AN EFFECTIVE AND EFFICIENT R&D FUNDING MECHANISM: AN EVALUATION STUDY ON PRIORITIZED R&D GRANT PROGRAM (1003) OF TUBITAK

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ABSTRACT

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This thesis aims to detect differences in the features of the proposed and supported projects for different priority technology areas (PTAs) of the TUBITAK 1003 Prioritized Areas R&D Grant Program together with the measurement and comparison of output, input and behavioral additionality of the supported projects.

Within the scope of this thesis, firstly, descriptive statistics of program indicators including calls, projects, funds and outputs is analyzed. Then, relationship between output amount and the characteristics of the supported projects and their calls is estimated for different PTAs by the Ordinary Least Square (OLS) method. Moreover, interviews involving questions to measure output, behavioral and input additionalities are also conducted with a sample of supported project coordinators. For these analyses, data retrieved from the TUBITAK database is used.

It is detected from these exercises that amount of proposed and supported projects and average requested and given fund per project differ with PTAs while distribution of project amounts, funds and outputs according to project

characteristics is unbalanced. Additionally, effects of these characteristics on output amount are different for each PTAs. Moreover, supported projects and their outputs are inadequate to meet the specific targets of the 1003 Program despite their significant project and input additionalities.

In conclusion, it is observed that the 1003 Program could not meet the expectations and targets of the authority fully. To eliminate the detected deficiencies with the aim of increasing the effectiveness and efficiency of the 1003 R&D Grant program, some policies are recommended as the output of the thesis.

Keywords: impact analysis, additionality, resource allocation, prioritization

öz

ETKİLİ VE ETKİN BİR AR-GE DESTEK MEKANİZMASI:
TÜBİTAK'IN ÖNCELİKLİ AR-GE DESTEK PROGRAMI (1003) İÇİN BİR DEĞERLENDİRME ÇALIŞMASI

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Bu tez, desteklenen projelerin çıktı, girdi ve davranışsal artımsallıklarının ölçülmesi ve karşılaştırılması ile birlikte TÜBİTAK 1003 Öncelikli Alanlar Ar-Ge Hibe Programının farklı öncelikli teknoloji alanları (ÖTA'lar) için önerilen ve desteklenen projelerin özelliklerinin farklılıklarını tespit etmeyi amaçlamaktadır.

Bu tez kapsamında öncelikle çağrı, proje, fon ve çıktıları içeren program göstergelerinin tanımlayıcı istatistikleri incelendi. Ardından, çıktı miktarı ile desteklenen projelerin ve çağrılarının özellikleri arasındaki ilişkisi, Olağan En Küçük Kare (OLS) yöntemiyle farklı ÖTA'lar için tahmin edildi. Ayrıca, desteklenen proje koordinatörlerinin bir örneklemi ile çıktı, davranış ve girdi artımsallığını ölçmek için sorular içeren görüşmeler de gerçekleştirildi. Bu analizler için, TÜBİTAK veri tabanından alınan veriler kullanıldı.

Bu çalışmalardan; proje miktarı fon ve çıktıların proje özelliklerine göre dağılımı dengesizken, önerilen ve desteklenen projeler ve proje başına talep edilen ve verilen ortalama fon miktarının ÖTA'larla farklılık gösterdiği tespit edildi. Ek olarak, bu özelliklerin çıktı miktarına olan etkileri her bir ÖTA için farklıdır. Ayrıca, desteklenen projeler ve bunların çıktıları, belirgin proje ve girdi

artımsallıklarına rağmen, 1003 Programının belirli hedeflerini karşılamada yetersiz kalmaktadır.

Sonuç olarak, 1003 Programının, otoritenin beklentilerini ve hedeflerini tamamıyla karşılayamadığı gözlendi. 1003 Ar-Ge Destek Programının etkililiğinin ve etkinliğinin artırılması amacıyla tespit edilen eksikliklerin giderilmesi için bu tezin çıktısı olarak bazı politikalar önerildi.

Anahtar Kelimeler: etki analizi, artımsallık, kaynak dağılımı, önceliklendirme

To My Family

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LIST OF ABBREVIATIONS

ARDEB: The Directorate of the Research Grant Programs

CPCB: Call Program Consulting Board

EU: European Union

ICT: Information and Communication Technologies

NSI: National Systems of Innovation

NSTIS: National Science Technology and Innovation Systems

OECD: The Organization for Economic Co-operation and Development

OLS: Ordinary Least Square

PTA: Priority Technology Areas

R&D: Research and Development

S&T: Science and Technology

SB: Science Board

SCST: The Supreme Council of Science and Technology

SSH: Social Sciences and Innovation

STI: Science Technology and Innovation

TRL: Technology Readiness Level

TUBITAK: The Scientific and Technological Research Council of Turkey

CHAPTER 1

INTRODUCTION

Scientific and technological developments, knowledge obtained by these studies and spillover of this knowledge have become the crucial part of economic theories since the beginning of Industrial Revolutions with the invention of steam engines. Economic growth and development depend on technological growth in addition to growth of population and capital according to different economic thoughts and growth models. It is also assumed that process of scientific and technological development protects capitalist economies from stability trap by providing dynamism to them. *(Erdil et al., 2016)*

Ülkü (2004) indicates that 1% increase in innovation enhances GDP per capita of OECD and non-OECD countries by 0.05% according to the results of the study conducted with the sample of these countries for 1981-97 periods. Moreover, *Gülmez & Yardımcıoğlu (2012)* analyze the relation of R&D expenditure and GDP growth in OECD countries for the period of 1990-2010. It is found that 1% increase in R&D spending raises GDP of France by 1.167%, which is the highest value. This value is 0.44%, the lowest rate among the OECD countries, for Portugal, while it is found as 0.636% for Turkey.

Scientific and technological knowledge contribute to the development of technology and so does economic growth and social welfare. According to List's model, this system is formed by universities with research institutions, public institutions and private sector. The first one of these components contributes to the system with its researchers producing knowledge. Government, however, work as policymaker and fiscal source planner/provider with public institutions while the last one is transformer of knowledge to commercial product constitute this system. *(Erdil et al., 2016)*

Long-term development aim of Turkey is to raise the international status of the country and to enhance the welfare of citizens with the help of structural reforms, which are consistent with the core values and their expectations. In

this context, by 2023, it is targeted to raise GDP per capita to $25000, to increase export to $500billion, to reduce unemployment rate to 5% and to have sustainable and single-digit inflation rate.

Governments use policy tools related to the R&D and innovation systems to contribute to scientific and technological development and so economic growth. These tools vary according to their economic and social targets of each country. By means of the Ministry of Economy, Ministry of Development and Ministry of Science, Industry and Technology with its affiliated and related organizations (Turkish Patent and Trademark Office, Turkish Academy of Science, the Scientific and Technological Research Council of Turkey-TUBITAK, Turkish Standards Institution, Small and Medium Business Development and Support Administration), Turkey has also been implementing several policies, programs and projects to reach the level of developed countries and compete with them. Even, science, technology and innovation policies having this aim have become crucial part of government's economic policies since "Vision 2023" Project and the publication of the National Science and Technology Policies (NSTP): 2003-2023 Strategy Paper. During the ongoing planned period started with the establishment of State Planning Organization, development plans, science and technology (S&T) policies, and S&T strategy documents have become the fundamental aspects of S&T plans of Turkey. In addition, TUBITAK and the Supreme Council of Science and Technology (SCST), founded during this period, have played an active role in creation, management and monitoring processes of these plans and policy tools. Besides, fiscal sources allocated to research studies of universities have increased. Additionally, direct fiscal supports provided to R&D and innovation projects of private sector and indirect subsidies given as tax abatement and exemptions to them have reached the high levels *(Erdil et al., 2016)*.

1003 Priority Areas R&D Grant Program of TUBITAK is one of the S&T policy tools, scope of which is determined by considering SCST decisions, development plans, results of Technology Foresight Project and STI policies and strategies. It contributes to the development level of the country in the direction of science and technological progress.

1.1. Description of Research Questions, Thesis Statement and Scope

1003 grants are given via launched calls related with ten different Priority Technology Areas (PTAs). These areas are completely different from each other in terms of not only the impacts and outputs of the supported projects, but also their level of development in Turkey. In the view of national R&D strategies, S&T policies and national development plans; periodical strategic plans including number of prospective calls for each PTA are developed and conducted. However, social, economic, technological and scientific effects of the related projects are not monitored in order to revise these plans and reallocate 1003 grants to the PTAs. Moreover, although literature and technological progress of each PTA is different, not only the criteria used to evaluate proposed projects (originality, method, project management-team-research eligibility, widespread effect, suitability to call program aims and targets) but also weight of these criteria and minimum passing score are the same for all of them. By using such a supporting mechanism, lots of moderate projects can be selected out of similar projects to support at the field that Turkey is strong while a unique project at a field which is studied less may not get fund. Lastly, due to the nonexistence of a target development level to reach as a result of the supported projects for PTAs and calls, proposed and supported projects may not be focus on a result and output consistent with the priority target. All of these lead to inefficient use of the limited funding resources, obtaining the less benefit from the Program and loss of effectiveness and effectiveness of the program in terms of its contribution to the level of development and growth.

The main target of this thesis is obtaining an effective 1003 Program, outputs and impacts of which really and always serve to the Vision 2023, development plans, STI policies and strategies of Turkey. It also intends to increase output, input and behavioral additionality of 1003 Program obtained from minimum amount of grant. This means making the program more efficient. It finally aims to adapt PTAs of the 1003 Program together with their funding amount and targets to the developments in economic and social situation of the country and improvements in the literature. As a result, total benefit of 1003 program will be enhanced and obtaining more meaningful impact in long-run will be provided, as the objective of this study.

Within the scope of this thesis, differences in PTAs in terms of proposing a project and getting support are measured in addition to output, input and

behavioral additionality by using both quantitative and qualitative methods. Firstly, data of both proposed and supported 1003 projects of ten PTAs obtained from TUBITAK database is analyzed with descriptive statistics to detect current situation of the program. An econometric analysis is also conducted to detect the relation of output amount with some characteristics of projects and calls like budget, team size, peer-review grade, supporting criteria and restriction on scaling for different PTAs. Additionally, qualitative results of the projects are evaluated via interviews conducted with coordinators of supported projects. Quantitative analyses measure the output additionality of the 1003 Program while qualitative one mainly measures the behavioral and output additionality additional to the input one. Both econometric analysis and interviews are done for only three of PTAs; Information and Communication Technologies (ICT), Energy and Health. The main reason of this simplification is that these three fields represent different prioritization characteristics. Moreover, these areas dominate 1003 Program since not only majority of launched calls but also those of proposed, accepted and finalized projects belong to these fields and amount of projects belonging to other PTAs are still so few. Finally, the results are analyzed and compared to suggest more evidence-based policy which will be provided more efficient, effective and dynamic 1003 grant portfolio.

In order to reach the objective of increasing the total benefit of 1003 R&D grants, the following research question will be responded:

"How can qualitative and quantitative impacts of 1003 Grant Program of TUBITAK be improved and do these impacts differ with PTAs?"

The thesis statement which will be proved in this study is:

"Supported 1003 R&D projects could emerge more benefit and contribute to the development and growth of the country more with a new S&T policy which revises (sub) PTAs and reallocates the funds among them."

There are also sub-hypotheses which will support the main thesis statement:

- Results of the analyses of 1003 R&D Grant Program data and comparison of them with respect to could help to develop new policies and strategies which will contribute to improvement of 1003 Grant Program.

- Reallocation of funds by using different application and supporting criteria for different PTAs and researchers having different features will result in more effective and efficient 1003 Program.

1.2. Widespread Effect and Originality

In order to attain the aim of reaching the level of developed countries and compete with them, government needs not only to develop new policies but also to improve the existing ones. This thesis study will serve the latter one by making one of the policy tools implemented by TUBITAK more efficient and effective.

The suggestions, which will be claimed as a result of the study, will indirectly serve economic and social improvement as this is the aim of the 1003 Grant Program. Moreover, since TUBITAK will begin to support the more qualified 1003 projects, quality of proposed projects would also rise under these challenging conditions. Considering the mission of 1003 Grant program, it can also be stated that the project with higher quality could decrease foreign source dependency and so minimize economic vulnerability and budget deficit of Turkey. In addition, evaluation results of 1003 Grant Program obtained from this thesis, may lead to application of similar studies for other R&D grant programs managed by TUBITAK and other governmental agencies. This means that results of this thesis will have important effects on not only for 1003 Program of TUBITAK, but also for other R&D funding mechanisms conducted in Turkey.

As stated in the "Literature Review", there exist many studies in the literature on the efficient allocation of R&D budgets to projects However, most of these studies are at the project selection level and the efficiency of the project is measured individually to support those with low risk and budget, as well as the high potential to produce value-added output. There are few studies considering R&D support program's overall efficiency. Similarly, for the case of Turkey, number of studies on the efficiency and effectiveness of R&D projects is limited and most of the existing studies are impact analysis studies consisting of only output analysis of R&D projects in a selected field. There is hardly any study on grant program efficiency. Even, since it is relatively new program, no study on the evaluation of the 1003 Program has been conducted until now. To conclude, this thesis is original in terms of not only allocating R&D incentives efficiently, but also analyses to be made on the 1003 Program.

This study begins with the review of the literature. In addition to the conceptual framework, this part includes the studies for which impact analysis and evaluation, budget allocation and project portfolio selection methods are applied for cases of both Turkey and other countries. Benchmarking including priority-setting methods and prioritization policies of both developed and emerging countries is also given in this part. Then, some background information on not only plans and programs of Turkish government on STI, but also SCST, TUBITAK and 1003 Grant Program is stated in Chapter 3. Following this, the methodology of the thesis is given in Chapter 4. In this chapter, the procedure applied for analyses of descriptive statistics of the data belonging to 1003 R&D Grant Program, econometric analysis and the interviews conducted with coordinators of supported 1003 projects is explained in detail. The content and the features of the data used during these analyses are also stated here. Next, the results of these analyses are discussed analytically and comparatively in Chapter 5. PTAs and sub-PTAs for which 1003 Grant is given are also compared with global benchmarking stated in the "Literature Review". Finally, the thesis is concluded with a policy proposal which could be applied to make 1003 Grant Program and R&D funding mechanism of Turkey more efficient and effective.

CHAPTER 2

LITERATURE REVIEW

Before analyses conducted for the thesis, previous studies in the literature related to the subject and the scope of this study are reviewed with an analytical standpoint. In this chapter, firstly, the framework involving the philosophy of concepts and theories with arguments on them existing in the literature is given. It is followed by the discussion of prioritized R&D funding examples from both developed and emerging countries with their prioritization policies and methods as a benchmarking study. Then, methods used for not only impact assessment and program evaluation, but also allocation of funding resources to the R&D projects are described additional to the discussion of studies in the literature conducted by using these methods.

2.1. Conceptual Framework

Before discussing the studies in the literature related to the subject of this thesis, conceptual framework including research and development (R&D), national systems of innovation (NSI), Technology Readiness Levels (TRLs), impact analysis, resource allocation and prioritization will be given to become familiar with the philosophy of the area in which this thesis is conducted in addition to terminology, concepts and discussions.

According to the Frascati Manual *(OECD, 2015)* Research and Development (R&D) means:

"creative and systematic work undertaken in order to increase the stock of knowledge, including knowledge of humankind, culture and society, and to devise new applications of available knowledge"

According to this definition, R&D activities are classified into three categories. Basic research aims to find out new knowledge of facts and phenomena with experimental and theoretical studies. If obtaining new knowledge is targeted for

a specific practical objective, this will be an applied research. For experimental development, on the other hand, existing knowledge obtained from other R&D activities is used to produce or improve new material, product, device, process, system and service, systematically.

Dejellal et al. (2003) asserts that although these definitions cover social sciences and humanities, services and systems; due to their abstract and multidisciplinary nature, it is still so difficult to decide whether an activity in these fields is an R&D activity and which type of R&D activity it is. In order to solve this ambiguity, how to identify R&D activities in these sectors is clarified with some specific examples. However, *Dejellal et al. (2003)* claims that this identification should be included in the definition of R&D by revising development part of it as design and development (D&D) without changing main body of OECD's definition. Then, RD&D is defined as:

"creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society (particularly knowledge of behavior of economic agents and that of productive organizations), and the use of this stock of this knowledge to devise new applications (whether they involve goods, services, processes, methods and organizations)."

Although better recognition to R&D seems to be achieved with this revision, the added clarifications are still not adequate to provide a way for the identification of R&D activities in service, systems, and social sciences and humanities, in general. This revised definition could be helpful no more than the OECD's method of identification activities in these sectors specifically. The best solution of this problem could be obtained by creating a new definition with radical changes.

In addition to arguments on the R&D definition of OECD, there are also discussions on the classification of R&D activities. Another three-level classification example of R&D belongs to Hauser (1998), which is stated as research, development and engineering. In addition, Werner and Souder (1997) classify it into 4 categories as basic research, applied research, product development and manufacturing process while classification of Pappas and Remer (1985) include 5 levels, which are basic research, exploratory research, applied research, development and product improvement. Kim and Oh (2002) also suggest a different classification covering not only common features but

also characteristics of other classifications: basic R&D (experimental research and observation of facts), applied R&D (core technology development using basic R&D to form basis for commercial one) and commercial R&D (commercial product development). They also claim that their classification is quite similar to that of OECD in terms of the meaning and scope of R&D activity types. Thus, they support the R&D classification of OECD as the most inclusive one, which is also accepted by most of researchers all around the world. *(Kim and Oh, 2002)*

Knowledge created by basic research and technologies generated from research activities is used to conduct applied research and experimental development. It is stated in the literature that the maturity of available and generated technology determines the level of research activities which is conducted *(Nelson and Rosemberg, 1993; Moultrie, 2015)*. To assess this maturity, Technology Readiness Levels (TRLs) are used as a systematic measurement system. However, *Smith (2004)* states that a product or technology defined as mature may not be as ready as the one with lower maturity, to use in a system; i.e., readiness and maturity are not the same thing.

TRL was firstly developed by NASA in 1970's with the aim of developing a technology-independent scale based on the idea of expressing the status of a new technology claimed at the end of 1960's. Although the original TRL scale included seven different maturity levels, in 1980's, it was extended to nine levels, which is the current standard. In 1990's, TRL was started to use not only in the other departments of NASA, but also outside the Agency. By 2000's it has spread to Japan, France and other European countries from their space agencies and after 2005, the standard version of the TRL scale has been adopted all around the world *(Mankins, 2009).* Today, TRL is used with the aim of maturity comparison for different technologies and risk assessment additional to maturity measurement *(Sauser et al., 2006).*

TRLs range from level 1, basic research, to level 9, actual systems/operations proven as successful. Formulation and proof-of-concept studies are conducted under level 2 and 3 while Level 4 and 5 represent validation studies. Being at level 6 and 7, on the other hand, means that both prototype and actual system are developed *(Mankins, 2009)*. General Accounting Office of NASA recommends reaching at least level 7 to start development and demonstration of a system. In addition, level 8 is stated as the requirement for the use of a new technology for the invention of a new product *(Smith, 2004).* Additionally,

the USA's Department of Defense (DoD) classifies TRLs as System Phases of Development. According to this classification, TRLs represent concept refinement from level 2 to 4 while from level 5 to 7, they represent systems development and demonstration. The last two level of TRL, however, indicates operation and support of a system *(Sauser et al., 2006)*.

As stated in the literature, TRL framework has different disadvantages and shortcomings in addition to its various advantages despite the revisions and improvements made on TRL since its invention in 1970's. *Sauser et al. (2006)* indicate that comparison of different maturity levels is not possible with the TRL measurement system. Besides, some authors assert TRL's inability not only to represent integration of technologies and operational systems, but also to guide on the uncertainties in maturity process of a technology *(Sauser et al., 2006; Mankins, 2002). Smith (2004)* also promotes this idea with the argument that TRL disregards both importance of the technology for the success of the system and the conformity of it with its intended purpose in the system. As another disadvantage, *Smith (2004)* criticizes TRL that technologies can move only in upward direction in its measurement concept. Therefore, it could not provide observing the depreciation of a technology as it ages, especially for software technologies. Additionally, he asserts that since the definition of TRL include the different characteristics of technology, it is impossible to distinguish the real feature enabling the technology to reach that readiness level.

In order to solve the problems arisen from the shortcomings of TRL, many alternative maturity measurement methods are developed by researchers.

One of the alternative methods is Systems Readiness Levels (SRLs), developed by *Sauser et al. (2006)*. It aims to eliminate TRL's inability to integrate technologies with operational systems. This method is developed by considering the information flow between the subsystems and the causality among subsystems additional to the environment in which systems operate. It is also taken into account that overall system has greater effect than sum of the subsystems' individual effects. In addition, it is designed by incorporating both current TRLs and System Phases of Development developed by DoD. SRL consists of 5 different levels, which are concept refinement, technology development, system development and consideration, production and development operations and support.

Another alternative maturity measurement model is STAM model developed by *Phaal et al. (2011)*. STAM model provides direct comparison of TRLs. In addition, it has broader scope than TRL, spanning from the fundamental scientific researches of a technology to its application and commercialization stages. STAM is abbreviation of its 4 stages, which are science, technology, application and market. In this model, there exist different phases for development process of a new technology, which are precursor science, embryonic technology, future application and growth market. Precursor phase indicates the initial scientific researches for technology-based industrial developments while embryonic phase represents the transformation of proof-of-concepts to prototypes. Application phase, however, is the specialization of a technology for a particular application. Lastly, growth market phase is the commercialization of a technology.

TRL can only be used for the technology for which scientific underpinning and basic principles have already been revealed. In order to measure the level of fundamental scientific researches behind TRLs, Applied Science Readiness Levels (ASRLs) is designed by *Millis (2005).* ASRL framework composes 3 different stages and each stage consists of 5 steps. This corresponds to 15 maturity level for fundamental scientific researches, which is equivalent to TRL 1. ASRL stages are defined as general physics, critical issues and desired effects. For each stage, firstly, pre-science activities are conducted to formulate the problem. Then, a relevant hypothesis is proposed and it is tested. The stage is concluded with the report of results.

Despite its failures, TRL is preferred to its alternatives and it is still the best-known and the most widely used method for maturity measurement. Therefore, improving TRL rather than developing a new measurement method could be chosen as an alternative way to eliminate its failures. The description of TRLs could be revised as they involve the service sector activities and their fundamental characteristics in detail. In addition, TRL concept could enable the comparison of maturity levels and backward movement along TRLs. However, all these improvements are not under the scope of this study.

TRL and alternative maturity level measurement methods could be used as the starting and target points for prioritization strategies of R&D funding mechanisms. It may be useful to identify such levels in order to support the projects only being the most related to the targets of the prioritization strategy.

Research activities started from TRL1 as a basic research aim to obtain innovative products and services or more effective and efficient production processes which can contribute to both economic growth and welfare improvement with their marketing nature. Results and outputs of these activities should also be integrated to be able to conduct studies having maturity at TRL8 and TRL9. To achieve these processes, governments support R&D activities in the light of plans and programs related to the issues of technology, R&D and innovation. These plans and programs are included in economic policies under the National Systems of Innovation. In the literature, Lundvall (1992) is known as the first person to express the "National Systems of Innovation". However, by many researchers, including Lundvall himself, it is also asserted that this idea roots from the "National Systems of Political Economy" theory arisen by Friedrich List on the basis of German's "catching-up" strategy, in 1841. In published form, on the other hand, this term is firstly used by Freeman in 1987, in the spirit of List. *(Freeman, 1995; Edquist, 1997; Lundvall, 2007)*

Despite their similar perspectives, Lundvall (1992) and Freeman (1987) define NSI in different ways. Freeman (1987) defines NSI considering the Japanese system as the coordinated activities of public and private institutions aiming to reveal, remodel and spread new technologies *(Edquist, 1997)*. According to *Freeman (1995),* NSI is based on the assumption that innovation processes of different countries are different. In addition, he states that the innovation procedure of a country images the predominating policies of that government. Lundvall's definition (1992), on the other hand, is broader than this definition since it also involves the marketing and finance system as subsystems in which learning activities of technology and innovation takes place *(Edquist, 1997).*

Some authors approach to innovation systems from national perspectives as Lundvall, Freeman and Nelson while others think that innovation systems should be sectoral, i.e. specific for each technology fields, and/or regional *(Edquist, 1997)*. *Edquist (1997)*, on the other hand, claims that innovation systems may examine with each of the global, partially-global and regional perspectives separately or with the combination of these perspectives. He states that although innovation systems become more open due to international

linkages in science, innovation and diffusion patterns; the required adaptations are still done in the national level since it is embodied by national features.

Lundvall (2007) criticizes the approach of innovation systems that it is not applied as ex-ante concept for system building. Moreover, he states that it is unable to offer recipe for difficult aspects of development.

According *to Edquist (1997),* the innovation system is not an isolated concept. It is developed and operated by different agencies at national level. Not only political, bureaucratic, regulatory, social, educational and knowledge oriented bodies, such as ministries, national councils for S&T, academies, universities, schools and government laboratories; but also non-profit organizations with economic goals and profit-oriented firms contribute to NSI of a country.

To obtain the desired benefit from NSI policies, scarce resources should be used effectively and efficiently. Thus, some studies are conducted to prioritize R&D policies which contribute to NSI strategies the most. Moreover, there are also impact assessment and evaluation studies on R&D projects and funding programs additional to the ones on allocation of given resources to the alternative projects.

2.2. Prioritization of R&D Policies with Examples from Different Countries

Competition in international markets has quite increased, and then the requirement of specialization in particular areas has emerged. Governments try to choose technological areas which are fundamental for their future socio-economic-structure and in which their S&T infrastructure is relatively strong to specialize. In order to decide which areas provide these features, they apply different priority-setting strategies. (Gassler, 2004)

Priority setting is a method used to allocate resources to the most beneficial technology areas. This becomes a significant innovation system approach to the arguments about technology policy, which emphasizes functional aspects determining the limits of the innovation processes (Gassler, 2004).

Prioritization should address the knowledge demand of scientists, industry, government and their all regional, national and global network (Hemert, 2008). This could be done by using instruments considering all political, scientific social policies and requirements at both national and international levels. Technology

foresight, which was firstly adopted by the UK in 1993 with the aim of providing better allocation of finite resources for funding agencies, is one of these instruments. It defines the technology fields by setting national S&T priorities. (Keenan, 2003)

Prioritization mechanisms have changed since 1950. Three approaches, which are engine of progress, solution of a problem and R&D as a strategy, exist complementing each other. According to the first approach, R&D activities, designed by researchers, are conducted for social welfare and a linear relation exists between them. Second approach claims, on the other hand, that R&D activities are designed in line with the needs of the society and independent of the researchers' decisions. The last one, which is still used today, means that R&D and society completely engage in each other. (Akser, 2012)

Gassler (2004) investigates the historical evolution of priority-setting methods. He states that in early years, strategic technologic fields are identified with top-down approach while after 1980, decentralization of priorities to intermediary institutions, research centers and universities became common. In today's world, more functionalist approach is asserted to adopt the thematic priorities, which aims to improve the structural features of NSI policies. The author mentions that resources allocated to funding programs having thematic priority are lower than the ones allocated to non-prioritized ones.

Gassler (2004) also asserts that the prioritization procedure and its results are different for each country due to their national cultures, historical backgrounds, and institutional characteristics. However, governments get inspired and learn from NSI and prioritization concepts of other countries to understand and catch S&T trends.

In order to analyze the quality, convenience and competitiveness of the technology areas prioritized by the Turkish government for R&D studies, such policies applied by both developed and emerging countries and the tools used by them are investigated. As a result of this research, a benchmark is obtained.

2.2.1. Developed Country Examples

Motohashi (2003) discusses the changes in the RDI Policy of Japan in 2000's including the prioritization in technology fields. It is claimed that the S&T Plan of Japan became more target-oriented, its targets became more specific and expressed more specifically and directly after 2001. This occurs with the help of

not only prioritization of some technology areas in order to reallocate R&D budget to more important ones, but also the aim of maximizing research output. As written in the paper, the policy of rating output types to get more benefit from them is also referred in the new plan. However, which outputs are more important, how to rate them and why some of the output types are defined as being more important is not discussed in the paper. In addition, priority fields are selected by the Council of S&T Policy (CSTP) of Japan, which includes the prime minister, related ministers and experts from universities and industry. In the paper, the selected areas are given as Life Sciences, ICT, Environmental Sciences and Nanotechnology and Materials with criteria used for the selection of these fields, which are enhancing intellectual assets with economic and social effects of the technology fields. The existence of both sub-fields of these areas and qualitative and quantitative goals aimed to reach by enforcing these areas is also stated; but no information is given about what they are and how to decide whether to reach these goals or not, in the paper. Moreover, the author criticizes Japanese government for not taking action to redistribute the budget after determining the prioritized field. Nevertheless, if the shortness of the time after the introduction of the new system is considered-which is approximately one and half year as the author states, it is not too late to reallocate the budget to the prioritized areas.

Akser (2012) also analyzes prioritization system of Japan considering the prioritized fields given above and the new ones added in 2006, which are Energy, Production, Social Infrastructure, Space and Marine Sciences. The objectives of the CSTP to achieve with this prioritization are given in this study, but there is no information on how to determine reaching these aims. In addition, it is stated that approximately 50% of the overall R&D budget is allocated to R&D activities in prioritized fields; although, there is no information on allocation of this budget among the priority technology areas. Moreover, it is stated that which of the prioritized areas have more or less priority than others is not determined by the CSTP.

The prioritization policies of the USA and EU are also compared by *Akser (2012)*. Although priorities in R&D supports depend on Congress's approval of budget in the USA, this decision is taken by considering the opinions of the National Science Board of NSF. The bottom-up approach is used by NSF for the generation of a R&D support policy. NSF allows scientist to hazard their opinion as consultants in seminars and workshops. Thus, technology areas continuously

change according to the preference of researchers and there is no pre-prioritized technology area in the USA. However, the final decision of prioritizing an area is taken by NSF administrators considering its economic and employment effects, whether it causes reduction in energy dependency and climate change or not, how it affects life standards and national and public security. In EU, on the other hand, prioritized technology areas are determined by the top-down methods for its Framework Programs. The EU Council and the Parliament determine priority areas with the contribution of internal and external advisory committees from member states. To be prioritized, a technology area is evaluated according to its effect on Europe's R&D potential, its contribution to EU policies and its European added-value. Some of the prioritized thematic technology areas of the European Framework Program are listed as Health (medicine, biotechnology), ICT, Energy, Life Quality, Environment (zero waste), Manufacturing Techniques (nanotechnology), Transportation, Social Sciences and Agriculture.

Hemert (2008) explains the benefit-cost method and the system-based method of priority setting, developed by Steward. The first method is used by institutions which are less information-intensive and which have objectives only based on money benefits. In the scope of this method, research objectives are ranked according to their economic and strategic importance and the capacity of organization in which this research will be conducted, which means being demand-driven. In addition, the benefit-cost method has top-down decision procedure. Decisions are taken by a specific group; although different stakeholders are usually involved in this process, too. The system-based or systemic priority-setting method, on the other hand, is supply-driven with its bottom-up decision process. In the context of this method, researchers, market-oriented-users and governmental institutions determine priority fields considering only their own benefits. They make decision without regarding long-term national strategies and requirement of whole research systems.

