total R&D
personnel
/* phdemp total R&D personel number with PHd divided by total R&D
personnel
/* obs1 decision of observer yes or no
/* smatch1 observer1's sector mactch yes or no
/* phd1 observer1's gradution year from PhD
/* rank1 observer1's university Times Higher Education rank
/* obs2 same as obs1
/* smatch2 same as obs1
/* phd2 same as obs1
/* rank2 same as obs1
/* acmsmatch1 commissioner academicians sector match with R&D
application
/* acpub1 total publication numnber of commissioner academicians
/* acpat1 total patent number of commissioner academicians
/* acpat1 years after PhD of commissioner academicians
/* acrank1 THE rankg of commissioner academicians
/* acmsmatch2 commissioner academicians sector match with R&D
application
/* acpub2 total publication numnber of commissioner academicians
/* acpat2 total patent number of commissioner academicians
/* acpat2 years after PhD of commissioner academicians
/* acrank2 THE rankg of commissioner academicians
/* checking data with graphs
hist sppro
hist unsppro
hist coll
```

```

hist act
hist ipr
hist emp
hist mscemp
hist phdemp
hist obs1
hist smatch1
hist phd1
hist rank1
hist obs2
hist smatch2
hist phd2
hist rank2
hist acmsmatch1
hist acpub1
hist acpat1
hist acphd1
hist acrank1
hist acmsmatch2
hist acphd2
hist acpat2
hist acpub2
hist acrank2
/* dependent variable DECISION is binary so I will use logistic
regression
logit decision sppro unsppro coll act ipr emp mscemp phdemp obs1
smatch1 phd1 rank1 obs2 smatch2 phd2 rank2 acmsmatch1 acpub1 acpat1
acphd1 acrank1 acmsmatch2 acphd2 acpat2 acpub2 acrank2
mfx
estat classification
/* R square is unnaturally high, I will move on some tests. Moreover
failures and dropped data are also high
corr decision sppro unsppro coll act ipr emp mscemp phdemp obs1
smatch1 phd1 rank1 obs2 smatch2 phd2 rank2 acmsmatch1 acpub1 acpat1
acphd1 acrank1 acmsmatch2 acphd2 acpat2 acpub2 acrank2
/* probit regression tried instead of logit
probit decision sppro unsppro coll act ipr emp mscemp phdemp obs1
smatch1 phd1 rank1 obs2 smatch2 phd2 rank2 acmsmatch1 acpub1 acpat1
acphd1 acrank1 acmsmatch2 acphd2 acpat2 acpub2 acrank2
/* R2 is still 1
/* right censoring tobit was tried
tobit decision sppro unsppro coll act ipr emp mscemp phdemp obs1
smatch1 phd1 rank1 obs2 smatch2 phd2 rank2 acmsmatch1 acpub1 acpat1
acphd1 acrank1 acmsmatch2 acphd2 acpat2 acpub2 acrank2, ul(1)
/* right censoring ul(0) tobit works R2== 0.5454 and estimation is
smooth
/* left censoring tobit also was tried
tobit decision sppro unsppro coll act ipr emp mscemp phdemp obs1
smatch1 phd1 rank1 obs2 smatch2 phd2 rank2 acmsmatch1 acpub1 acpat1
acphd1 acrank1 acmsmatch2 acphd2 acpat2 acpub2 acrank2, ll(0)
/* This result is also appropriate and R2== 0.6309. This regression
model results much more fit.
mfx

```

E. NETLOGO SIMULATION CODES

globals [

attend ;; maximum number of academicians at red (stable state) or grey (instable state). It is 3 for this simulation

home-patches ;; agentset of green patches representing the decision making status

stationary-state ;; agents at the red square represent a state which all observer and application reports signal towards to a certain decision (accept or reject)

instability-state ;; agents at the grey square do not have a strong recommendation. In this state observer and application reports do not give a clue about the final decision of the outcome of the project (accept or reject)

total_turtles

number_of_turtles_r;; it is variable indicates total turtles at "stable-state (red patch)". This variables are used at calculations

number_of_turtles_g;; it is variable indicates total turtles at "instable-state (grey patch)". This variables are used at calculations

number_of_w_moved;; it is variable of HESITANTS (white color turtles)

number_of_r_r ;; it is variable indicates number of non-experts (red color turtles) at the stable-state (red patch)

number_of_r_y ;; it is variable indicates number of friends (yellow color turtles) at the stable-state (red patch)

number_of_r_b ;; it is variable indicates number of experts (blue color turtles) at the stable-state (red patch)

number_of_g_r ;; it is variable indicates number of non-experts (red color turtles) at the instable-state (grey patch)

number_of_g_y ;; it is variable indicates number of friends (yellow color turtles) at the instable-state (grey patch)

number_of_g_b ;; it is variable indicates number of experts (blue color turtles) at the instable-state (blue patch)

probability_r ;; it is variable indicates probabiltly of changing mind of HESITANTS at the stable-state (red patch) these probalities found according to qulitative researches.

probability_g ;; it is variable indicates probabiltly of changing mind of HESITANTS at the instable-state (grey patch) these probalities found according to qulitative researches.

random_r ;; According to the set-up in the model, the possibility of changing the decision of a stable-state patch (red Patch) is certain, and the model sets a random number between 0 and 100 for the possibility of changing the decision. The probability of this number will be lower than our possibility

random_g ;; According to the set-up in the model, the possibility of changing the decision of a instable-state patch (grey Patch) is certain, and the model sets a random number between 0 and 100 for the possibility of changing the decision. The probability of this number will be lower than our possibility

number_of_black_turtles ;;Number of rurtles that changed decision according to the random probability calculation made in the model

black_list;;This variable decision is the file where the HESITANTS) is kept

total_n ;; This variable indicates the total decision-changers

]
;; if either grey and red patches have 3 academicians, fourth academician should go non-occupied one

patches-own [

n-jobs-to-fill]

turtles-own [

HESITANTS

experts

non-experts

friends

]

to setup

ca

set-default-shape turtles "person" ;; turtles represent the academicians that are going to make decision

ask patches [

set n-jobs-to-fill random academicians;; For random placement of academics (all turtles)

]

;; use one of the patch labels to visually indicate whether or not the commissioner academecian change her/his initial decision

;; if the rules (the rules are indicated below) HESITANTS (white turtles) color change into black

```
ask patch (0.75 * max-pxcor) (0.5 * max-pycor) [  
  set stationary-state self  
  set plabel-color red  
]
```

```
ask patch (0.75 * max-pxcor) (0.5 * max-pycor) [  
  set instability-state self  
  set plabel-color gray  
]
```

;; creating hesitant academicians

;; agents are about to make decision. The color of expert is "white". Also known as HESITANTS

```
set total_turtles number-of-HESITANTS + number-of-experts + number-of-non-experts +  
number-of-friends
```

;; The total number of academicians should be sum of HESITANTS experts and not experts. The code above is essential for this rule.

```
if (total_turtles <= academicians) [  
  create-turtles number-of-HESITANTS [ setxy -15 random-ycor  
  set color white]  
  ask turtles [ set SIZE 2]
```

;; creating expert academicians

;; agents who are expert of the subject. The color of expert is "blue"

```
create-turtles number-of-experts [ setxy -3 random-ycor  
set color blue]  
ask turtles [ set SIZE 2]
```

;; creating non-expert academicians

;; agents who are not expert of the subject. The color of expert is "red"

```

create-turtles number-of-non-experts [ setxy -6 random-ycor
set color 13]

ask turtles [ set SIZE 2]

;; creating socially known trusted academicians

;; agents who are socially close to hesitant agents (white ones). The color of expert is
"yellow"

    create-turtles number-of-friends [ setxy -10 random-ycor
set color yellow]

    ask turtles [ set SIZE 2]

]

;; The code below was written so that the totals of created HESITANTS (white), red (non-
experts), blue (experts) and friend (yellow) agents (aka turtles) do not exceed the total
number of academics determined by the slider in the interface section

if (total_turtles > academicians)

[show("Check the academicians numbers")

]

;; create the 'decision-making status'

set home-patches patches with [pycor < 0 or (pxcor < 0 and pycor >= 0)]

ask home-patches [ set pcolor green ]

;; create the 'stable-state' this state represents observer and application reports give a
strong recommendation about proposal

set stationary-state patches with [pxcor >= 0 and pycor >= 0]

ask stationary-state [ set pcolor red ]

ask patch 10 8 [set plabel "stable-state"]

;; create the 'instability-state' this state represents observer and application reports do not
give a clue about final decision of the R&D project proposal

set instability-state patches with [pxcor >= 0 and pycor <= 0]

ask instability-state [ set pcolor grey ]

ask patch 10 -8 [set plabel "instable-state"]

reset-ticks

end

```

to go

;; the codes below distributed the agents

;; White agents (HESITANTS) go either red or grey patches one-by-one

;; The distribution of agents is random, patches will carry 2 or 3 agents. Each distribution will have only one white agent

```
ask turtles [  
  move-to one-of patches with [pcolor = green ]  
]
```

```
set number_of_turtles_r 2 + (random (2))
```

```
set number_of_turtles_g 2 + (random (2))
```

```
set number_of_w_moved 0
```

;;The following 4 lines of code have been written for maximum 3 academicians to make a decision at once in red (stable) and gray (instable) situations.

;;Accordingly, if there are 3 academics in one of the 2 patches, the next academician moves to the other patch.

;;These codes provide the benefit of random selection of stability and instability commissions at the same time.

;;In reality, commissions that are likely to win and commissions without any jurisdiction are also randomly generated.

```
ask turtles [  
  
  ifelse (number_of_w_moved = 0) and (color = white) [  
    move-to one-of patches with [pcolor = red ]  
    set number_of_turtles_r number_of_turtles_r - 1  
    set number_of_w_moved number_of_w_moved + 1  
  
  ]  
  
  [ifelse (number_of_w_moved = 1) and (color = white) [  
    move-to one-of patches with [pcolor = grey ]
```



```

set number_of_turtles_g number_of_turtles_g - 1
set number_of_w_moved number_of_w_moved + 1

]
[ ]
]

]

ask turtles [

  ifelse ((number_of_turtles_r > 0) and (pcolor = green) and (color != white)) [
    move-to one-of patches with [pcolor = red ]
    set number_of_turtles_r number_of_turtles_r - 1
    if (color = 13) [

      set number_of_r_r number_of_r_r + 1

    ]

    if (color = blue) [

      set number_of_r_b number_of_r_b + 1

    ]

    if (color = yellow) [

      set number_of_r_y number_of_r_y + 1

    ]

```

```

]

[
    ifelse ((number_of_turtles_g > 0) and (number_of_turtles_r = 0) and (pcolor = green)
and (color != white))[
        move-to one-of patches with [pcolor = grey ]
        set number_of_turtles_g number_of_turtles_g - 1

        if (color = 13) [

            set number_of_g_r number_of_g_r + 1

        ]
        if (color = blue) [

            set number_of_g_b number_of_g_b + 1

        ]
        if (color = yellow) [

            set number_of_g_y number_of_g_y + 1

        ]

    ]

]

```

]

tick

end

to change

;; When the change command is pressed, white-colored academics (HESITANTS) who are in the decision-making phase will or will not

;; change their color within the scope of the probability (p) calculated with the survey results, depending on the situation of encountering expert (blue), non-expert (red) and fellow (yellow) academics.

;;For example, if non-expert (red turtle) and HESITANT (white) meet in stable-state (red patch), the probability of white being black is 9.6%.

;;However, since the algorithm randomly determines a number, 2 ticks can turn black in a row. It was made this way because life is random. In real experiences, low odds can occur one after the other.

ask turtles with [pcolor = red][

ifelse (number_of_r_r = 1 and number_of_r_b = 0 and number_of_r_y = 0)

[set probability_r 9.6]

[ifelse (number_of_r_r = 2)

[set probability_r 13]

[ifelse (number_of_r_r = 1 and number_of_r_b = 1)

[set probability_r 40 * level_of_expert / 10;; Such a code has been added to this section because the expertise level of each expert is not the same. Accordingly, the specialization ranges from 1 to 10. The expert with 10 is the full expert on the subject and 1 is the person with the least expertise. Accordingly, the probability of following the decision of the blue person is multiplied between 0.1 and 1.

]

[ifelse (number_of_r_r = 1 and number_of_r_y = 1)

```
[set probability_r 17]
```

```
[ ifelse (number_of_r_r = 0 and number_of_r_b = 0 and number_of_r_y = 1)
```

```
  [set probability_r 13]
```

```
  [ ifelse (number_of_r_y = 2 )
```

```
    [set probability_r 18]
```

```
    [ ifelse (number_of_r_r = 0 and number_of_r_b = 1 and number_of_r_y = 0)
```

[set probability_r 46 * level_of_expert / 10];; Such a code has been added to this section because the expertise level of each expert is not the same. Accordingly, the specialization ranges from 1 to 10. The expert with 10 is the full expert on the subject and 1 is the person with the least expertise. Accordingly, the probability of following the decision of the blue person is multiplied between 0.1 and 1.

```
    ]
```

```
  [ ifelse (number_of_r_b = 2 )
```

[set probability_r 59 * level_of_expert / 10] ;; Such a code has been added to this section because the expertise level of each expert is not the same. Accordingly, the specialization ranges from 1 to 10. The expert with 10 is the full expert on the subject and 1 is the person with the least expertise. Accordingly, the probability of following the decision of the blue person is multiplied between 0.1 and 1.

[set probability_r 43 * level_of_expert / 10 ;; Such a code has been added to this section because the expertise level of each expert is not the same. Accordingly, the specialization ranges from 1 to 10. The expert with 10 is the full expert on the subject and 1 is the person with the least expertise. Accordingly, the probability of following the decision of the blue person is multiplied between 0.1 and 1.