Hemert (2008) also investigates the Dutch's prioritization method in the same study with the priority setting strategy of EU. In the Netherlands, the bottom-up strategy is used to propose priority programs. Netherlands Organization for Scientific Research (NWO) is stated as the institution setting-up these programs with system-based priority setting method. Priority programs in the Netherland are designed in line with the opinions of scientists and other interest groups being consulted. In EU, on the other hand, prioritization is done with a more

centralized method, which is an example of the benefit-cost method. EU links both future technology and social needs emerging from social, ecological and economic problems. Thus, priority setting process of EU is demand-driven with top-down approach.

The prioritization policy of the Netherlands is also discussed in the study of *Gassler (2004)* with that of Ireland, New Zealand, Canada and the UK. For the Netherlands, it is stated that the functional priorities are set by the bottom-up process with the participation and consensus of consultants from universities. These priorities are claimed to be based on important issues of the day. In the case of Ireland, on the other hand, thematic priorities are asserted to use additional to functional ones. Biotechnology and ICT are stated as the final prioritized fields in Ireland by government regarding the results of foresight exercises. Similarly, New-Zealand has explicit functional and thematic priorities set by using top-down process. Ministry of Research, Science and Technology (MoRST) introduces priorities for areas to which New Zealand has comparative advantage in the global economy by considering the opinions of stakeholders and long-term social and environmental goals. These areas are Natural Resources and Biology, New Physical Technologies and Future Human Technologies. Top-down process is also used by the Canadian government to detect thematic priorities. In order to achieve strategic targets, which are promoting the benefit of Canadians, enhancing the quality of human resources, providing better innovation environment and contributing to the economic competitiveness, the Prime Minister's Advisory Council on S&T (ACST), responsible for setting the thematic priorities, identify Life Sciences and Health, ICT, Space Environment, Water and Natural Resources, Agriculture as prioritized areas. Unlike others, the bottom-up approach is used with the top-down one for prioritization activities of different R&D funding agencies of the UK. Even, the opinions of stakeholders getting fund are also taken into consideration for the prioritization with top-down approach. Panel discussions are organized with the participation of experts from industry, universities and research centers as foresight studies. Functional priorities exist as national R&D policy of the UK. However, despite not being an obligation, thematic priorities may be set by funding agencies to meet their specific targets with little or no coordination between them. These priorities are consistent with both international trends, technology-field-specific requirements and national and social needs of the UK.

2.2.2. Emerging Country Examples

Akser (2012) investigates the priority setting systems of China. The study is majorly about medium and long-run plans (MLP). At MLP, government's R&D policy agencies, researchers and other stakeholders should arrive at consensus on priority fields by considering needs of industry with technological and scientific development in global basis. It is stated that in 2006, 11 different technology areas are prioritized for the period of 2006-2020, which are Energy, Water, Environment, Agriculture, Production, Transportation, Information Sciences, Health, Urbanization, Public Security and National Defense.

Korea's prioritization policy is discussed by Gassler *(2004).* It is asserted that the S&T prioritization is done by the National Science and Technology Council (NSTC), administered by the prime minister, regarding the opinions of industry and research institutions. The method used by Korea for priority-setting is thematic priorities decided by the top-down approach. In 2003, ten thematic industry fields are prioritized, which are ICT, biotechnology, life sciences, healthy society, nanotechnology, environmental technology, space, new materials, national security and nuclear energy. Gassler claims that the success of setting thematic priorities with top-down approach in catching up technologically advanced economies may not continue in the future if it is not combined with functional priority setting.

Wu et al. (2013) describe the STI policy of Taiwan and introduce a new tool to apply for prioritization of these policies in the future. The proposed system is based on Analytical Hierarchy Process (AHP) method with the combination of top-down and bottom-up policy making mechanisms to balance supply-side and demand-side considerations. This system aims to allocate resources to STI policies by ranking them with respect to their prioritization for Taiwanese economy regarding their long-term target of having sustainable, high-quality living environment offering safe, secure, fast and convenient services. Functional priorities of Taiwan are evaluated by not only politicians, leaders and policy makers from government side but also experts and stakeholders from industry, academia and research centers. They make pairwise comparison of the priorities by giving numerical scale to each of them. This method is stated to reduce biases in the decision making process.

Table 2.1: Summary of prioritization policies applied in different countries

Country	Prioritization Method	Prioritization Year	Prioritized Fields	Selection Criteria
Japan	Top-Down	2001, 2006	Life Sciences, ICT, Nanotechnology/Material, Environment ,Energy, Production, Social Infrastructure, Space and Marine Sciences	-
USA	Bottom-Up	-	Only functional priorities	preferences of researchers
The Netherlands	Bottom-Up method with systemic model	-	Only functional priorities	• Researchers' expression of interest • Important issues of day
EU	Top-Down method with benefit-cost model	1994, 1998, 2002, 2007, 2014	Health (medicine, biotechnology), ICT, Energy, Life Quality, Environment (zero waste), Manufacturing Techniques (nanotechnology), Agriculture, Transportation, Social Sciences	• European added value • Contribution to EU policies • Effect on European R&D potential
New Zealand	Top-Down method with consultation	-	Natural Resources and Biology, New Physical Technologies, Future Human Technologies	• Having comparative advantage and strength • Relation with environment and social goals
Canada	Top-Down	1996, 2001	Life Sciences and Health, ICT, Space Environment, Water and Natural Resources, Agriculture	• Contribution to economic competitiveness • Social benefits of Canadians
Ireland	Top-Down method with foresight exercises	-	Biotechnology, ICT Functional priorities	-
UK	Bottom-Up and Top-Down methods with foresight studies used by different agencies	-	Functional priorities Thematic priorities set by each agency (not expressed specifically)	• International trends • National and social needs
China	Consensus between policy agencies and stakeholders	2006	Energy, Water, Environment, Agriculture, Production, Transportation, Information Sciences, Health, Urbanization, Public Security, National Defense	• Needs of industry • S&T development in the world
Korea	Top-Down	2003	ICT, Biotechnology, Life Sciences, Nanotechnology, Environment, Material, Space, National Security, Nuclear Energy, Healthy Society	-
Taiwan (suggested by Wu et al.)	Combination of Top-Down and Bottom-Up methods with AHP	2013	Functional priorities	• having sustainable, high-quality living environment • offering safe, secure, fast and convenient services to citizens

To conclude, both developed and emerging countries uses prioritization policy to fund STI studies to allocate scarce budget more effectively and efficient. These priorities, which might be thematic or functional, are decided via top-down or bottom-up approaches. Prioritized technology fields vary across not only the economic and social situation of the countries, but also the S&T trends in other countries. The STI priorities of different countries mentioned here are summarized below (Table 2.1.) with the targets lying under them and the methods used during the decision process, as benchmarking.

2.3. Selected Methods and Studies on the Impact Analysis

There is a need for evaluating the success of national STI policies to attain economic growth and welfare in a continuous improvement environment. To achieve these; measuring the effects of R&D activities, technological progresses and innovations is required. Impact analysis is a tool used for this purpose.

Various but similar definitions and descriptions exist for the term of impact. The broadest definition is made by OECD as positive or negative, primary or secondary long-term effects of an intervention emerged directly or indirectly and intended and unintended (Kelley et al., 2008). The European Venture Philanthropy Association, EVPA, (Hehenberger et al., 2013), on the other hand, defines impact briefly as *"the attribution of an organization's activities to broader and long-term outcomes"* by ignoring the short-term effects.

According to the EVPA (Hehenberger et al., 2013), there is a distinction between impact, outcome and output. *"The changes, benefits, learning or other long-term or short-term effects of its activities"* represent **outcome** while meaning of **output** is narrowed down to "the tangible products and services that result from these activities". Kelley et al. (2008) claim that outputs and outcomes may be related to some of the intermediate impact indicators, but not all of them. As a support of this claim, it is argued in the EVPA's guide that although there is an increase in the impact analysis studies, still 84% of these studies are limited to output measurement. When the scopes of previous impact assessment studies given in the progressive parts of this study are examined, it can easily be seen that this argument is valid.

Impact assessment studies having quite importance and several advantages are implemented to reach different targets. Sayın Uzun (2014) asserts the objectives of impact analysis while Tandoğan (2011) specifies the importance of

it for public R&D funding programs. The objectives of impact analysis are listed as detection of policy options, comparison of them with evaluation of their benefits and drawbacks, better explaining of precautions to the public and enhancing the quality of processes. Additionally, Tandoğan (2011) claims that impact analysis studies are conducted for public R&D funding programs to justify the use of public sources, to compare with other national/international funding programs and to detect the problems confronting during the design and conduct process of these programs. Despite these benefits, it is mentioned in the literature that, impact analysis studies are not preferred so much due to entrepreneurs' perception of low value to it, unwillingness of beneficiaries for surveys, low budgets allocated for measurements, so insufficient data and inadequate supports for social impacts (So and Staskevicius, 2015).

Various classifications exist in the literature for impact assessment. Adıgüzel et al. (2015) classify impact evaluation into 3 categories according to its timing, which are **ex-ante, interim and ex-post**. Ex-ante evaluation is stated to be applied before the program to determine the applicability and to increase the quality of it while interim one is said to be done during the application of the program to monitor it regularly with the aim of detecting the failing points. On the other hand, it is asserted that ex-post evaluation enables to determine the long-term expected and unexpected effects of a program having been applied on both the participants of the program and society and it is given as the analogy of impact assessment. This claim is also supported by the argument of Roper et al. (2004), which states that ex-post evaluation results provide indications for ex-ante evaluation.

Gertler et al. (2011), however, categorize impact analysis as retrospective and prospective. Retrospective evaluation, which means assessing the impact of the program after its implementation, is criticized by the authors since it depends on the strong assumptions and the limited information which is gathered during the progressing stage of the program without thinking the evaluation criteria. It is also claimed that with retrospective evaluation, successes and benefits of the program could not be measured during the implementation of it. Thus, it is impossible to intervene the program being not as successful as expected before finalization. On the other hand, Gertler et al. indicate the prospective evaluation, which is described as the evaluation method simultaneous with the design stage of the program, stronger than retrospective one due to several reasons. Since information about the treatment and control group is available

at the beginning of the program, program is designed to serve the demands of the target group. Besides, prospective evaluation enables the designer to shed light on its objectives with the help of relation between evaluation and the programs' theory of change.

There is also another classification for impact analysis belonging to So and Staskevicius (2015). They classify it into 4 categories as due diligence before investment decision (estimation), planning actions, improving the program (monitoring) and proving its social value (evaluation) with respect to its aim. In addition, impact analysis is claimed to use to report the impact for stakeholders.

There are both quantitative and qualitative methods in the literature used to evaluate the impacts of the projects and programs. *So & Staskevicius (2015)* report the ones which are currently used. The authors categorize these methods in terms of intended use, analyze their pros and cons and recommend an integrated method as an output. The Social Return on Investment (SROI) method is used for the impact estimation as due diligence and the impact evaluation to prove social value after investment additional to monitoring the impact during the investment to improve the program. The Logic Model, however, aims to plan and estimate the prospective impacts. Additionally, mission alignment methods, which are Social Value Criteria and Scorecard, are claimed to be used during pre-approval and post-investment stages with the aim of planning and monitoring the impact. Nevertheless, experimental and quasi-experimental methods, which are Randomized Control Trial (RCT), Historical Baseline, Pre/Post Test, Regression Discontinuity Design and Difference-in-Difference, are used for both impact estimation as due diligence and evaluation of it after the investment. It is recommended to apply the integration of some of these methods, rather than only one of them, to increase the obtained utility. The integrated model, recommended as a simple one, includes Logic Model to identify the theory of change for strategic planning and Social Value Criteria to rate investments and monitoring the progress of them. Different set of methods, providing all of required objectives of impact measurement studies can be used as an integrated method, but the authors do not explain why they prefer this one, sufficiently. It can be deduced from the given features that using appropriate experimental/quasi-experimental methods at due diligence and post investment stages with scorecards or social value criteria one may serve all aims of impact analysis.

The book of *Gertler et al. (2011)* is also about the theoretical background of impact evaluation, impact analysis methods and their implementation procedures written for the World Bank. Difference-in-Difference, Propensity Score Matching (PSM), cost-effectiveness analysis, Randomized Effectiveness Methods, regression methods and integrated methods combining these are discussed within the scope of this book. *Tassey (2003)* also prepares a report for the US National Institute of Standard and Technology (NIST) related to impact evaluation conducted for government R&D studies. Analytical framework and data collection strategies are also mentioned in this report. Net present value, benefit-cost ratio and internal rate of return are investigated as impact measures.

There are various studies in the literature as the examples of the application of these methods.

Czarnitzki and Hussinger (2004) investigate the impact of subsidies on R&D and innovation output, which is measured by patent applications. Propensity score matching method is used to compare R&D outputs of funded and non-funded firms. Before this, the descriptive statistics of funded and non-funded firms are analyzed to obtain the best match of firms with the most similar features. It is concluded that the R&D expenditure of the funded firms is significantly larger than that of non-funded ones with similar features, which rejects the crowding-out possibility of public R&D grants to firms. The method used here is appropriate to measure the impact of R&D subsidies given to the private sector. In addition, the sample is large enough to find out sufficient amount of funded and non-funded firms with similar features to match. Moreover, the period, within which the sample is chosen, enables to measure long-term impacts, too. However, narrowing down performance measure only to patenting behavior and using only quantitative methods to detect the impact of R&D subsidy are so inefficient that it is unable to measure the economic and social impacts of R&D subsidies only with them.

Feldman & Kelley (2006) conduct a study to find out the prospective impacts of R&D projects. The aim of this study is developing an ex-ante assessment method to enable identifying the project with the greatest impact on the economic and social benefit indicators. Multivariate LOGIT regression model with maximum-likelihood estimation is used in this study. Data obtained from 20-30 minutes-lasted telephone surveys conducted with nominee of firms

demanding fund, technology area of proposals, technical and business scores of firms, and their prior applications and awards are used as variables. The results of the study indicate that university researches should be funded in any circumstance due to existence of market failure, externalities or knowledge spillover, even if the returns of the projects are limited. Riskier R&D projects of private firms, on the other hand, should not be supported regardless of their potential to provide the highest social benefit if these projects are not able to generate positive externality and enhance innovation investment in the future.

The effects of the innovation policy in Austria are measured by *Falk (2007)* with the help of survey evidence obtained from 1200 Austrian firms. This study attempts to relate the additionality with the characteristic features of the firms, their prejudgments to innovations and the amount they utilize from the public support system. During the survey, questions about the case of not getting subsidy and the effect of it on their innovation activities are asked to firms following to the ones about the characteristics of firms such as number of employees, establishment year and sectoral affiliation. Then, the answers of the firms are compared by dividing them into four different sub-groups. The results indicate that R&D activity and private R&D investment increases with government supports additional to the positive effects of subsidies on the size and time-frame of the projects. Although the applied methods and the obtained results are reasonable, there are some weaknesses. The most important gap of this study is that it only relies on the results of the survey which may be subjective and biased since questions may be answered with concerns of further subsidy applications. In addition, although the sample is large enough, long-term impacts could not be seen since there is not a time interval after the support given to the firms in the sample.

The study of *Conte et al. (2009)* investigates the innovation performance of different EU Member States. The relative impact of publicly financed R&D activities, found out with the quantitative measurement of efficiency levels and the qualitative analysis of policy instruments, is compared. Firstly, the best method between Data Envelopment Analysis (DEA), which is a nonparametric method, and the Stochastic Frontier Analysis (SFA), which is a parametric regression approach, is chosen to calculate efficiency scores. The latter is preferred due to its several advantages. Publications, citations and patent applications are used as output indicator while the amount of public and private R&D expenditures and funds are considered as inputs. In addition, not only

variables directly related to R&D, but also the ones related to the R&D and human resource infrastructure of governments and those representing industrial dynamics and policy instruments are also used. The use of all these variables provides consideration of not only direct but also indirect effects from both economic and social perspectives. Moreover, it also ensures getting the study as effective and as possible. In addition, using both quantitative and qualitative approaches together to gather data, calculate efficiency scores and compare them enlarges the perspective of the study and contributes to the effectiveness of it. The results show that although there are huge differences between the measured efficiencies of EU Members; new members are catching up the others. After the comparison of efficiency scores, a complementary survey on the policy instruments of the national governments is conducted and it highlights the instruments contributing to the efficiency of R&D and innovation policies, in particular at national level.

Tandoğan (2011) analyzes the impacts of public subsidies on private sector R&D in Turkey and evaluates the period of increasing public incentives in business R&D with the increased resource for diversified policy measures. Before starting the study, the author not only discuss the theoretical framework on R&D supports and impact assessment, but also review the previous empirical studies related to the scope of this study and give information about the subsidy system which will be studied in this thesis. This highlights the importance and originality of the study. For the case study, firstly, Tobit model is used to indicate the relationship between private R&D intensity and receiving a subsidy. Then, the effectiveness of receiving a grant from Industrial R&D Support Program of TUBIAK is examined by using propensity score matching and difference-in-difference methods. It is concluded that getting support from public R&D funding programs is beneficial for the private sector as it leads to an increase in the firms' own R&D spending and number of R&D personnel. In other words, public R&D subsidies given to the firms have input additionality in terms of R&D intensity and R&D expenditures per employee in Turkey. This study is very important since it is one of the few studies conducted as the impact assessment of R&D subsidies given in Turkey. Moreover, using quantitative methods with both quantitative and qualitative data, increases the reliability, effectiveness and objectivity of the study.

The impact of South African R&D funding mechanism is evaluated by *Fedderke & Goldschmidt (2014).* PSM method is applied with the bibliometric data of

funded and unfunded projects. In addition, peer review, based on rating the performance of projects both funded and unfunded by R&D subsidy mechanism of South Africa, is also utilized.

2.4. Selected Methods and Studies on Allocation of R&D Funds

In order to increase the benefits obtained from R&D activities, scarce resources should be allocated to them in an efficient and effective way. There are both qualitative and quantitative methods used for this aim. There are various studies explaining these methods deeply with case studies in the literature.

Heidenberger and Stummer (1999) analyze R&D project selection and resource allocation methods, which are benefit measurement, mathematical programming, cognitive, stochastic and heuristic ones. The advantages and disadvantages of these methods are also examined with the cases for which such methods are used in the literature. The benefit measurement methods are divided into 4 parts, which are comparative models, scoring models, traditional economic models and group decision techniques. Comparative models are Q-sort approach with which set of items are classified according to different opinions of the decision group, and Analytical Hierarchy Process (AHP) which allows making complex evaluation considering the hierarchy of multiple (sub) objectives. Scoring models, on the other hand, include the checklist approach proving the control of the fulfillments of requirements, and multi-attribute utility analysis for which it is assumed that the decision makers try to maximize a multi-objective utility function. Traditional economic approaches are analysis and comparison of the economic indexes additional to net present value of the discounted cash flows while group decision techniques include Delphi method and nominal interacting process. After examining the benefit measurement methods, mathematical programming approaches including linear, nonlinear, integer, goal, dynamic, stochastic and fuzzy programming methods; game theory methods with decision tree and game-theoretical approaches; and cognitive approaches consisting of statistical methods, expert systems and decision process analysis are also analyzed in addition to simulation models and heuristics. This paper is quite informative as a taxonomy study, but it has some weaknesses. Firstly, application procedure of the methods, except for benefit measurement and mathematical programming ones is not given in detail. Moreover, case studies given as examples of methods are summarized so shortly that their scope and methodology could not be understood. In addition,

some of the basic methods used for the development of simulation, heuristic and cognitive methods such as Data Envelopment Analysis and Balance Scorecard are not mentioned in this paper.

Chuls (n.d.) explains the Delphi Method. According to this paper, this method is used for specifying objectives and qualification, prioritization and decision on whether doing something is worthwhile or not. Within the scope of Delphi Method, surveys are done with experts to learn their future foresights. First of all, the problem is defined, sample of the experts are formed and survey questions are prepared. During the survey, the opinions of each expert are taken via online surveys separately. Then, the descriptive statistics of the survey results are examined. Thirdly, quarter, mean and median values of each question are shared with experts as a feedback and their new opinion for the same questions are asked. This process continues until reaching the joint answers. This study so informative that all steps on Delphi Method with its advantages and disadvantages could be understood. That is, when and how to use this method is certain. Besides, examples in which Delphi method are applied is also instructive.

Linton et al. (2002) deal with two problems, which are measuring R&D performance or potential and choosing an optimal project portfolio. In order to evaluate R&D projects quantitatively and qualitatively, not only management science techniques and graphic decision support systems are analyzed, but also the use of Data Envelope Analysis (DEA) for this purpose is explained. Then, all of these methods are compared and DEA and Value Creation Model (VCM) are chosen as the best methods to apply for the case targeting the R&D portfolio selection within the set of 469. With the help of DEA, having multi-criteria-decision-making process, projects are sorted according to their relative efficiency scores. These scores are calculated by considering only the economic aspects of the projects, which is an important weakness since it may cause underestimation of the efficiency scores or failure of weighting and ranking of them. Finally, VCM is used for selection of projects among the most effective ones.

Eilat et al. (2008) evaluate R&D projects in different stages of their life cycle to distribute the scarce resource for them optimally. Data Envelopment Analysis (DEA) integrated to Balanced Scorecard (BSC) is used to achieve this target. Firstly, BSC with its financial, marketing, operational and strategic dimensions

is introduced as a useful qualitative method. It is used to set appropriate criteria for project's attractiveness, to set targets and allocate resources within and among projects, to provide relative measure of performance and to evaluate the value of the projects considering variant circumstances and priorities. DEA is also stated as a helpful method to find the relative efficiency of multiple decision-making units by linear programming technology without any misleading. Thus, integrating BSC to DEA is suggested with the aim of not only linking the evaluation criteria with short-term and long-term objectives obtained as a result of BSC application, but also composing project portfolio by maximizing the net value of subsidized projects having found via BSC. This suggestion is shown on a case study with the sample of 50 projects, which is sufficient for statistical analysis. 11 different output measures and 2 different input measures are also used as evaluation criteria. Quantitative and qualitative, economic and social, objective and subjective issues are involved in these criteria, which makes the model suggested in this paper reasonable at least for this case.

Wonglimpiyarat (2008) develops an interactive evaluation system for the research projects. This system aims to contribute the decision making process of allocating resources to different technology fields. These fields are agriculture, science, technology and industry, health and medicine, and social and cultural development. The proposed system evaluates the outputs, outcomes and impacts of the funded projects from different disciplines by using both quantitative output data of the projects and the review of the experts as input.

Garrison et al. (2011) propose a quantitative model to allocate scarce resource for innovation activities on measles vaccinations funded by UN. The proposed model is based on choosing the most effective projects in terms of unit cost impacts. A transmission model is developed to detect mortality and morbidity impacts of innovation activities. Then, the impacts of the activities over their unit costs are estimated and compared to select the activity with the highest cost-effectiveness.

European Commission (2011) conducts impact assessment study on both policy options (BAU, BAU+, H2020 and renationalization) and priorities of them in order to make allocation of budget more effective and efficient. Firstly, an impact assessment study is conducted to find out which fields and which of the

alternative policies is better than the others. For this step, both quantitative and qualitative impact analysis methods are used with the consultation of all stakeholders including industrial enterprises, universities, research centers, public organizations and government bodies. For quantitative analyses, ex-post and interim evaluations, statistical data analyses, analyses of science-technology-innovation indicators and econometric estimation exercises are conducted by regarding all of the economic, social and scientific aspects. Moreover, expert panels and online surveys are also implemented as qualitative impact assessment studies. Casting net wide of analyses, and taking the opinions of all internal and external stakeholders make the study so effective that policies recommended as a result of it become worthwhile. By considering the results of impact analyses, Horizon2020 is chosen as the best policy tool with its better effectiveness, efficiency and coherence features. Then, its budget is reallocated to 3 priorities of the program, which are Societal Challenge, Excellent Science and Industrial Leadership. To achieve this, the characteristics of these priorities with their expected outcomes are examined by taking into account related technology fields, EU2020 targets and the Innovation Union Flagship. As a result, the largest share of the budget is decided to assign to "Societal Challenge" since it seems to contribute the EU 2020 targets most directly while the size of this ratio is decided by considering its possible negative effects on the basic research, applied research and innovation activities of EU. The methods used for allocation of the budget to the priorities of H2020 are reasonable. However, this part could be more objective, if some indicators and variables are added to the quantitative analyses and if a few questions are added to qualitative surveys. In addition, the use of the results obtained from qualitative and quantitative analyses could be emphasized. Apart from this, the budgets allocated to priorities of H2020 are not reallocated to technology fields related to them, which is a missing part of this study.

Volinskiy et al. (2011) work on a case study of resource allocation for Canadian public research funds on applications of agricultural biotechnology. Fusing approaches and methods from the different frameworks are used for analysis of individual and social choices as a useful tool. The solution approach including the combination of Bayesian decision-making framework and the probabilistic target criterion with incorporation of preference heterogeneity enables the conversion of individual utilities into values, as in a benefit-cost analysis. Then, a choice experiment is conducted in which participants select one of the five

different research funding allocations. These choices are varied across the five specified areas (health, industry, environment, consumer and social, economic and public policy) of PMF research. The method seems to be appropriate for this case. However, the assumptions used to apply this methodology may be problematic. In particular, the assumption that panel members and decision makers have no information about the R&D returns will be invalid since the theory fully depends on their preferences and expectations. As a practical result of the case study on Canadian data, two allocation strategies for the PMF research funding are generated. The first one is increasing PMF research funding by up to 10% while keeping the current allocations among the five fields constant. The other one is, on the other hand, keeping the current total research funding levels constant while increasing the funding share of the health and social policy areas.

As expressed above, some of the methods mentioned as impact assessment methods are also used for resource allocation. Studies in the literature using these methods with the aim of impact analysis and resource allocation are summarized below (Table 2.2.).

Table 2.2: Summary of studies on impact assessment and resource allocation in the literature

Author(s)	Year	Aim of the Study	Dataset	Methodology Used
Czarnitzki & Hussinger	2004	Finding out impact of R&D subsidy given to innovation and innovation output	Patent application as R&D outputs of funded and unfunded firms	PSM (quantitative)
Feldman & Kelley	2006	Developing ex-ante evaluation system to detect projects with highest prospective impact on economic and social indicators	Technical and business scores, prior proposals and prior awards Survey results	Multivariate LOGIT model with MLE
Falk	2007	Measuring effects of innovation policy in Austria Finding out relation of firms' characteristics with additionality	Results of survey conducted with 1200 firms subsidized and non-subsidized	Comparison of group analysis
Conte et al.	2009	Measuring and comparing innovation performance of different EU members	Number of publication, citation and patent application Public and private R&D expenditures and funds (quantitative) Policy instruments data	SFA

Table 2.2 (Continued)

Author(s)	Year	Aim of the Study	Dataset	Methodology Used
Tandoğan	2011	Measuring impact of public subsidies on private sector R&D activities and investment in Turkey	TUBITAK and TSI database Survey results	Tobit model PSM Difference-in-Difference
Fedderke & Goldschmidt	2014	Evaluating the impact of R&D funding in South Africa	Bibliometric measures of funded and unfunded projects	PSM Peer-review
Eilat et al.	2008	Optimal distribution of resources to R&D projects being in different stages	Economic and social about inputs (budget, human resources etc. and outputs (publication, citation, patent, product etc.) of projects	DEA BSC
Linton et al.	2002	Measuring potential of R&D studies to choose optimal portfolio	Relative efficiency scores	DEA VCM
Wonglimpiyarat	2008	Developing a system for optimal resource allocation to different technology fields	Project outputs Review of experts	Output, outcome and impact evaluation
Garrison et al.	2011	Choosing innovation activities being the most cost-effective	UN database Previous cost reports Quantitative policy goals	Cost-effectiveness analysis
Volinskiy et al.	2011	Allocation of resources for Canadian public research funding mechanism	Survey results	Benefit-Cost analysis Choice experiment
European Commission	2011	Impact analysis to detect fields and policies which are better to finance Allocation of resources to selected programs	Project outputs Results of surveys conducted with stakeholders Review of experts	Analysis of STI indicators Econometric analysis and descriptive statistics of outputs Panel discussions with experts and stakeholders

2.5. Concluding Remarks

From various definitions on R&D and different classifications of R&D activities, those of OECD given in Frascati Manuel are the ones the most widely used. Accordingly, R&D is classified as Basic Research, Applied Research and Experimental Development. The type of an R&D and innovation activity can be decided by using TRL measurement method. Although this method is quite effective to measure the maturity of a recently generated product and technology from its basic research (TRL1 and TRL2) to experimental development activities (TRL8 and TRL9), it needs to be improved in order to be

able to use for R&D activities conducted in service sector, systems and the area of social sciences and humanities.

With the 1003 Program, it is expected to support applied research projects mostly. However, the majority of the proposed and supported projects are at the basic level due to the nonexistence of starting and target TRL for each call and PTA. This may result in obtaining relatively less product-oriented output from supported projects contrary to the 1003 Program objectives.

For a country, National Systems of Innovation (NSI) is required in order to move from TRL1 to TRL9 for R&D and innovation activities in a planned, systematic and systemic way. NSI involves not only R&D activities, but also related marketing, finance and learning ones. Policies related with NSI are planned by governmental bodies with the participation of both non-profit organizations and profit-oriented firms. The ultimate target of NSI is to create a new system, service, technology or product which serves economic growth, competence in international trade, and social welfare. The NSI of a country should be revised periodically considering the improvement in research activities, i.e., changes in their maturity levels. However, in Turkey, effects of NSI policies and the improvement in R&D system could not be monitored effectively. This might be due to the uncommon use of TRL measurement and the improper classification of R&D activities according to their characteristics.

In order to detect the success of national STI policies in terms of economic growth and social welfare; direct and indirect short-run and long-run effects of R&D activities, technological progresses and innovations should be evaluated. To achieve this, three types of impact analysis exist: ex-ante as due diligence method to set targets, interim providing to monitor application process; and ex-post to evaluate the success of the activities. These should be applied integrated and sequentially and the output of one should be the input of the following one to obtain beneficial results.

There are various quantitative and qualitative methods are used in the literature for all types of impact analysis having the aim of evaluating STI systems. Propensity score matching, difference-in-difference and econometric analysis are quantitative methods used frequently with data on outputs, revenues and costs. However, studies conducted by using qualitative methods and data in the literature are quite few. In addition, despite the importance and benefits of impact analysis, it is not preferred so much due to its high costs, its

requirement of long time, and difficulties in obtaining data. Thus, examples of such kind of studies are very limited in the literature not only for Turkish cases, but also for the ones of other developed and emerging countries. Even, most studies classified as impact assessment in the literature are, in fact, output analysis since they do not consider other impacts including input, and behavioral additionality. The only comprehensive evaluation study on the Grant Programs of TUBITAK is the one conducted by Tandoğan (2011). Although, there is also no study on the impact evaluation of TUBITAK Grants given for projects on prioritized areas, including 1003, this is reasonable since not much time has elapsed since 2011, when these programs started.

Competitiveness in international markets has been rising. However, the available technological, financial and human resources of a country used to conduct research activities are scarce. Thus, there is a need for selecting particular areas to specialize, and so setting priorities for research activities considering not only international trends, but also national needs, socio-economic structures, research infrastructure and competences. There are two approaches in the literature for priority setting: top-down approach with thematic priorities and bottom-up one with functional priorities. Priorities are dictated by governmental bodies for the former while foresight studies, surveys and group discussions are conducted with the participation of all stakeholders to reach a consensus on priorities for the latter. For Turkish case, these approaches are used in integrated manner. Thematic priorities, i.e. PTAs, are announced by the Supreme Council of Science and Technology (SCST) and the Science Board (SB) of TUBITAK with top-down approach. However, foresight studies are conducted with bottom-up approach to determine the contents and scope of these priorities. Sub-technology areas of PTAs and priority calls of 1003 Program with their title, scope, aims and special issues are also decided with the contribution of all stakeholders regarding not only their competences and preferences, but also national requirements and international trends.

In order to increase the benefits obtained from R&D activities, scarce resources should be allocated to prioritized fields in an efficient and effective way. In the literature there exist both quantitative methods such as cost-effectiveness and DEA and qualitative ones like BSC and choice experiment applied for this aim. However, most of the studies on resource allocation are at project selection level. Allocation of funding resources for different technology fields or different

R&D policy programs is not studied extensively. Even, such a study does not exist for Turkish case.

In conclusion, it is seen that NSI and prioritization gain importance not only for R&D activities, but also for economic and social development. This brings along the requirement for the use of TRL which provides the effective classification of prioritization targets, and so does that of projects proposed and supported for these priorities. In addition, due to the scarcity of resources; measuring and evaluating the impacts of R&D activities and allocating resources to the most efficient ones become crucial to obtain the highest additionality by giving minimum funds. However, the number of studies on these issues is limited in the literature for both Turkish and other countries' cases. It can be inferred from all of these facts that the analyses done in the remaining chapters of this thesis and the policies recommended as a result of them will contribute not only to the efficiency and effectiveness of 1003 Program funding mechanism, but also to the literature.

CHAPTER 3

BACKGROUND INFORMATION

During the ongoing planned period started with the establishment of State Planning Organization, development plans, S&T policies, and S&T strategy documents have become the fundamental aspects of S&T plans of Turkey. In addition, TUBITAK and the Supreme Council of SCST (SCST), founded during this period, play an active role in formation, management and monitoring these plans and policy tools. In this chapter, some background information not only about the S&T policy tools which provide a basis for 1003 Grant Program, but also TUBITAK and SCST as the agencies responsible from the results of it.

3.1. Development Plans of Turkey

Development plans, which are prescriptive to public institutions and guidance for private sector organizations, put into practice after 1960's. 10 development plans, each of which having 5 years' horizon, have been prepared and applied since 1963. These plans have expanded S&T policies, which were limited to universities until 1960's.

While the initial development plans aimed to create an inventory of R&D studies and to increase the number of researchers, increasing R&D resources and R&D share in GDP was targeted in the following ones mentioning the S&T policies, firstly. In those plans, providing effective use and domestic production of imported technologies, especially ICT, was prescribed with the legislation of intellectual and industrial property rights. In the latest and expired plans, on the other hand, the numerical targets on the share of R&D spending in GDP and R&D resources were stated. However, none of the numerical targets were reached in the planned periods. R&D studies on genetic-biotechnology, nuclear energy, new material and aerospace technologies were also planned for this period. Moreover, it was aimed to generate an information society additional to

provide university-public-industry cooperation, technology transfer and international cooperation. (Ministry of Development, 2017)

In 2013, the Tenth Development Plan was designed in line with the Vision 2023 for the period of 2014-2018. The components of this plan are about steady and inclusive economic growth, the supremacy of law, knowledge-based society, international competitive power, human development, environmental protection and sustainable consumption of sources. It was designed under the coordination of the Ministry of Development and with the participation of academicians, public employees, representatives from private institutions and non-governmental organizations, public institutions and other groups of the society. (Ministry of Development, 2014)

During the preparatory studies of the plan, current development level of Turkey is taken into consideration with the progresses in all over the world and how they affect Turkey in terms of not only macroeconomic but also sectoral and regional issues. These issues are production, growth, financial markets, scientific and technologic progresses, international trade, demographic structure, health and social security, education and skilled labor, urbanization, climate change and environment, nourishment, water, energy and use of natural resources. (Ministry of Development, 2014)

Raising the share of R&D spending in GDP from 0.95% to 1.8% and raising industry share in R&D spending from 47.5% to 60% until 2018 were expressed as the targets of the Tenth Development Plan, in addition to the 2023 targets, which are raising GDP per capita to $25000, increasing export to $500billion, reducing unemployment rate to 5% and having sustainable and single-digit inflation rate. In this regard, 25 programs are designed under the scope of the Tenth Development Plan. These programs include centralized application and intervention tools designed with sectoral and inter-sectoral approaches. Programs are kept in a limited number for the prioritized subjects related to agriculture, health, tourism, logistics, family and society, economy and development, technological progress, labor force, energy, investment and production sectors. Aims of this limitation are having manageable programs with measurable results and enabling to monitor processes of the Plan easily. The institutions which are responsible from the application and the coordination of programs and their targets are also stated within the context of the Plan. (Ministry of Development, 2014)

3.2. S&T Policy and Strategy Papers

From its establishment to 1980's, TUBITAK conducted S&T policies in verbal agreement with government without any policy paper. In this period, progresses in S&T limited to the creation of a research tradition to capture basic R&D values, researcher training with the aim of establishing R&D infrastructure, and the preparation of R&D facilities. After 1980's, S&T policies started to be documented as a symbolic support on technological progresses in Turkey. (Bayraktutan and Bıdırdı, 2015).

The first policy paper, Turkish Science and Technology Policy: 1983-2003, could not be put into practice, but it is still important for the S&T history of Turkey since it provided the establishment of SCST. This paper was followed by two policy papers: Turkish Science and Technology Policy: 1993-2003 which had the aim of increasing the number of researchers and R&D spending by giving priority to the fields of informatics, advanced technology materials, biotechnology, nuclear technology and space technology; and Science and Technology Policies Implementation Plan: 2005-2010 in which the Turkish Research Area is defined.

Simultaneous with the Implementation Plan, the National Science and Technology Policies (NSTP): 2003-2023 Strategy Paper was published in November 2004 after the completion of the Vision 2023 Project, started in 2002. This paper contains the findings and the results of the Technology Foresight Project, sub-project of Vision 2023. In addition, a roadmap for the strategic technology fields, which are ICT, biotechnology and gene technologies, material technologies, energy and environment technologies and design technologies, is stated in this paper.

The last strategy paper, National Science, Technology and Innovation Strategy (NSTIS):2011-2016 is prepared at the meeting of SCST, held in December 2010. The vision of the NSTIS: 2011-2016 is:

"to contribute to new knowledge and develop innovative technologies to improve the quality of life by transforming the former into products, processes, and services for the benefit of the country and humanity"

It is the basic strategy including the STI vision and priorities. It aims to ensure the sustainability of the acceleration captured in STI with the help of the 2005-2010 S&T Policies Implementation Plan. Moreover, the adoption of objective-

driven approaches for the areas in which R&D and innovation capacity of Turkey is strong (automotive, machine-production and ICT) and requirement-driven approaches for the ones in which an acceleration is essential (defense, space, health[1], energy, water and agriculture) is decided (see Figure 3.1.).

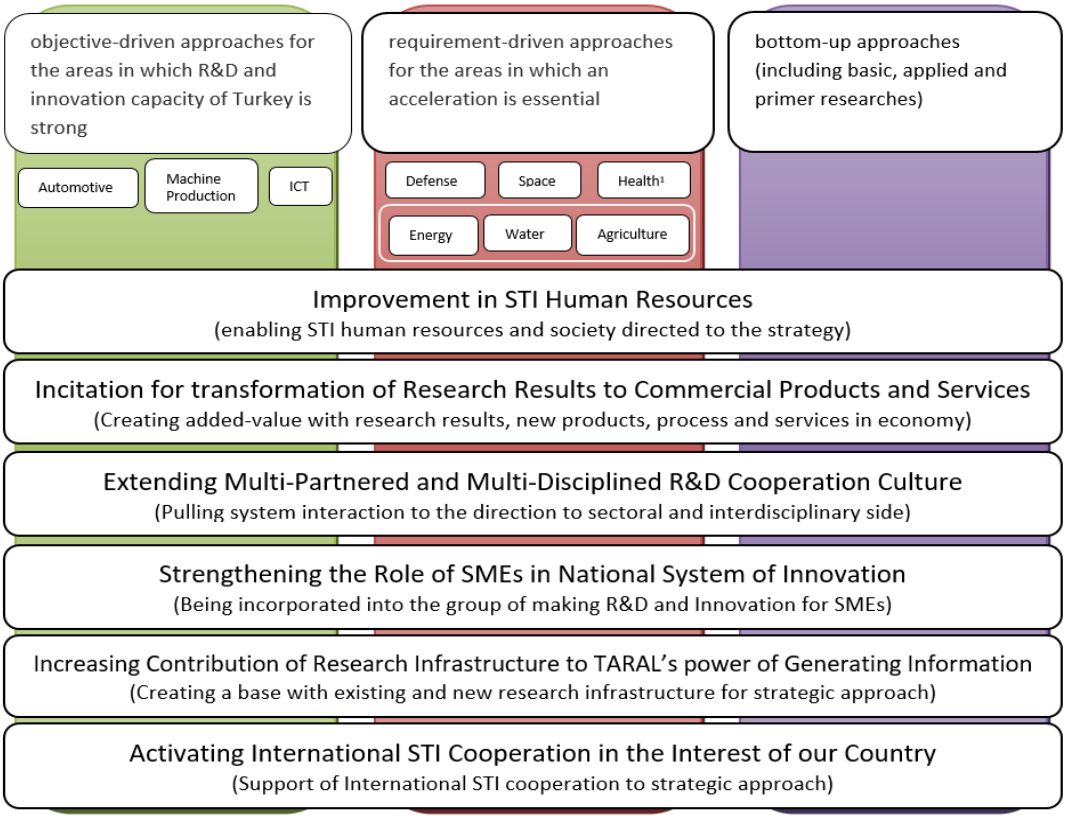

Figure 3.1: Strategic Framework of NSTIS: 2011-2016

3.3. Vision 2023

There are variety of projects and studies in order to reach the 2023 Vision of Turkey; which is defined as Turkey, which efforts to establish permanent and fair peace in its region and all over the world, which has an democratic and fair legal system, which considers sustainable development, which has balanced income distribution, which becomes competent in S&T and innovation, which produces and increases its net value-adding with the help of its own brain

[1] It should be noted that Health is included in the areas requiring acceleration in the meeting of SCST in January 2013.

power, citizens of which have right and decision for the future of their country and in which health, education and culture needs are guaranteed by the state. "Vision 2023" Project is one of these studies. It is confirmed by SCST in December 2001 as a study for the preparation of National S&T Policies: 2003-2023 Strategy Document. The main theme of this project is reaching the level of modern civilizations and 2023 Vision of Turkey until the 100th Anniversary of the Republic in line with the target pointed out by Ataturk while creating an affluent society being competent in science and technology, using technology consciously, being capable of developing new technologies and possessing the skill of converting technological developments into social and economic benefits. (TUBITAK, 2017b)

Under its 4 sub-projects; which are National Technology Competence Inventory, Researcher Information System (ARBIS), National R&D Infrastructure (TARABIS) and Technology Foresight; "Vision 2023" plans to involve the following activities (TUBITAK, 2017b):

- assessment of the current status of Turkey in the field of science and technology
- assessment of the long termed scientific and technological developments in the world
- identification of the strategic technologies required for the achievement of the stated targets
- recommendation of policies aiming the development and/or the acquisition of the stated technologies

3.3.1. Technology Foresight Project

On April 13th, 2002, the Technology Foresight Panels were formed. In these panels, scientists, industrialists, experts from public and non-governmental organizations came together and decided that four socioeconomic targets are prerequisite to reach the 2023 Vision of Turkey by getting the opinions of related groups via surveys and meetings. These targets are (TUBITAK, 2017b):

- receiving considerable share in the international trade for specified production areas by obtaining competitive advantage,
- increasing the living-standard of the citizens,
- reaching sustainable development,

- strengthening ICT infrastructure to keep in step with the world in which communities' competence of producing information and transforming it to economic and social benefit are reshaped national economies and community life.

As a result of these panels, the strategic and prioritized areas are specified as: education and human resources; environment and sustainable development; information and communication; energy and natural resources; health and drug; defense and aerospace; agriculture and nutrition; machine and material; transportation and tourism; chemistry; textile; construction and infrastructure. (TUBITAK, 2017b)

3.4. The Supreme Council for Science and Technology (SCST)

As a result of Turkish S&T Policy:1983-2003, the Supreme Council for Science and Technology (SCST) was established by the Decree Law with number 77 which was published in the Official Newspaper dated October 4, 1983 and numbered 18181. Permanent members of the council are ministers and undersecretaries, Chairman of the Council of Higher Education, Chairman of Turkish Atomic Energy Authority, President of TUBITAK and a Vice President, General Director of Turkish Radio and Television, Chairman of Union of Chambers and Commodity Exchanges of Turkey, a member to be appointed by a university to be designated by the Council of Higher Education. In addition, relevant stakeholders could be invited to the meetings with advisory capacity, from the governmental bodies, higher education and business enterprise sectors. SCST is moderated by the Prime Minister. (TUBITAK, 2017a)

Identifying long-term S&T policy, detecting targets, specifying Priority Technology Areas, preparing plans and programs, appointing public institutions, collaborating with private institutions, preparing required law designs and legislations, providing training of research human resources, taking measures to establish private sector research centers and providing coordination of sectors and institutions are the duty of the SCST. The Scientific and Technological Research Council of Turkey (TUBITAK) is appointed to carry out secretariat activities of SCST. It is responsible for disseminating and following up the implementation of SCST decrees. (TUBITAK, 2017a)

3.5. Scientific and Technological Research Council of Turkey (TUBITAK)

The Scientific and Technological Research Council of Turkey (TUBITAK) was founded in 1963 as an agency responsible for promoting, developing, organizing, conducting and coordinating research and development in line with the national targets and priorities of Turkey. It is an autonomous institution and governed by the Science Board (SB) whose members are selected from prominent scholars from universities, industry and research institutions. (TUBITAK, 2017c)

Vision of TUBITAK is being an innovative, guiding, participating and cooperating institution in the fields of science and technology, which serves improvement of the economic, social and environmental life standards of our society and sustainable development of Turkey. Its mission is set as preparing S&T policy proposals by considering national priorities, supporting and conducting R&D, innovation and entrepreneurship activities, advancing science and technology, and playing pioneering role in creating S&T culture in order to enhance and perpetuate the welfare and competitiveness of Turkey. (TUBITAK, 2017c)

TUBITAK acts as an advisory agency to Turkish government on science and research issues, additional to being the secretariat of SCST, the highest S&T policy making body in Turkey. It supports government for S&T policy making and constitutes international S&T collaborations by representing Turkey. In addition, SCST appointed TUBITAK to specify new S&T policy of Turkey for the period until 2023, which is 100th anniversary of Turkish Republic, in December 2000. Moreover, it makes S&T researches at its R&D institutions/centers. Additional to all of these, TUBITAK encourages not only R&D, innovation and entrepreneurship activities of public and private institutions and settlement of S&T culture but also S&T research studies and its infrastructure with the development of human resources required for S&T via a number of funding programs. These programs are conducted by 4 Funding/Grant Program Directorates of it: Technology and Innovation Funding Programs (TEYDEB), Science Fellowship Grant Programs (BIDEB), Science and Society Activities Grant Programs (BITO) and Academic Research Funding Programs (ARDEB). (TUBITAK, 2017c)

3.6. 1003 - Priority Areas R&D Projects Grant Program

TUBITAK is one of the agencies responsible from the studies about S&T policies and strategies of Turkey pointed out in NSTP:2003-2023, NSTIS:2011-2016 and the Tenth Development Plan. In this regard, it has programs via which grants or funds are given to researchers from universities, industry and public institutions for the projects related to the strategic and prioritized technology fields. The two Programs conducted in this scope are: 1003 - Prioritized Areas R&D Projects Grant Program and 1511 – Priority Areas Research Technology Development and Innovation Projects Grant Program.

"1003-Priority Areas R&D Projects Grant Program", which is conducted by TUBITAK-ARDEB, is started in 2012 with the aim of supporting and coordinating the domestic R&D projects which are result-oriented, having observable targets and looking after dynamics of related science and technology fields. These projects are about the priority areas determined by SCST and SB of TUBITAK considering not only 2023 Vision and development plans of Turkey, but also its S&T policies and strategies.

Since 2012, 1003 Grants are given for ten different PTAs and various sub-technology ones. The PTAs for which 1003 Grants have been giving are information and communication technologies (ICT), machine/production, automotive, agriculture, water, energy, health, chemistry, aerospace, and social sciences and humanities (SSH). These technology areas are specified in the meetings of SCST and Scientific Board of TUBITAK with efficient and broad participation considering development plans, NSTP: 2003-2023 prepared as a result of Technology Foresight Project and NSTIS: 2011-2016.

TUBITAK gets application from researchers with specific calls launched for 1003 Grant Program. From the time at which the program was started to May 2017, 166 calls have been launched. The researchers working as full-time in universities, research institutions/centers, public and private institutions can submit project proposal to 1003 Program as coordinator or researcher. According to their budget, projects are divided into 3 scales as small (up to ₺500.000), medium (up to ₺1.000.000) and large (up to ₺2.500.000). Medium and large scale projects could also include sub-projects up to three. Small scale projects could last for at most 24 months and other projects could last for at most 36 months. Two-stage application and evaluation procedure is used to get project proposals. The projects proposed for 1st stage are evaluated by Call

Program Consulting Board (CPCB). During evaluation, consistency of the project proposals with the requirement and aims of the call and whether the R&D project criteria defined in Frascati Manual of OECD are provided are considered. Project only passing 1st stage could apply for 2nd stage. These projects are evaluated with peer-review method in panel discussion regarding the criteria of Originality; Methods; Project Management, Team and Research Infrastructure; Convenience with Aims and Targets of the Call Program; and Widespread Effect by using the evaluation form, sample of which is given in Appendix F. The projects getting the point above the pre-identified passing score for each evaluation criteria and for total point are supported with the approval of TUBITAK's President. (See Figure 3.2)

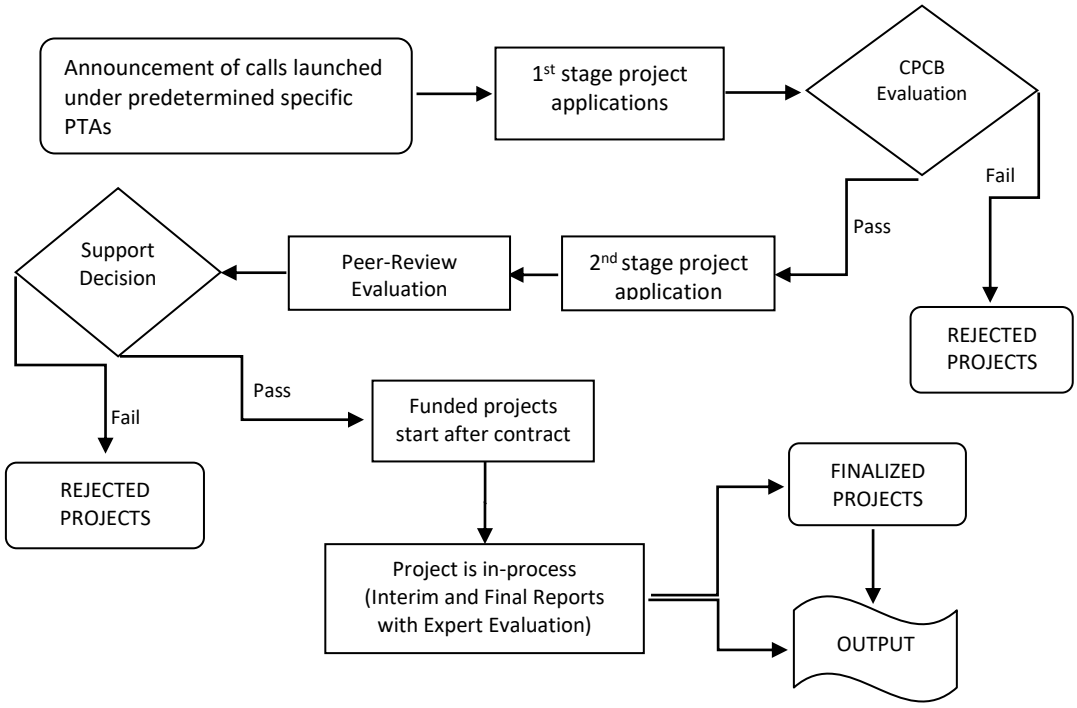

Figure 3.2: Flow chart of projects proposed to 1003 Prioritized R&D Grant Program

3.7. Concluding Remarks

Turkey has been implementing various policies, programs and projects contributing to economic growth and development in order to reach the level of developed countries and compete with them. Development Plans, STI policy and strategy papers, SCST decisions, incentives and funding programs conducted by the related institutions are examples of tools used by government for this aim. Policies related with STI constitute the main part of these tools, as indicated.

TUBITAK conducts the S&T policies defined in the strategy papers and documents considering the SCST decisions. It also encourages not only R&D, innovation and entrepreneurship activities of public and private institutions but also S&T research studies and its infrastructure with the development of human resources required for S&T via a number of programs. For this aim, TUBITAK has been funding R&D projects via 1003 Priority Areas R&D Grant Program of TUBITAK since 2012. Under 1003 program, funds are given to the projects proposed to specific calls. These calls are related to PTAs identified by SCST and SB of TUBITAK, which are ICT machine/production, automotive, agriculture, water, energy, health, chemistry, aerospace and SSH.

National Science, Technology and Innovation Strategies (NSTIS): 2011-2016 is the basic strategy including the STI vision and priorities. 1003 Grant of TUBITAK serves the object-driven and requirement-driven approaches of this strategy by funding projects related to the areas expressed under these approaches. In addition, it serves the bottom-up approaches since the proposed and supported projects could be basic, applied or primer research according to their content and the preferences of researchers. There is no restriction applied on the research level for the 1003 calls. Besides, 1003 Program also aims to contribute to some horizontal targets of this strategy indirectly with the help of the outputs and long-run impacts of its supported projects. These projects also extend the culture of multi-partnered and multi-disciplined R&D cooperation, improve the STI human infrastructure, reinforce the commercialization of research results, and increase the contribution of research infrastructure to the generation of information. However, how much it is successful to reach these aims is questionable and discussed under the scope of this study.

PTAs, sub-technology fields and call subjects of 1003 Program also reflects the subjects underlined with the Tenth Development Plan and the National Science

and Technology Policies (NSTP): 2003-2023 Strategy Paper, prepared in the direction of Technology Foresight Project and Vision 2023.

In order to reach the aim of reaching the level of developed countries and compete with them, government needs not only to develop new policies but also to improve the existing ones. This thesis study will serve the latter by making one of the policy tools implemented by TUBITAK more efficient and effective.

CHAPTER 4

METHODOLOGY AND DATA

Previous studies related to the impact assessment and resource allocation were discussed in the "Literature Review" with priority-setting strategies and prioritization policies of both developed and emerging economies. It is recognized as a result of this review that no evaluation and impact assessment study is conducted for prioritization-oriented funding programs of TUBITAK, which are 1003 and 1511 Grant Programs. In addition, although prioritized technology areas are decided by top-down approach with foresight studies in Turkey as in the majority of other countries, there is no strategy for how to allocate scarce resources to these technology fields efficiently and effectively. Even, such strategies do not exist for other countries. Thus, it is decided to evaluate the 1003 Grant Program of TUBITAK by comparing its output, input and behavioral additionalities for different PTAs. The aim of this evaluation is increasing the efficiency and effectiveness of the program by recommending new policies.

For this evaluation study, identification and analysis of the program indicators, and econometric analysis to estimate the relation of these indicators with output amount are chosen as the quantitative methods. Conducting interviews with a sample of supported project coordinators, on the other hand will be used as the qualitative one.

Program indicators will be identified and analyzed for all PTAs while econometric analysis and interviews are conducted for only three of PTAs; ICT, Energy and Health. The reasons of choosing these areas can be listed as follows:

- The Number of launched calls is higher for these areas.
- Since the initial calls belong to these areas finalization rate of projects are also high for their calls.

- The total and average amount of proposed projects are high enough for these areas.

  The average amount of proposed project is higher for the areas of Chemistry, SSH, and Aerospace than at least one of the selected areas. However, these areas could not be chosen since majority of their supported projects have not been started, yet.

  Agriculture has also calls launched in the first years of the Program. In addition, total and average amount of proposed projects are high for Agriculture calls, too. However, this area is not also chosen due to its low output amounts, low passing first stage and supporting rates, and nonexistence of supported projects conducted in a private institution for this area.

- ICT represents the fields in which R&D and innovation capacity of Turkey is strong, while Energy is the area in which acceleration is essential according to NSTIS: 2011-2016, prepared in December 2010. Health is also the one requiring acceleration, but it is added to this strategy in January 2013. In addition, a separate strategy paper exists for the area of Energy. Thus, it can be inferred that ICT, Energy and Health represents the areas having different characteristics.

Methods applied in this thesis with their interactions are summarized in Figure 4.1.

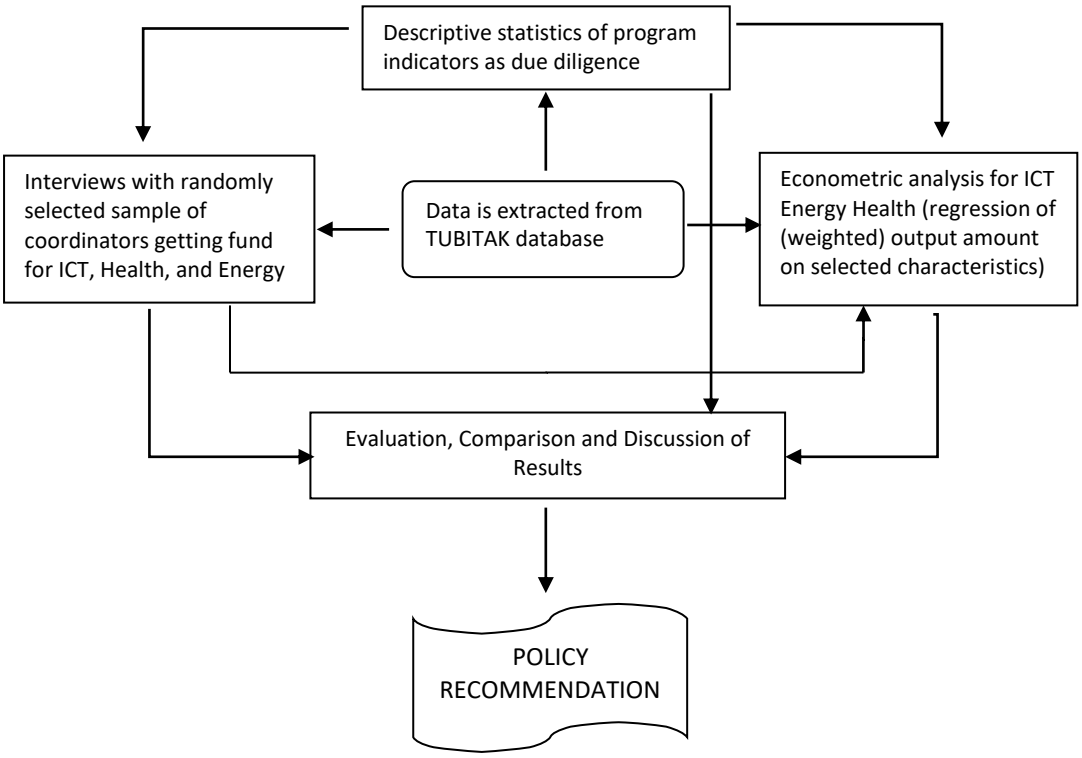

Figure 4.1: Graphical expression of analyses conducted in this study

4.1. Analysis of Program Indicators

As the first stage, the program indicators are identified as historical baseline by using the datasets of projects and outputs retrieved from the TUBITAK database on April 21st, 2017. These indicators are about the following issues:

- Launched calls
- Total and average amounts of proposed, supported and finalized projects with their distribution by project scale, institution type, gender of the coordinator, number of sub-projects and province
- Requested budgets and given fund including their distribution with respect to institution type and gender of the coordinators
- Outputs of projects including their distribution according to project scale, output types (presentation, scientific paper, dissemination, patent application, registration, thesis, new project, book, prize), and time when output emerged

Total and average amounts of these issues for each PTA and each year are given as analysis on descriptive statistics of program indicators. Average amounts are calculated as dividing the total amount by the number of calls launched for the respective PTA/in respective year.

Restrictions and considerations valid only for particular calls are also given and discussed with the indicators about launched calls. Besides, PTAs, sub-technology areas and subject of calls are compared with the R&D priority of other developed and emerging countries given in the "Literature Review" as a benchmarking study.

There are also discussions about the distribution of projects by scale and number of sub-projects. 1003 projects can be small, medium or large-scaled according to their budget and duration. The budget of a small-scaled project can be up to ₺500.000 while the duration of it can be up to 24 months. On the other hand, the duration of medium and large-scaled projects can be up to 36 months and their budget can be up to ₺1.000.000 and ₺2.500.000, respectively. In addition, medium and large scale projects could include sub-projects up to three.

This study is conducted with the aim of due diligence and ex-post evaluation. As a result of these analyses, it is expected to find out current situation of 1003 Grant Program with its inefficient and ineffective points, differences between PTAs in terms of project amount, characteristics of projects, their output and funding budget allocation to PTAs. Moreover, these indicators provide information for the selection of independent variables to econometric analyses.

4.2. Econometric Analysis

As the second stage, econometric analyses are conducted in order to create policy recommendations to make 1003 Program more effective and efficient in terms of output additionality.

Two different types of model are used in order to illustrate the relation of output amounts with features of both projects and calls. The characteristics of projects and calls, which are detected to distribute unbalanced for different PTAs as a result of the analyses on the program indicators, are chosen as independent variables. These are variables about the scale of the projects, funding amount, number of sub-projects and number of supported projects. Moreover, there are also some characteristics added to the models since they

are used in similar studies discussed in the "Literature Review". Variables related to peer-review grades are added to the models considering the paper of Fedderke & Goldschmidt (2015). Inspired by the variables of firm size and existence of cooperation used in the study of Tandoğan (2011), variables related to the sub-project amount and private sector participation are also included in the models.