```
  ]
```

```
] ]
```

```
] ]
```

```
] ]
```

```
] ]
```

```
] ]
```

```
] ]
```

```
] ]
```

]

ask turtles with [pcolor = grey][

ifelse (number_of_g_r = 1 and number_of_g_b = 0 and number_of_g_y = 0)

[set probability_g 12]

[ifelse (number_of_g_r = 2)

[set probability_g 16]

[ifelse (number_of_g_r = 1 and number_of_g_b = 1)

[set probability_g 43 * level_of_expert / 10] ;; Such a code has been added to this section because the expertise level of each expert is not the same. Accordingly, the specialization ranges from 1 to 10. The expert with 10 is the full expert on the subject and 1 is the person with the least expertise. Accordingly, the probability of following the decision of the blue person is multiplied between 0.1 and 1.

[ifelse (number_of_g_r = 1 and number_of_g_y = 1)

[set probability_g 21]

[ifelse (number_of_g_r = 0 and number_of_g_b = 0 and number_of_g_y = 1)

[set probability_g 16]

[ifelse (number_of_g_y = 2)

[set probability_g 22]

[ifelse (number_of_g_r = 0 and number_of_g_b = 1 and number_of_g_y = 0)

[set probability_g 49 * level_of_expert / 10] ;; Such a code has been added to this section because the expertise level of each expert is not the same. Accordingly, the specialization ranges from 1 to 10. The expert with 10 is the full expert on the subject and 1 is the person with the least expertise. Accordingly, the probability of following the decision of the blue person is multiplied between 0.1 and 1.

[ifelse (number_of_g_b = 2)

[set probability_g 65 * level_of_expert / 10] ;; Such a code has been added to this section because the expertise level of each expert is not the same. Accordingly, the specialization ranges from 1 to 10. The expert with 10 is the full expert on the subject and 1 is the person with the least expertise. Accordingly, the probability of following the decision of the blue person is multiplied between 0.1 and 1.

[set probability_g 49 * level_of_expert / 10] ;; Such a code has been added to this section because the expertise level of each expert is not the same. Accordingly, the specialization ranges from 1 to 10. The expert with 10 is the full expert on the subject and 1

is the person with the least expertise. Accordingly, the probability of following the decision of the blue person is multiplied between 0.1 and 1.

```
    ]
  ]
]

]
]
]
]

set random_r random-float 100
set random_g random-float 100

if (random_r <= probability_r)[
  ask turtles with [pcolor = red][
    if (color = white)[
      set color black

      set number_of_black_turtles 1
      file-open "black_list.txt"
      file-write number_of_black_turtles
      file-close-all

    ]
  ]
]
```

```

if (random_g <= probability_g)[
  ask turtles with [pcolor = grey][
    if (color = white)[
      set color black

      set number_of_black_turtles 1
      file-open "black_list.txt"
      file-write number_of_black_turtles
      file-close-all
    ]
  ]
]

tick

end

to start

```

;;In the start part, these codes are written for the go and change commands to run at the same time.

;; Again in this section, the number of academics who turn black at every tick, that is, change their minds, is collected in a txt file. Otherwise, we could not count the number of those who changed their minds.

```

carefully [ file-delete "black_list.txt" ] [ ]

while [NUMBEROFCOMMISSIONS > 0][

  setup

  go

  change

```

```
set NUMBEROFCOMMISSIONS NUMBEROFCOMMISSIONS - 1  
]  
  