As the first model, total output amount of supported projects is regressed on the characteristics of projects which are detected as different for each PTA as a result of the descriptive analyses on the program indicators (See Eq. 1). For this model, both the original and weighted total output amount are regressed and the one explained better with existing independent variable is chosen as the dependent variable.

Total (weighted) output amount= f(vector of project characteristics) + u (Eq. 1)

Dependent and independent variables used for the estimation of Eq. 1 are listed in Table 4.1:

Table 4.1: Dependent and independent variables of project-based estimation model

Expression of Variable in Equation	Explanation of Variable
output	Total number of outputs produced from the project
woutput	Total number of outputs weighted according to the weighting rule given below and produced from the project
timeafterstart	Number of years elapsed after the beginning of the project
timeaftercall	Number of years elapsed after the launch of the call to which the project belongs
finalization	Whether the project had been finalized (1) when the data was retrieved or not (0)
fund (million ₺)	Amount of funds given to the project
small	Whether the project is small-scaled (1) or not (0)
medium	Whether the project is medium-scaled (1) or not (0)
large	Whether the project is large-scaled (1) or not (0)
privateparticipation	Whether any researcher from private sector institutions exists in project team (1) or not (0)
subprojects	Number of sub-project belonging to the project
teamsize	Number of researchers in the project team
proportionalgrade	Proportionated grade which the project get from the peer-review evaluation

The sample used for this regression consists of 216 projects: 65 projects for Energy, 47 projects for ICT and 103 projects for Health calls. The projects in the sample are the ones having supported and started by the time the data was retrieved.

To calculate the weighted output amount, a weight is assigned to each output type which is also different for each PTA. Weights are determined by considering not only the distribution of outputs according to their types for different PTAs, but also responses received from the coordinators participated to the interviews. The specified weights of each output type for each PTA are given in Appendix B.

Weighted total output amount of a project is calculated as in Eq. 2:

woutput = $\sum_i Weight_{ij} * (Output\ Amount)_i$ / Total Output Amount (Eq. 2)

Where "i" represents output types and "j" represents PTA to which related project/call belongs.

As an example, the calculation of the weighted output amount for a sample of projects from different PTAs is given in Table 4.2:

Table 4.2: Examples of weighted output amount calculation for different PTAs

Project	PTA	Outputs	Original Output Amount	Rank	Weighted Output Amount	Rank
A	Health	3 Thesis 2 Scientific Paper 3 Presentation	8	2	(11*3 + 10*2 + 9.5*3) / 8 = **10.19**	2
B	Health	5 Book Chapter 2 Registration 3 Prize	10	1	(5*5 + 7*2 + 5.5*3) / 10 = **5.55**	4
C	ICT	1 Scientific Paper 1 Thesis 2 Patent Application 1 Registration	5	3	(15*1 + 15.5*1 + 11.5*2 + 11.5*1) / 5 = **13**	1
D	ICT	2 Presentation 2 Book Chapter 1 Prize	5	3	(10*2 + 8*2 + 4*1) / 5 = **8**	3

In the second model, on the other hand, mean output amount of projects supported for each call is regressed on both the features of calls and mean

value of the variables used in previous model if it is applicable (See Eq. 3). If estimation of the weighted output amount gives better results for the project-based estimation, mean of the weighted output amount is regressed instead of the original one in the call-based model. The sample of this regression includes 62 calls distributed as 23 for Energy, 18 for ICT and 21 for Health. The calls in the sample are the ones support decisions of which are given and the projects of which are started.

Mean (weighted) output amount = f(vector of call characteristics) + u (Eq. 3)

Independent variables used for the estimation of Eq. 3 are listed in Table 4.3:

Table 4.3: Independent variables of call-based estimation model

Expression of Variable in Equation	Explanation of Variable
timeaftercall	Number of years elapsed after the launch of the call
mainprojects	Number of supported projects belonging to the call
finalizedprojects	Number of finalized projects belonging to the call
finalizationrate	Rate of finalized projects to all of the supported ones for the call
meanfund (million ₺)	Average value of funds given per a supported project belonging to the call
scalerest	Whether a restriction on the scaling of the projects exists (1) or not (0) for the call
privateparticipation	Rate of projects having researchers from private sector institutions to all of the supported projects for the call
meanteamsize	Average number of researchers existing in the team of a supported project belonging to the call
minproportionalgrade	Minimum value of proportionated peer-review evaluation grade of supported projects belonging to the call

The described models will be estimated by using the Ordinary Least Square (OLS) Estimation method. For both models, it is assumed that the requirements of the OLS method are satisfied. To verify this, diagnostic tests are applied to the selected models. These tests are VIF to control the serious multi-collinearity between independent variables, White Test to check the homoscedasticity, Ramsey RESET to detect the existence of prospective structural error and Chow Breakpoint Tests to find out the possible structural breaks. If any deficiency is observed, the required adjustments are done on the selected linear models. In addition, the weight of output types decided for each PTA is postulated to be

objective and reasonable. Besides, it is supposed that there is no significant measurement error for the independent variables, i.e., the data retrieved from the TUBITAK database is true.

The procedure applied for the estimation of both models is summarized in Figure 4.2.

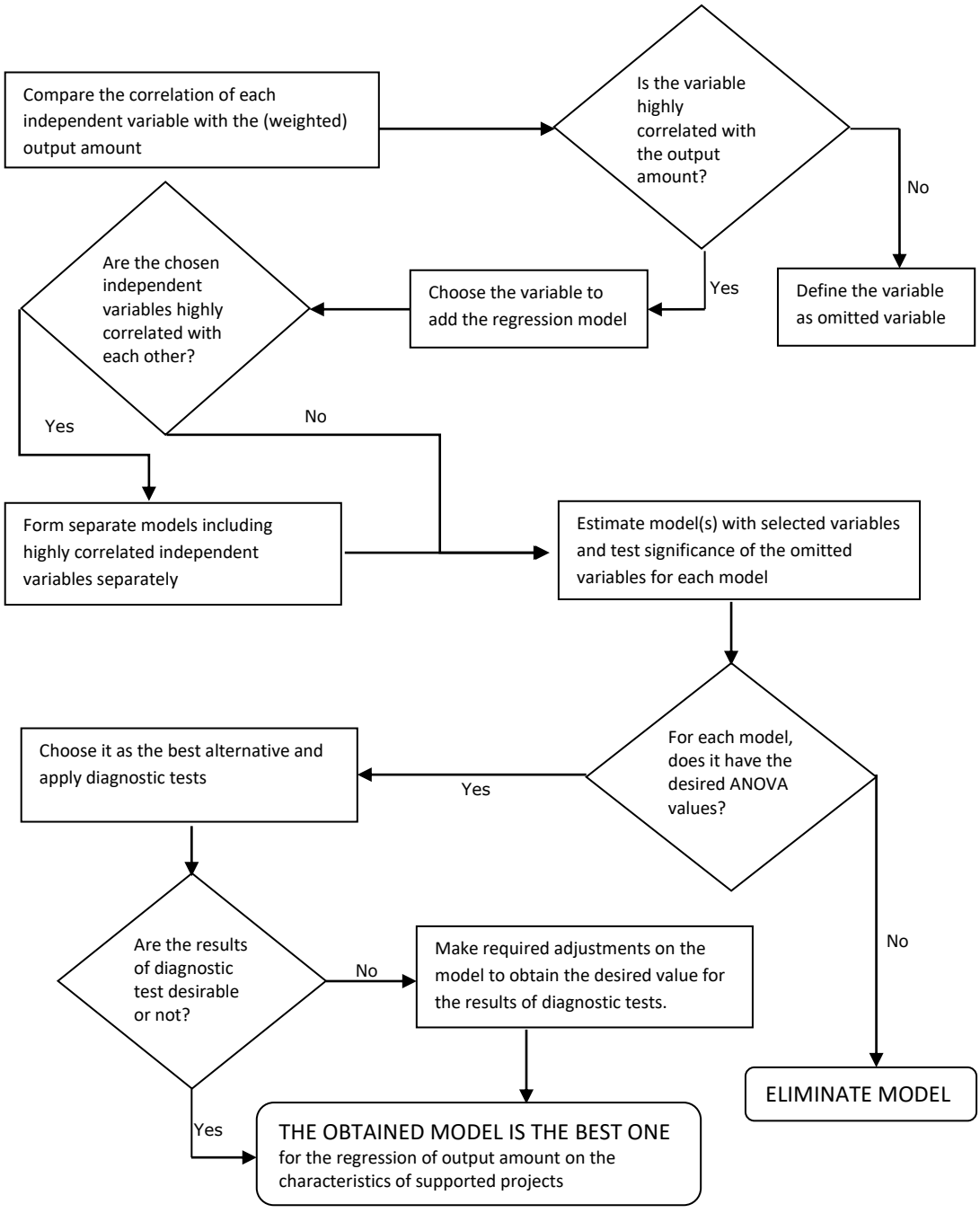

Figure 4.2: Flow chart of econometric analysis

4.3. Interviews

As the last stage, interviews are organized with the sample of coordinators. The interview consists of 4 main part; pre-project situation (other projects of the team members before this project, emergence of the project idea, studies of team members about the subject of this project and start-up TRL of the project), about the project (its impacts, methodological improvements, benefits and costs), about policy of the overall program (success and failure of the program with the suggestions) and post-project activities (projects of the team members after this project). The questions of the interview; especially the ones in the pre-project, about the projects and post-project part; are prepared by adapting the survey and interview questions used by Tandoğan (2011), Kim & Oh (2002) and those used in the report of the European Research Council (2012). Some additional questions related to the nature of this case, especially questions in the part of about the policy of the overall program, are also used in this exercise. Whole content of the interview questions is given in Appendix A.

The sample includes coordinators of 16 supported projects (both finalized and being in-process) having and not having outputs. The distribution of the projects, coordinators of which participate in interviews, according to the existence of output and the finalization situation is given in Table 4.4.

Table 4.4: Distribution of projects for which interviews are done according to finalization situation and existence of output

	Having Output	**Having No Output**
Being In-Process	5	4
Finalized	6	1

Projects of coordinators in the sample are distributed to each PTA and each year in proportion to the results of the descriptive analysis on program indicators such as gender of the coordinators, type of their institutions and the province. The distribution of coordinators in the sample with respect to characteristics of their projects is given in Table 4.5.

Table 4.5: Distribution of the coordinators participating in interviews

	ICT		ENERGY		HEALTH	
	MALE	**FEMALE**	**MALE**	**FEMALE**	**MALE**	**FEMALE**
Istanbul	2012 university 2015 university	2015 university	2012 university			2014 university
Ankara	---	2013 university	2014 university 2014 university	---	2012 university 2012 private inst.	2014 public inst.
Kocaeli			2013 public inst. 2015 public inst.	2013 public inst.		
Others*				2014 university (Eskişehir)		2013 university (İzmir)

The main target of this exercise is to detect not only output but also input, project and behavioral additionality of 1003 Grant Program from the perspective of stakeholders for different technology fields. The questions about the cooperation of the team members before and after the project are used to detect behavioral additionality with those about the opportunities and opportunity costs faced by the team members and the coordinator institution as a result of the project. The projects proposed by the coordinators to the funding programs of TUBITAK before and after the 1003 project are also questioned to find out the project additionality. Besides, there are also questions to reveal the output additionality in terms of both long-run impacts of the project, and their scientific contribution to the literature. The questions about the ability of the project to train new qualified researchers also enable the detection of the input additionality. Moreover, successes and failures of the program observed by the coordinators with their suggestions for improvement are also questioned. Benefits of the project not only for project team and coordinator institutions but also for the aims and targets of the related call are also examined.

The results are also used as inputs for other analyses conducted in this thesis. There are questions about how to rank the output types considering their

contributions to the related research areas and the 1003 Program. Considering these sequences, the obtained outputs are weighted according to their types and for each PTA. These weights are used as input for econometric analysis. In addition, answers given to the questions about the team members and outputs are used to verify the data retrieved from TUBITAK database.

4.4. The Data

Two different datasets are used for these exercises. The first dataset includes the information of projects proposed for the 1st and 2nd stage of the calls launched from 2012 to April 21st, 2017, retrieval date of the data. Data in this dataset are as follows:

- Type (1st/2nd stage and main/sub-project) and final situation (proposed, returned, rejected, supported, in-process, finalized, etc.) of projects
- Call, for which project is proposed
- Requested budget and scale of proposed projects
- Funding amount and duration of supported projects
- Information about the project team members (date of participation to and leaving from project, gender, institution, institution type, province)

The other dataset is about the outputs belonging to the supported 1003 Projects. It consists of the following information for each output:

- Type of the output (scientific paper, presentation, thesis, dissemination, patent application, book chapter, new project, prize, registration)
- Date of the output
- Project information to which output belongs

After discussing the methods which will be applied for this thesis with their aims and assumptions, results of these analyses are given and discussed with their comparison in the following chapter.

CHAPTER 5

COMPARISON AND DISCUSSION OF RESULTS

After the application of quantitative and qualitative methods explained in the "Methodology", their results are expressed, evaluated and argumentatively compared with each other.

5.1. Program Indicators

Situation of the R&D funding for the prioritized technology areas in Turkey is examined with the indicators of the 1003 Grant Program of TUBITAK. To achieve this, firstly calls launched in the scope of 1003 Program are analyzed in terms of their distribution to years and PTAs. PTAs and sub-technology programs on which calls are launched are also compared with the thematic priorities of other countries as benchmarking. Moreover, total and average numbers of proposed, supported and finalized projects are examined for each PTA. Their distributions with respect to scale, sub-project amount, type and province of the institution in which projects are conducted and gender of the coordinators are also investigated for each PTA. It is followed by the analyses on requested and given funds. In addition, it should be noted that average amounts are counted as project/funding amount per a call for each PTA. This part is finalized with the examination of outputs obtained from the supported 1003 projects, which is also an example of impact evaluation methods applied on funding programs in the literature. Both dataset expressed in the "Methodology" and retrieved from the TUBITAK database on April 21st, 2017 are used for this part of the study.

5.1.1. Launched Calls

Project proposals for 1003 Grant Program is taken by TUBITAK-ARDEB with the specific calls launched on PTAs of Turkey. The first 1003 call is launched in 2012. While these calls had been launched at any time in a year without a plan

before 2014, they have opened twice a year at predetermined dates since 2014.

In the scope of 1003 program, calls are launched not only for ICT, Automotive and Machine-Production, in which R&D capacity of Turkey is high, but also for Energy, Water, Agriculture, Health and Aerospace, in which acceleration is essential. Moreover, there are calls on the areas of Chemistry and SSH, which are chosen as PTA by SB of TUBITAK. On the contrary, there is no 1003 call for defense which is also a PTA requiring acceleration according to the NSTIS: 2011-2016. List of launched calls and the sub-technology areas to which they belong is given in Appendix C. Sub-technology areas are generally determined via foresight studies and workshops with the participation of governmental bodies and other stakeholders by using the bottom-up approach. Additionally, there are also sub-technology areas on which calls are launched for the needs of other governmental agencies in the direction of the protocols signed between them and TUBITAK. Projects supported under these calls are funded with the contribution and coordination of these institutions.

When PTAs and sub-technology areas are compared with thematic priorities of other countries expressed in the "Literature Review", it is seen that most of them are similar with the international trends since they mainly represent societal challenges. ICT, Health, Agriculture, SSH, Water and Energy are the areas prioritized by nearly all of developed and emerging countries. Production Technologies is chosen as prioritized area only by China and EU, which are relatively less developed countries. (Aero)space is, on the other hand, prioritized by two of developed countries: Japan and Canada. On the contrary, Automotive does not exist within the areas prioritized by the countries expressed in benchmarking. Moreover, there are also areas prioritized by many other countries, but not by Turkey directly, which are Transportation, National Defense, Public Security, Waste and Environment.

Under normal circumstances, 1003 projects can be small, medium or large-scaled according to their budget and duration. Budget of a small-scaled project can be up to ₺500.000 while duration of it can be up to 24 months. On the other hand, duration of medium and large-scaled projects can be up to 36 months and their budget can be up to ₺1.000.000 and ₺2.500.000, respectively. Medium and large-scaled projects can also include sub-projects up

to three. However, for some calls, there are some restrictions about the total funding budget, sub-project amount and scale of the projects which are stated in call texts. Below, these restrictions are analyzed in detail:

- Restriction on total funding budget for the call exists for only four calls. One of these is the first ICT call with at most ₺6.000.000 funding budget. It is about the FATIH project of the Ministry of National Education. Others are Energy calls about the boron technologies with at most ₺4.000.000 funding budget for each call. These calls are conducted with the coordination of Boron Institute. It should also be noted that budget restriction is not used for other 2 calls about FATIH project and calls on boron technologies launched after 2014.
- Restriction on minimum and maximum sub-project amount is used for 8 calls-1 Health call launched in 2014, 2 Water calls launched in 2015 and 2016, 2 ICT calls launched in 2017 and 3 SSH calls launched in 2016 and 2017.
- Scale of the proposed projects is restricted for 12 calls; 4 ICT calls and 8 Energy calls launched in miscellaneous years.

Until the time that the data was retrieved, 166 calls had been launched under the scope of the 1003 Program. It should be noted that, calls launched in 2017 should have been launched in 2016, but it was postponed due to the unpreventable and unpredictable obstacles. Thus, year of these calls is revised as 2016 and analyses are done according to this change. In addition, evaluation of the projects proposed to these calls had not been completed by April 2017.

As seen in Figure 5.1, ICT, Energy and Health are the areas for which the highest amount of calls were launched, while Aerospace, Chemistry and Machine-Production are the ones with the lowest call amounts. Low call amounts for Aerospace, Chemistry, Machine-Production and SSH is not surprising as calls have been launching for these areas since 2015. However, relatively lower amount of call for Automotive, having been launching since 2012, is interesting. The reason might be that there are not so many sub-technology areas and subjects on which an extensive R&D study needs to be conducted, since it is the PTA in which Turkey is strong. Another reason might be that this area is not preferred by stakeholders to study during foresight studies and workshop. This might be due to the its intensive requirements for

the technological infrastructure and machinery-equipment investment, which could not be provided with the funding limit of 1003 Program. Being not preferred globally to study on can also be the reason of having fewer number of call for Automotive.

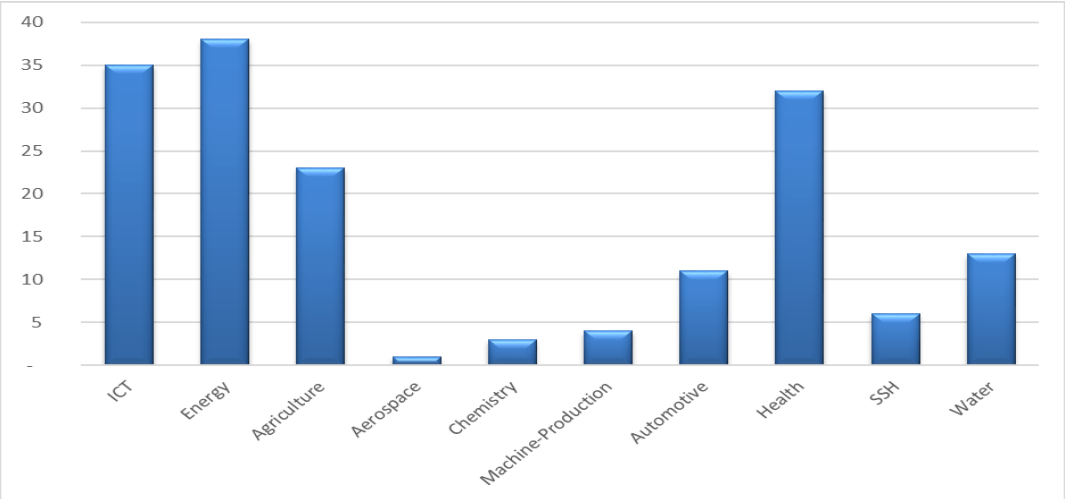

Figure 5.1: Number of calls launched for each PTA

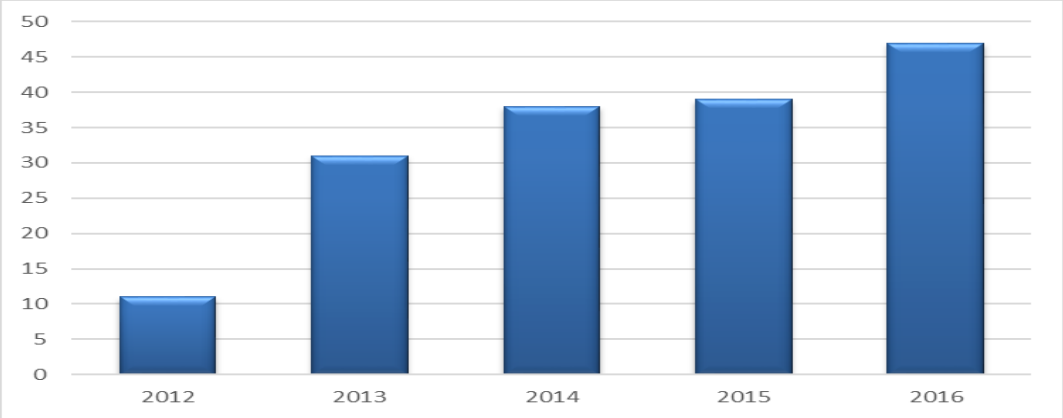

Figure 5.2: Number of calls launched for each year

From Figure 5.2, it is seen that the number of calls launched in a year is increasing over time. The main reason of the increase in the call amount after 2015 is probably that calls beginning to be launched for the areas of Chemistry, Machine-Production, Aerospace and SSH since then. However, much higher increase is observed in call amount for 2013, 2014 and 2016, although there is

not any new technology area for which calls begin to be launched. This rise might be due to the expansion and deepening of studies on the existing PTAs in terms of both sub-technology areas and call subjects.

5.1.2. Projects

Figure 5.3 indicates that total project proposal amounts of PTAs are generally consistent with their number of calls, if it is compared with Figure 5.1. Health, ICT and Energy, having the highest amount of calls, are also the PTAs with the highest project proposal amount. Average number of projects proposed for a call, however, is the highest for Chemistry and SSH. The reason of this fact is probably that these areas are relatively newer and they have fewer amount of call. However, average proposal amount for aerospace and machine-production is oppositely low, although these areas are also new ones with lower number of calls. This situation might be due to lower amount of researchers in Turkey, studying on these subjects.

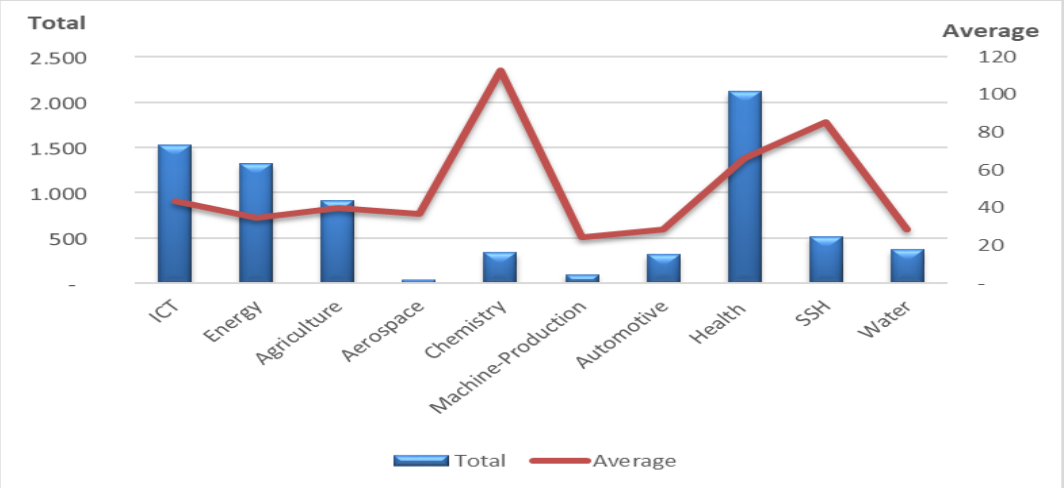

Figure 5.3: Total and average number of proposed projects for each PTA

Projects are proposed to 1003 Grant program with 2 stage. Projects having R&D characteristics and providing the main aims and targets of calls with their special considerations pass the 1st stage and take the right of applying for the 2nd one.

Figure 5.4 states that the rate of passing first stage is generally between 50% and 60%. However, the projects proposed to SSH, Agriculture and Aerospace calls have the lowest rate of passing first stage with approximately 20%, 30% and 40%, respectively. This means that projects proposed to the calls of these areas are less related to the aims and targets of the call or they do not have R&D project characteristics defined in the Frascati Manual of OECD. In addition, being far away from the bureaucracy and regulations may also results in such situation, especially for Aerospace having more project proposals from the private sector as seen in Figure 5.10. Besides, non-existence of researchers being able to specialize in the features and expectations of 1003 Grant Program and having the experience on 1003 might be another reason of such situation. This reason may especially be valid for the SSH projects since calls of this area are launched much more recently than those of others.

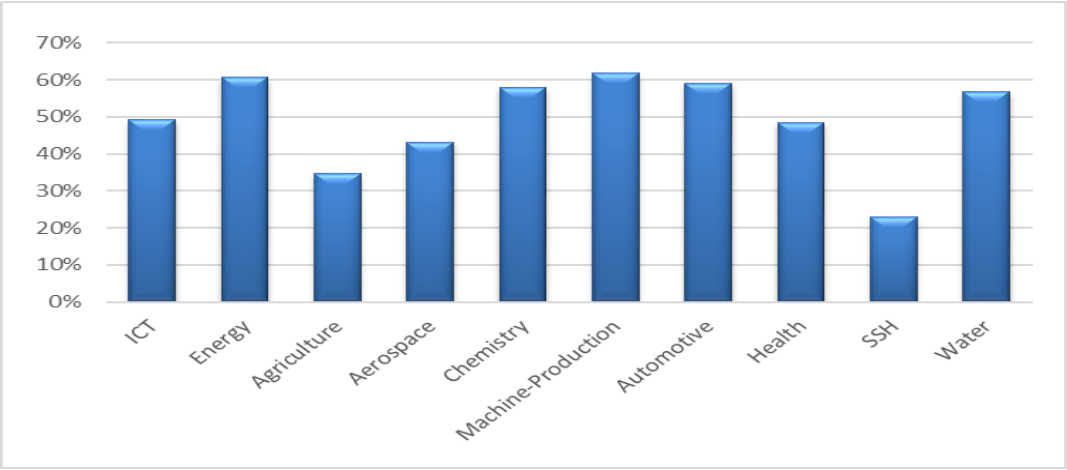

Figure 5.4: Rate of project passing first stage for each PTA

In the 2nd stage, projects are evaluated deeply by using peer-review method with respect to their originality, feasibility, widespread impact, methodology and convenience with aims and targets of calls. Projects getting points above the predetermined threshold are supported with the approval of TUBITAK's President.

At this point, it should be noted that success rates are the rate of supported projects to the proposed ones at 2nd stage. The reason of using 2nd stage project proposal amounts rather than 1st stage ones is that it is aimed to use

projects really related to the aims of the calls and the ones being consistent with the Program in order to reach the more reliable and realistic values.

Figure 5.5 shows the distribution of supported projects to PTAs and average supported project amount per a call for each PTA. It is seen that these values are lowest for the PTAs which are relatively new, except the average supported project amount of Chemistry. Health, having relatively higher call and average project proposal amount, is the area with the highest total and average supported project amount.

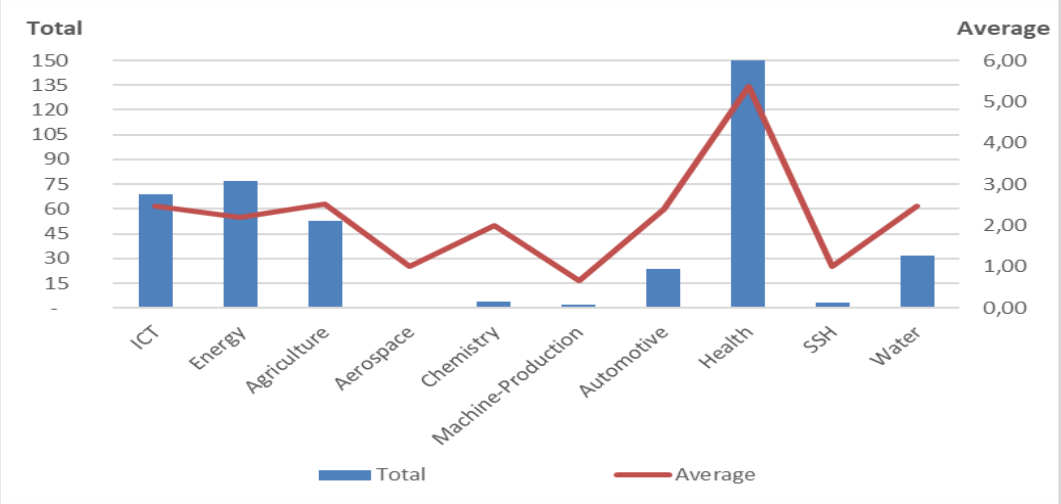

Figure 5.5: Total and average number of supported project for each PTA

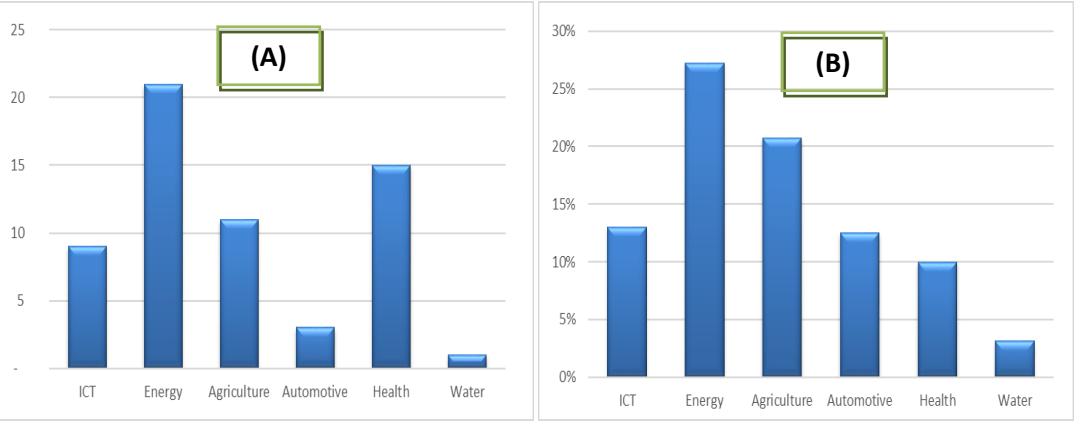

Figure 5.6: Number of finalized projects (A) and finalization rate of supported projects (B) for each PTA

As seen in Figure 5.6 and Figure 5.7, only few projects are finalized. The highest finalization rate belongs to projects proposed to calls launched in 2012 with approximately 51%. Thus, the areas, calls of which are launched relatively earlier, have higher finalization rate, such as Energy with the rate of 27% approximately. It is also indicated that there is no finalization project for the calls of Aerospace, Chemistry, Machine-Production and SSH, projects of which had not started yet by the time the data was retrieved.

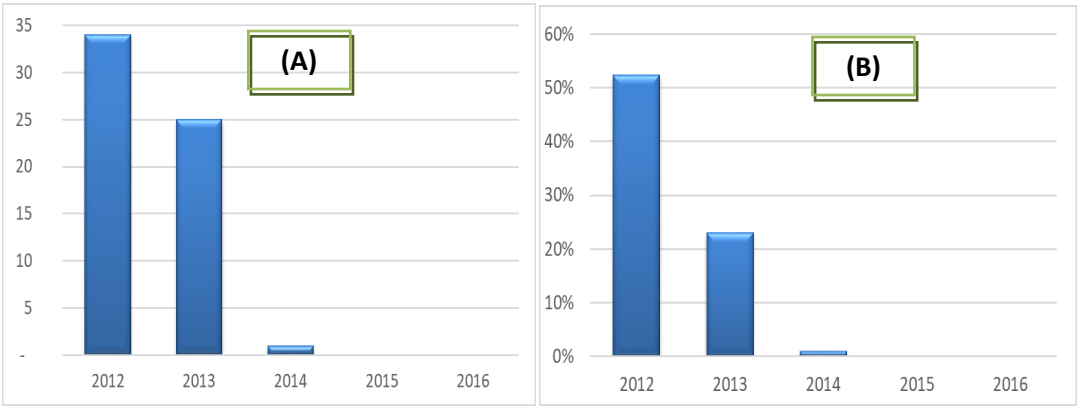

Figure 5.7: Number of finalized projects (A) and finalization rate of supported projects (B) for each year

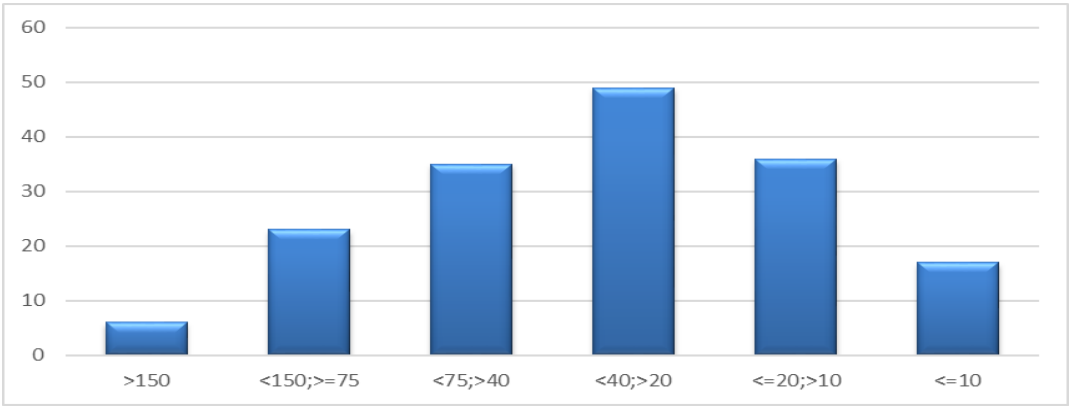

Figure 5.8: Number of calls having total number of project proposals within given intervals

Figure 5.8 asserts that number of projects proposed for a call has a large range from more than 150 to less than 10. Such a wide range could be a conclusion of the difference in the existing number of qualified researchers which can be

applied for 1003 program for different technology areas. Increasing amount of calls launched in the same area while the number of researcher is constant could also be a reason of this situation.

Similarly, number of supported projects for a call has also large range, as seen in Figure 5.9. This means that applying the same evaluation and supporting criteria for all calls affect the supporting rate of calls differently since not only the experience and competence of researchers working on those areas, but also the expectation of calls is different for each call.

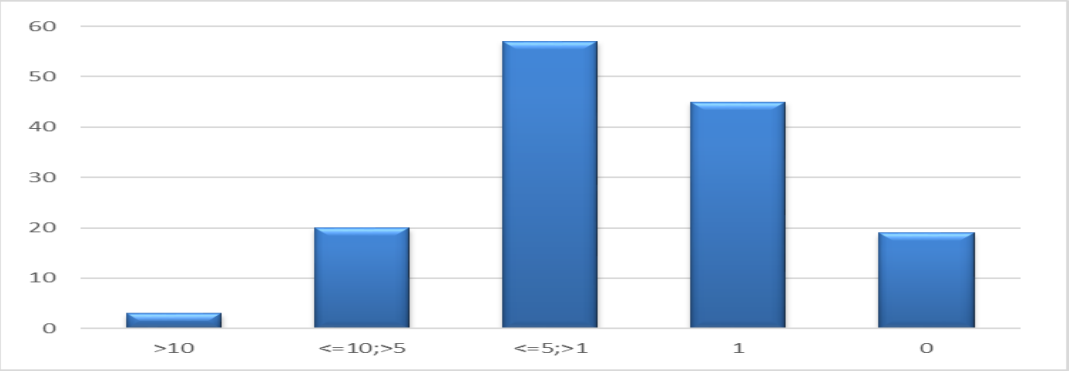

Figure 5.9: Number of calls having total number of supported projects within given intervals

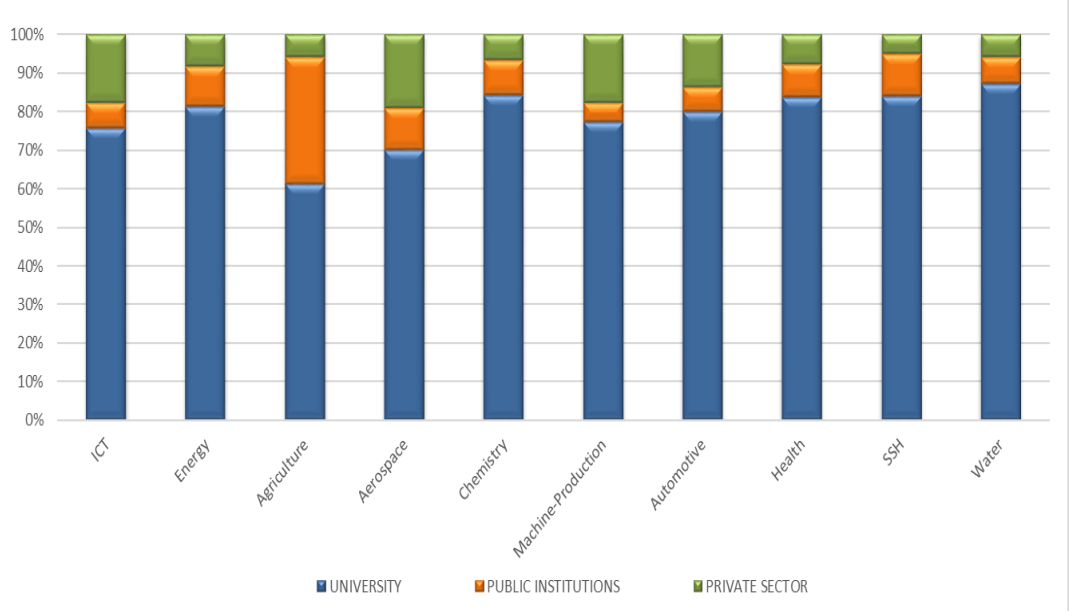

Figure 5.10: Distribution of project proposals with respect to the institution types for each PTA

Figure 5.10 states that distribution of project proposal amounts with respect to each institution type are similar for different PTAs, with some exceptions. For instance, share of public institutions is higher and that of university is lower for Agriculture than for other areas. This is due to the existence of General Directorate of Agricultural Research and Policies, and Food Institute of TUBITAK conducting R&D studies on Agriculture as the major representatives of the public research institutions in Turkey working on this area with their high competence. Besides, share of the private sector is higher for the areas of ICT, Automotive, Machine-Production and Aerospace. It is reasonable since the private sector intensely engages with these areas in Turkey. However, fewer applications from the private sector for Energy calls, the area on which private sector is also intensely work in Turkey, is questionable. Likewise, researchers from the public institutions do not generally prefer applying 1003 program for Health and SSH calls despite the active role of those institutions on these areas. This might be because such institutions are engaged with these areas not for R&D, but for marketing and trading purposes.

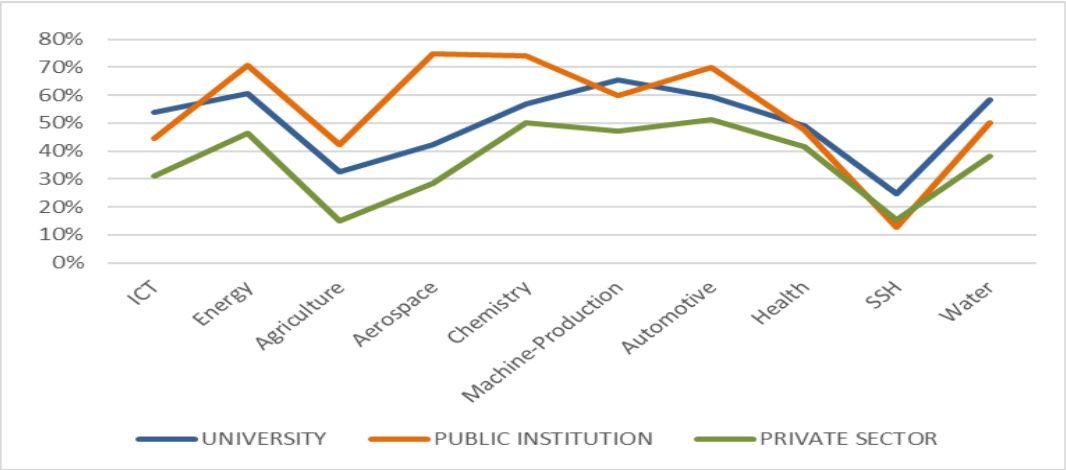

Figure 5.11: Rate of project passing first stage with respect to institution types for each PTA

It is seen in Figure 5.11 that projects from the public institutions has the highest rate of passing 1st stage for Energy, Agriculture, Aerospace, Chemistry and Automotive. This shows that public institutions from which projects are proposed are specialized sufficiently on the subjects of these calls, and so they

could propose the projects mostly related to the calls. For ICT, Machine-Production, SSH and Water areas, on the other hand, projects proposed from universities has higher rate. This might be due to the lack of public and private institutions specially working on these areas. Success rates of the projects with respect to institution types, given in Figure 5.12, also promote this idea for Machine-Production and SSH since there is no supported projects from public and private sector institutions for these areas.

If Figure 5.11 and 5.12 are compared, it is also inferred that for Automotive and Energy, projects of public institutions, specialized on this area, are not qualified as those of universities and private sector due to their lower success rate. For Chemistry and ICT, on the other hand, private sector projects having the highest success rate despite their lower rate of passing first stage indicate that they are much more qualified than those of universities and public institutions.

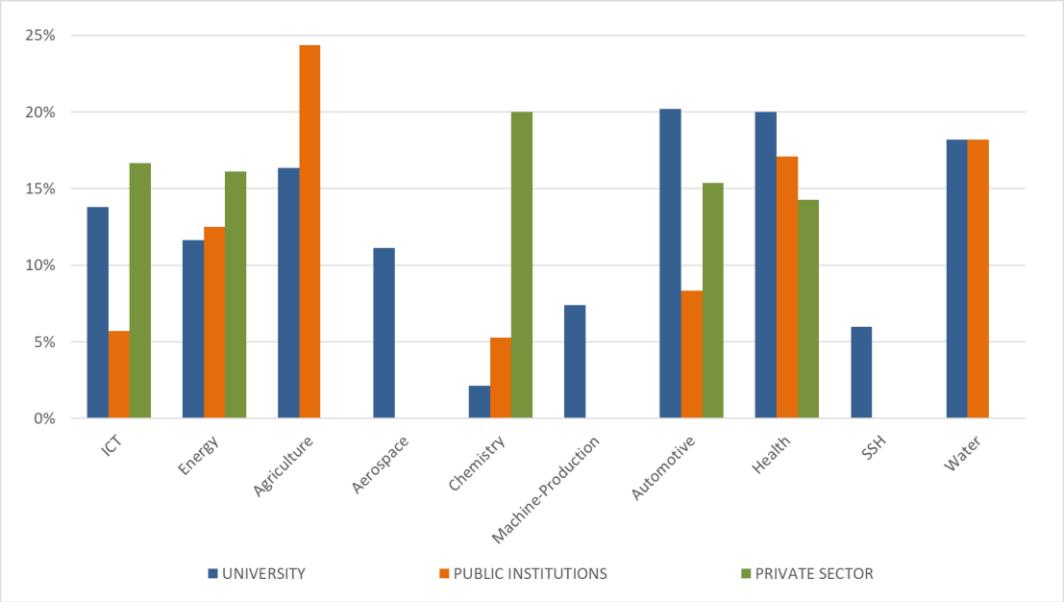

Figure 5.12: Success rate with respect to institution types for each PTA

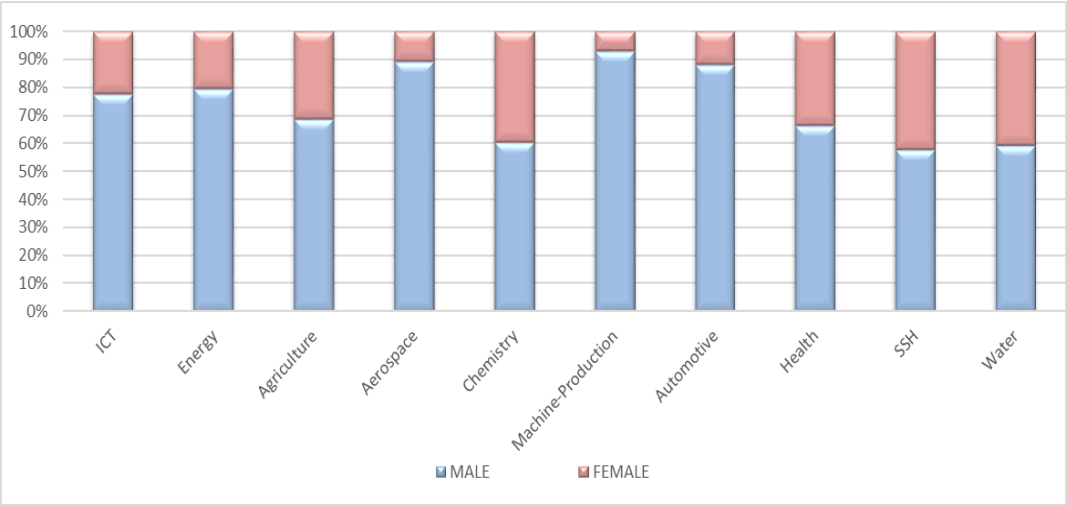

Figure 5.13: Distribution of project proposals with respect to genders of their coordinators for each PTA

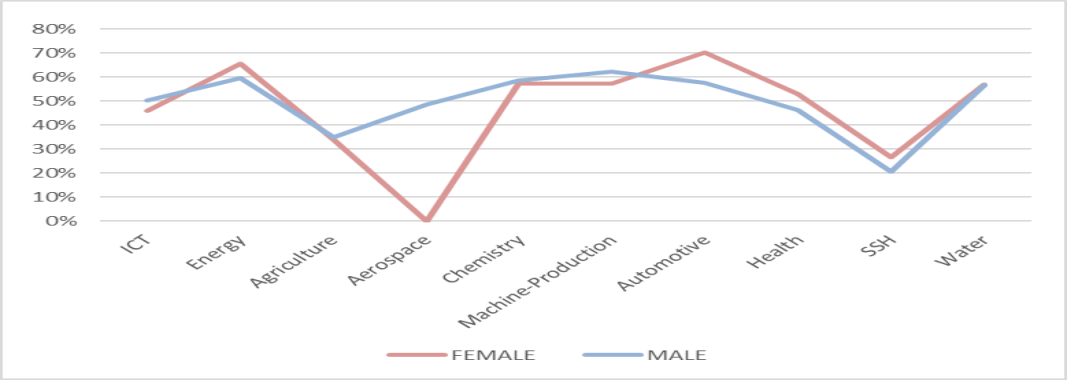

Figure 5.14: Rate of project passing first stage with respect to genders of their coordinators for each PTA

Figure 5.13 indicates that men have more project proposals than women in the scope of 1003 Program. Even, for Aerospace, Automotive and Machine-Production calls, there is nearly no women as coordinator, which is consistent with the intensity of female researchers studying on these areas in Turkey. However, both projects of males and females have approximately the same passing first and the success rates for nearly all PTAs (Figure 5.14 and 4.15). In fact, for automotive calls, rate of passing first stage is 10% higher for women. This is interesting since Automotive is male-dominated sector in Turkey and more than 90% of project proposals belong to males in this area, as seen in

Figure 5.13. For Machine-Production calls, on the other hand, equal passing first stage rate is dominated by much higher success rate of males.

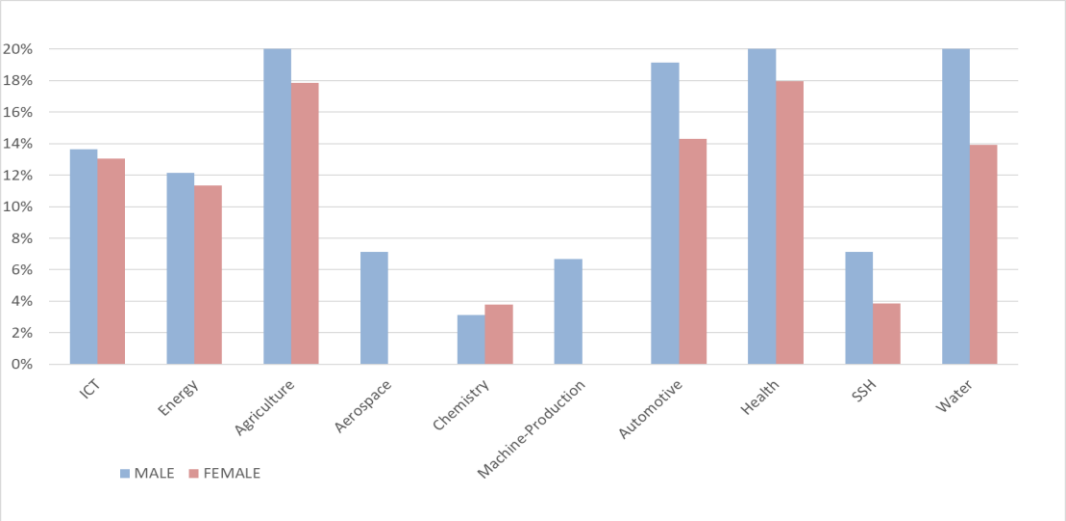

Figure 5.15: Success rate with respect to genders of their coordinators for each PTA

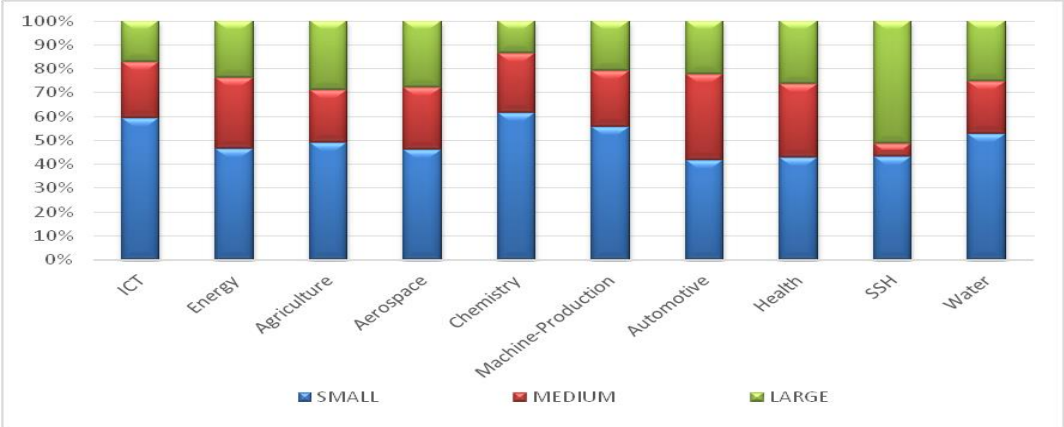

Figure 5.16: Distribution of project proposals with respect to scale for each PTA

According to the Figure 5.16, small-scaled project proposals range from 40% to 60% of overall projects and constitute the majority of them for all PTAs, except SSH. Fewer small-scaled projects for SSH is interesting since the machine-equipment cost, which is generally the highest component of the budget, must be lower for the projects of this area. On the contrary, small-scaled projects

dominates the project proposals for ICT and Machine-Production projects, machine-equipment costs of which must be high. The same analysis on supported projects indicates that majority of supported projects are also small-scaled, except Agriculture, Health and Water. Even, supported Aerospace projects are all small scaled (Figure 5.17).

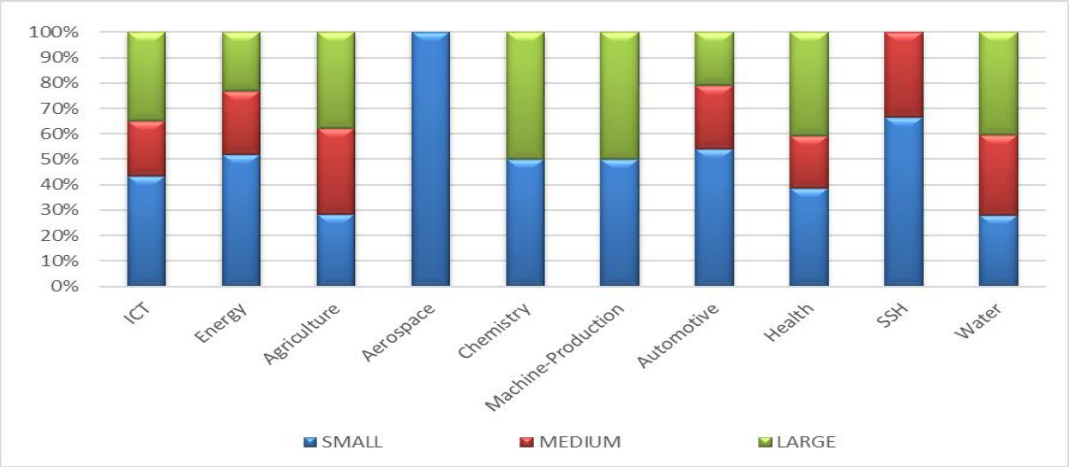

Figure 5.17: Distribution of supported projects with respect to scale for each PTA

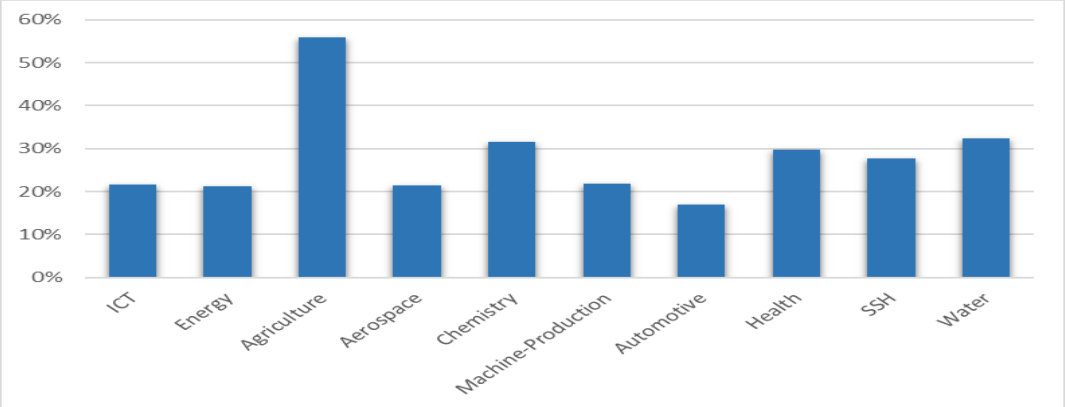

Figure 5.18: Rate of projects having sub-project to 2nd stage project proposals for each PTA

As stated before, medium and large-scaled projects may have sub-projects up to three unless any other restriction exists in the call text. Figure 5.18 analyzes the projects having sub-projects. These projects are detected from 2nd stage

proposals since the information about whether a project has a sub-project or not is not available for the first stage. According to the data, it is seen that the rate of having sub-project approximately range from 20% to 30% for all PTAs, except Agriculture. This result indicates that issues in call texts about the obligation of having sub-project or restriction on sub-project amount for medium-scaled and large-scaled projects do not affect the overall statistics. For ICT; Health and Water cases, this may be because the rate of calls having such obligation or restriction is too low. It can also be argued for other PTAs having such restrictions that this situation prompts researchers to propose small-scaled projects rather than medium and large scaled ones. The rate of medium and small scaled project proposals given in Figure 5.16 and distribution of project proposals according to sub-project amounts shown in Figure 5.19 below promote this claim.

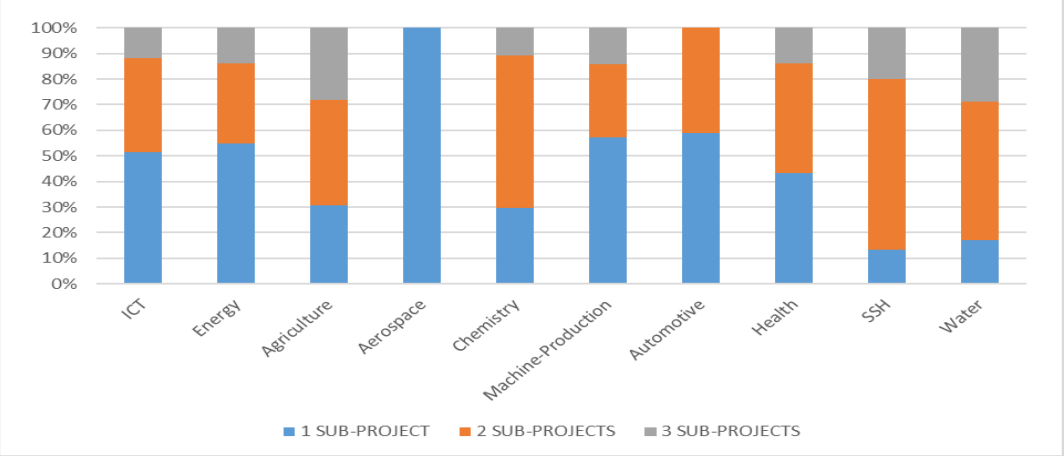

Figure 5.19: Distribution of project proposals having sub-project with respect to their sub-project amount for each PTA

It is seen in Figure 5.19 that the rate of projects having 3 sub-projects does not change much with PTA while those of others fluctuate so much. Rate of project having 1 sub-project is the lowest and that of projects having 2 sub-projects is the highest for SSH, Water and Chemistry projects. If the restriction on minimum sub-project amount for three of SSH and two of Water calls is considered, it is seen that researchers prefer proposing project having as few sub-project as possible. The reason of this might be the additional bureaucratic

procedures during application and operation processes for the projects having sub-projects and the difficulties in the management of a project having crowded team in multiple institutions.

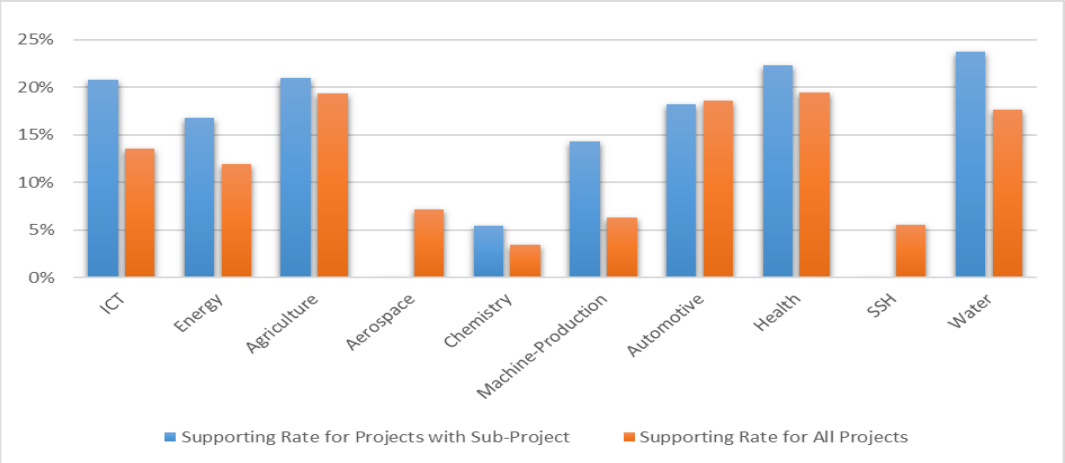

Figure 5.20: Success rate of all projects and projects having sub-project for each PTA

Figure 5.20, shows the supporting rate of all projects and projects having sub-projects for each PTA. It should be noted that these rates are computed by dividing the number of supported projects by that of proposed ones in 2nd stage. If the low passing first stage rate of Agriculture projects and the high one of Energy and Machine-Production projects are considered, Agriculture projects become less successful while success of Energy and Machine-Production projects increases. Moreover, having sub-project is more advantageous to get support from 1003 Program for all PTAs, except Automotive, Aerospace and SSH, the last two of which have no supported projects with sub-projects.

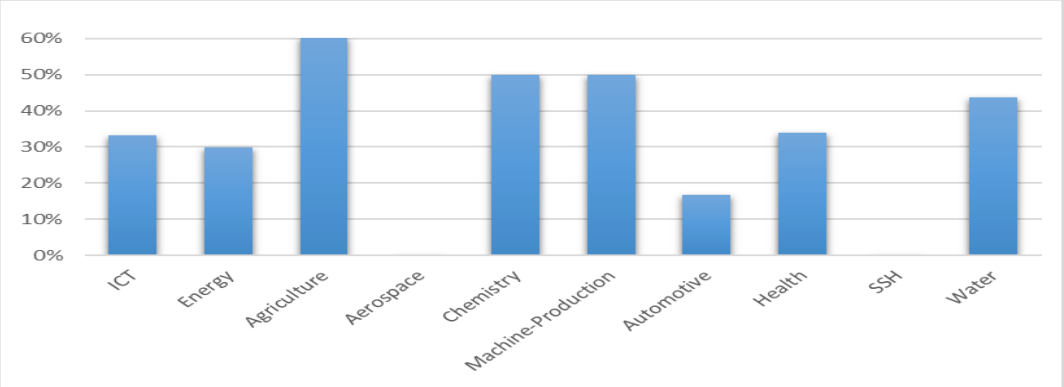

Figure 5.21: Rate of projects having sub-project to supported projects for each PTA

The rate of projects with sub-projects among the all supported projects is low for majority of PTAs, except Agriculture, Chemistry, Machine-Production and Water calls, as seen in Figure 5.21. Moreover, Figure 5.22 indicates that the success rate of projects having different sub-project amount differs with PTAs. For Energy and Automotive calls projects having 3 sub-projects are more successful while those having 1 sub-project are supported more for Agriculture calls. If restrictions on existence of sub-projects and their amounts are considered, it can be concluded that these restrictions are not effective with the same degree for all PTAs in terms of increasing the success rate of projects. Thus, restrictions on sub-project amounts should be different for each PTA to increase their effectiveness.