file-open "black_list.txt"  
while [not file-at-end?]  
[  
  
    print file-read-characters 2  
    set total_n total_n + 1  
  
]  
file-close  
  
show total_n  
  
tick  
end
```


F. CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Koraman, Emrah

Nationality: Turkish (TC)

Date and Place of Birth:

Marital Status:

Phone:

email:

EDUCATION

Degree	Institution	Year of Graduation
MS	ITU Material Science	2011
BS	ITU Department of Metallurgical and Materials Engineering	2008

WORK EXPERIENCE

Year	Place	Enrollment
2023-	ASELSAN A.Ş.	Team Leader
2023-2023	ASELSAN A.Ş.	Chief Engineer
2009-2023	Ministry of Science and Technology	Industry and Technology Expert
2008-2009	Konak Civata Ltd. Şti.	Expert Responsible

FOREIGN LANGUAGES

Advanced English

G. TURKISH SUMMARY / TRKE ZET

1. GİRİŞ

Kapitalist sistemlerde inovasyon ve teknolojik gelişim büyümenin ana unsurlarından biridir. Konu kapitalizm olduğunda ise kamu yararına olacak yenilik ve teknolojik gelişmeler ikinci plana atılabilmektedir. Bu tezde kamu yararına pek düşünülmesi de düşünülmesi durumunda fayda sağlayabileceği öngörülen blokzincir teknolojisinin kamu Ar-Ge sisteminde kullanılması durumunda neleri değiştirilebileceğine değinilmektedir.

Teknolojik yeniliklerin kar amacı gütmeyen kamu sektöründe uygulanması ve politika yapıcılar tarafında benimsenmesi için ise bahse konu yeniliğin mevcutta kullanılan sisteme kalıcı ve dirençli bir yenilik önermesi gerekmektedir. Bu sebeple, tezde sunulan ve hali hazırda uygulaması olmayan Ar-Ge fon seçiminde blokzincir teknolojisinin uygulanması fikrinin kabul edilebilir olması için mevcut sistemde ne gibi değişiklikler önerdiğinin altı çizilmelidir. Bu sebeple, bu tezde blokzincir uygulamasının sisteme yapması öngörülen yeniliklere kavramsal olarak değinildikten sonra analitik yöntemler ile ispat edilmektedir.

Vergi verenlerden toplanan kaynaklar ile yürütölen Ar-Ge teşviklerinin her zaman daha güvenilir, hesap verebilir ve şeffaf olarak yürütölmesi devletlerin vatandaşlarına olan sorumluluklarından biridir. Bu gerçekten hareketle, hem Ar-Ge ve inovasyon ekosisteminin geliştirilmesi hem de kamu kaynaklarının adil bir şekilde dağıtılması için teşvik sisteminin gelişen teknolojik imkanlar ile donatılması gerekmektedir. Anılan gerçekten hareketle teşvik sisteminin daha iyi bir yapıya kavuşturulması için öncelikle çalışmada teşvik sistemleri incelenmiştir. Mevcut teşvik sistemlerine blokzincir teknolojisinin nasıl katkı sağlayabileceğinin ispat edilebilmesi için teknoloji birçok yönüyle tezde ele alınmaktadır. Mevcut bilgiler ışığında benzer bir çalışmaya rastlanılmadığından çalışmanın genel literatüre katkısına da teorik kısımda değinilmektedir.

Anılan motivasyondan hareketle Ar-Ge merkezleri değerlendirme süreçleri alt proseslere ayrılarak, sonuca en çok katkı sunan süreç analitik yöntemler ile belirlenmiştir. Buna göre süreçte Ar-Ge merkezleri değerlendirme kararına en çok katkı sunan alt sürecin, yüz-yüze yapılan değerlendirme komisyonları olduğu yapılan analizlerce tespit edilmiştir. Değerlendirme komisyonlarında yer alan akademisyenlere ait bilgiler üzerinde yapılan analizler sonucunda, yüz-yüze grup karar verme süreçlerinde hiyerarşik güç mesafesi gibi sosyal ve bilişsel değişkenlerin de karar üzerinde etkili olduğu yine yapılan analizler ile tespit edilmiştir. Son olarak, bu bilişsel ve sosyal etkilerin Ar-Ge merkezlerinin belirlenmesi kararında ne kadar etkili olduğunun tespiti için simülasyon yapılmıştır. Ajan Bazlı Modelleme (ABM) metodu kullanılarak yapılan bu simülasyon sonucunda bazı komisyon üyelerinin dissertation içerisinde bahsedilen bilişsel ve sosyal etkiler sonucunda karar verme yetkisini bilişsel liderler olarak gördüğü diğer komisyon üyesi akademisyenlere devrettiği tespit edilmiştir. Özet olarak, Ar-Ge merkezlerinin belirlenmesi için süreçte en etkili olan soyut ve somut değişkenler belirlenmiş olup, nitel değişkenler arasında en etkili olanların sonucu ne ölçüde değiştirdiği yapılan nitel ve nicel metodlar ile tespit edilmiştir.

İki farklı ana akımdan analiz yöntemlerinin kullanılması anlamında da bu çalışma diğer çalışmalardan ayrılmaktadır. Ek olarak, hiyerarşik güç ilişkisinin karar alma süreçlerinde bu etkisini inceler benzer bir çalışmaya rastlanılmamıştır.

Son olarak, tespit edilen bu bilişsel ve sosyal etkilerin blokzincir gibi güvenli ve çok merkezli bir yazılım ile yapılması durumunda mevcut olmayacağı bilinmektedir. Çünkü, mevcut Ar-Ge merkezi komisyonları yüz-yüze yapıldığından insan-insan tarzı bir iletişimde bu kişiler anılan etkilere maruz kalabiliyor iken, insan-makine-insan türü bir iletişimin olduğu blokzincir teknolojisinde bu etkiler olmamaktadır.

1.1. Problem Tanımı-İddia ve Tezin Mantıksal Çerçevesi

Kamu Ar-Ge fonlarında olması gereken unsurlar tezin iskeletini oluşturmaktadır. Tez sorumluluk ve şeffaflık gibi unsurların teşvik mekanizmalarında yer almadığı iddia edilmese de çalışmanın amacı bu unsurların teknolojik imkanlarla daha üst düzeye

ıkarılmasıdır. Bu arada srete iyileştirilmesi gereken sreler de nitel ve nicel araştırma yöntemleri kullanılarak araştırılmaktadır. Ayrıca sre ierisinde yz yze grşmelerin online olarak yapılmasının nihai karara etkisi de araştırılmaktadır.

Sz konusu araştırma sonucunda, hassas ve nemli bir konu olan kamu Ar-Ge fonlarına ynelik kamuoyu algısının iyileştirilmesi ve Trkiye'de BTİ ekosisteminin etkinleştirilmesi iin politika nerilerinde bulunulmuştur.

1.2. Araştırma Sorusu

alıřma boyunca birok araştırma sorusuna cevap aranırken bu sorular temel bir araştırma sorusu etrafında dağılmaktadır. Buna gre, ana araştırma sorusu "Blok zincir teknolojisinin kamu Ar-Ge fonlarına nasıl bir katkı saėlaması beklenmektedir?" şeklindedir.

Araştırma sorusuna cevap aranırken ncelikle literatrden yararlanılmaktadır. Literatr alıřmasının atıėı yolda, Ar-Ge teřvik sisteminin adımları ve adımların srece katkısı araştırılmakta ve blok zincirin sreteki nemli kararlara nasıl katkı saėlayabileceėi konusunda nerilerde bulunulmaktadır. Bu kararlarda karar ortamının evrimii bir platforma tařınması durumunda karar verme srelerinde biliřsel etkilerinin karara etkisi incelenmiřtir.

2. KAMU AR-GE FONLA SİSTEMİ, VERİ VE KURALLAR

2.1. Kamu Ar-Ge Fonlama Sistemi

Tez alıřmasında 5746 sayılı Araştırma, Geliřtirme ve Tasarım Faaliyetlerinin Desteklenmesi Hakkındaki Kanun kapsamına giren Ar-Ge Merkezlerinin bařvuru, deėerlendirme ve desteklenme ařamaları konu edilmektedir.



řekil 2.1 Ar-Ge Merkezleri Bařvuru Sreci

Şekil 2.1’de de görüleceği üzere Ar-Ge Merkezi olmak için başvuruda bulunan firma önce bir başvuru dosyası doldurmaktadır. Başvuru dosyasında aşağıdaki bilgiler bulunmaktadır. Bu bilgilerden türetilen değişkenler tezde analizlerde kullanılmıştır.

- Destekli proje sayısı
- Öz kaynakla üretilen desteksiz proje sayısı
- İşbirliği (üniversiteler, diğer Ar-Ge Merkezleri veya firmalar ile) sayısı
- Etkinlik (eğitim, kongre veya konferans) sayısı
- Toplam FSMH sayısı
- Toplam makale sayısı
- Toplam Ar-Ge personeli sayısı
- Toplam doktora mezunu Ar-Ge personeli sayısı
- Toplam yüksek lisans mezunu Ar-Ge personeli sayısı

Firma başvurusunun agtm.sanayi.gov.tr adresinden online olarak gerçekleştirir. Başvuru dosyası kullanılan web portalinde, başvurunun alanına göre sorumlu uzmanlara dağıtılır. Başvuru dosyasındaki projelerin içeriğine ve sayısına göre şekilde Bakanlık uzmanları akademisyenlerden izleyiciler belirlemektedir. İzleyicilerin kararlarında etkili olabilecek sayısal aşağıdaki veriler tezde çalışılmıştır.

- İzleyicinin doktora mezuniyetinden geçen süre
- İzleyicinin izleme tarihindeki akademik unvanı (Dr., Doç. Dr., Prof. Dr.)
- İzleyicilik görevi sırasında mensubu olduğu üniversitenin THE sıralaması
- İzleyicinin çalışma alanları ile izleyicilik yaptığı projelerin uyumu

Yukarıda bilgileri verilen izleyici kararına ilişkin gerekçelerini belirterek ve raporunda desteklenmeye uygun ya da değil şeklinde işaretleme yaparak raporunu bakanlığa sunar. Bakanlık en az iki izleyiciden gelen (proje sayısı çok ise daha çok izleyici de olabilmektedir) raporları ve başvuru formu ve eklerini 3 akademisyenin bulunduğu komisyona sunar. Komisyon üEveti akademisyenlerin ise Bakanlık’tan listeler alındıktan sonra internet araştırmalarından derlenen bilgileri aşağıdaki gibidir:

- Komisyon üyesi akademisyen ile incelenen projelerin uyumluluđu
- Komisyon üyesinin toplam FSMH sayısı
- Komisyon üyesinin toplam makale sayısı
- Doktora mezuniyetinden geçen süre
- Komisyon sırasındaki akademik unvanı (Dr., Doç. Dr., Prof. Dr.)
- Komisyon sırasında mensubu olduđu üniversitenin THE sıralaması

Komisyonun başvuru dosyası ve izleyici raporları ışığında oylama ile desteklensin ya da desteklenmesin (evet/hayır) şeklinde ikili bir karar verir. Kararlarda oy çokluğu esası vardır. Başvuru ve izleyici raporlarının bağlayıcılığı bulunmamaktadır. Bu sebeple bu çalışmada başvuru ve izleyici raporlarının bağlayıcılığı da çalışılan konulardan biridir.

2.2. Veri

Tez çalışmasında, Sanayi ve Teknoloji Bakanlığı'nın Araştırma, Geliştirme ve Tasarım Faaliyetlerinin Desteklenmesi Hakkında Kanun (5746 sayılı Kanun) kapsamında yürütölen Ar-Ge ve Tasarım Merkezlerine yönelik desteklere ilişkin verilerden yararlanılmıştır.

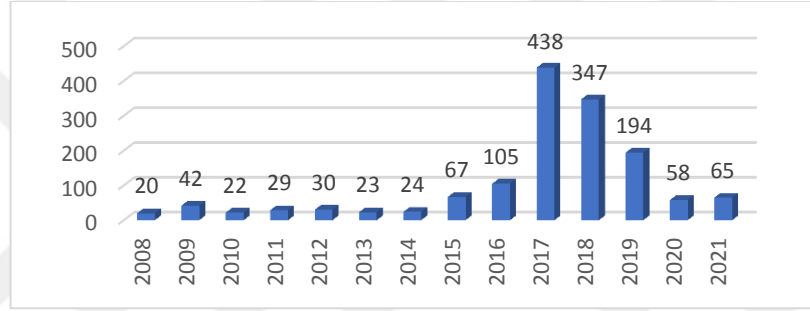
Tezin ilk aşamasında Ar-Ge ve Tasarım Merkezleri ile ilgili veriler, yürütücü kurum olan Ar-Ge Teşvikleri Genel Müdürlüğü'nün izni ile kullanılmaktadır.

Tez çalışmasında kullanılan veriler 2009 yılından itibaren yürütölen Ar-Ge Merkezleri desteklerine ilişkin verilerdir. 2016 yılında yapılan Kanun değışikliğı ile yürürlüğe giren Tasarım Merkezleri desteğı nispeten yeni bir teşvik olduğı için bu çalışmaya dahil edilmemiştir.

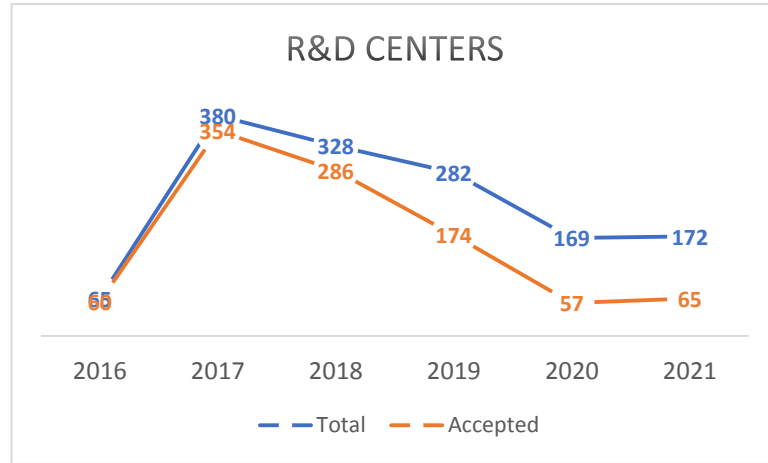
Sanayi ve Teknoloji Bakanlığı'ndan sağlanan veriler yukarıdaki tüm unsurları içermekle birlikte hem kişisel veridir hem de analizde değıştirilerek uygulanmıştır (örneğin doktora derecesine sahip toplam personel sayısı başvuran şirketin büyüklüğü ile ilgili olduğundan toplam doktoralı personel sayısının toplam Ar-Ge personeli sayısına bölünmesiyle kullanılmaktadır).

Ar-Ge merkezlerine yönelik teşvikler 2008 yılından itibaren Sanayi ve Teknoloji Bakanlığı tarafından verilmektedir. Ancak Bakanlık yetkililerinden alınan sözlü açıklamaya göre, Bakanlık başvuruların alındığı web sitesi sistemine 2016 yılında geçebilmiştir. 2009-2016 yılları arasında yapılan iş ve işlemlere ait veriler Bakanlık arşivlerinde basılı belgeler olarak mevcuttur. Bu nedenle 2016 yılı öncesi verilerin analizini yapmak mümkün değildir. Ayrıca 2016 yılında yapılan kapsamlı Kanun değişikliği ile Ar-Ge Merkezi belgesi almak için aranan şartlar değiştirilmiştir. Bu, 2016 ve sonrasındaki verileri kullanmanın başka bir nedenidir.

Şekil 2.2, yıllar itibariyle Ar-Ge merkezi sayısını göstermektedir. Analizlerde kullanılan 2016-2018 yılları Ar-Ge merkezi başvurularının yoğun olduğu ve ilginin yoğun olduğu yıllara denk gelmektedir.



Şekil 2.2 Türkiye'de yıllara göre kamu Ar-Ge Merkezi belgesi alan firma sayısı



Şekil 2.3 Türkiye'de 2016-2021 yılları arasında Ar-Ge merkezi belge başvuruları ve kabul oranları

Ancak COVID-19 pandemisi ile birlikte birçok uygulamada olduğu gibi Bakanlıkta da uzaktan çalışma ve toplantılar yaygınlaştı. Bu nedenle pandeminin başladığı yıl

olan 2018 ile yasal deęiřiklięin yapıldığı 2016 yılı arasındaki veriler kullanılmıştır. Şekil 2.3, Ar-Ge merkezi başvuru kabul oranlarını göstermektedir. Tezde kullanılan başvuru ve kabul oranlarının 2016-2018 yılları arasında benzer eğrilere sahip olması da bu yılların kullanılmasında bir dięer etkidir.

2016-2018 yılları arasında Ar-Ge merkezlerine 773 başvuru yapılmıştır. Başvuruların 700'ü kabul edilirken, 73'ü reddedilmiştir. Tezde Sanayi ve Teknoloji Bakanlığı tarafından verilen sınırlı veri izni ile 2016-2018 yılları için 100 başvuru için izin verilmiştir. 100 başvurudan 50'si reddedilirken geri kalanı kabul edilmiştir. Bu şekilde bir oran kabul edilen başvurular ile reddedilen başvuruların arasında bir denge gözetmek için belirlenmiştir.

2.3. Karar Vermeye Etki Eden Kurallar

Karar verme, alternatifler arasından en uygun olanı seçme sürecidir. Öte yandan karar verme bir anı anlatırken, almak bir süreçtir (Saha, 2017). Bu nedenle tezde nihai karara götüren adımlar modellendięi için karar verme terimi kullanılmaktadır.