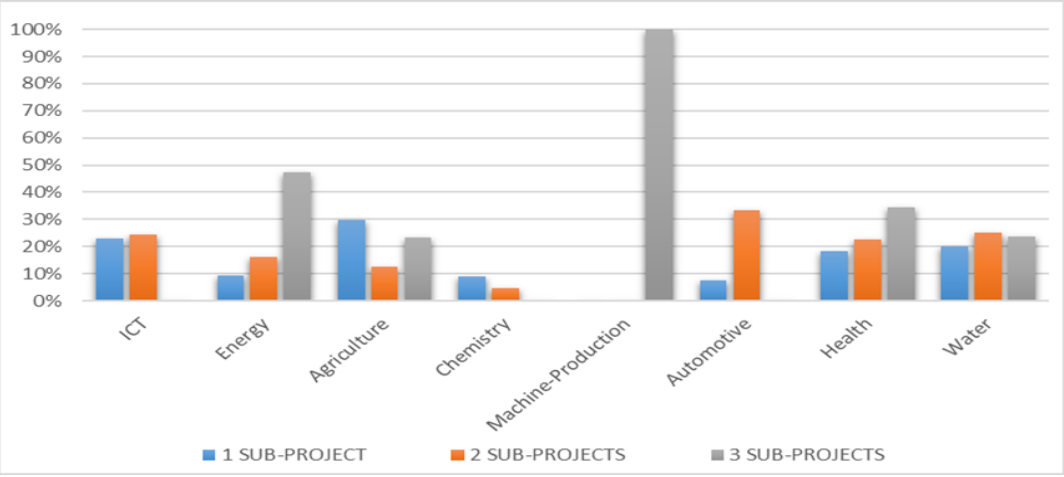

Figure 5.22: Success rate of projects having sub-project with respect to their sub-project amount for each PTA

If Figure 5.23 is compared with Figure 5.19, it is seen that distribution of supported projects having sub-projects with respect to sub-project amounts are not proportional with that of proposed projects for Machine-Production, Energy, Chemistry and Automotive calls.

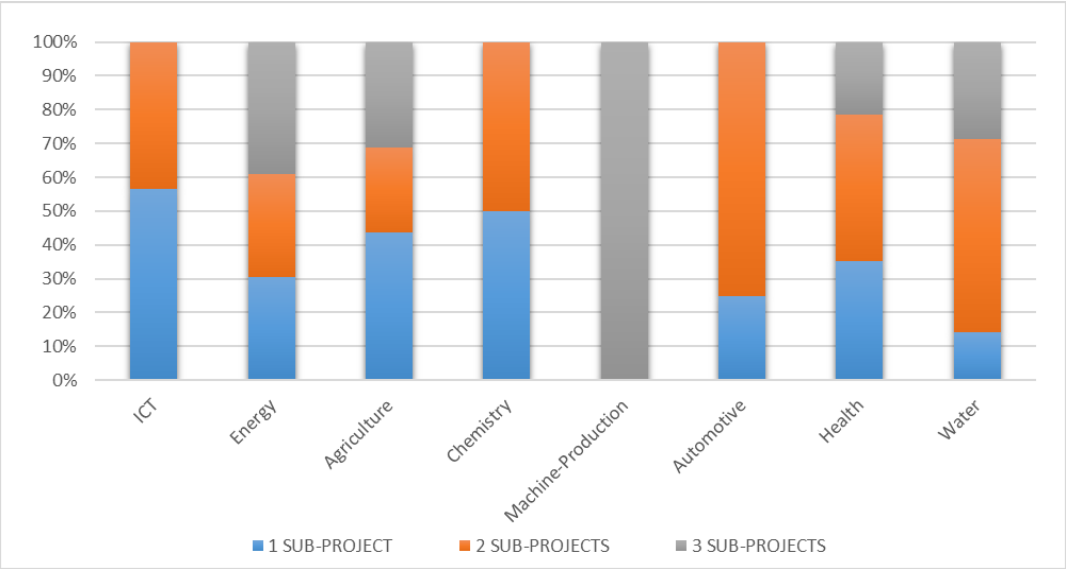

Figure 5.23: Distribution of supported projects having sub-project with respect to their sub-project amount for each PTA

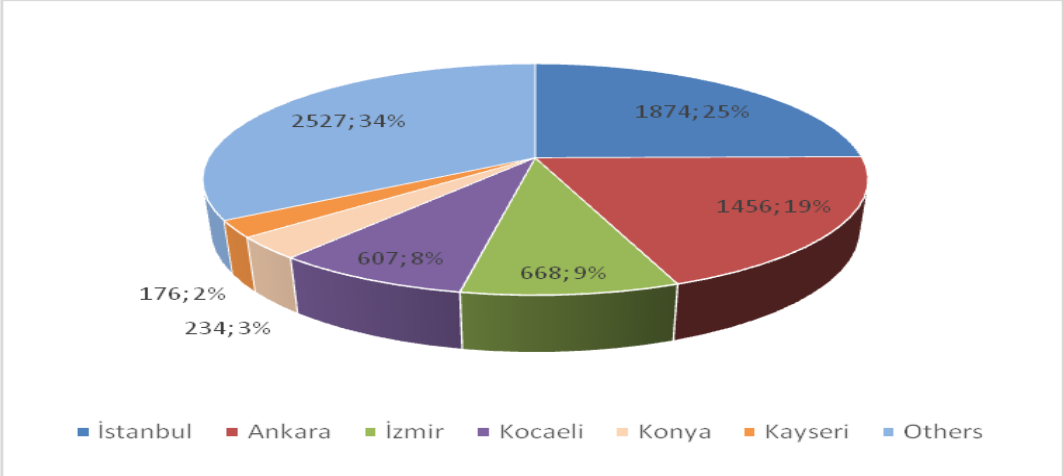

Figure 5.24: Number and distribution of the project proposals with respect to province of their coordinator institution

Majority of the 1003 projects are proposed from the three provinces having the highest population -Istanbul, Ankara and İzmir- and from Kocaeli, in which industry density is the highest. Konya and Kayseri, in which many universities and industrial firms are located, follow these cities. (Figure 5.24)

Figure 5.25 indicates that projects proposed from these cities have nearly the same rate of passing first stage, except Kocaeli and Konya. Projects proposed from Kocaeli are more related to the call aims and more consistent with the characteristics of R&D projects. However, this situation is opposite for the projects proposed from Konya.

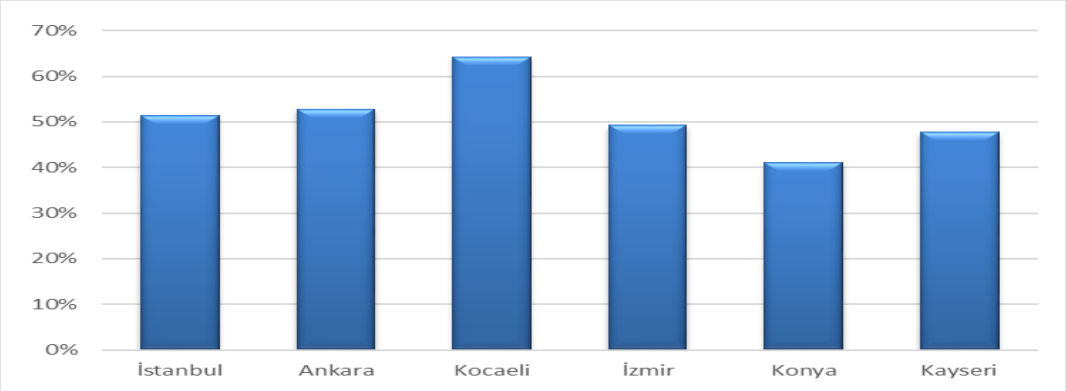

Figure 5.25: Rate of project passing first stage for the provinces having the highest number of project proposals

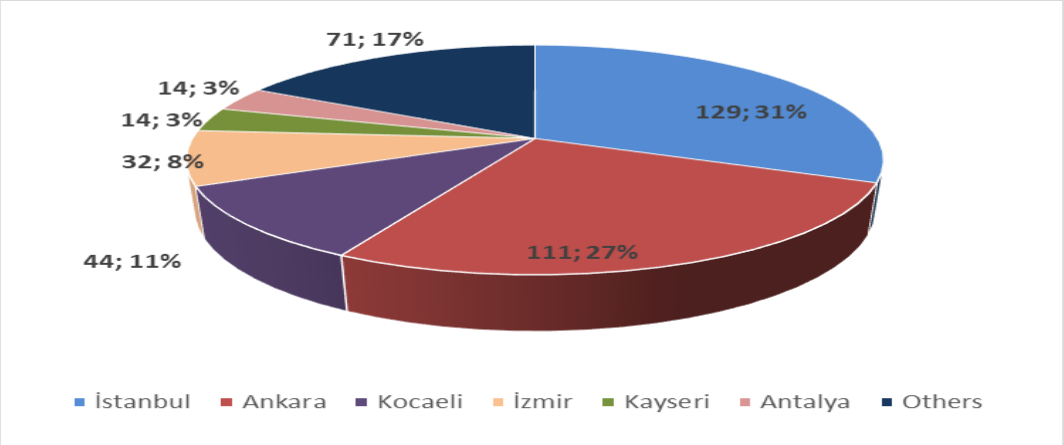

Figure 5.26: Number and distribution of supported projects with respect to province of their coordinator institution

If Figure 5.26 is compared with Figure 5.24, it is observed that order of the cities with respect to the number of proposed and supported projects from them are nearly the same except Kocaeli and Kayseri. If the rates of passing first stage given in Figure 5.25 are also considered, it can be inferred that at supporting stage, having the highest rate of passing first stage may create an advantage for Kocaeli to be more successful than İzmir while the opposite is also true for the projects proposed from Konya.

When the success rate of projects proposed from the provinces having the highest number of supported projects are compared, it is observed that the provinces having the highest number of project proposals are not as successful as Antalya and Kayseri and Samsun. Istanbul, Ankara and Kocaeli fall behind Antalya and Samsun while Kocaeli and İzmir also fall behind Kayseri (Figure 5.27).

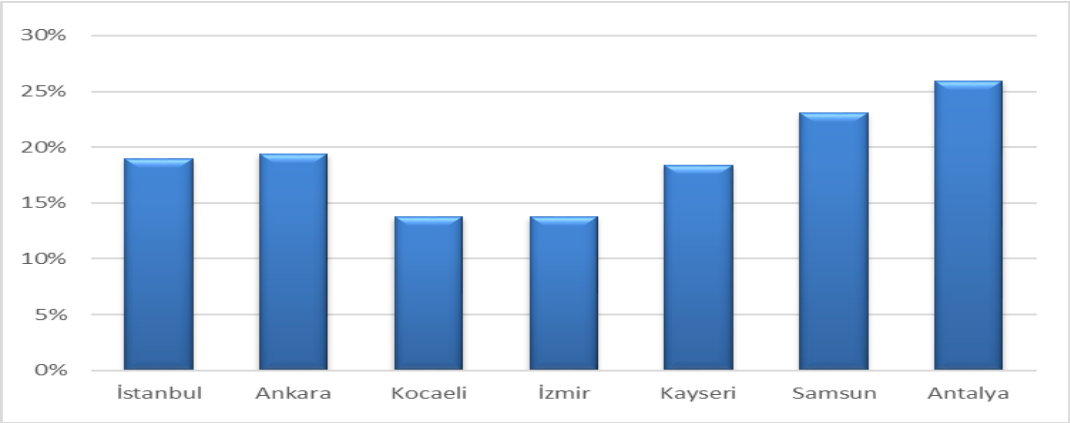

Figure 5.27: Success rate of projects from the provinces having the highest number of supported projects

Figure 5.28 asserts that majority of the finalized projects are from Istanbul and Ankara, the cities with the highest population while they are followed by İzmir, Kayseri and Kocaeli, which are also important provinces in terms of population and economic activities.

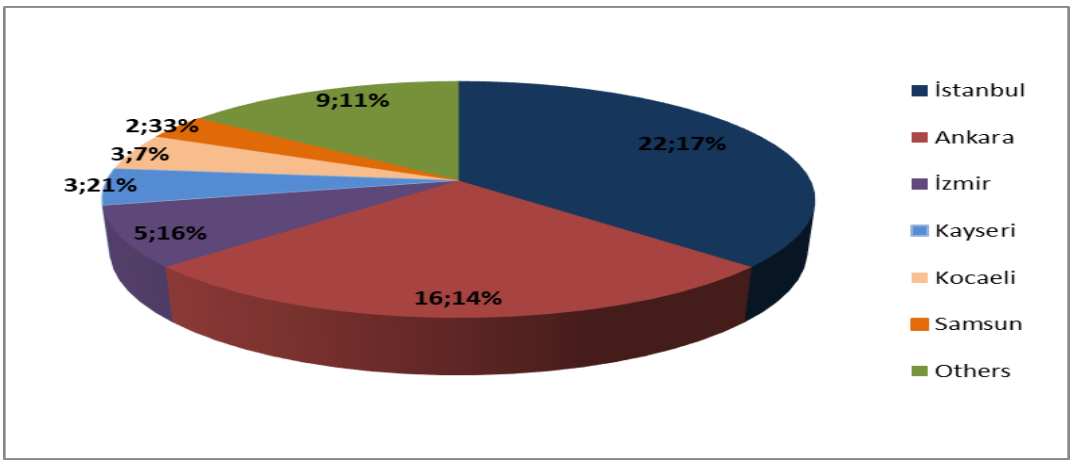

Figure 5.28: Number and distribution of finalized projects with respect to province of their coordinator institution

5.1.3. Funds

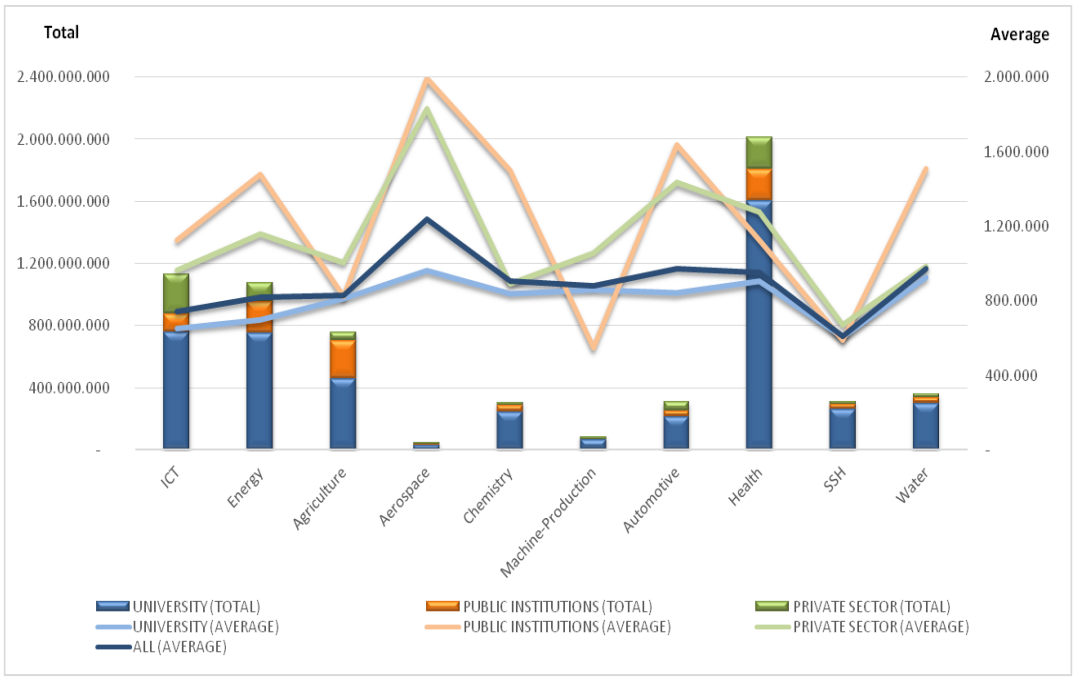

Figure 5.29: Total and average amount of fund requested for proposed projects with respect to institution types for each PTA

According to Figure 5.29, the average requested budget of projects proposed from each institution type differs with PTAs. These differences are similar with that observed for the average requested budget of all projects, except machine-production projects from public institutions and Automotive and Agriculture projects from universities. Moreover, the average requested budget of projects proposed from public and private institutions are relatively much higher than that of other projects for Energy, Aerospace and Automotive. From the total budget perspective, on the other hand, it is indicated that for each institution types, areas having the highest value are the same with ones having the highest amount of proposed projects, given in Figure 5.10. Besides, distribution of the total requested funding to institution types is proportional with that of total project proposal amount, for all PTAs. In addition, requested budget of projects from universities constitute the largest part of the total one for all PTAs while that of projects from private sector has the lowest share for all PTAs except ICT.

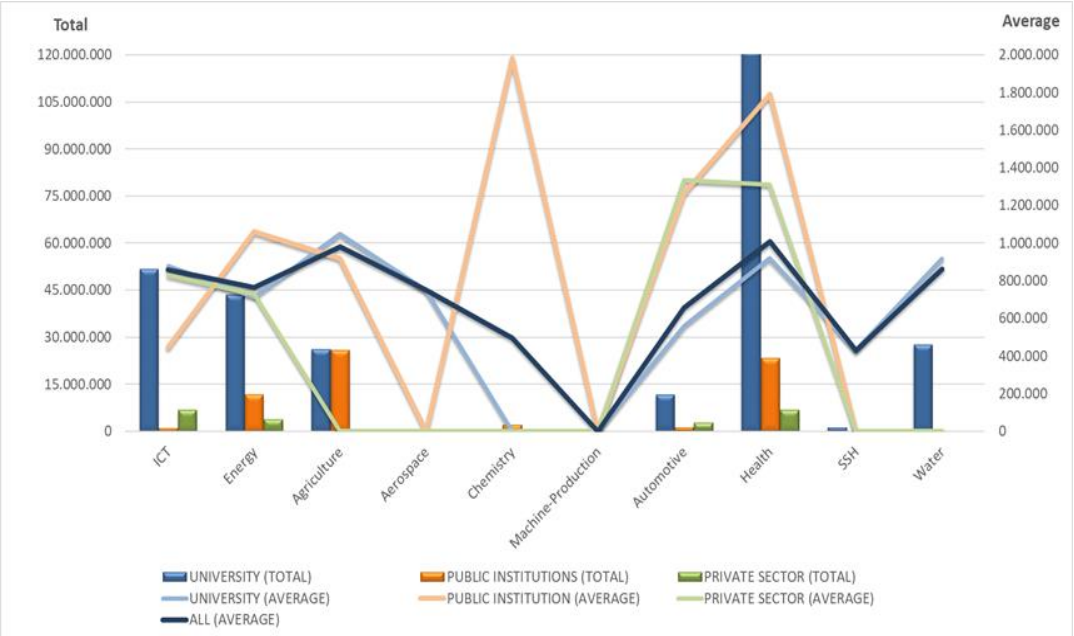

Figure 5.30: Total and average amount of fund given to supported projects with respect to institution types for each PTA

Figure 5.30 indicates that the average funding amount given to the projects from universities is nearly the same with that given to projects from all

institutions. However, the average funding amount given to the projects from other institution types follows a quite different pattern. In addition, for Aerospace, Chemistry, Machine-Production and SSH projects and for Water projects from public institutions, no fund has been given yet as these projects had not started when the data was retrieved.

It is expected that the given funds for the projects from private sector should be higher due to the payments of project team included in the budget, but it is not the case except for Automotive and Health. Even, average funding amount of public institutions is higher than that of private ones for Health projects. The reason of this situation is probably that project budgets are dominated by machinery & equipment costs since only 50% of these costs are funded for the projects proposed from private sector.

When the total amount of given funds are compared with that of requested funds, given in Figure 5.29, it is observed that the distributions of these two values with respect to institution types are proportional with each other. Similarly, proportions of the average given funds with respect to institution type are similar with those of average requested funds, as seen by considering the success rates (Figure 5.20). Moreover, it is observed that average amount of given funds are lower than that of requested ones for all PTAs, especially for Aerospace, Chemistry, Automotive and SSH.

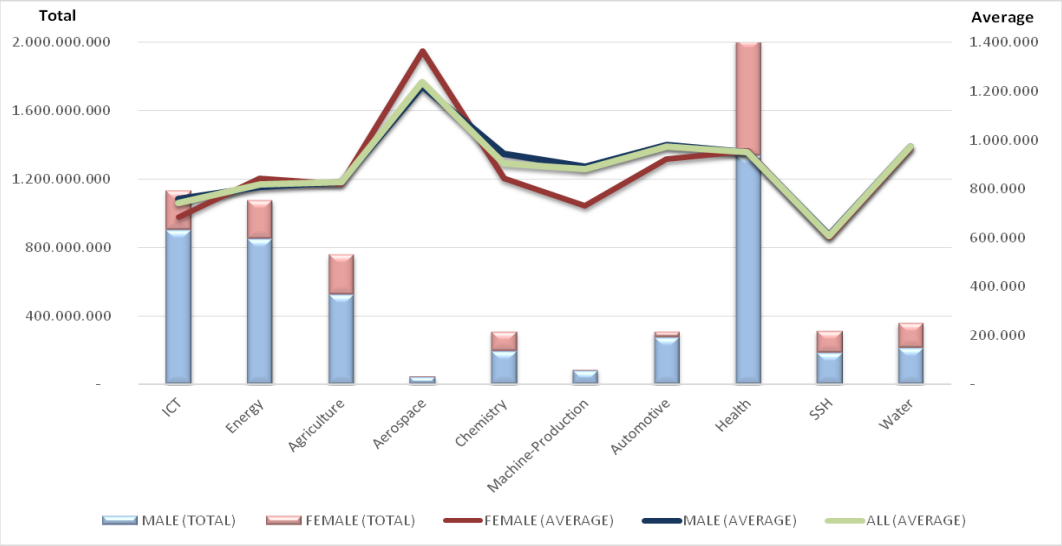

Figure 5.31: Total and average amount of fund requested for proposed projects with respect to gender of their coordinator for each PTA

According to Figure 5.31, although the total requested budget of projects proposed by men is higher for all PTAs, average requested budget of projects proposed by men and women are generally the same for all PTAs except Aerospace and Machine-Production.

Figure 5.32 indicates that this situation is also valid for funds given to the supported projects, with some exceptions. The average value of funds given to supported projects of females is higher for Water projects and lower for ICT and Health projects. It should be noted that the values of Aerospace having no supported and so started projects proposed by a woman, those of Chemistry having no started projects proposed by a man and those of Machine-Production having no started projects are ignored.

If Figure 5.31 is compared with Figure 5.32, it is seen that the average value of given funds is higher than that of requested ones for ICT, Agriculture and Health while it is lower for Aerospace, Chemistry, Automotive, SSH and Water. In addition, it is observed that the average funding amount of projects proposed by women falls below that of all projects after being supported for Energy and Health calls. For Water calls, on the other hand, the opposite case is seen.

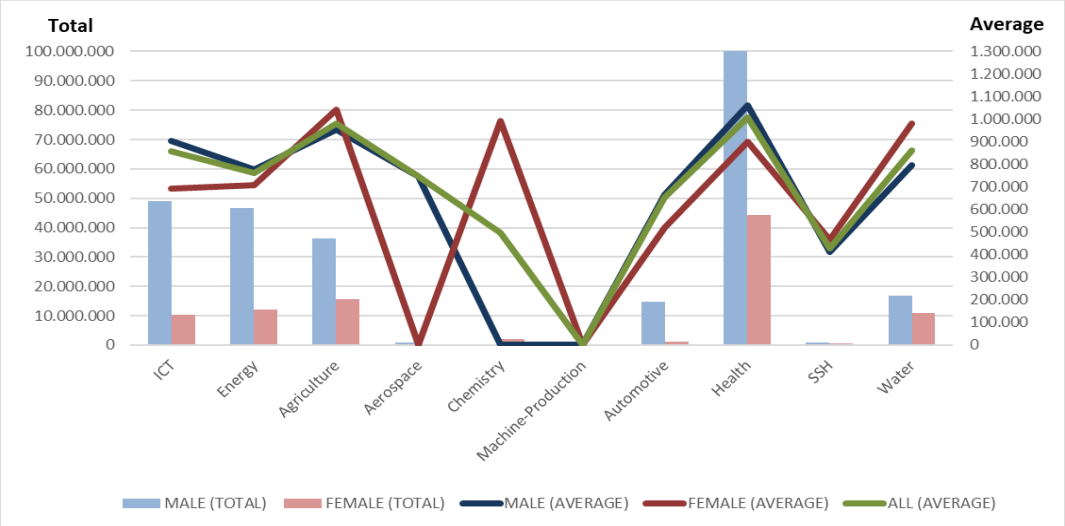

Figure 5.32: Total and average amount of fund given to supported projects with respect to gender of their coordinator for each PTA

Average funding amount requested for projects proposed to a call, could be more than ₺1.250.000 or less than ₺500.000, but majority of the calls belong to the interval of ₺750.000-₺1.000.000 (Figure 5.33). Although average of requested funds is within the limits of medium scale for majority of the calls, projects proposed as medium scale constitute only 25% of all projects on average, as seen in Figure 5.16. This means that for the projects proposed to the same call, and so trying to meet the same expectations, quite different amount of funds could be requested.

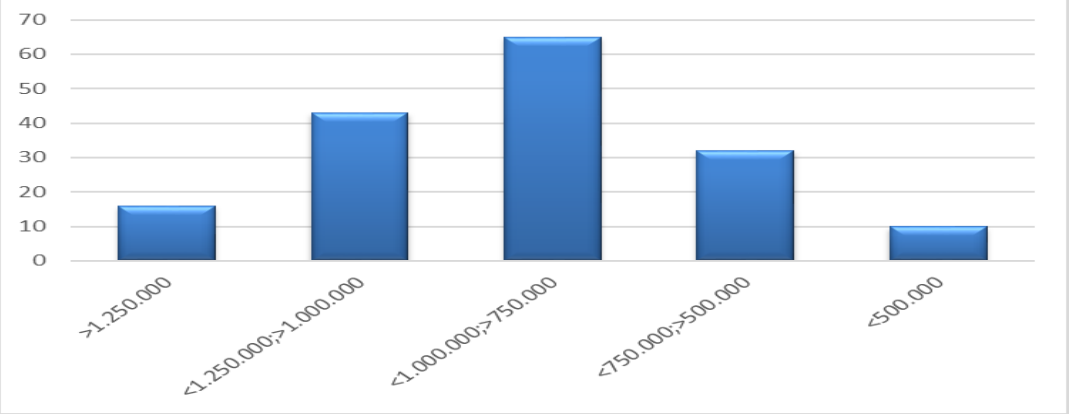

Figure 5.33: Number of calls having average amount of requested fund per a proposed project within given intervals

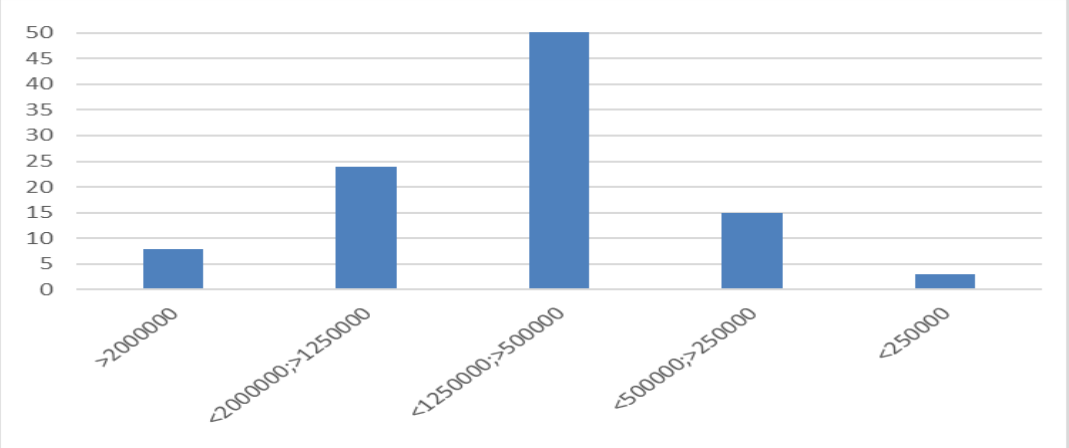

Figure 5.34: Number of calls having average amount of given fund per a supported project within given intervals

In terms of average funding amount given for a call, on the other hand, majority of the calls belong to the interval of ₺500.000-₺1.250.000, which is also the range of medium-scaled projects. However, it could be more than ₺2.000.000 or less than ₺250.000. (Figure 5.34)

Both of the cases observed in Figure 5.33 and 5.34 indicate there is a need of special scaling and limitation of total funded budget for each call in order not to fund calls with different features and requirements with the same amount.

5.1.4. Outputs

Before starting, it should be noted that, this analysis is done with the assumption that all output information of supported projects are entered the Project Tracking System of TUBITAK by the coordinators of them.

Output types existing in the system are scientific paper, presentation (verbal/poster), book, patent application, registration, thesis (master/PhD), dissemination, prize and new project. Although information about whether the outputs are national or international exists, quality and recognition of them such as the situation of being published in an indexed journal and number of citation could not be obtained from the available data.

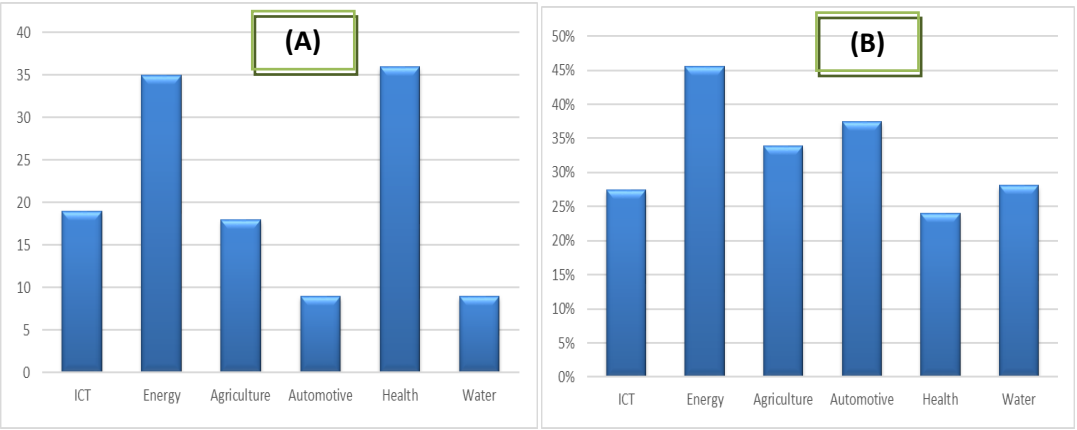

Figure 5.35: Number of projects having output (A) and rate of them to all supported projects (B) for each PTA

Figure 5.35 indicates that rate of having output is range from 24% to 45% for each PTA while projects of Aerospace, Chemistry, Machine-Production and SSH

do not have output. The highest rate of having output belongs to the Energy projects while the lowest one is for the Health projects.