Karar verme doğası gereęi karmařık bir süreçtir (Ekenberg, Danielson & Boman, 1997). Ayrıca karar verme süreçlerinin birçok disiplini içine alan ve üzerinde yoğun bir şekilde çalışılan disiplinler arası bir yönü olduęu da aşıkârdır. Karar vermenin bu disiplinler arası doğası nedeniyle, bu konudaki bir çalışmada multidisipliner bir metodoloji uygulamak gereklidir (Tyran ve dięerleri, 1988).

Karar verme süreçleri, ekoHayırmi literatüründe kapsamlı bir şekilde incelenmektedir. Ancak bu çalışmalar iktisadın doğal ilgi alanı olan müşteri davranışlarına odaklanırken, bu tezde ele alınan Ar-Ge projelerinin deęerlendirilmesine ilişkin karar verme süreçleri iktisadi seçimlerden farklı olarak ikili bir süreçtir. Bu açıdan nispeten kolaydır.

Karar verme süreçleri, bireysel ve grup karar verme olarak birbiriyle ilişkili ve döngüsel olarak iki aşamada incelenmektedir. Ar-Ge projelerinin karar verme süreçlerinde, proje bilgileri önceden paylaşıldığı için iki aşamalı bir karar verme

süreci modellenmekte ve komisyon üyeleri, proje hakkında belirli bir bilgi ve ön bilgi ile komisyonlara gelerek karar almaktadırlar.

Tezin evrimci iktisada katkısı literatür bölümünde tartışılrsa da psikolojik önyargılar, sınırlı bilişsel kaynaklar ve diğer değerlere önem verme gibi faktörler nedeniyle çalışmanın "davranışsal iktisat" literatürüne de katkı sağlayabileceğini belirtmekte fayda bulunmaktadır. (Miller ve Amit, 2016).

Bu bölümde, bireysel ve grup karar verme süreçlerini etkileyen kurallar ve bunların nihai karar üzerindeki etkileri incelenmektedir.

Tezde modellenen karar verme süreci karmaşık ve iç içe geçmiş parametrelerden oluşmaktadır. Bu bölümde karar verme süreçlerine ilişkin kurallar ve bu kuralların diğer kurallar ve nihai kararlarla ilişkisi ele alınmaktadır.

Kuralların birbirine etkisi ve karar alma sonuçları “uzman değerlendirmesi” müzakereleri sonucunda belirlenir. Buna göre, matematiksel modellemede kuralların ağırlıklandırması deneyimli komisyon üyelerinin ortak görüşüne dayanılarak verilmiştir.

Aşağıda belirtilen karar verme aşamalarının karmaşıklığını bir şekilde anlaşılır kılmak için, bireysel karar verme için A, B, C Kuralları vb. Grup karar verme kuralları 1,2,3 vb. olarak adlandırılır.

Ayrıca karar vermenin karmaşık yapısını anlamak için kuralların birbirleriyle olan ilişkilerine ilişkin şekiller çizilir (bkz. Şekil 4.5-11). Bu çizgilerin renkleri kurala özgüdür.

Tablo 2.1 tezin modelinde de kullanılan bireysel ve grup kararlarına etki eden değişkenler bulunmaktadır.

Aşağıdaki bilgiler ışığında tez çalışmasında 3 istatistiki analiz, 2 anket ve 1 adet simülasyon çalışması yapılmıştır. Bu çalışmalara ilişkin detaylar ve sonuçları bir sonraki bölümde ele alınmaktadır.

Tablo 2.1 Bireysel ve Grup Karar Vermeye Etki Eden Değişkenler

Bireysel	Grup
Cinsiyet	Karar Tekrarı
Davranış	Cinsiyet Kompozisyonu
İzleyici Kararı	Grup Büyüklüğü
Hiyerarşik Güç İlişkisi	Çoğunluk
Karakter Özellikleri	Bilgi Birikimi
Bireysel Anlaşmazlık	Gruplar Arası Anlaşmazlık
Benzersizlik	
Kişiler Arası Anlaşmazlık	

3. ANALİZLER

Doktora çalışmasının ilk aşamasında yukarıda anılan değişkenlerin etkililiği ölçmek için makine öğrenmesi temelli ID3 algoritması kullanılarak bir ön analiz çalışması yapılmıştır. Bu nitel çalışmayı daha önce komisyonlarda görev almış akademisyenler ile yapılan nicel anket çalışması takip etmektedir. Bu hazırlık çalışmalarında amaç derin analizlerde yol gösterici olmasıdır. Yine yapılan classification learner ve Tobit analizleriyle bu çalışmalar karşılaştırılmış olup farklılıklar olmasına rağmen sonuçlar çoğunlukla paraleldir.

3.1. Makine Öğrenmesi Analizleri

Ajan Tabanlı Modelleme (ABM) bu tezde temel yöntem olarak kullanılmıştır. ABM'nin özellikleri ve detayları ilgili bölümde yer almaktadır. Buna göre, ABM'nin özellikleri otonom, heterojen, aktif (proaktif/hedef yönelimli, reaktif/algısal, sınırlı rasyonellik, etkileşimli/iletişimsel, hareketlilik ve uyum sağlama/öğrenme) şeklindedir. Bu özellikleri ile blok zincir tabanlı karar verme için uygun yöntem olarak seçilmiştir. Öte yandan, bu bölümde Makine öğrenmesi algoritmaları kullanılarak bir ön analiz gerçekleştirilmektedir. Bu çalışmanın amacı bir sonraki bölümde yoğun olarak yapılacak olan analiz çalışmalarının sonuçlarını doğrulamak,

kullanılan deęişkenlerden genel sonuçları test etmek ve mevcut entropi uygulamasını tezde kullanmaktır.

Makine öğrenmesinin amacı, öğrenen bilgisayar programları oluşturmaktır. Bu yöntemle geçmiş verilerle çalışan bilgisayar programı benzer bir geleceęi çok az veriyle veya hiç veri olmadan tahmin edebilmektedir (Ayodele, 2014). Ayrıca makine öğrenmesi algoritmalarında kullanılan veriler sürekli, ikili veya kategorik olabilir. Hem sayısal hem de evet/hayır yanıtı bir dizi deęerin bir eşik deęere göre dallandığı karar ağacı algoritmaları ise en çok kullanılan makine öğrenimi algoritmaları arasındadır. Yinelemeli İkilemler 3 (ID3), ID3'ün Ardılı (C4.5), Sınıflandırma ve Regresyon Ağacı (CART), Chi-kare Otomatik Etkileşim Detektörü (CHAID), Çok Deęişkenli Uyarlanabilir Regresyon Çizgileri (MARS) gibi çeşitli DT algoritma türleri vardır. (Abdulazeez, 2021).

Yukarıdaki karar ağacı algoritmalarından tez için hazırlanan veriye en uygun olan ID3 algoritması çalışma için seçilmiştir. Tablo 3.1'de analizlerde kullanılan verilere ilişkin detaylar bulunmaktadır. Ancak tablodan da görüleceęi gibi komisyon kararlarının ortak karar vererek verilmiş olması, komisyon içerisindeki dinamikleri öğrenememize engel olmaktadır. Söz gelimi, destek kararı verilen bir başvuru için eldeki veride bütün komisyon üyelerinin de evet olarak tercihte bulunduğu görülmektedir. Ek olarak, komisyonların kayıt altına alınmamasından ötürü komisyon üyeleri arasındaki fikir ayrılıklarından ve kararların dönüm Hayırtalarına ait ne yazık ki ulaşamamaktadır.

3.2. Makine Öğrenmesi Sonuçları

Karar ağacı analizinde kullanılan Iterative Dichotomiser 3 (ID3) algoritmasının her iterasyonunda aşağıdaki formüle göre entropi hesabı yapılmaktadır. Bu hesaba göre karar ağacı dallanır. Entropinin 0 olduęu kısımlarda dallanma olmadığı için bu kısmın karara etkisinin olmadığı sonucuna varılmıştır. Her yinelemede hesaplanan entropi, o deęişkenden ne kadar bilgi elde edilebileceęini bulur. Daha düşük entropiye sahip bir deęişkenden daha fazla sonuç alınabileceęi sonucuna varılabilir (Ogheneovo ve Nlerum, 2020).

Çalışmada, izleyici ve komisyon üyeleri, akademisyenlerin kararının nihai karara etkisi yoktur; yani entropisi 0'a eşittir.

Python üzerinde kodlama yapıldıktan sonra destek kararında en etkili değişkenin firma başvuru dosyasında belirtilen doktoralı personel sayısı olduğu hesaplanmıştır. Bunu toplam Fikri Mülkiyet Hakları (FSMH) ve entropi farkı yüksek olan şirketin sahip olduğu makale sayısı takip etmektedir. Önem açısından üçüncü sırada, yüksek lisans derecesine sahip personel fazlası bulunmaktadır. Dördüncü sırayı şirketin diğer kamu kurum ve kuruluşları tarafından desteklenen Ar-Ge proje sayısı ve başvuru döneminde personeline sunduğu eğitim fırsatlarının bolluğu paylaşıyor. Ayrıca şirketin desteklenmeyen diğer Ar-Ge projeleri fazlası beşinci sırada yer almaktadır. Kararda en az etkiye sahip olan faktör, diğer Ar-Ge merkezleri ve üniversiteler ile yapılan işbirliklerinin sayısıdır.

Sonuç olarak, Sanayi ve Teknoloji Bakanlığı tarafından sağlanan verilerde teşvik kararlarında oybirliğiyle bir politika izlendiğinden, komisyon üyelerinin bireysel kararlarının etkisi ölçülememiştir.

3.3. Birinci Anket

Makine öğrenmesi analizinde nihai karara en çok etki eden ve başvuru formunda yer alan değişkenlerden, nitelikli insan kaynağı ve firmanın yaptığı Ar-Ge projelerinin sayısı en önemli iki değişken olarak hesaplanmıştır.

Bu çalışmayı desteklemek için 2009 yılından beri en az 1 kere komisyonlarda yer almış akademisyenlere Tablo 3.1'de yer alan değişkenler gönderilmiş ve puanlamaları istenmiştir. Bu ilk anket çalışmasına 96 akademisyen yanıt vermiştir.

3.4. Birinci Anket Sonuçları

Karar ağacı algoritması sonuçlarından farklı olarak, anket katılımcıları kararlarındaki en önemli faktörü izleyiciden gelen raporlar olarak bildirmiştir. Şirketin başvuru raporu önemde ikinci sırada yer almaktadır. Nitel analizlerde olumlu karardaki en önemli değişkenin şirketin insan kaynağı olduğu (özellikle en önemli değişken doktoralı personel sayısı) olduğu görülmüştür. Anket sonuçlarında başvuru raporu değişkenleri arasında en önemli kriter firma tarafından yürütülen proje sayısıdır.

Tablo 3.1 ID3 Formatında Ar-Ge Merkezi Verisi

Sektör	Destekli Proje Sayısı	Desteksiz Proje Sayısı	İşbirliği Sayısı	Etkinlik Sayısı	FSMH Sayısı	Ar-Ge Çalışanı	Yüksek Lisanslı Ar-Ge Personeli	Doktoralı Ar-Ge Personeli Sayısı	İzleyici 1	İzleyici 2	Akademisyen 1	Akademisyen 2	Sonuç
Makine İmalatı	4	7	7	3	1	19	1	0	Hayır	Hayır	Hayır	Hayır	HAYIR
Bilgisayar ve İletişim Teknolojileri	4	3	6	10	9	19	1	0	Hayır	Hayır	Hayır	Hayır	HAYIR
Yazılım	0	8	4	24	0	45	3	1	Hayır	Hayır	Hayır	Hayır	HAYIR
Üretim Sanayi	2	5	17	17	0	22	1	0	Hayır	Hayır	Hayır	Hayır	HAYIR
Otomotiv	0	4	0	0	0	19	0	0	Evet	Hayır	Hayır	Hayır	HAYIR
Bankacılık ve Finans	0	7	2	44	5	19	6	1	Hayır	Evet	Hayır	Hayır	HAYIR
Yazılım	1	5	9	5	0	27	6	0	Hayır	Hayır	Hayır	Hayır	HAYIR
Medya ve İletişim	0	6	27	18	2	24	8	0	Hayır	Evet	Hayır	Hayır	HAYIR
Üretim Endüstrisi	0	10	8	15	0	31	2	0	Hayır	Evet	Hayır	Hayır	HAYIR
Plastik	0	10	12	26	61	21	1	0	Evet	Hayır	Hayır	Hayır	HAYIR
Yazılım	1	46	26	149	29	30	11	9	Evet	Evet	Evet	Evet	EVET
Tarım	2	40	8	47	10	57	0	1	Evet	Evet	Evet	Evet	EVET
Tekstil	2	16	59	55	10	27	1	0	Evet	Evet	Evet	Evet	EVET
Gıda	2	9	45	48	0	20	9	0	Hayır	Evet	Evet	Evet	EVET
İlaç	0	15	47	0	0	66	0	10	Evet	Evet	Evet	Evet	EVET
Ulaşım ve Lojistik	0	7	6	0	0	20	1	1	Evet	Hayır	Evet	Evet	EVET
Savunma Sanayi	4	1	0	2	0	20	1	1	Hayır	Evet	Evet	Evet	EVET
Tarım	0	12	10	5	0	29	2	0	Evet	Evet	Evet	Evet	EVET
Dayanıklı Tüketim Malları	7	8	5	5	6	39	19	8	Evet	Evet	Evet	Evet	EVET
Kağıt ve Kağıt Ürünleri	0	8	7	17	0	20	4	0	Evet	Evet	Evet	Evet	EVET
Tekstil	2	17	20	12	0	20	3	0	Evet	Evet	Evet	Evet	EVET
Kimya	2	9	45	48	0	20	9	0	Evet	Evet	Evet	Evet	EVET
Elektronik	0	4	1	2	0	19	0	0	Evet	Evet	Evet	Evet	EVET

3.5. Komisyon Kararlarını Etkileyen Unsurlar ve Classification Learner Analizleri

Şekil 2.1’de görüldüğü üzere Ar-Ge Merkezleri teşviği 3 ardışık süreçten geçmektedir. Bu üç süreçte bir eleme olmayıp, destek kararı son aşama olan komisyon aşamasında verilmektedir. Başvuru ve izleyici raporları komisyona karar aşamasında bilgi sağlamaktadır. Bu bölümde komisyonun kararlarını verirken ne ölçüde bu kararlardan faydalandığını ve en çok hangi aşamadan hangi değişkenden faydalandığı analiz edilmektedir.

Analizler için Matlab programının bir alt uygulaması olan “Classification Learner” programı kullanılmıştır. Classification Learner, birçok yöntem arasından en iyi istatistiksel yöntemi seçmeye olanak sağlayan bir yazılımdır. Bu yazılımda, verilerin bir kısmı test için ayrılmıştır. Ayrılan test verileri, sonucun (tez için evet/hayır ikili kararı) en iyi yöntemle ne kadar doğru tahmin edilebileceğini gösterir. Ayrıca Makine Öğrenimi algoritmaları ile bilgisayar, eğitim için ayrılan verilerle sonuçları tahmin etmeye çalışır (Kotsiantis, Zaharakis ve Pintelas, 2006; Chamorro-Atalaya vd., 2021). Classification Learnerda bulunan *Maximumum Relevance Minimum Redundancy* (MRMR) analizleri ile de süreç içerisindeki en etkin değişkenler hesaplanmıştır.

MRMR, ilgisiz özellikleri ortadan kaldırarak, model eğitimi ve tahmin hızını hızlandırarak, daha iyi model yorumlama ve teşhis yeteneği sağlayarak tahmin doğruluğunu sağlayabilmektedir (Zhao, Anand ve Wang, 2019). Sonuç olarak, MRMR, araştırmacıların değişkenler ve alt değişkenler arasında en önemli değişkeni belirlemesine olanak tanır.

1. Deneme

İlk denemede, Şekil 2.1’deki gerçek durum makine öğrenmesi ile incelenmiştir. Tahmin edildiği gibi, bilgisayar yukarıdaki modeli %100 doğrulukla buldu. Çalışılan modeller ve tahmini yüzdeleri Şekil 3.1’de verilmiştir.

Sort by: Model Number	
1 Tree	Accuracy (Validation): 100.0%
Last change: Fine Tree	15/15 features
2.1 Tree	Accuracy (Validation): 100.0%
Last change: Fine Tree	15/15 features
2.2 Tree	Accuracy (Validation): 100.0%
Last change: Medium Tree	15/15 features
2.3 Tree	Accuracy (Validation): 100.0%
Last change: Coarse Tree	15/15 features
2.4 KNN	Accuracy (Validation): 96.0%
Last change: Fine KNN	15/15 features
2.5 KNN	Accuracy (Validation): 98.0%
Last change: Medium KNN	15/15 features
2.6 KNN	Accuracy (Validation): 50.0%
Last change: Coarse KNN	15/15 features
2.7 KNN	Accuracy (Validation): 98.0%
Last change: Cosine KNN	15/15 features

Şekil 3.1 Deneme için Modellerin İstatistiki Netlik Oranları

Bu doğruluk payının nedeni, belirtildiği gibi, nihai kararın komisyon tarafından verilmiş olmasıdır. Komisyonun evet dediği başvurular kabul edilirken, aleyhte oy kullananlar reddedilmiştir. Bu nedenle doğruluk oranı %100'dür. Ayrıca MRMR analizi ile özellik sıralaması incelendiğinde doğal olarak akademisyenin görüşü en etkili değişkendir.

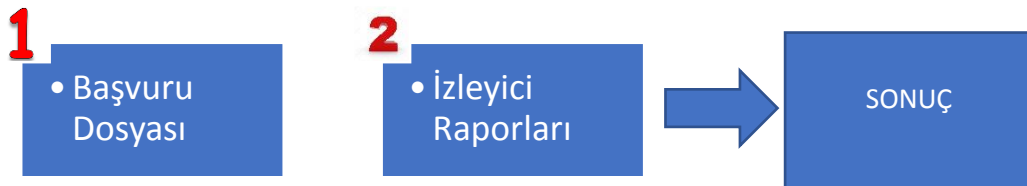
Tablo 3.2 MRMR Analiz Skorlarına Göre En Önemli Değişkenler

Özellik	MRMR
Komisyon üyesi akademisyenin kararı	0.6931
Toplam etkinlik sayısı	0.5783

2. Deneme

Bu denemede, komisyon verileri ve aşaması atlanır ve Şekil 6.4 gibi bir durum analiz edilir.

analyzed.



Şekil 3.2 Deneme Süreci

Şekil 3.2'deki gibi bir durum olsaydı, Matlab R2022b Classification Learner uygulaması Şekil 3.3'teki doğrulukla uygulama sonucunu tahmin edebilmektedir. Bu denemede Medium KNN ve Coarse Gaussian SVM yöntemleri en yüksek %84 ile doğru tahmin ederken, en düşük %48 ile SVM Kernell yöntemi doğru tahmin etmiştir.

Komisyon aşamasının olmadığı bu durumda eldeki veriler ile en iyi ihtimal ile %84 oranın da sonuç tahmin edilebilmektedir. Metodun farklı seçilmesi durumunda ise bu oran %48'e kadar düşmektedir. Yüksek ihtimalli tahminlerin izleyici raporların sonuca dair net bir bildirim yapabilmesine borçlu olduğu düşünülmektedir. Özellikle izleyici raporlarının kesin olarak kabul ya da red diyemediği durumlarda kararı komisyon üyeleri vermektedir. Bu durumda ise, komisyon içerisindeki sosyal etkileşimler ve hiyerarşik güç ilişkileri devreye girebilmektedir. Tezin ana teması da bu ilişkilerin sonuca olan etkisinin incelenmesi üzerinedir.

☆ 3.1 Tree	Accuracy (Validation): 78.0%
Last change: Fine Tree	10/10 features
☆ 3.2 Tree	Accuracy (Validation): 78.0%
Last change: Medium Tree	10/10 features
☆ 3.3 Tree	Accuracy (Validation): 74.0%
Last change: Coarse Tree	10/10 features
☆ 3.4 Linear Discriminant	Accuracy (Validation): 76.0%
Last change: Linear Discriminant	10/10 features
☆ 3.5 Quadratic Discriminant	Failed
Last change: Quadratic Discriminant	10/10 features
☆ 3.6 Logistic Regression	Accuracy (Validation): 70.0%
Last change: Logistic Regression	10/10 features
☆ 3.7 Naive Bayes	Failed
Last change: Gaussian Naive Bayes	10/10 features
☆ 3.8 Naive Bayes	Accuracy (Validation): 60.0%
Last change: Kernel Naive Bayes	10/10 features
☆ 3.9 SVM	Accuracy (Validation): 78.0%
Last change: Linear SVM	10/10 features
☆ 3.10 SVM	Accuracy (Validation): 74.0%
Last change: Quadratic SVM	10/10 features
☆ 3.11 SVM	Accuracy (Validation): 74.0%
Last change: Cubic SVM	10/10 features
☆ 3.12 SVM	Accuracy (Validation): 66.0%
Last change: Fine Gaussian SVM	10/10 features

Şekil 3.3 Deneme için Modellerin İstatistikî Netlik Oranları

MRMR algoritmasına göre özelliklerin önem sırası deneme 2 için aşağıdaki gibidir.

Tablo 3.3 MRMR Analiz Skorlarına Göre En Önemli Değişkenler

Özellik	MRMR
İzleyici Kararı	0.2262
Destekli Ar-Ge proje sayısı/Ar-Ge personeli sayısı	0.0914
Toplam FSMH/Ar-Ge personeli sayısı	0.0260
Doktoralı sayısı/Ar-Ge personeli sayısı	0.0082
Desteksiz Ar-Ge proje sayısı/Ar-Ge personeli sayısı	0.0049
Toplam araştırmacı sayısı	0.005

Buna göre teşvik başvurusunda bulunan firmanın yerinde incelemesini yapan izleyicinin kararının nihai karar üzerinde en etkili değişken olduğu görülmektedir. Bu deneme göstermektedir ki seçilen modele göre değişmek ile birlikte komisyon verisi neticenin en çok %52 ile en az %16'sını oluşturmaktadır. Bu oran içerisinde sosyal ilişkilerin ve hiyerarşik güç ilişkilerinin önemini ve yerini göstermek için ise Ajan-Bazlı modelleme metodu kullanılmaktadır.

3. Deneme

Karar verme dinamik bir süreçtir. Bu süreçte karar vericilerin karakter özellikleri gibi soyut kavramların yanı sıra, karar vericilerin deneyimleri, bilgileri, hiyerarşik konumları gibi faktörler de nihai karar üzerinde etkili olmaktadır. Karar verme dinamikleri, soyut ve somut unsurlar dikkate alınarak bir sonraki bölümde detaylandırılacaktır.

Bu bölümde nicel verilerin nihai karar üzerindeki etkileri analiz edilmektedir. Buna göre komisyon üyesi ile başvuran firma arasındaki uyum (sektör uyumu), komisyon üyelerinin toplam yayın sayıları, doktora mezuniyet tarihinden itibaren geçen süre, unvanları, çalıştıkları üniversitenin Times Higher Education (THE) sıralaması, sahip oldukları toplam patent sayısı (Tablo 3.4'te bu değişkenlerin sayısallaştırma yöntemleri belirtilmektedir) ve komisyonların nihai kararına etki eden faktörler analiz edilmektedir.

Matlab R2022b Classification Learner yazılımı ile yapılan analiz sonucunda komisyonun nihai karardaki doğruluk oranı Fine Tree yöntemine göre %61 olmuştur (Lojistik Regresyon Çekirdek yöntemi %63 doğrulukla en yüksek oranı tahmin

ederken, Boosted Tree ve Medium Neural Network yöntemleri %48 doğrulukla tahmin yapabilmektedir).

Tablo 3.4 Karar Komisyonu Üyesi Akademisyenlerin Sayısal Verileri ve Tanımları

Özellik	Değer	Tanım	Açıklamalar
Sektör uyumu	Hayır (0)	Karar vericinin çıkarları, başvuranın sektörüyle uyuşmuyorsa	Sektörel uyum sağlanması durumunda başvuru sahibi ile değerlendirici arasındaki bilgi uyumsuzluğunun daha az olacağı düşünülmektedir.
	Evet (1)	Karar vericinin ilgi alanları, başvuranın sektörüyle örtüşüyorsa	
Toplam yayın sayısı	Sayısal veri	Yüksek ise sonuç iyi çıkmalı	Toplam yayın sayısı, karar vericinin genel bilgisinin sayısal değerlendirmesini temsil eder.
Doktora mezuniyetinden geçen süre	Sayısal veri (yıllar)	Yüksek olursa daha etkili olur.	Doktora mezuniyetinden itibaren geçen süre, karar vericinin deneyim ve bilgisini temsil eder.
Unvan	Prof. (3)	Başlık ne kadar yüksek olursa, verilen sayısal değer o kadar yüksek olur	Sayısallaştırılmış hiyerarşik güç mesafesi
	Doç. D.r (2)		
	Dr. (1)		
Times Higher Education (THE) sıralaması	Sayısal veri	Başlık ne kadar yüksek olursa, verilen sayısal değer o kadar yüksek olur	Daha saygın üniversitelerde görev yapan karar komisyonu üyesi akademisyenlerin hiyerarşik güç mesafesinin önünde olduğu düşünülmektedir.
Toplam patent sayısı	Sayısal veri	Yüksek olursa daha etkili olur.	Toplam patent sayısı, karar vericinin genel bilgisinin sayısal değerlendirmesini temsil eder.

Son olarak, komisyon kararları Matlab ile maksimum %63 doğruluk oranı ile tahmin edilebilmektedir. Kalan %37'lik kısım dikkate alındığında, grubun karar verme dinamikleri, grup üyelerinin kararlarındaki dönüm noktaları ve etki koşulları incelenmeye değerdir. Bu dinamikler tezin bir sonraki bölümünde incelenecektir. Tablo 3.5, MRMR algoritmasını kullanarak hangi değişkenin karar üzerinde en etkili olduğunu göstermektedir. Buna göre en etkili özelliğin karar verici akademisyen unvanı olduğu görülmektedir. Bu durum bizim çalışmamızla paralellik göstermektedir. Tez karar komisyonu üyelerinin unvan ve üniversite gibi bileşenlerden oluşan “Hiyerarşik Güç Mesafesinin” blok zincir ortamında bir etkisinin olmayacağını önermektedir. Blok zincir karar verme ortamında insan-makine tipi bir iletişim olduğu için hiyerarşik güç mesafesi etkisinin olmayacağı varsayılmaktadır. Analizler, mevcut komisyon yapısında karar vericilerin hiyerarşik güç mesafesi etkisinden etkilendiğini kanıtlamıştır.

Tablo 3.5 MRMR Analizlerine Göre Deneme 3 için Önemli Değişkenler

Features	MRMR
Title	0.0156
Number of publications	0.0074
Number of patents	0.0010
Sectoral match	0.00007

Ayrıca diğer değişkenler (yayın sayısı ve patent sayısı gibi) ikinci ve üçüncü önemli değişkenlerdir. Bu durum karar vermede bilginin önemini göstermektedir. Blok zincir ise değişmez yapısı sayesinde karar vericilere karar verme aşamasında daha kaliteli bilgi sunmayı teklif ediyor. Bu sonuç tezin öne sürdüğü önermelerle uyumludur.

3.6. Tobit Analizleri ve Diğer Analizler ile Karşılaştırmaları

Şu aşamaya kadar ID3 makine öğrenmesi analizi yapılmış sonuçları birinci anket sonuçlarıyla karşılaştırılmıştır. Sonrasında benzer analizler Matlab Classification Learner kullanılarak yapılmıştır. Ancak bu 3 analiz sonuçları arasında benzer sonuçlar olduğu gibi farklı sonuçlar da elde edilmiştir. Bu sebeple 3 analizin sonuçlarının başka bir istatistiki model üzerinde doğrulanması ihtiyacı hasıl olmuştur. Bu sebeple, bu bölümde bu sonuçların karşılaştırılması için Tobit analizi yapılmıştır.

3.6.1. Genel Bilgi

Analiz kapsamında Sanayi ve Teknoloji Bakanlıđından elde edilen veriler ve bu veriler kullanılarak oluřturulan deđiřkenler kullanılmaktadır. Buna gre 100 Ar-Ge Merkezi belirleme komisyonunun verileri iin 27 deđiřken kullanılmıřtır. Bu deđiřkenler Tobit analizinde kullanılmak zere kısaltılmıřtır, bu deđiřkenler ve zellikleri Tablo 3.6'da listelenmiřtir ve analizlerde bulunan tm veriler Ek-C'de yer almaktadır.

Tezde olduđu gibi, birok stratejik kararın sonucu evet veya hayırdır. İstatistiksel olarak kullanılan probit ve logit yntemleriyle eldeki verilerle ikili sonucun gerekleřme olasılıđı hesaplanır (Amore ve Murtinu, 2021). Probit ynteminin zelleřmiř bir tr olan Tobit yntemi, belirli bir sayı etrafında (tez iin 0 ve 1) kmelenmiř ok fazla veri olduđuunda ve analizde yer almayan ancak analizi etkileyebilecek sansrlenmiř veriler olduđuunda kullanılır (McDonald ve Moffitt, 1980).

Sonucun da ikili olduđu tezde benzer bir durum vardır. Tezde incelenen biliřsel etkiler, komisyon sırasında veriye evrilemediđi karar deđiřtirme noktaları ve elde edilemeyen birok sayısal veri sonucu etkileyen unsurlar sansrl deđiřkenlerdir. Bu nedenle analizin bu blmnde Tobit yntemi tercih edilmiřtir.

Tobit analizinde Stata v10 kullanılmıřtır. Analiz kodları ve "do file" ieriđi Ek D'de yer almaktadır.

3.6.2. Analizler

Belirtildiđi gibi Tobit analizi maksimum ve minimum iki deđiřken arasında dađılan ancak analize dahil edilemeyen verilerin etkisini ieren bir analizdir. Bu nedenle maksimum ve minimum deđerlere limitler (sansrl) getirilerek analiz yapılır. Bu sansr, analizdeki en yksek ve en dřk deđerlere (sol ve sađ sansrl) uygulanır.

Tobit ynteminde veriler sađ ve sol sansrl olarak analiz edilir. Sađ sansrl analizlerde karar bađımlı deđiřken iin en yksek 1 (evet) kodu olarak u1 kodu, sol sansrl analizler iin 11(0) kodu, en dřk 0 (hayır) kodu ise karar bađımlı deđiřken iin kullanılır. (Ayrıntılar ve do dosyası iin Ek D grntlenebilir).

Tablo 3.6 Tobit’de Kullanılan Değişkenler

Sıra	Değişken Adı	Tanım	Data Kaynağı
1	sppro	Destekli proje sayısı	San. ve Tek. Bak.
2	unsppro	Öz kaynaklı proje sayısı	San. ve Tek. Bak.
3	coll	İşbirliği sayısı/toplam Ar-Ge personeli sayısı	San. ve Tek. Bak.
4	act	Etkinlik sayısı/toplam Ar-Ge personeli sayısı	San. ve Tek. Bak.
5	ipr	FSMH sayısı/toplam Ar-Ge personeli sayısı	San. ve Tek. Bak.
6	emp	Toplam Ar-Ge personeli sayısı	San. ve Tek. Bak.
7	mscemp	Yüksek lisanslı Ar-Ge personeli sayısı /toplam Ar-Ge personeli sayısı	San. ve Tek. Bak.
8	phdemp	Doktoralı personel sayısı /toplam Ar-Ge personeli sayısı	San. ve Tek. Bak.
9	obs ¹⁶	İzleyici kararı	San. ve Tek. Bak.
10	smatch	İzleyicinin projeler ile uyumu	Bireysel hesaplamalar
11	phd	İzleyicinin doktora mezuniyetinden geçen süre	Bireysel hesaplamalar
12	rank	İzleyicinin mensubu olduğu üniversitenin Times Higher Education (THE) sıralaması	Bireysel hesaplamalar
13	acmsmatch	Komisyon üyesi akademisyenin çalışma alanlarıyla firmanın projelerinin uyumu	Bireysel hesaplamalar
14	acpub	Komisyon üyesinin toplam makale sayısı	Avesis
15	acpat	Komisyon üyesinin toplam yayın sayısı	Avesis
16	acphd	Komisyon üyesinin doktora mezuniyetinden geçen süre	Bireysel hesaplamalar
17	acrank	Komisyon üyesinin mensubu olduğu üniversitenin THE sıralaması	Bireysel hesaplamalar
18	decision (dependent variable)	Son kara	San. ve Tek. Bak.

Tablo 3.7, sol sansürlü Tobit analizi sonucunda elde edilmiştir. Analiz sonucunda eldeki veriler yaklaşık %55 (R2) oranında tahmin edilebilmiştir.

Tablo 3.7’de de gözlemleneceği üzere sol sansürlü Tobit analiz analiz sonucunda, başvuru raporunu yerinde inceleyen izleyici akademisyenlerin kararları nihai sonuç üzerinde etkilidir. Öte yandan, 5746 sayılı Araştırma, Geliştirme ve Tasarım Faaliyetlerinin Desteklenmesi Hakkındaki Kanun kapsamında Ar-Ge ve Tasarım Merkezlerinin değerlendirilmesinde komisyon, izleyici ve başvuru raporlarından bağımsız kararı tek başına vermeye yetkilidir. Karar verme komisyonun bu yetkiyi