It is seen in Figure 5.36 that majority of the projects having output are small-scaled with the rate of 60% approximately. Although majority of the projects proposed in 2012 and 2013, which have higher chance of belonging output and having more output, are small-scaled; this is not sufficient to explain such a huge gap. Thus, there is a need of detail investigation for the effect of funding amount and scaling on output amount.

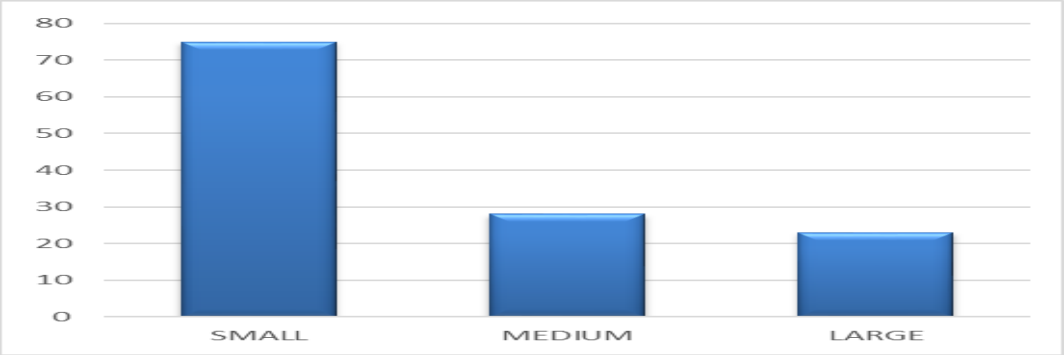

Figure 5.36: Distribution of projects having output with respect to their scale

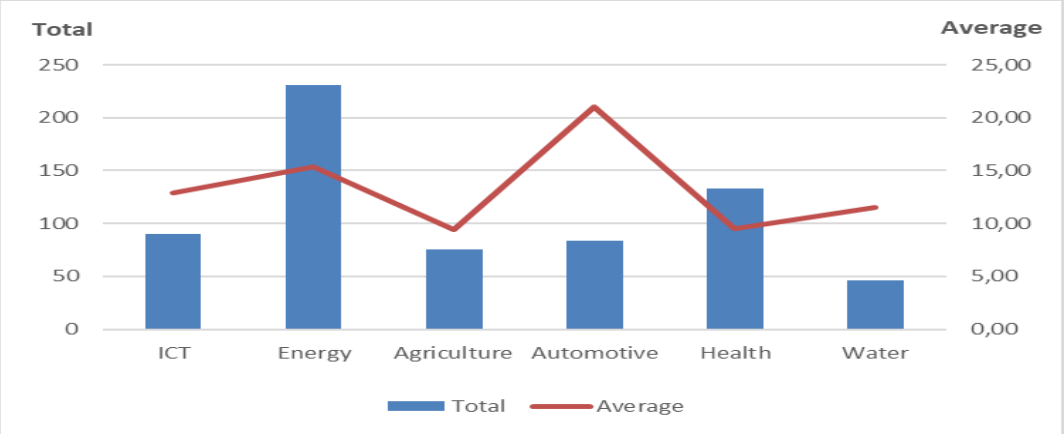

Figure 5.37: Total and average number of output for each PTA

Total and average output amount are quite different with respect to PTAs, as indicated in Figure 5.37. Average output amount per a project is the highest for Automotive while total one is the highest for Energy. If the latter is examined

with respect to output types, it is seen that majority of the outputs are presentations for all PTAs. In addition, diversity of the outputs with respect to their types and distribution of them according to this are fairly different for each PTA. For instance, for ICT and Water projects there are only 4 different output types while Automotive and Agriculture projects have nearly all types of outputs (Figure 5.38).

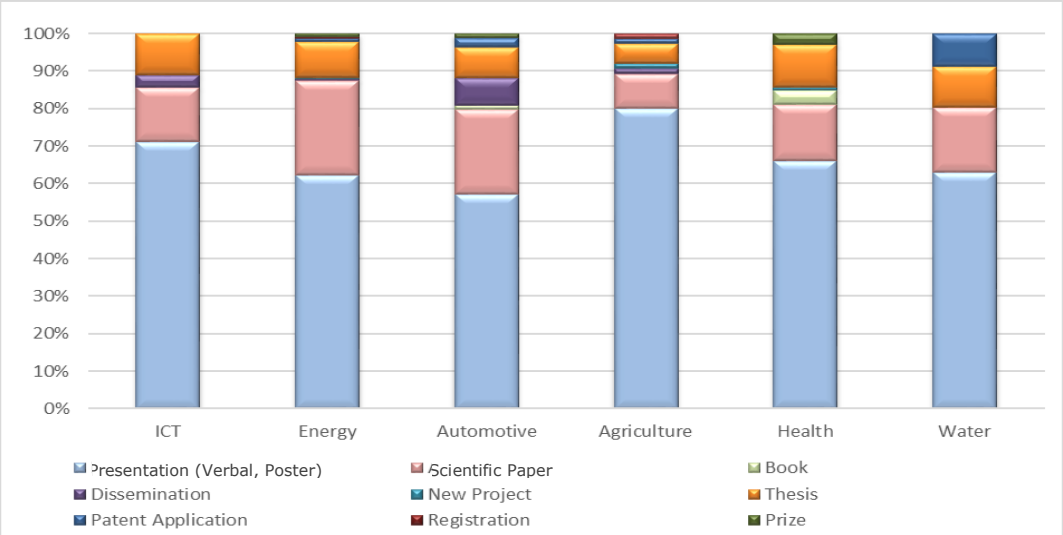

Figure 5.38: Distribution of outputs with respect to their types for each PTA

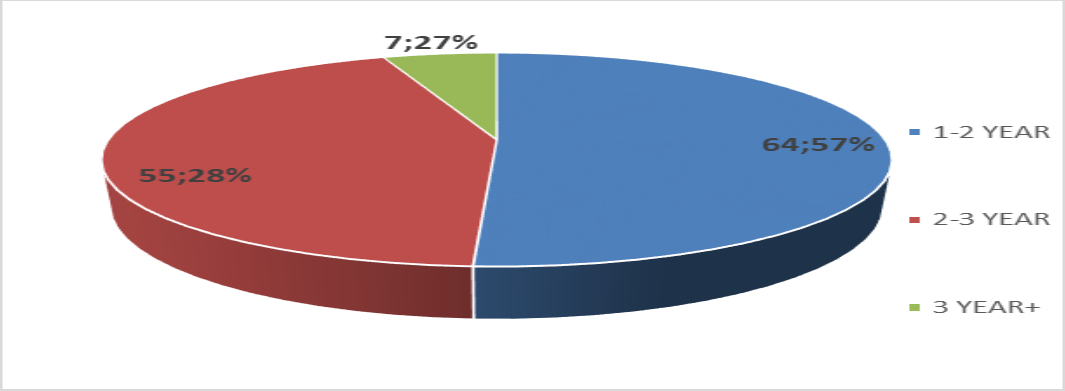

Figure 5.39: Distribution of projects having output according to their duration

Duration of nearly all projects having output is 1-year and 2-year while those with duration of 3-year and more is only 7% of all, as seen in Figure 5.39. This means that majority of the outputs are obtained within the 2 years after project

starts but before finalizing, which is also supported by Figure 5.40. Moreover, Figure 5.40 also indicates that very few outputs are obtained within the 6 months after project starts. Amount of the output obtained after the finalization of projects is also so low reason of which might be that coordinators do not enter output information of their projects after they finish.

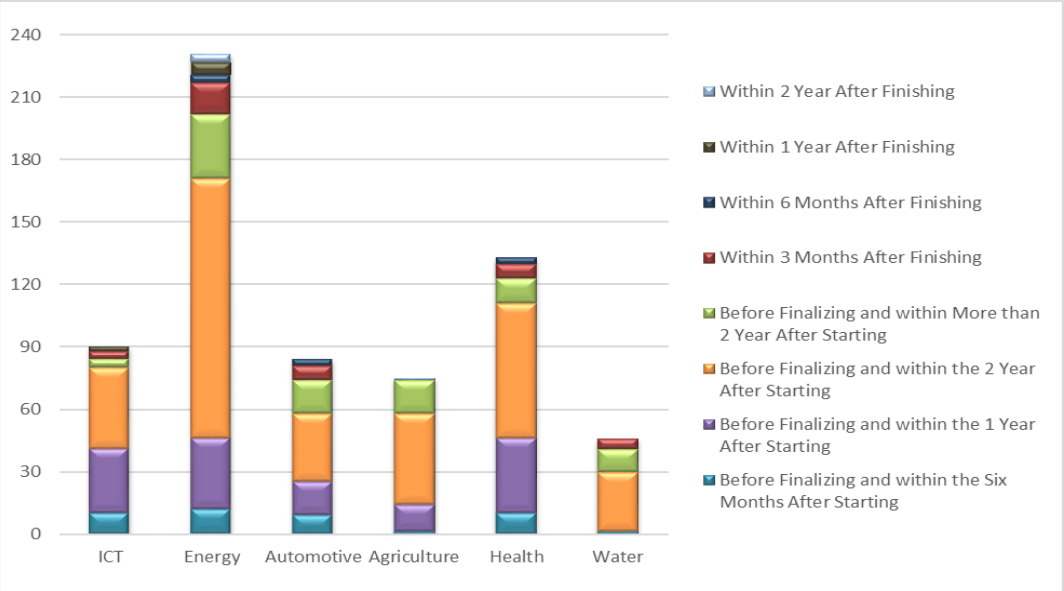

Figure 5.40: Distribution of outputs with respect to their acquisition time for each PTA

5.1.5. Concluding Remarks

The results of descriptive analysis on program indicators and discussions on them can be concluded as follows:

- Number of researchers studying on some of the technology areas is so few, which is the reason of low amount of proposed and supported projects on those areas such as Aerospace. Thus, there is a need of policy tool to educate and attract qualified researchers on these areas.

- Rate of passing first stage is low for Aerospace and SSH projects. This may be due to being far away from bureaucracy for researchers applying for Aerospace calls, who prefer directly concentrate on the technical issues. The views of the coordinators involved in the interview exercise about the intensity

and complexity of the bureaucracy, especially in the application period, can be regarded as the supportive point of this claim. The high rate of coordinators from private sector for Aerospace, who are far away from bureaucracy, could also support this claim. For SSH, on the other hand, there might be another reason of this situation. This can be the lack of deep knowledge of coordinators proposed projects to 1003 on the requirement of R&D study and 1003 calls. The range of the subjects on which SSH calls are launched is wide. In addition, these subjects are directly related to the daily social problems of whole society. Thus, anyone could propose projects regardless of their relevance with R&D activities. This might result in the low rate of researchers who really have the required capability for proposed SSH projects. These indicate the requirement of briefings on bureaucratic processes with their simplification. Moreover, educating the coordinators about the characteristics and requirements of R&D activities given in Frascati Manual and those of 1003 Program is also required.

- Each call has very different amount of proposed and supported projects, ranging from 10 to 150 and from 0 to 10, respectively. This means that applying the same application and evaluation criteria for all calls, having different expectations and target group, might be ineffective.

- Nearly all of the proposed and supported projects are from universities for all PTAs. In addition, the rate of having sub-project for proposed and supported projects is low. It can be concluded from these facts that attempts to provide university-industry cooperation within the scope of 1003 Program are not as successful as intended.

- Coordinators of the proposed projects are predominantly male especially for Machine-Production and Aerospace calls, which might be the indicator of the low female concentration in these areas. On the other hand, both rate of passing first-stage and supporting rate of projects proposed by female researchers are much closed with those of projects proposed by male ones. This means that female concentration in some technology areas should be improved with their interest to 1003 Program.

- Amount of projects having sub-projects is low despite the restrictions on having sub-projects for medium and large-scaled projects. This is because majority of the proposed and supported projects are small-scaled for nearly all PTAs. Preference of researchers for proposing projects with as low amount of sub-project as possible for medium and large-scaled projects is also another

reason. Researchers prefer to propose such projects since supporting rate of projects having and without sub-projects are nearly the same. Additionally, supporting rate of projects unchanged with sub-project amount despite the increase in bureaucratic and managing challenges with increase in number of sub-projects. This indicates the ineffectiveness of scaling and sub-project amount, which is also proved by econometric analysis. Failure of university-industry cooperation might also be the result of preferences of proposing smaller scaled projects with fewer sub-projects.

- Although there are proposed and supported projects from nearly all cities of Turkey, majority of these projects are from the provinces where not only population, but also economic and industrial activities are highly dense. To eliminate the regional disparity in application amount, regional prioritization policies could be applied. For the difference in the supporting rates, on the other hand, regional selection mechanisms could be beneficial. In addition, mechanisms to increase cooperation between researchers from regions having fewer projects and ones from much more active and successful provinces could be helpful to eliminate the regional disparity.

- Machinery and equipment costs of projects, half of which are provided by institutions for projects proposed from private sector, dominate the budget of the projects. Thus, funds given to private sector projects are not higher than those from other types of institutions despite their higher staff costs. As another indicator of this, projects from public institutions, having poorer R&D infrastructure, have higher funding amounts. This situation points out the requirement of a mechanism to provide machinery and equipment infrastructure for some institutions.

- Rank of PTAs with respect to rate of projects having output for each of them is so similar with that of PTAs with respect to their finalization rate. In addition, majority of outputs obtained within 2 years after starting and before finalizing for all PTAs, although acquisition time of outputs is different for each PTA. Moreover, order of PTAs with respect to average and total output amount is so different from that of PTAs with respect to finalization rate and so rate of project having output. This shows that probability of having output, output amount and acquisition time of output could change with characteristics of both PTA and the project, such as initial and target TRL of them, which can be tested by conducting ex-ante TRL assessment studies before a call.

5.2. Econometric Analysis

Output amounts are regressed on some characteristics of projects and calls which are detected as different for each PTA as a result of analyses on program indicators. Regression analyses are done for both total output amount of supported projects and average output amount of projects supported for each call. These models are also estimated by using output amounts weighted with respect to output types as explained in the "Methodology". The independent variables on which output amounts are regressed, with their indicators used in the models are also described in that chapter.

Firstly, correlation matrix of dependent and independent variables is analyzed in order to detect the possible multi-collinearities and irrelevances. Secondly, output amounts are regressed on the variables having higher correlation with it. Thirdly, significance of omitted variables is tested and significant ones are added to the model. Lastly, analyses are with diagnostic tests and required adjustments.

5.2.1. Project-Based Estimation

"output" is the most correlated with variables related to timing, which are "timeafterstart", "timeaftercall" and "finalization", which are also highly correlated with each other. Correlations of "large", "budget", "small" and "privatesector" with "output" are also relatively high. However, correlation of "budget", "small" and "large" with each other is also high. (See Figure A.1 in Appendix D) Thus, so they could not be used as independent variable at the same time to estimate output amount. Then, the following procedure is pursued:

i. "output" is regressed on "timeafterstart", "timeaftercall" and "finalization" separately and the one with the highest R^2 value is chosen to continue with.

ii. Separate models including "budget", "small", "large" and "privatesector" separately additional to the variable selected in previous step are regressed.

iii. Then, significance of omitted variables having relatively lower correlation with "output", which are "subproject", "teamsize" and "proportionalgrade" is tested for each model.

iv. For the selected model(s), existence of heteroscedasticity and breakpoint with the differences in structural form are tested. If there is any significant breakpoint, model(s) are estimated again for divided sub-samples.

v. The same procedure is applied for the regression of weighted output amounts, which is called as "woutput".

Regression analysis starts with the estimation of total output amount of each projects on "timeafterstart", "timeaftercall" and "finalization" separately.

According to regression results given in Table 5.1, "timeafterstart" is the best alternative to use as independent variable at the beginning with its higher R^2 and log-likelihood values and lower AIC and SC ones.

According to regression results given in Table 5.1, "timeafterstart" is the best alternative to use as independent variable at the beginning with its higher R^2 and log-likelihood values and lower AIC and SC ones.

Table 5.1: Estimation results for regression of "output" on time-wise variables for project-based model

	coefficient	**std. dev.**	**coefficient**	**std. dev.**	**coefficient**	**std. dev.**
c	-1.215**	0.5856	-3.262***	0.9816	1.485***	0.2875
timeafterstart	1.433***	0.2294	---	---	---	---
timeaftercall	---	---	1.478***	0.2615	---	---
finalization	---	---	---	---	2.959***	0.6298
Sample Size	**216**		**216**		**216**	
R^2 (adjusted)	0.1503		0.1258		0.0893	
AIC	5.4261		5.4545		5.4954	
SC	5.4573		5.4857		5.5266	
Log Likelihood	-584.013		-587.082		-591.503	

Table 5.2: Estimation results for regression of "output" on given variables for project-based model with "timeafterstart"

	timeafterstart							
	coefficient	**std. dev.**	**coefficient**	**std. dev.**	**coefficient**	**std. dev.**	**coefficient**	**std. dev.**
c	-0.175	0.8019	-1.488**	0.5934	-0.390	0.6347	-0.7930	0.6193
timeafterstart	1.219***	0.1233	1.322***	0.2325	1.170***	0.1053	1.159***	0.1140
budget(million ₺)	-0.623***	0.2217	---	---	---	---	---	---
small	---	---	1.133**	0.5013	---	---	---	---
large	---	---	---	---	-1.773***	0.4830	---	---
privatesector	---	---	---	---	---	---	-1.233**	0.4784
subproject	0.229	0.3710	0.220	0.3634	0.420	0,3688	0.206	0.3664
teamsize	-0.007	0.0639	-0.009	0.0622	0.005	0.0609	0.035	0.0598
proportionalgrade	0.177	0.2757	0.118	0.2743	0.113	0.2707	0.103	0.2756
Sample Size	**216**		**216**		**216**		**216**	
R^2	0.1679		0.1740		0.1884		0.1632	
R^2 (adjusted)	0.1641		0.1663		0.1846		0.1593	
AIC	5.4097		5.4116		5.3849		5.4154	
SC	5.4410		5.4585		5.4161		5.4467	
Log Likelihood	-582.250		-581.456		-579.566		-582.864	

Then, the analysis continues with the estimation of regression models including "budget", "small", "large" and "privatesector" additional to "timeafterstart". It is seen in Table 5.2 that model with independent variable of "large" additional to "timeafterstart" is the best alternative, which is:

$$Output = 1.170*timeafterstart - 1.773*large + u$$

This model is called as general model. It is seen that output amount increases faster than time elapsed after projects start. In addition, it is also observed that being large-scaled instead of small and medium-scaled affects output amount negatively, which shows the inefficiencies in scaling.

Then, diagnostic tests are applied on this model. VIF test shows that there is no serious multi-collinearity between independent variables with uncentered values lower than 10. However, result of White Test rejects the homoscedasticity. It is inferred from the residual graph given in Figure A.3 (see Appendix E) that this situation might appear due to using inappropriate functional form and existence of structural break.

Firstly, whether there is a break at the points where PTAs change or not is tested by using Chow Breakpoint Test. According to results of this test (see Figure A.4. given in Appendix E), the null hypothesis of no break at specified point is rejected with p-value less than 0.05 for points where PTA of projects changes from Energy to ICT (65) and ICT to Health (112). This indicates that relation of output amount with different characteristics of projects is different

for each PTA. Thus, the selected model is estimated for Energy, ICT and Health projects separately.

Table 5.3: Estimation results for regression of "output" with selected project-based model for different PTAs

	ENERGY		**ICT**		**HEALTH**	
	coefficient	**std. dev.**	**coefficient**	**std. dev.**	**coefficient**	**std. dev.**
c	-8.759***	2.7840	0.394	0.9769	-0.352	0.5992
timeafterstart	3.119***	0.5785	1.099***	0.1897	0.570***	0.0910
large	-7.362***	2.4522	-1.442*	0.8314	0.707	0.4397
budget(million ₺)	3.760**	1.6141	0.189	0.6136	-0.216	0.2055
small/medium	0.853	1.7025	0.004	0.9458	0.404	0.4720
privatesector	-2.357	1.3408	-0.672	1.1662	-0.152	0.4680
subproject	0.267	0.8230	0.384	0.8765	-0.182	0.2609
teamsize	0.050	0.2279	0.081	0.1235	-0.007	0.0322
proportionalgrade	1.378*	0.7005	0.214	0.2769	-0.082	0.1645
Sample Size	**65**		**47**		**103**	
R^2	0.3976		0.2280		0.0755	
R^2 (adjusted)	0.3574		0.2109		0.0755	
AIC	5.9214		5.0118		4.5557	
SC	6.0887		5.0905		4.5812	
Log Likelihood	-187.445		-115.778		-235.898	

Table 5.3 indicates the results of regression analysis done for each PTA. The best alternative model,

- for Energy projects is:

  output = -8.759 + 3.119*timeafterstart -7.362*large + 3.760*budget + 1.378*proportionalgrade + u

- for ICT projects is:

  output = 1.099*timeafterstart -1.442*large + u

- for Health projects is:

  output = 0.570*timeafterstart + u

It is observed that for all PTAs, output amount is significantly related to timeafterstart, which is an expected and natural situation.

Output amount of health projects is significantly related to none of specified project features, including "large" too, and so output amount of these projects is the least explained one with available variables, which makes R^2 and R^2_{adj} values the lowest for model of health projects. R^2 and R^2_{adj} values for ICT and Energy projects, on the other hand, are higher than those of model estimated for overall PTAs.

As validation analyses, existence of serious multi-collinearity, heteroscedasticity and structural errors are tested again for separate models. It is inspected that none of these failures exists for models of ICT and Health. Thus, regression models of these projects are validated. For Energy projects case, on the other hand, null hypotheses of White and Ramsey RESET test are rejected. Thus, regression models having different structural forms are estimated for Energy projects, and then the following model gives the best value not only for White and Ramsey RESET tests, but also for R^2 values:

$$\sqrt{output} = -1.801 + 0.851*\text{timeafterstart} - 1.958*\text{large} + 0.893*\text{budget} + 0.281*\text{proportionalgrade} + u$$

If the final regression models estimated for each PTA are compared, it is seen than time elapsed after projects start affects the output amount for ICT projects much higher than for other PTAs, but lower than for general model. On the contrary, negative effect of being large-scaled on output amount is less than that of general model, for ICT. However, this effect is much higher for Energy model.

For ICT, there are not any significant independent variables different from that in general model, while output amount of Energy projects are significantly related to "budget" and "proportionalgrade", too. For the Health projects, on the other hand, being large-scaled or not is not significant for output amount. Output amount proportional with "timeafterstart" for all PTAs, and positive effect of rise in budget and "proportionalgrade" on output amount for Energy projects are desired and meaningful cases, which means that the regression models estimated for different PTAs are verified. In addition, it can be inferred that not only fund given to Energy projects, but also peer-review evaluation results are more effective for Energy projects than others in terms of output additionality. However, negative effect of being large-scaled for ICT and Energy projects and insignificant effect of it for Health project makes scaling inefficient and ineffective, as obtained from the general model.

After determining the regression models for output amount on characteristics of projects for different PTAs, it is repeated for total output amounts weighted with respect to type of outputs, which are scientific paper, presentation (verbal/poster), book, patent application, registration, thesis (master/PhD), dissemination, prize and new project. Weight of output types also differs for each PTA, according to the nature and the requirements of them. "timeafterstart" is again used as starting point to estimate model from specific to general.

Table 5.4: Estimation results for regression of "woutput" on given variables for project-based-model with "timeafterstart"

	timeafterstart							
	coefficient	**std. dev.**	**coefficient**	**std. dev.**	**coefficient**	**std. dev.**	**coefficient**	**std. dev.**
c	2.191**	1.0510	-1.403*	0.7898	1.366	0.9006	1.256	0.9055
timeafterstart	1.811***	0.3208	2.071***	0.3094	2.083***	0.3028	2.551***	0.1832
budget(million ₺)	-1.674***	0.4015	---	---	---	---	---	---
small	---	---	2.313***	0.6672	---	---	---	---
large	---	---	---	---	-2.163***	0.8166	---	---
privatesector	---	---	---	---	---	---	-1.265*	0.7026
subproject	-0.006	0.4833	-0.136	0.4772	0.076	0.4863	-0.096	0.4790
teamsize	-0.138	0.0833	-0.164	0.0816	-0.145**	0.0720	-0.157***	0.0596
proportionalgrade	-0.125	0.3591	-0.209	0.3601	-0.215	0.3570	-0.236	0.3603
Sample Size	**216**		**216**		**216**		**216**	
R^2	0.2643		0.2467		0.2797		0.2628	
R^2 (adjusted)	0.2574		0.2396		0.2695		0.2559	
AIC	5.9597		5.9834		5.9478		5.9618	
SC	6.0066		6.0303		6.0103		6.0086	
Log Likelihood	-640.650		-643.207		-638.359		-640.870	

According to the results of regression analyses given on Table 5.4, the best alternative for the general model of "woutput" is:

$$woutput = 2.083*timeafterstart - 2.163*large - 0.145*teamsize + u$$

It is inferred that if weighted output is used instead of original value, output amount could be explained better with available variables since R^2_{adj} value is higher for regression of weighted output amount. It is also observed that effect of "timeafterstart" and "large" on "woutput" is greater than that on original output value while direction of their relation with output amount does not change. Moreover, there exists an additional significant independent variable,

"teamsize" for regression of weighted output, which is one of the reasons of increase in R^2 value. This means that different types of outputs has different importance for each PTA according to their nature and requirements

As a result of diagnostic tests, it is detected that there is no serious multi-collinearity between independent variables. However, result of White Test rejects the homoscedasticity, which might be due to using inappropriate functional form and existence of structural break according to residual graph seen in Figure A.5 given in Appendix E. Firstly, whether there is a break for different breakpoints is tested by Chow Breakpoint Test. According to results of this test (see Figure A.6 given in Appendix E), the null hypothesis of no break at specified point is rejected at %90 significance level with p-value less than 0.1 for points where PTA of projects changes from Energy to ICT (65) and ICT to Health (112). This indicates that output amount is related to different characteristics of projects at different level for each PTA. Thus, the selected model is estimated for Energy, ICT and Health projects separately.

Table 5.5: Estimation results for regression of "woutput" with selected project-based model for different PTAs

	ENERGY		**ICT**		**HEALTH**	
	coefficient	**std. dev.**	**coefficient**	**std. dev.**	**coefficient**	**std. dev.**
c	1.004	3.6956	1.420	1.6746	-1.088	2.4624
timeafterstart	2.968***	0.2576	2.601***	0.3412	1.839***	0.2304
large	-2.803*	1.5048	-3.043**	1.4155	0.7006	---
teamsize	-0.094	0.2978	-0.245	0.2537	-0.122**	0.0566
budget(million ₺)	2.105	2.2114	-1.661	1.6576	-0.193	1.0970
small	-0.672	2.1179	-3.051	2.0400	0.880	0.8693
medium	1.588	1.7596	3.203*	1.8473	-0.534	0.9373
privatesector	-2.684**	1.3225	-0.399	2.2259	0.303	1.0015
subproject	-0.244	0.9652	0.541	1.6947	0.072	0.6666
proportionalgrade	0.178	0.8511	0.434	1.0135	0.128	0.3358
Sample Size	**65**		**47**		**103**	
R^2 (adjusted)	0.3582		0.3814		0.1801	
AIC	5.9884		6.0786		5.7028	
SC	6.0887		6.1967		5.7536	
Log Likelihood	-191.623		-139.848		-294.544	

Table 5.5 indicates the results of regression analysis done for each PTA. The best alternative model,

- for Energy projects is:

  woutput = 2.968*timeafterstart – 2.803*large – 2.684*privatesector+ u

- for ICT projects is:

  woutput = 2.601*timeafterstart – 3.043*large + 3.203*medium + u

- for Health projects is:

  woutput = 1.839*timeafterstart – 0.122*teamsize + u

It is observed for all PTAs that as original value of total output amount, weighted output amount is also significantly related to "timeafterstart". Moreover, weighted output amount of health projects is significantly related only to "teamsize" additional to "timeafterstart" and so it is the least explained one with available variables, which makes R^2 and R^2_{adj} values the lowest for model of health projects. R^2 and R^2_{adj} values for ICT and Energy projects, on the other hand, are higher than those of general model. In addition, these values are higher for all PTAs than those obtained from the regression of original output amount. Thus, it can be concluded that available variables representing special features of projects are explained weighted output amount better, that is, giving different importance to outputs according to their type and PTAs of projects from which they are obtained makes them more related to the characteristics of projects and their technological fields.

As validation analyses, existence of serious multi-collinearity, heteroscedasticity and structural errors are tested. It is inspected that none of these failures exists for models of ICT. However, for the case of Energy projects, null hypothesis of Ramsey RESET test, and for the case of Health projects, that of White Test are rejected. Thus, regression models having different structural forms are estimated for Energy and Health projects, and then the following models have not only the best p-value for White and Ramsey RESET tests, but also the best R^2 values:

- For Energy:

$\sqrt{woutput}$ = 1.208 + 0.147*timeafterstart^2 – 0.821*large - 0.804*privatesector + u

- For Health:

$e^{woutput}$ = 3148.654*timeafterstart - 220.164*teamsize + u

If the final regression models estimated for each PTA are compared, it is seen than time elapsed after projects start affects the weighted output amount for Health projects much higher than both for other PTAs and for general model. This value, on the other hand, is the lowest for Energy projects until the time elapsed after start becomes 3. In addition, effect of change in team size is also higher for the model of Health projects than for general model. Being large scaled, however, has higher effect for the model of ICT projects than for that of Energy projects and for the general one. Besides, having a researcher from privatesector and being medium-scaled have effect on estimated weighted output amount for Energy and ICT projects, respectively, but not for others.

If these models are compared with those obtained from regression of original output amounts, it is seen that the effects of project features on estimated output amount is higher for weighted amount except for Energy projects. In addition, more characteristics are related to the weighted output amount than the original value for all PTAs. The additional independent variable for Energy projects is "privatesector" while "proportionalgrade" is not related to the weighted output amount anymore. In addition, being medium-scaled and team size are additional independent variables for ICT and Health projects, respectively for the estimation of weighted output amount rather than the original one.

Additional to the inefficiency of scaling for all PTAs; team size-having negative effect for Health projects and insignificant effect for other PTAs- and "privatesector"-having negative effect for Energy projects and insignificant effect for other PTAs- are also inefficient and ineffective.

5.2.2. Call-Based Estimation

After estimating the regression model of output amounts using its original and weighted values on characteristics of projects for each PTA, relation of call features with output amount is also investigated.

In this case mean value of weighted output amount is regressed on characteristics of calls, additional to average characteristics of projects

belonging to that call. Mean of weighted output amount is used instead of original one, since it gives better results in project-based case.