¹⁶ İzleyici ve komisyon üyesi akademisyenler her başvuru için 2 kişidir. Analizlerde her iki izleyici akademisyenin verileri kullanılmaktadır. obs1 ilk gözlemciyi tanımlarken obs2 diğerini tanımlar. Bu nedenle 2 komisyon üyesi için obs, smatch, phd, rank değişkenleri, komisyon üyesi olan 2 akademisyen için acmsmatch, acpub, acpat, acphd, acrank değişkenleri ayrı ayrı analizlere dahil edilmiştir.

sonuna kadar kullandığı eldeki verilerden de gözlemlenebilmektedir. Veriler incelendiğinde, izleyici hakemlerin raporlarının aksi yönünde kararların verildiği durumlar da bulunmaktadır. Bu sebeple izleyici hakemin kararı istatistiki olarak önemli dahi olsa karar da etkisi olmayabilmektedir.

Tablo 3.7 Sol Sensörlü Tobit Analiz Sonuçları

Tobit regression

Number of obs = 95

LR chi2(26) = 108.45

Prob > chi2 = 0.0000

Log likelihood = -44.568521

Pseudo R2 = 0.5489

decision	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
sppro	.0949456	.0418818	2.27	0.027	.0113936	.1784976
unsppro	-.0324087	.0133983	-2.42	0.018	-.0591376	-.0056798
coll	-.1022792	.0986181	-1.04	0.303	-.299017	.0944586
act	.0165735	.0388092	0.43	0.671	-.0608487	.0939958
ipr	-.2605547	.1314064	-1.98	0.051	-.5227032	.0015939
emp	.0034614	.0073394	0.47	0.639	-.0111802	.0181031
mscemp	1.249324	.7184822	1.74	0.087	-.1840083	2.682657
phdemp	-1.328388	1.847926	-0.72	0.475	-5.014899	2.358123
obs1	.5738977	.1553921	3.69	0.000	.263899	.8838965
smatch1	.0809853	.1596202	0.51	0.614	-.2374483	.3994188
phd1	-.0045527	.0111316	-0.41	0.684	-.0267597	.0176542
rank1	.000119	.0000489	2.43	0.018	.0000215	.0002165
obs2	.828626	.1666003	4.97	0.000	.4962674	1.160985
smatch2	-.1080353	.1004066	-1.08	0.286	-.308341	.0922704
phd2	-.0138439	.0110452	-1.25	0.214	-.0358785	.0081906
rank2	.0000419	.0000407	1.03	0.306	-.0000392	.0001231
acmsmatch1	.1072678	.1762531	0.61	0.545	-.2443475	.4588832
acpub1	-.0004686	.0010427	-0.45	0.655	-.0025488	.0016116
acpat1	-.0096324	.0841398	-0.11	0.909	-.1774868	.158222
acphd1	.0001067	.011184	0.01	0.992	-.0222047	.0224181
acrank1	-2.63e-06	.0000642	-0.04	0.967	-.0001308	.0001255
acmsmatch2	.2074502	.1470268	1.41	0.163	-.0858603	.5007606
acphd2	.0037982	.0016995	2.23	0.029	.0004078	.0071886
acpat2	-.0033761	.0244228	-0.14	0.890	-.0520983	.0453461
acpub2	.0152972	.0113546	1.35	0.182	-.0073547	.037949

acrank2	.0000851	.0000467	1.82	0.073	-8.11e-06	.0001783
_cons	-.9214754	.4384045	-2.10	0.039	-1.796068	-.0468824
/sigma	.4317713	.0495937			.3328346	.5307081

Tablo 3.7'de görüldüğü gibi unsppro, coll, ipr, phdemp, phd1, smatch2, phd2, acpub, acpat1, acrank1 ve acpat2 değişkenlerinin karar üzerinde olumsuz etkiye sahip olduğu bulunmuştur. Bir önceki bölümde yapılan analizlerin aksine, başvuru yapan firmanın Ar-Ge projesi (desteksiz) (unppro), işbirliği (coll), IPR (ipr) ve doktora personeli (phdemp) sayılarının da negatif hesaplandığı dikkat çekmektedir. Öte yandan izleyicilerin alanında uzman (smatch2), deneyimlerinin (phd2) yüksek, akademisyenlerin yayın sayılarının (acpub) ve patent sayılarının yüksek (acpat1 ve acpat2) olması karara negatif yönde etki etmesi öngörülebilir bir sonuçtur. Çünkü izleyici ve komisyon üyelerinin beklentileri yüksek olabilir ve bu da sonucu olumsuz etkileyebilir.

Öte yandan izleyicinin kararlarının (obs1 ve obs2) sonuca en çok etki eden değişkenler olması da MRMR analizi ile uyumludur.

Komisyon üyelerinin (acpat, acphd ve acrank) bilgi ve deneyimlerinin önemli olması etkisi bir sonraki bölümde incelenecek olan "hiyerarşik güç mesafesi" etkisinin varlığını kanıtlamaktadır.

3.6.3. Sonuçlar

Sonuç olarak Tobit analizinin Matlab Classification Learner ve MRMR analizi ile uyumlu olduğu görülmüştür. Kararda ID3 analizinde belirlenen desteklenen proje sayısı (sppro) ve doktoralı personel sayısının (phdemp) önemi Tobit analizlerinde de önem taşımaktadır.

Classification Learner analizinde bulunan somut verilerin komisyon kararını %63 oranında tahmin edebilmesi sonucunda Tobit (sağ sansürlü) analizinde birebir aynı bulunmuştur.

Yine MRMR analizlerinde belirlenen "hiyerarşik güç mesafesi" etkisi, komisyon öğretim üyesinin deneyim, bilgi ve üniversite sıralaması (acpub, acphd, acpat ve acrank) değişkenleri ile doğrulanmıştır.

3.7. İkinci Anket

Komisyon içerisinde karar değişikliklerini analiz edebilmek ve simülasyonda girdi olarak kullanabilmek için Ar-Ge merkezi komisyonlarında en az 1 kere görev almış akademisyenlere EK-B'deki sorular sorularak ikinci bir anket yapılmıştır.

3.7.1. Sonuçlar

Ankete verilen yanıtlardan elde edilen sonuçlar aşağıdaki gibidir.

Tablo 3.8 Anket Sonuçlarından Senaryo Bazlı Elde Edilen Karar Değiştirme İhtimalleri

SENARYO 1			SENARYO 2		
Grafik Gösterim	İhtimal	Soru No	Grafik Gösterim	İhtimal	Soru No
	%9.6	3		%12	12
	%13	4		%16	13
	%40	5		%43	14
	%17	6		%21	15
	%13	7		%16	16
	%18	8		%22	17
	%46	9		%49	18
	%59	10		%65	19
	%43	11		%49	20

Tablo 3.8 (devam)

Açıklama	
	Başvuru konusu alanda uzman olmayan karar vericiyi temsil eder
	Başvuru konusunda uzman olan karar vericiyi temsil eder
	Başvuru konusunda uzmanlığı bilinmeyen ancak karar vermesi beklenen karar vericinin sosyal çevresinden karar verici temsil eder
	Karar vericiyi temsil eder

1. Başvuru ve izleyici raporlarının incelenmesi sonucunda komisyon üyelerinin net bir karara varamadığı muğlak bir durum ortaya çıkması halinde, karar vericiden önce başvuru hakkında kanaat bildirilmiş akademisyen eğer konunun uzmanı değil ise bu negatif bir durum oluşturmaktadır. Yani akademisyen kendisinden önce karar vermiş olan akademisyenlerin kararlarının aksi yönde karar vermektedir.
2. İzleyici raporlarının nihai komisyon kararı üzerindeki etkisi sınırlıdır. Bu sonuç, makine öğrenmesi ile yapılan analitik sonuçlarla da uyumludur.
3. Kararlar, izleyici ve başvuru raporlarından etkilenmeden, komisyonun kendi içindeki sosyal etkileşimler sonucunda alınır.
4. Sosyal yakınlığın Ar-Ge projelerine etkisi, konu hakkında uzman bilgisine sahip olunan duruma göre sınırlıdır.
5. Komisyon üyelerinin kararsız kaldığı durumlarda, hiyerarşik olarak lider olan komisyon üyesi liderlik rolünü üstlenir ve diğer komisyon üyeleri liderin kararına uyar.
6. Ar-Ge projelerinin değerlendirilmesinde bilgiye dayalı hiyerarşi etkilidir.
7. Bilgiye dayalı hiyerarşinin oluşturulduğu komisyonlarda gözlemciden gelen bilgilerin ve uygulama raporlarının etkisi diğer komisyonlara göre daha da sınırlıdır.

8. Gözlemci ve uygulama raporlarının başvuru konusu proje hakkında net bir görüş vermediği durumlarda, komisyonda uzman komisyon üyesi akademisyenin görüşü öne çıkar.

3.8. Ajan Bazlı Modelleme

Tezin bu aşamasına kadar, komisyon sürecine kadar olan alt süreçlerin ve yüz yüze komisyonların Ar-Ge Merkezlerinin karar alma süreçlerine etkisini gösterecek analizler yapılmıştır. Buna göre Python ortamında yapılan "entropi" hesaplamalarında, komisyon nezdinde yapılan gözlemci değerlendirmeleri ve başvuru raporunun sonuca etkisinin sınırlı olduğu hesaplanmıştır. Bunun dışında Matlab ortamında yapılan "Classification Learner" ile kullanılan matematiksel ve istatistiksel yöntemlerin en fazla %84 ile %48 arasında bir kesinlik ile destek kararını ancak hesaplayabildiği kanıtlanmıştır. Buna göre sonuca yazı tura atmak kadar yaklaşmak ancak mümkündür. Bu sonuçlar, yüz yüze yapılan komisyonlardaki sosyal etkileşimin nihai karar üzerinde ne kadar etkili olduğunu göstermektedir.

Bu aşamada "hiyerarşik güç mesafesi" etkisi, NetLogo programı kullanılarak ajan bazında modellenmektedir. İlgili bölümde belirtildiği gibi, "ajan tabanlı modelleme", hem ajanların (tezde akademisyenler) hem de çevrenin dinamik bir ortamda birbirlerinin sonuçları üzerinde doğrudan bir etkisi modellenmektedir.

Başvuru süreci 3 aşamadan oluşmaktadır. Bunlar başvuru raporunun sunulması, izleyici raporları ve komisyon kararıdır. İlk iki aşamaya ait verilerin analizinde ilgili bölümlerde de aktarıldığı gibi komisyon kararının belirleyiciliği ortaya çıkmaktadır. Buna göre, aksi görüşler olsa da komisyon farklı yönde karar verebilir. Yüz yüze yapılan komisyonlarda sosyal etkileşim olduğu yadsınamaz bir gerçektir. Ancak komisyon içindeki olası rol dağılımı tam olarak bilinmemektedir. Bu nedenle bu rol dağılımlarını modelleyebilmek için komisyon üyesi akademisyenler arasında bir anket çalışması yapılmıştır. Bu çalışmadan elde edilen sonuçlar sayısallaştırılmış ve etmen tabanlı modelleme yöntemi ile ortam simüle edilmiştir.

Bu bölümde daha önce komisyonlarda görev almış karar verici akademisyenlerin Tablo 3.8'de gösterilen durumlara göre karar değiştirme olasılıkları anket yöntemiyle

toplanmış ve bu sonuçlar kural olarak modele yerleştirilmiştir. Senaryolarda kararsız (beyaz insan figürü) akademisyen, başvuru, izleyici raporlarından gelen bilgiler ve sosyal etkileşim altında bir karar vermeye çalışır. Bu kararlar, diğer üyelerin konu hakkında bilgi sahibi olup olmaması, konudan bağımsız bir dostluk ilişkisi ve aksi yönde çoğunluk kararının baskısı altında alınmaktadır.

3.8.1. ABM Sonuçları

Sanayi ve Teknoloji Bakanlığı'ndan 774 adet komisyon için veri tedarik edilmiştir. Bu sebeple eldeki veriler ile uyum sağlaması açısından Tablo 3.9'da 774 adet başvuru değerlendirme komisyonu için karar değiştiren akademisyenlerin sayısı bulunmaktadır. Buna göre yaklaşık olarak 100 akademisyenden 30'u stokastik senaryolardaki durumlara göre karar verme yetkisini devretmiş gözükmektedir.

Simülasyon sonuçlarının analizinden aşağıdaki sonuçlar elde edilebilir.

1. Yüz yüze karar alma sırasında tüm karar vericilerin bilgi ve deneyimlerinden tam olarak yararlanılamaz.
2. Yüz yüze karar oturumlarında karar vericiler arasında kısa süreli güvene ve hiyerarşiye dayalı bir ilişki kurulur.
3. Karar vericiler, karar vermenin maliyetini karşılayamaz ve karar verme sorumluluğundan kaçınırlar.
4. Yüz yüze karar verme sürecinde karar vericiler arasında kesin bir güç ilişkisi vardır. Bu hiyerarşi Ar-Ge projelerinde güçlüden zayıfa bilgi, çoğunluk ve sosyal yakınlık şeklindedir.

Table 3.9 Simülasyona Göre Karar Değiştirme Rakamları

Deneme	Sonuç	Deneme	Sonuç	Deneme	Sonuç	Deneme	Sonuç
1	222	26	229	51	226	76	235
2	218	27	228	52	214	77	231

3	222	28	203	53	228	78	216
4	239	29	216	54	242	79	246
5	212	30	212	55	249	80	207
6	243	31	219	56	249	81	229
7	243	32	237	57	220	82	240
8	264	33	216	58	208	83	234
9	222	34	229	59	213	84	238
10	221	35	233	60	204	85	238
11	230	36	234	61	227	86	203
12	231	37	235	62	231	87	263
13	231	38	228	63	233	88	254
14	221	39	219	64	234	89	239
15	234	40	201	65	216	90	217
16	226	41	240	66	236	91	224
17	223	42	223	67	230	92	230
18	208	43	237	68	215	93	223
19	234	44	228	69	247	94	239
20	232	45	243	70	235	95	223
21	232	46	202	71	233	96	231
22	227	47	236	72	239	97	230
23	232	48	223	73	225	98	246
24	218	49	239	74	217	99	230
25	219	50	223	75	215	100	217

5. Verilecek kararın içeriğine göre karar verme ortamının değiştirilmesi önerilir. Buna göre karar verilecek konu daha çok bilgiye dayalı ise (Ar-Ge projelerinin değerlendirilmesi gibi) blok zincir gibi ortamlarda yapılması, duyguya dayalı karar verilecekse ise tercih edilmesi önerilir.

6. Tez kapsamında Ar-Ge projelerinin değerlendirilmesinde başvuru dosyasının ve izleyici raporunun destek kararına etkisinin çok az olduğu ortaya çıkmıştır.

7. Kaynakların daha etkin kullanılabilmesi için izleyici raporunun nihai karara etki etmesi (katkı yüzdesi gibi) zorunlu hale getirilmelidir.

8. Kararlarını değiştiren akademisyenlerin bunu çoğunlukla bilgiye duydukları güvenden dolayı yaptıkları tespit edilmiştir. Ancak bu kararı alırken duyulan güvenin kaynağını ne kadar araştırdıkları bilinmemektedir.

9. Yüz yüze komisyonlardan sonra kararlarını değiştiren akademisyenlerin bu yeni karara ne ölçüde bağlı kalacakları önemlidir.

10. Komisyon sonrası akademisyenlerin kararlarını deęiřtirmeleri ve ilgi alanlarını ve arařtırmalarını bu yeni alana uyarlamaları durumunda arařtırma alanlarını deęiřtirme riski vardır.

11. Bu deęiřim sonucunda akademisyen yeni bir alana yneldięi iin bilgi ve zaman kayıpları yařanabilmektedir.

Yapılan alıřmalar sonucunda komisyondaki sosyal etkileřimlerin komisyon sonucuna etkisi ortaya konulmuřtur. Buna gre komisyon ii tartiřmalarda yeler (akademisyenler) arasında bir rol daęılımı ortaya ıkmaktadır. Bu psikolojik etki, karar vermenin aęırlıęından kaynaklanmaktadır. Bilimsel bir danıřma kurulu olan komisyonlarda, karar verici akademisyenler, komisyon iindeki g iliřkileri sonucunda toplumsal etkileri ve kamu kurumlarının kendilerine verdięi karar alma yetkisini en gl olana aktarırlar. İstenilenin aksine gl olmak komisyonlarda her zaman konu hakkında bilgi sahibi olmak demek deęildir. Ayrıca komisyon yeleri tm komisyon yelerinin bilgi ve birikimlerinden en st dzeyde yararlanmaya alıřırken kendilerine tanınan ve beklenen bu hakkı devrederler. Bu sonuca dayalı olarak, komisyon yapısı ve iliřkilerinin dzenlenmesine ynelik politika aksiyonlarının alınması nemlidir. Son blm, bu politika nerilerini tartiřmaktadır.

3.8.2. Validasyon Testleri

Sanayi ve Teknoloji Bakanlığı'ndan alınan verilerde komisyon sonuları bulunmaktadır ama komisyon iindeki dinamikler ve komisyon yesi olan akademisyenlerin kararlarındaki hareketler hakkında veri bulunmamaktadır. řu anda bu tr verileri elde etmek mmkn grnmemektedir. te yandan tez, yz yze karar verme yerine gemesi planlanan blok zincirli bir gelecekte karar verme dinamiklerini ngrmektedir. Bu nedenle biliřsel durumların karar deęiřikliklerine etkisi anket ve simlasyon verileri ile incelenmiřtir. alıřmada dinamik karar verme srecine en yakın sonucu verdięi iin literatrde kabul gren ABM yntemi tercih edilmiřtir. te yandan, ABM stokastik veriler saęlamaktadır. Bu kořullar altında, literatrde analizlerin saęlamlık testleri iin saęlıklı bir yntem belirtilmemiřtir. Bu nedenle Tablo 3.8'de sonuları yazılan test dzeneęi tasarlanmıřtır. Buna gre analizlerin

validasyonu için Tablo 3.8'deki durumlar simülasyon üzerinde yaratılmış ve anketten elde edilen sonuçlar ile uyuşup uyuşmadığına bakılmıştır.

Teste göre tabloda belirtilen kararın değişme olasılığı diğer koşullar sabit tutularak yeniden çalışılmıştır. Örneğin, kırmızı ve gri senaryolarda alanında uzman akademisyenin (mavi kişi) ve ardından karar vericinin (beyaz kişi) kararını değiştirme olasılığı sırasıyla %46 ve %49 iken, doğruluk testi sonuçları %48 olarak ölçülmüştür. Tüm analizde beyaz, sarı, mavi ve kırmızı insanlar beyaz ve kırmızı senaryolara rastgele dağıtılır ve tabloda belirtilen olasılıklara göre kararlarını stokastik olarak değiştirir. Sağlamlık testleri ise bu sonuçları doğrulamaktadır.

4. POLİTİKA ÖNERİLERİ

Kamu Ar-Ge fonlarının seçiminde hiyerarşik güç ilişkisinin etkisinin araştırıldığı bu tezde, blok zincir teknolojisi ile hiyerarşik güç ilişkisinin azaltılması ve blok zincirin özellikleri nedeniyle fon dağılımının daha şeffaf ve hesap verebilir hale getirilmesi ele alınmıştır. Çalışma, vergi mükelleflerinin katkılarıyla oluşturulan Kamu Ar-Ge fonunun sorumluluğunu taşımaktadır. Bu bölümde, bu sorumluluğun gereği olarak elde edilen sonuçlar politika önerileri şeklinde tartışılmaktadır.

Tez, temelde geleneksel yöntemler ile blok zincir üzerinde karar verme arasındaki farkları tartışırken, aslında teknolojik gelişmelerin iş alışkanlıkları üzerindeki etkilerini de incelemektedir. Bu bölümde, mevcut ve devam eden teknolojik yeniliklerin kolaylıkları ve mevcut yöntemlerin eksiklikleri tartışılırken, Türkiye'deki Ar-Ge teşviği veren kurumlar için önerilen politika önerileri tartışılmaktadır. Yapılan çalışmalar özelinde Türk Ar-Ge teşvik mekanizması için en önemli eksikliğin şeffaflık ve hesap verilebilirlik olarak söylenebilir. Bu sebeple ana politika önerisi aşağıdaki gibidir:

Ar-Ge projelerinde kullanılan kamu kaynaklarının daha etkin, hesap verebilir ve şeffaf bir şekilde dağıtılması ve üretilen değerli bilgilerin kamu tarafından tekrar kullanılabilmesi için önlemler alınması temel politika hedefidir.

Bu bölümde belirtilen politika hedefleri, ana politika hedefini gerçekleştirmek için geliştirilmiş araçlardır. Yararlı önerilerin bir kısmı analiz sonucunda ortaya çıkarken, bir kısmı da blok zincir teknolojisinin benzer teknolojilere olan üstünlüğünden esinlenilmiştir. Öte yandan Türkiye'de Ar-Ge teşviklerinden sorumlu kurumların bu konuda bir çalışmalarının olmaması nedeniyle bazı politika önerileri ortaya atılmıştır. Bunlardan birincisi şeffaflık ve hesap verebilirliktir. Kamu kaynaklarının kullanıldığı bu teşviklerde bu önemli bir unsurdur.

4.1. Şeffaflığı ve Hesap Verilebilirliği Arttırma

Ar-Ge projeleri doğası gereği yüksek risk içermektedir. Buna göre, Ar-Ge projelerinin sonuçlarından gelir elde etme beklentisi çoğunlukla göz ardı edilmektedir. Bunun yerine, projelerin başarısında yeni bilgi veya becerilerin üretilmesi gibi nispeten soyut ve uzun vadede başarıya ulaşabilecek göstergeler kullanılmaktadır. Ayrıca Ar-Ge projelerinin başarısını takip etmek zor olduğundan, başarısız olarak gösterilen bir projeyi başarısızlığa iten deneme-yanılma çalışmalarından elde edilen kazanımlar, başka bir Ar-Ge projesine deneyim olarak katkı sağlamasından ötürü yapılan başarılı projelere katkısını ölçmek zordur. Sonuç olarak Ar-Ge projelerini geleneksel yöntemlerle ölçmek doğru sonuçlar vermeyecektir. Öte yandan, sosyal devletin bir gereği olarak hükümetler, vergi ödeyenlere yapılan harcamaların hesabını verebilmelidir. Ar-Ge projeleri için bu kolay olmayacağından blok zincir gibi defter tabanlı teknolojiler hesap verebilirliği daha da kolaylaştırabilir. Ayrıca blok zincirin çok merkezli yapısı Ar-Ge proje sistemine entegre edilirse şeffaflık çok kolay sağlanacaktır. Bu bilgiler ışığında politika önerisi şu şekildedir.

Politika Önerisi 1 Mükelleflerin kaynaklarıyla yapılan Ar-Ge teşvikleri, teknoloji unsurlarından yararlanılarak daha şeffaf ve hesap verebilir hale getirilmelidir.

Son yıllarda biraz durağanlaşsa da Türkiye'de Ar-Ge teşviklerine ayrılan pay yıllara sair artmaktadır. GSYİH içindeki Ar-Ge harcamalarındaki artış da bu oluşumun bir göstergesi olarak algılanmalıdır. Öte yandan sınırlı imkanlar dahilinde yapılan bu harcamaların mükelleflere hesap verebilir ve şeffaf bir şekilde anlatılabilmesi önemlidir.

Türkiye'de teşviklerin etkin bir şekilde takip edilebilmesi için etki değerlendirmesi kanunu çıkarılmış olmasına rağmen bu kanun yukarıda sayılan özellikleri nedeniyle Ar-Ge teşvikleri için yetersiz kalmaktadır. Bu politika önerisinin gerçekleşmesi için tek başına etki değerlendirmesi yasası yeterli değildir. Bunun için iki politika aracı önerilir. Buna göre, verilerin toplanması, diğer projelerle eşleştirilmesi ve daha sonra projelerin izlenmesi ve izlenmesinden sorumlu merkezi bir istatistik biriminin kurulması tavsiye edilmektedir. Şu anda Sanayi ve Teknoloji Bakanlığı, KOSGEB, TÜBİTAK gibi kurumlar Ar-Ge teşviki vermektedir. Bunlara ek olarak 3 farklı bakanlıkta AB fonlarının (IPA) dağıtımından sorumlu birimleri de Ar-Ge teşvikleri vermektedir. Ayrıca Tarım ve Orman Bakanlığı gibi kurumlara arzu etmeleri halinde Ar-Ge teşviki verme yetkisi de ilgili kanunla verilmektedir (5746 sayılı Ar-Ge ve Tasarım Faaliyetlerinin Desteklenmesi Hakkında Kanun). Kaynakların çok sınırlı olduğu düşünülürse, böylesine kaotik bir ortamda verilen teşviklerin şeffaflığı ve hesap verilebilirliği çok önemlidir. Bunun için güvenli, çok merkezli ve değişmez yapısıyla öne çıkan blok zincir teknolojisinin kullanılması ikinci bir politika aracı olarak önerilmektedir.

4.2. Başvuru Öncesi Etki Değerlendirmesi

Finansman kuruluşları, firmaların Ar-Ge projelerinin finansmanında önemli bir rol oynamaktadır. Ancak firmaların yararına olmayan durumlar da olabilir. Fon verenler ve fon talep edenler arasındaki “bilgi asimetrisi”, Ar-Ge projelerinin desteklenmesinin önündeki engellerden biridir. Buna göre, başvuru sahibi projeye körü körüne bağlanarak değerinin üzerinde bir bedel talep edebilirken, projenin içeriğini iyi bilmeyen fon veren, proje değerinin altında bir fiyat belirleyebilir. Bu sorunun önüne geçmek için her iki tarafın da bilgisine hitap edebilecek fizibilite raporları ile ortak bir kazanımla buluşmak tarafları ikna edebilir (Uğur ve Trushin, 2022). Benzer şekilde, projelerin kamu Ar-Ge fonlarından destek talep edenler ile kamu kurumları arasında daha etkin bir ilişki kurulması ve proje başlangıcında olası bir yanlışlığın önüne geçilmesi amacıyla ön ödeme değerlendir uygulanması da bir başka politika önerisi olarak sunulmaktadır. Buna göre böyle bir değerlendirmenin yapılması para ve zaman kaybının önüne geçecektir. Ayrıca sürecin en başında yapılacak bir analiz, ileride kartopu gibi büyüyecek sorunların daha en baştan önüne geçebilecektir. Buna göre ikinci politika önerisi şu şekildedir:

Politika Önerisi 2 Ön değerlendirme, Ar-Ge projelerinin performansını ve sonuçlarını doğrudan etkilediğinden, teşvik uygulaması uygulanan projelerde ön değerlendirmenin zorunlu hale getirilmesi sonuçlar açısından faydalı olacaktır.

Böyle bir analiz bağımsız kuruluşlar tarafından yapılırsa, kaçınılmaz olarak bir maliyeti olacaktır. Bu maliyetin teşvik kuruluşları ve istekliler tarafından paylaşılması politika aracı olarak politika teklifimizde yer alacaktır. Ar-Ge projelerinde uzmanlaşmış bu tür bağımsız kuruluşların varlığı ülkedeki proje kültürüne katkı sağlayacak ve bu anlamda bir yetkinlik ülkenin Horizon 2020 gibi AB fonlarına yapılan başvurulara katılımını da artıracaktır.

4.3. Özelleşmiş Değerlendirme Kriterleri

Üçüncü politika önerisi, Ar-Ge projelerinin değerlendirme kriterlerinin standartlaştırılmasıyla ilişkindir. Yapılan incelemelerde (komisyonların proje alanlarına göre seçilmesine rağmen) ne proje başvuru formlarında ne de gözlemci değerlendirme raporlarında sektörel ve/veya teknolojik bir ayırım olmadığı görülmüştür. Böyle bir makro yaklaşım sektörel dinamikleri göz ardı edebilmektedir. Örnek vermek gerekirse, yaptığımız MRMR analizlerimizde doktora derecesine sahip Ar-Ge personeli sayısının karar vericiler tarafından önemli görüldüğü tespit edilmiştir. Ancak Türkiye'deki mezun sayısında sektörel bir farklılıklar bulunmaktadır. YÖK verilerine göre 2020-2021 yılsonu itibarıyla tüm bölümlerde doktora mezunu sayısı 8857'dir. YÖK istatistikleri yakından incelendiğinde özellikle mühendislik dalları arasında büyük farklılıklar görülmektedir. Örnek vermek gerekirse 2021 yılı sonu itibarıyla Bilgisayar Mühendisliği Bölümü görece yeni bir mühendislik dalı olmasına rağmen toplamda 164 kişi mezun olurken, Metalurji ve Malzeme Mühendisliği bölümünden 39 kişi mezun olmuştur (YÖK, 2021). Doğal olarak bu durum işgücü piyasasına da yansımaktadır. Bazı branşlarda doktoralı eleman temininde sorun yokken bazılarında var. Bu durum proje uygulaması personel arzının az olduğu bölgelerden olan firmalarda istihdam yapısına da yansımaktadır. Bu irade dışı durum, değerlendirme kriterlerinde bir taraf adına haksız rekabete yol açmaktadır. Benzer şekilde Avrupa Birliği Fikri Mülkiyet Ofisi (EUIPO) verilerinden görülebileceği gibi (European Patent Office , 2016), bazı NACE

kodlarında patent sayısı yüksekken, patent sayısı bazı işlerin gereği olarak daha düşük (Örneğin Savunma Sanayii). Yapılan MRMR analizlerinde patentin önemli bir kriter olduğu dikkat çekmektedir. Makro politikalar sonucunda her sektör için patent talebinde bulunulması, görüldüğü gibi haksız rekabete yol açmaktadır.

Tartışmalardan da anlaşılacağı üzere bu politika önerisini gerçekleştirmek için sektörel ihtisaslaşmış Ar-Ge proje değerlendirme ve izleme setlerinin oluşturulmasıdır. Bu sayede daha adil bir değerlendirme süreci mümkün olacak ve daha fazla yatırım çeken sektörler ile çekmeyen sektörler arasında denge sağlanacaktır.

Politika Önerisi 3 Başarı sonuçlarının tahmin edilmesinin güç olduğu Ar-Ge projelerinde, firmalar teşvik sağlayan kurumlara başvurduklarında standart başvuru ve değerlendirme formları ile değerlendirilmektedir. Ancak Ar-Ge projelerinin değerlendirilmesinde sektörel veya teknolojik dinamikleri dikkate alan ve bu dinamikleri dikkate alan kriterler ile değerlendirilmesi gerekmektedir.

Sektörel veya teknolojik dinamikleri dikkate alan bir politika önerisi yapabilmek için öncelikle tüm destek kuruluşlarından geçmiş Ar-Ge proje başvurularına ait verilerin toplanması gerekmektedir. İkinci adım olarak Ar-Ge projelerinin dağılımına bakılarak sektörel mi yoksa teknolojik dinamiklerin mi dikkate alınacağı değerlendirilmelidir. Değerlendirme sonuçlarına bağlı olarak sektörel veya teknolojik dinamiklerin tespit edilebilmesi için teşvik alabilen veya başvurup teşvik almayan firmaların başvuru ve izleyici raporlarında nelerin dikkate alındığı konusunda bir ayırım yapılmalıdır. Kriter değerlendirmesi sonunda yeni kriter seti üzerinde çalışılmalıdır. Yeni kriterler seti, başvuru süreçlerinde başarılı olan ve olmayan adaylar için yeniden kullanılmalıdır. Yeni kriterler sektörel veya teknolojik dinamikleri karşılıyorsa devreye alınmalıdır.

4.4. Ulusal Ar-Ge Veri Ağı

Ar-Ge projelerinin değerlendirilmesinde kamu kurumlarından yararlanılmaktadır. Bu imkanlar sadece maddi imkanlarla sınırlı kalmamakta, ayrıca emek de

harcanmaktadır. Teşvik başvurusunda bulunan Ar-Ge projesini soru olarak ele aldığımızda, kamu kaynakları kullanılarak oluşturulan gözlemci ve komisyon raporları sorunun cevabı konusunda bizlere eşsiz bilgiler sunmaktadır. Bu süreçten elde edilen bilginin önemi daha da anlaşılmaktadır. Öte yandan, daha önce de belirtildiği gibi, Türkiye'de birçok kamu kurumu Ar-Ge teşviki dağıtmaktadır. Kurumlar arasında etkin bir iletişim ağı olmadığı için benzer projeler hatta aynı projeler farklı kurumlar tarafından değerlendirilmekte ve bazen desteklenmektedir. Bu nedenle Ar-Ge projelerinin değerlendirme süreçlerinde üretilen bilgilerin kayıt altına alınması ve benzer projelerin tekrar tekrar desteklenmesinin önlenmesi için Ulusal Proje Ağı'nın oluşturulması politika önerisi olarak sunulmaktadır. Blok zincir gibi güvenli ve oldukça merkezi bir teknoloji, bu ağı oluşturmak için uygun bir araçtır.

Ağ teklifi için politika önerisi aşağıdaki gibidir:

Politika Önerisi 4 Kamu kaynakları ile desteklenen Ar-Ge projelerinde üretilen değerli bilgilerin sistematik olarak saklanması, dağıtılması ve yeniden kullanılması için gerekli ulusal ağ ve yasal altyapının oluşturulması gerekmektedir.

Ulusal Proje Ağı'nın sağladığı olanaklar da politikanın gerçekleştirilmesinde bir araç görevi görecektir. Politika önerme araçları dört başlık altında toplanmıştır. Bunlar kısaca talep, bilgi, ağlar ve birlikte değerlendirmedir.

Talep: Bu projelerle ilgilenebilecek diğer firmalara Ulusal Ağda yer alan projelerin künye bilgilerinden ulaşılabilir. Bu sayede iki şirket arasında ağ yapısı üzerinde bir iş birliği fırsatı başlatılabilir.

Bilgi: Proje değerlendirme ve sonuçlandırma aşamasından sonra üretilen bilgiler, fikri mülkiyet hakkı dikkate alınarak bu blok zincir tabanlı ağda saklanacağından, gerekirse zincir içinde oylama yapılarak üçüncü şahıslara aktarılabilir. Ar-Ge projelerinde üretilen bilgilerin fikri mülkiyet hakları her zaman sorunlu bir konu olmuştur. Bu araçtaki tüm bilgiler zaten blok zincirinde kayıtlı olduğundan ve birçok bilgisayarda kayıtlı olduğundan ve bu kayıtları kimin kaydettiği defterlerde açıkça görüldüğünden, herhangi bir çakışma durumunda bu kayıtlar kullanılabilir.

Ağ: Bu ulusal ağın mevcut proje sahipleri olacaktır. Talep kısmında bahsedilen diğer talepkar firmalar da bu ağa dahil edildiğinde tam bir iş ağı ortaya çıkacaktır.

Değerlendirme: Blok zincir tabanlı bu ağda, blok zincirin getirdiği güven ortamı sayesinde fikri mülkiyet hakkı olmayacaktır. Bu durumda zincir katılım şartnamesini kabul eden firmalar dahil edilebilir ve projelerden elde edilen kazanımlarla yeni projeler yapılabilir.

Sorumluktan kaçınma tez kapsamında yapılan analizlerde komisyonlarda görevlendirilen akademisyenlerin karar verme yetkisini bir süreliğine hiyerarşik lidere devretme durumudur.

4.5. Sorumluluktan Kaçınma

Tezin ana önermesi, insanların karar vermenin ağırlığı altında ezilmeleri ve bu sorumluluğu başkalarına devretmeleridir. Yüz yüze görüşmelerde karşılaşılan bu durumda kişiler, psikolojik etkenler sonucunda kendilerine verilen "karar verme hakkını" grup içinde psikolojik üstünlüğü (hiyerarşik güç mesafesi) elinde bulunduranlara devretme eğilimindedirler. Analiz çalışmalarında, gruptaki karar vericilerin bu hakları çoğunlukla (daha bilgili olduklarından emin olmasalar da) gruptaki görece daha bilgili kişilere devrettikleri gözlemlenmiştir. Bu hakkı sırasıyla arkadaşlarına, ardından çoğunluğa verdiği belirlenmiştir. Yapılan analizler de bu transfer sürecinin hafife alınamayacağını kanıtlamıştır. Buna göre, bir sonraki politika önerisi:

Politika Önerisi 5: Teşvik kararlarının alındığı yüz yüze komisyonlarda, komisyon üyeleri arasındaki hiyerarşik güç dağılımı nedeniyle azınlığın kararının çoğunluğun kararı olduğu yanılması vardır. Bunu önlemek için gerekli teknolojik ve psikolojik ortamın sağlanması gerekmektedir.

Kamu kurumları karar verme yetkisini zaman zaman devredebilir. Bunu yaparken hesap verebilirlik, uzmanlara danışma ve şeffaflık ilkeleri gözetilir. Ar-Ge komisyonları da benzer saiklerle hareket etmektedir. Buna göre hesap verebilirlik

ilkesi kapsamında komisyonlara karar yetkisi vermekte, her konuda uzman kişilerden oluşturduğu komisyonlar sayesinde konuya hâkim olmakta ve bu komisyonları kapsam dahilinde yüz yüze görüşmeler yaparak gerçekleştirmektedir. Ancak tüm bu amaçlara rağmen komisyon üyelerinin kendilerine verilen yetkiyi çok zorlanmadan başkalarına devrettikleri bu tez kapsamında kanıtlanmıştır.

Bunun önüne geçmek için politika aracı olarak ilk önerimiz komisyonların yüz yüze yerine blok zincir gibi daha özgür ifade ortamlarında yapılmasıdır. Bu sayede insandan insana iletişim olmadığı için hiyerarşik güç mesafesi etkisi olmayacaktır. Bu sayede amaçlanan “kolektif zekaya” daha etkin bir şekilde ulaşılabilir. İkinci araç olarak ise psikoloji literatürünün önerdiği gibi toplu kararlar alınmadan en az 8, en fazla 12 kişilik komisyonlarda en yüksek verim alınmaktadır. Ancak geleneksel olarak komisyonlar en fazla 5 kişiden oluşur. Bunun birkaç nedeni var. Her şeyden önce, fazladan her kişi bir maliyet yaratır, ikincisi, aynı anda bu kadar çok insanın aynı yerde olmasının zorluğu ve son olarak komisyonların uzaması riski. Ancak blok zincir tabanlı karar vermede bu maliyetler azalacak, zamandan ve mekandan bağımsız karar alma imkanı olacak ve kişiler diledikleri zaman tartışmalara katılma imkanına sahip olacaklardır.

Ar-Ge projelerinin doğası gereği daha özgün bilgiler içermesi ve politika yapıcılarının riskli olduğunun farkında olması nedeniyle burada yapılan harcamalara vergi mükelleflerinin veya denetçilerin toleransı yüksek olabilmektedir. Öte yandan, kamu ihaleleri gibi nispeten daha fazla şeffaflığın istendiği komisyonlarda şeffaflık ve hesap verebilirlik çok daha önemlidir. Bu nedenle son zamanlarda adaleti sağlamak ve sürdürmek için ihaleler canlı yayında yapılmaktadır. İhalenin televizyonda canlı yayınlanması, hiyerarşik güç mesafesi etkisinin karar üzerinde etkili olmadığı anlamına gelmez. Hatta bu yöntemle televizyonu açan herkese sadece yayındaki bilgilere ulaşma hakkı verilmektedir. Bu durum, dağıtılmış defter teknolojisine sahip blok zincirinde zaten mevcuttur. Konu dışı etkilerden tamamen kaçınmak için şeffaflık, çok merkezlilik, güven ve kararlar ilgili tartışmanın net bir şekilde kaydedilmesi gerekir. Böylesine hassas bir alanda blok zincir sistemi kullanılarak bahsedilen tüm şartlar tek bir kaynaktan sağlanabilmektedir. Bu politika aracı, bu bölümdeki en önemli ve en öncelikli tavsiyedir.

4.6. Ar-Ge Teşviği Sonrası Davranışsal Etkileri Ölçülmesi

Ar-Ge teşviklerinin şirketin Ar-Ge inovasyon kültüründeki kalıcı değişiklik olan “davranışsal katkı” olarak tanımlandığı ilgili bölümde belirtilmektedir. Teşvikler kesintiye uğrasa bile firmanın Ar-Ge ve inovasyon projelerine devam etme isteği ülke çıkarları açısından önemlidir. Ayrıca şirketin öz kaynakları ile yapmayı planladığı Ar-Ge yatırımlarının teşviklerle ve kamu kaynaklarıyla desteklenmesi, sınırlı kaynakların verimli kullanılması açısından “dışlama” etkisi yaratması açısından önemlidir.

Blok zincir teknolojisinin değişmez defter yapısı sayesinde etki analizi çalışmalarının daha kolay ve bilgiye dayalı yapılabileceğinden önceki bölümlerde bahsedilmiştir. Blok zincirin bu özelliği, Ar-Ge teşviklerinin davranışsal etkilerinin ölçülmesi açısından da faydalı bir teknoloji olarak karşımıza çıkmaktadır. Blok zincirinin çok merkezli defterleri sayesinde teşvik alan şirketin Ar-Ge kültüründeki değişimler farklı açılardan gözlemlenebilmektedir. Ayrıca defterdeki bilgilerin zincirdeki üyeler tarafından oylanarak silinebilmesi veya yazılabilmesi sayesinde daha etkin politikalar ve etki analizleri yapılabilmektedir. Bu bilgilere dayanarak, nihai politika önerisi aşağıdaki gibidir.

Politika Önerisi 6: Destekten yararlanan firmada teşvikten sonraki “davranışsal katkı”, kamu kaynakları kullanılarak yürütülen Ar-Ge projelerinin sonuçları kadar önemlidir. Firmanın yenilikçi davranışındaki değişimin ölçülmesi de tavsiye edilir.

Sanayi ve Teknoloji Bakanlığı, Etki Analizi Kanunu ile kurum ve programları için zorunlu hale getirilen etki analizi çalışmalarını yürütmektedir. Hatta yapılan çalışmalar için Bakanlık bünyesinde bir birim kurulmuştur. Ancak ne yazık ki bu birimin çalışmaları hakkında kamuoyuna açıklanmış bir rapor bulunmamaktadır. Bu çalışmalara katkıda bulunmak açısından, Bölüm 2'de belirtildiği gibi “davranışsal katkı” etkisinin ölçülmesi bir politika aracı olarak önerilmektedir. Buna göre şirketin yeni proje yapma hızı, projelerin kapsamının genişletilmesi, iş birlikleri sayısındaki artış ve Ar-Ge proje bütçeleri davranışsal etkinin ölçülmesinde kullanılan yeni nesil göstergelerdir. Bu göstergelerin yer aldığı bir etki analizi çalışması sonucunda teşvik

sonrası şirkette Ar-Ge kültürünün kalıcılığı ölçülecektir. Böylece hem kamu kaynaklarının haksız kullanımının önüne geçilecek hem de ülke içinde yerleşik bir Ar-Ge kültürü oluşacaktır. Bu değişimlerin uzun vadeli etkisi ile katma değerli ürün ve hizmet üretme imkânı artacaktır.

5. ENGELLER VE ARAŞTIRMA ÖNERİLERİ

Bu tez, esas olarak veri yapısındaki değişiklikten kaynaklanan bir takım sınırlamalara sahiptir. Bu engellerden ilgili bölümlerde bahsedilmiştir, ancak bunların bir özeti aşağıda sunulmuştur.

Farklı Platformlarda Tutulan Veriler Nedeniyle Kısıtlama: Sanayi ve Teknoloji Bakanlığı tarafından sağlanan verilerde, bazı yıllara ait verilerin excel dosyalarında bulunmadığı, bazılarının ise online platformda tutulduğu beyan edilmiştir. Bu nedenle yıllara ait sınırlı paylaşılabılır verilerle çalışılmıştır.

Başvuru Sahibi Firmalardan ve İzleyici/Komisyon Üyesi Akademisyenlerden Talep Edilen Verilerden Kaynaklanan Kısıtlamalar: Başvuru esnasında firma ve akademisyenlerden talep edilen verilerde birçok değişiklik olmuştur. Bu değişimler analizlerde de belirleyici ve kısıtlayıcı olmuştur.

Anket Yönteminden Kaynaklanan Sınırlılıklar: Tez çalışması süresince Ar-Ge Merkezi seçim süreçlerine çoğunlukla katılan akademisyenler arasında 2 farklı anket yapılmıştır. Bu çalışmalarda ankete katılımları istenilen düzeyde olmamıştır. Özellikle akademisyenlerin ABM simülasyonunun karar verme noktalarının belirlenmesinde yüksek katılıma ihtiyaç duyulmuş ancak istenilen düzeyde olmamıştır. Ancak, anket sorularına yanıt verenlerin yanıtları ve verilerin kalitesi beklentilerin üzerindeydi.

5.1. Yeni Araştırma Önerileri

Ar-Ge teşvikleri konusunda birçok çalışma yapılmış olmasına rağmen, teşvik kararlarının alınmasında insan faktörünün kullanıldığı çok fazla çalışma yoktur.

Teşvikin içeriğine ve eksikliklerine odaklanan çalışmalar dışında, değerlendirmenin merkezindeki kişiye daha fazla odaklanması önerilir. Bu çalışmanın açtığı yolu takip edecek diğer araştırmacıların daha fazla veri ile daha kapsamlı çalışmalar yapmaları umulmaktadır.

Ayrıca teknolojik ilerlemenin ekonomik etkisine odaklanan birçok çalışma bulunurken, teknolojik ilerlemenin bir sonucu olarak insanların iş yapma şekillerinde meydana gelebilecek olası değişikliklere odaklanan çalışmaların sayısının artırılmasının da aynı derecede önemli olduğu düşünülmektedir. Teknolojik ilerlemenin insan üzerindeki etkisinin insanın merkezde olduğu ortamlarda ele alındığı bu çalışmanın bu ekseninde çeşitlendirilmesinin faydalı olacağı düşünülmektedir.

Son olarak bu çalışmada akademisyenlerin karara giden süreçte kararlarını etkileyen bilişsel faktörlere ilişkin veriler anket yöntemiyle elde edilmiştir. Öte yandan, daha kaliteli ve yansız veri elde etmek simülasyon sonuçlarını doğrudan etkiler. Bu nedenle bundan sonraki çalışmalarda veri toplama aracı olarak anket yerine yüz yüze yarı yapılandırılmış görüşmelerin kullanılması önerilmektedir.

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TEZİN ADI / TITLE OF THE THESIS (İngilizce / English): Emerging Opportunities for the Application of Blockchain: Turkish Case of R&D Funding System and Value Chain Approach

TEZİN TÜRÜ / DEGREE: **Yüksek Lisans / Master** ☐ **Doktora / PhD** ☒

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