Mean weighted output amount is the most correlated with the variable related to timing, which is "timeaftercall". Correlations of "mainprojects", "meanfund" and "finalizedprojects" with mean weighted output are also relatively high. However, since "finalizedprojects" is also highly correlated with "mainprojects" additional to "finalizationrate", it cannot be included in the regression model with "mainprojects". (See Figure A.2 in Appendix D) As a result, the following procedure is followed:

i. Mean weighted output is regressed on "timeaftercall".

ii. Then, "mainprojects", "meanfund" and "finalizationrate" are added to the model. It should be noted that "finalizationrate" is used instead of "finalizedprojects" since the latter is highly correlated with "mainprojects"

iii. "meanfund" is exchanged with "meanteamsize", additional to exchange of "mainprojects" and finalizedprojects" with "finalizationrate" due to the their high correlation. All combinations of these exchanges are applied one by one.

iv. Then, significance of the omitted variables having relatively lower correlation with mean weighted output, which are "minproportionalgrade", "privateparticipation" and "scalerest" is tested for each model.

v. For the selected model(s), existence of heteroscedasticity and then difference of structural form and existence of breakpoints according to different PTAs are tested. If there is any significant breakpoint, model(s) are estimated again for divided sub-samples.

Then, the analyses continue with the estimation of regression models including "meanfund"/"meanteamsize", "mainprojects" and "finalizationrate"/ "finalizedprojects" additional to "timeaftercall". It is seen in Table 5.6 that model with independent variable of "meanfund", "mainprojects" and "scalerest" additional to "timeaftercall" is the best alternative. All of the other alternative independent variables are insignificant at 95% significance level, with their p-value higher than 0.05.

Table 5.6: Estimation results for regression of "meanwoutput" on given variables for call-based model

	coefficient	std. dev.	coefficient	std. dev.	coefficient	std. dev.	coefficient	std. dev.
c	-1.564	16.1598	0.480	16.2812	-10.867	12.3267	-21.097*	11.7504
timeaftercall	6.025***	2.0660	5.252***	1.1669	5.252***	1.1669	9.052**	3.8109
meanfund (million ₺)	-10.712**	4.2372	-5.861	4.4174	---	---	---	---
meanteamsize	---	---	---	---	-0.121	0.8975	-0.263	0.9262
mainprojects	3.615***	1.1477	---	---	---	---	3.215***	1.1737
finalizationrate	7.680	15.6379	---	---	---	---	12.671	15.6666
finalizedprojects	---	---	8.313***	2.4110	8.313***	2.4110	---	---
minproportionalgrade	6.417	5.2201	4.911	5.1134	5.756	5.1746	7.738	5.1567
privateparticipation	2.273	19.6553	-5.841	19.9362	-11.010	19.7036	-4.112	19.6177
scalerest	24.459***	9.0361	24.627***	8.9536	24.627***	8.9536	27.372***	9.1224
Sample Size	**62**		**62**		**62**		**62**	
R^2	0.4136		0.3863		0.3863		0.3832	
R^2 (adjusted)	0.3832		0.3655		0.3655		0.3513	
AIC	9.4013		9.4145		9.4145		9.4518	
SC	9.5386		9.5174		9.5174		9.5890	
Log Likelihood	-287.441		-288.850		-288.850		-289.005	

As a result:

$$meanwoutput = 6.025*timeaftercall - 10.712*meanfund + 3.615*mainprojects + 24.459*scalerest$$

is the best alternative, which is called as general model. It is seen that mean weighted output amounts change faster than time elapsed after projects start and changes amount of "meanfund" and number of main projects. In addition, it is observed that having a restriction on scaling of the projects for a call affects its mean weighted output amount positively. This is a desired relation despite the negative relation of mean funding amount.

VIF test shows that there is no serious multi-collinearity between independent variables. However, result of White Test rejects the homoscedasticity.

Firstly, functional form is changed by using the square-root of mean weighted output instead of the original value and the problem about structural form is solved, which is decided by accepting null hypothesis in Ramsey RESET Test with p-values higher than both 0.05 and 0.1. Estimation results of the new model are given in Table 5.7. It is also seen that, R^2 and R^2_{adj} values also

increase with this change, which means that it improves the explanation of the model.

Table 5.7: Estimation results for regression of "$\sqrt{meanwoutput}$" on selected variables for call-based model

	coefficient	**std.dev.**
timeaftercall	1.111***	0.1957
meanfund (million ₺)	-1.392***	0.4315
mainprojects	0.412***	0.1192
scalerest	1.235	0.9347
Sample Size	**62**	
R^2	0.4339	
R^2 (adjusted)	0.4147	
AIC	4.8613	
SC	4.9642	
Log Likelihood	-147.700	

Then, whether there is a break for different breakpoints is tested by Chow Breakpoint Test. According to results of this test (see Figure A.7 given in Appendix E), the null hypothesis of no break at specified point is rejected at %95 significance level with p-value less than 0.05 for points where PTA of calls changes from Energy to ICT (23) and ICT to Health (41). This indicates that output amount is related to different characteristics of calls at different level for different PTAs. Thus, the selected model is estimated for Energy, ICT and Health calls separately.

Table 5.8 indicates the results of regression analysis done for each PTA. The best alternative model,

- for Energy projects is:

$$\sqrt{\text{meanwoutput}} = 0.695*\text{timeaftercall} - 1.306*\text{meanfund} + 1.033*\text{mainprojects} + u$$

- for ICT projects is:

$$\sqrt{\text{meanwoutput}} = 0.572*\text{mainprojects} + 5.315*\text{scalerest} + u$$

- for Health projects is:

$$\sqrt{\text{meanwoutput}} = 1.681 * \text{timeaftercall} - 1.385 * \text{meanfund} + u$$

Table 5.8: Estimation results of selected call-based model for different PTAs

	ENERGY		ICT		HEALTH	
	coefficient	**std. dev.**	**coefficient**	**std. dev.**	**coefficient**	**std. dev.**
c	0.177	4.3572	4.246	4.0848	0.543	5.2922
timeaftercall	0.695**	0.2453	-0.009	0.5510	1.681***	0.2554
meanfund (million ₺)	-1.306*	0.6516	-1.779	1.0515	-1.385**	0.166
meanteamsize	---	---	0.101	0.1580	---	---
mainprojects	1.033***	0.1841	0.572**	0.2261	0.048	0.1495
finalizationrate	-0.355	1.9400	2.370	5.0063	-5.111	5.4300
finalizedprojects	---	---	0.639	1.2295	-0.419	0.464
minproportionalgrade	-0.328	0.4304	0.820	1.0670	0.404	0.8086
privateparticipation	-1.407	2.9155	2.217	5.4325	10.621	6.4904
scalerest	-1.127	0.9490	5.315***	1.6960	---	---
Sample Size	**23**		**18**		**21**	
R^2	0.7312		0.4302		0.4966	
R^2 (adjusted)	0.7043		0.3946		0.4701	
AIC	4.3594		5.2108		4.3987	
SC	4.5075		5.3098		4.4982	
Log Likelihood	-47.133		-44.8976		-44.1869	

"timeaftercall" is significantly related to mean weighted output amount for Health and Energy calls. In addition, mean weighted output amount changes more than time elapsed after launch of call for Health calls, but not for Energy ones.

Weighted output amount of health calls is significantly related only to "meanfund" additional to "timeaftercall" while that of Energy calls is also positively related to "mainprojects". For ICT calls, on the other hand, mean weighted output amount is significantly related to "mainprojects" and "scalerest". R^2 and R^2_{adj} values are the lowest for model of ICT calls, which is also lower than that of general model. However, R^2 and R^2_{adj} values of Energy and Health calls are higher than those of general model.

As validation analyses, existence of serious multi-collinearity, heteroscedasticity and structural errors for models of each PTA are tested. It is inspected that

none of these failures exists for models of Energy and Health calls. However, for the case of ICT calls, null hypothesis of White test is rejected. Thus, regression models having different structural forms are estimated for ICT projects, and then the following model having suitable p-value for both White and Ramsey RESET tests and the best R^2 values is chosen as the best alternative for ICT:

$$\sqrt{\text{meanwoutput}} = 0.069^* \text{ mainprojects}^2 + 5.996^*\text{scalerest} + u$$

If the final regression models estimated for each PTA are compared, it is seen that time elapsed after projects start and mean of fund given to supported projects of a call affect mean weighted output amount much higher for Health calls than for Energy, but not for general model. Effect of supported main project amount, on the other hand, is the lowest for Energy calls until supported main projects becomes 8. If it becomes 15, this effect will be the highest for Energy calls.

Having restriction on the scale of proposed projects has significant and positive effect only for ICT calls, which makes it effective and efficient only for ICT calls but not for Energy ones. It should be noted that non-existence of this effect as a significant one is reasonable for Health calls since there is no Health call including such a restriction. In addition, negative significant relation of mean funds with output amounts makes funds given to Energy and Health calls inefficient while its insignificant relation for ICT calls makes it ineffective. Similarly, ”meanteamsize” is also inefficient and ineffective for ICT calls due to its high correlation with “meanfund”. Besides, insignificant effect of “privateparticipation” makes the restrictions and enforcements on participation of researchers from private sector ineffective. Their low rate of proposing 1003 projects and low passing first stage rate of the projects proposed from private sector also supports this claim. Similarly, minimum peer-review grade used as supporting criteria is also ineffective for all PTAs.

5.2.3. Concluding Remarks

- Characteristics of projects and calls have different effects on output amounts for different PTAs. Thus, different application, evaluation and supporting criteria should be used for calls of different PTAs, according to their nature and requirement.

- Due to the negative relation between funding amounts and output amounts, it can be concluded that fund given to supported projects are inefficient in terms of output additionality. Negative effect of being large-scaled, which means getting higher amount of fund for longer time-interval, also supports this claim. This result is also compatible with the results of interviews.

- Insignificancy of sub-project amount makes the restrictions on minimum sub-project amount inefficient.

- Insignificancy of having restrictions on the scale of the proposed projects for Energy calls makes it ineffective, while negative effect of being large-scaled and insignificancy of being small/medium scaled, make scaling ineffective and inefficient in terms of output additionality. The fact that most of the projects having output are small-scaled resulting from descriptive statistics also supports this claim with the opinions of interviewees about the scaling discussed in the following part.

- Insignificancy of peer-review grade of supported projects and that of minimum peer-review grade taken by projects supported under a call makes evaluation and supporting criteria ineffective in terms of output additionality.

- Insignificancy and negative effect of team size makes it ineffective and inefficient. In this direction, it can be concluded that enforcements on proposing projects with sub-project is meaningless for output additionality.

- Existence of a researcher from industry is ineffective and so, attempts to increase university-industry cooperation are meaningless for output additionality under the existing condition.

5.3. Interviews

Interviews are done with coordinators of 16 supported projects, which are randomly selected, to obtain information about the behavioral additionality of these projects additional to the input and output one.

Firstly, questions asked to investigate the previous and following studies conducted by project team members individually and/or as a team are analyzed. The following results are concluded from these analyses:

- Answers given to the questions about the previous and following TUBITAK projects of 1003 project team including the coordinators are examined. It is

seen that there exists at least one TUBITAK project belonging to the coordinators and/or other team members of nearly all 1003 projects before. There are only two coordinators, not having a TUBITAK project before 1003 and three projects, other team members of which did also not have such project. One of these coordinators, however, has proposed a new project after 1003. Similarly, all of three projects, team members of which did not have a project before 1003, have at least one researcher proposing a project to TUBITAK after 1003. As a result of these facts, project additionality of 1003 projects could be deducted.

- Project teams had conducted a research together before their 1003 projects for nearly half of the ICT and the Energy projects and only 20% of the Health projects. For more than half of the Health and Energy projects team of which had not studied together before 1003, rate of studying together after 1003 is more than 50%. On the contrary, such situation is not observed for the ICT case. This shows that 1003 projects contribute to scientific cooperation for Energy and Health, but not for ICT. This might be because the nature of ICT studies is more suitable to individual working.

In the second place, existence of basic research, proof-of-concept, similar studies and the idea of the projects before launching of the call are investigated with the reason of researchers for preferring 1003 program. Then, the following issues are obtained:

- It is learned that all interviewees, except the ones from university having ICT and Health projects (one for each), studied on a subject with regard to the relevant call previously. However, very few interviewees had the main idea of their 1003 project fully or partially before the launch of the call. Although this can be observed for most of the Energy projects from universities, the idea of only 1 Health and 1 ICT projects from universities fully exists before the call. This might be because the subjects and targets of ICT and Health calls are so original for the research environment in Turkey.

- The interviewees mostly prefer 1003 program due to its relatively much higher funding amount. It is interesting that the projects of two coordinators stating this as a reason of choosing 1003 program are small-scaled. However, they can easily be supported via other funding mechanisms of TUBITAK. Other coordinators, on the other hand, mainly proposed their projects to 1003 Program due to the ordinary reasons, which are facing the call while searching

fund to their project and the inspiration of the call to their project. Moreover, there is no basic research before the projects, idea of which is formed according to the call. In addition, these projects have not any output opposite to the ones proposed in 1003 program.

- 1003 Program gives an opportunity to conduct R&D study with university-industry cooperation. Moreover, it is a call-specific and more product-oriented grant program. These are the most important and distinctive features of 1003 program. However, only few coordinators state them as the main reason of choosing 1003 program to get fund. This means that the target group of 1003 program does not have a handle on the special features, targets, expectations and requirements of it. This might be a reason of the lower quality and supporting rate of 1003 projects.

- Answers given to the question about the existence of basic research and proof-of-concept before the project are investigated. It is observed that for all of the Energy projects and most of the ICT projects, basic research and proof-of-concept partially existed while project was proposed. However, for most of the Health projects, basic research on the subject of the project had not been conducted yet and it has done under 1003 projects. If the prioritization approach of these areas given in NSTIS: 2011-2016 are considered, existence of basic research activities for ICT projects is consistent with its feature of strong innovation capacity. On the other hand, when previous basic research activities for Energy and Health, it can be implied that required acceleration could be provided sooner for Energy than for Health.

- In addition, it is also inferred from this search that if proof-of-concept and basic research activities exist before the 1003 projects, these projects are more likely to have output for all PTAs. Thus, in order to increase the efficiency and output additionality of 1003 program, the basic research activities for the subjects of a 1003 project should have been completed or at least started before this project. To ensure this, starting and target TRLs should be decided for each call and stated in call texts clearly. Then, the proposed projects should be expected to satisfy these levels as an application or supporting criteria. Besides, projects as a basic research of PTAs, sub-technology fields and prioritized subjects should be supported by means of an additional funding program, before launching a call under 1003.

Then, questions about the sufficiency of funding amount and suitability of scaling applied in 1003 program are analyzed. The following results are obtained from these analyses:

- It is indicated that funds given for all Health projects and nearly all ICT projects are sufficient. However, for only half of the Energy projects, given fund is fully sufficient. Moreover, rate of the projects having sufficient funding amount does not change with scale for all PTAs. Besides it does not affect the situation of having output too, since coordinators of the projects having no outputs claim that their fund is sufficient. This means that funding amount is inefficient in terms of output additionality.

- Interviewees claiming that the funding amount is partially sufficient or insufficient complain about not being able to transfer the funding amount within the budget chapters. In addition, it is stated that funding amount could be sufficient if no revision on requested fund and its distribution to the budget chapters is done during the peer-review evaluation. Moreover, the opportunity of revising considering the changes in inflation and exchange rates could also solve this problem according to the interviewees. It is also suggested by the interviewees that funding limits should be different for different calls, according to their expectations. As a result, such revisions in 1003 rules may increases efficiency and effectiveness of funding amount in terms of output additionality.

- Scaling applied in 1003 program is found as acceptable by the coordinators of nearly all ICT projects and half Energy projects while it is seen as unsuitable by those of all Health projects, except one from private sector being medium-scaled. However, the rate of projects, coordinators of which think that scaling is suitable, does not change with scale for all PTAs. Moreover, opinions of the interviewees about scaling are not affected by the situation of having output for Energy and Health projects, but for ICT ones. Thus, scaling has different effects on output additionality for different PTAs and restrictions related to the scaling should be different for each PTA, as suggested by the interviewees.

Next, not only scientific contributions of the 1003 projects to the literature, but also their medium and long-run social and economic benefits are inferred. In addition, opportunities created by the 1003 projects for the project team members and the institutions in which projects are conducted are also analyzed considering their opportunity costs.

- All projects, except the one Energy project from a public institution having the aim of obtaining product-oriented output, contribute to the aim of creating employment (reducing unemployment) and raising the qualified researchers according to the opinions of the interviewees.

- All projects, except half of the ICT projects and one of the Health projects, have the effect of increasing the competitiveness of Turkey and decreasing the foreign-source dependency economically and technologically. However, only half of the projects contribute to economic growth and creation of social welfare, according to the claims of interviewees. Similarly, contribution to the university-industry cooperation remains at one third. Even, projects including researchers from private sector could not be entirely contribute to the university-industry cooperation. Coordinators of the projects having limited or no contribution to the university-industry cooperation claim that this cannot be achieved with the current situation of industry. Industry, which is not capable enough to convert the academic research outputs to real products, wait for information from universities and research centers in such a short time that qualified information cannot be produced. Then, they try to improve a product with the information being not qualified enough and with their limited capability and capacity, and so they fail. Moreover, technology transfer offices, which are relatively new established, are currently insufficient to improve and consolidate this relationship. However, if they acquire the required ability in accordance with their aims, they can solve this problem effectively and effectively.

- Projects, which are likely to provide university-industry cooperation, can contribute to reduce foreign-source dependency and increase competitiveness of the country with their support on the least studied areas. This infers that 1003 program can serve some targets of Vision 2023, but not all of them, since it could not fully convert advances in R&D to economic and social benefits.

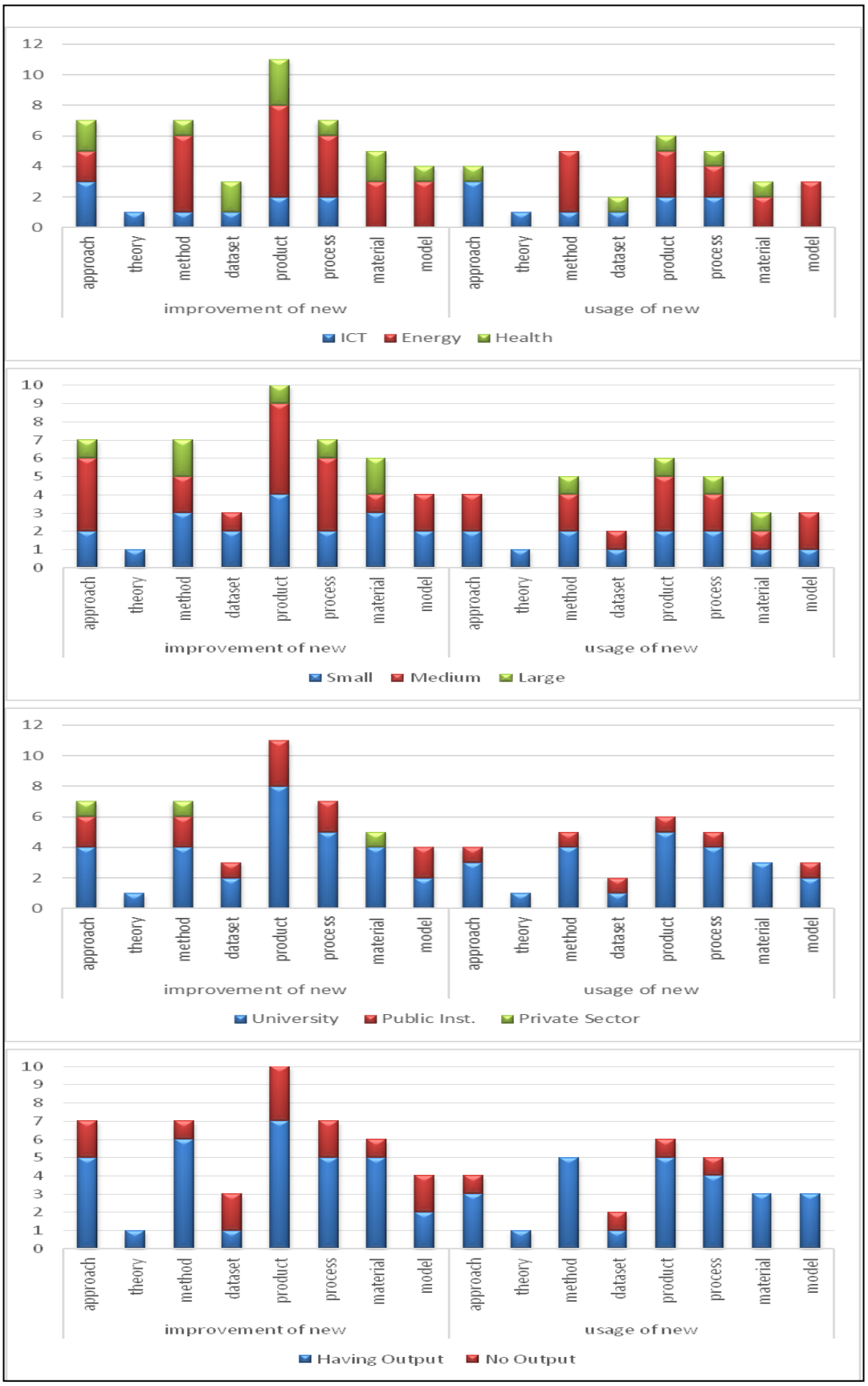

Figure 5.41: Distribution of projects according to form of scientific contribution

- Distributions of projects according to the form of their scientific contribution are examined in Figure 5.41, with respect to their PTA, scale, institution type and situation of having output. It is observed that Health projects do not provide theoretical contribution to the literature while ICT projects do not improve or use any new material and model. Similarly, Energy projects do not have aim of theoretical or dataset contribution while most of them have the aim of improving new product and method. This proves the necessity of weighting outputs with respect to their type for each PTA done in econometric analysis exercise. If this analysis is done with respect to scales, it is seen that there exist projects from each scale having all type of scientific contribution to the literature although there is no medium-scaled projects improving and using new theory and no large scaled-projects improving and using new theory, dataset and model. Similarly, there also exist projects from universities contributing to the literature with each way. However, none of the projects from public institutions improves or uses new theory and material. Lastly, it can be inferred that projects aiming to improve/use a new dataset are less likely to have output, while all of those aiming to improve/use a new theory have output.

- More than two-third of interviewees claim that they satisfy not only aims and targets of the calls, but also the scientific and social effect they expect to create. Projects of the ones not thinking in this way belong to Energy and Health calls. However, they state that if the time and budget became more flexible, they could achieve these targets. This shows the requirement of different time and budget restriction for different PTAs, even for different calls.

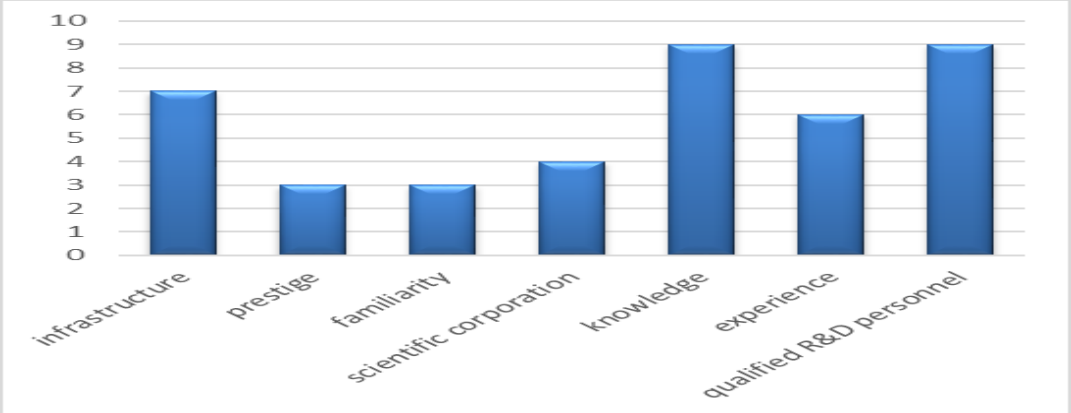

Figure 5.42: Number of projects providing given opportunities to project teams and coordinator institutions

- As seen in Figure 5.42, more than half of the projects provide knowledge to their team members and qualified R&D personnel to coordinator institutions while only three of these projects increase the prestige and familiarity of them.

- Interviewees are asked about what they, their institutions and team members of their projects forgo materially and spiritually to conduct their 1003 project. As seen in Figure 5.43, it is observed that according to the half of the interviewees, there is no opportunity cost. In addition, only four of the coordinators state that they forgo from the time and money which can be used for other R&D activities. This means that most of the capacity used for 1003 projects would be idle if these projects were not conducted.

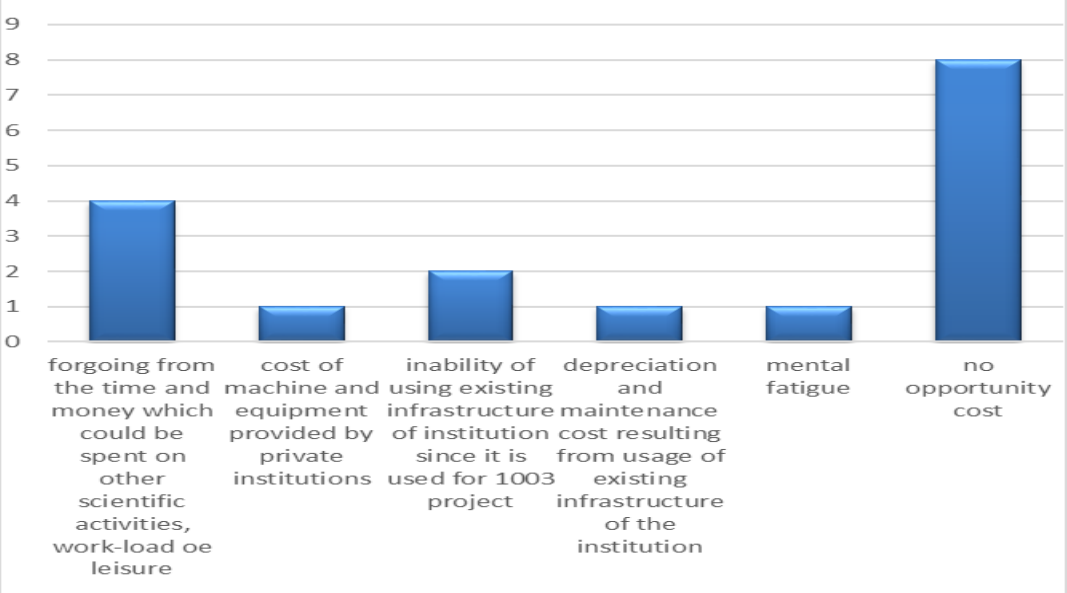

Figure 5.43: Number of projects causing given opportunity costs to project teams and coordinator institutions

Afterwards, opinions of interviewees about the 1003 program as a prioritization R&D policy tool, with the rules, regulations and procedures applied during presentation/application/evaluation/operation processes of it are examined considering their improvement suggestions. Issues given below are concluded as a result of this analysis:

- All of interviewees claim that the program satisfies their expectations.

- Simplification in rules and regulation, especially for financial issues is the most demanded arrangement for the improvement of 1003 program. Besides, shortening application, evaluation, contract and operation processes and reduction in the bureaucratic procedures applied during them, including combining two-stage application procedure, are also suggested by many interviewees. An interviewee asserts that some parts of the projects could become unnecessary while waiting for support decision in the continuously improving environment of science and technology since the application and evaluation process take much long time.

- Including panelists to the peer-review evaluation and selecting members to the Call Program Consulting Board (CPCB) from industry and public research centers is also suggested not only to create calls having broader vision but also to detect such projects more accurately. Additionally, applying different evaluation and supporting criteria for different calls according to the expectation of them could provide selecting the project having medium and long-run expected impacts, according to the opinions of the interviewees.

- It is also stated by interviewees that giving TRL targets while launching calls can be useful to increase the quality of proposed projects and output additionality of supported ones. However, these targets should be consistent with both the qualification of researchers and existing research infrastructure.

- Despite the criticisms on application and evaluation criteria, it is asserted by almost all interviewees that monitoring and concluding reports and feedbacks given to these reports are all sufficient, reliable and objective, and they have positive effects on the results of projects. However, it is also suggested by few interviewees that including experts from private sector and stakeholders from public institutions related to the targets of the calls to these processes might be beneficial.

Lastly, suggestions of interviewees about the areas and subjects which could be prioritized in the future, as a foresight study, and about the additional mechanisms which could be supported by 1003 Program are analyzed. According to this:

- From the PTAs, which are prioritized in current situation, Health and Energy become the ones preferred as PTA the most while Aerospace, Social Sciences

and Humanities, Automotive and Water are suggested by nearly none of interviewees. Even, an interviewee argues that machine-production and automotive are not as popular as in the previous years in the world. As sub-technology fields and call subjects, on the other hand, biotechnology, renewable energy, alternative energy resources, storage of energy, multi-dimensional products and materials, and Industry 4.0 are asserted by many interviewees. It should be noted that these results are compatible with the prioritization strategies of other developed and emerging countries, given in the "Literature Review".

- It is proposed by some interviewees that a new funding program for basic research activities of 1003 calls, which do not have proof-of-concept, should be developed to conduct R&D studies at TRL1 and TRL2 under it rather than 1003. This enables TRL of 1003 projects to move from 1-2 to 3-4 range, and so makes this program more product-oriented. Besides, qualified R&D personnel are also provided for the 1003 projects, especially for the areas having few qualified researchers. In addition to this suggestion, linkage of the projects supported under this new program and their teams should also be provided, while proposing project to 1003. Even, 1003 project should be proposed after conducting such projects with cooperation by using outputs of all these projects. If this achieved, an increase in the quality and effectiveness of 1003 projects could be provided.

- In order to convert applied research and experimental design activities conducted under 1003 projects to a real product, integration of 1003 and 1511 programs should be activated effectively, according to some interviewees. To achieve this, results of 1003 projects should be presented to the related stakeholders, especially to industrial institutions. Then, cooperation between the researchers of the supported 1003 projects and the prospective researchers of 1511 projects should be provided. Even, interviewees state that the use of 1003 outputs should be obligation for the projects proposed to 1511 program. Besides, it is suggested that an incentive should be given to the industrial institutions, attempting to commercialize 1003 outputs. Moreover, to enable the transformation of 1003 outputs to real competitive and exportable products, international cooperation is also suggested by interviewees.

In conclusion, it is inferred from the interviews that there is a need for some rearrangement in the rules, procedures and bureaucratic processes of 1003 Program for all PTAs. In addition, some additional funding mechanisms are required not only to provide researchers and knowledge for 1003 projects, but also to make outputs of them more qualified and to convert them real product which can be easily commercialized. Prospective technology areas and sub-technology fields which could be prioritized in near future are also detected as a foresight study.

5.4. Comparative Summary of Main Findings

As a result of the quantitative and qualitative analyses, some deficiencies making 1003 Program inefficient and ineffective are pointed out. The findings obtained from different analyses are compatible with each other. Moreover, some of these findings root from the reasons associated with the similar features of projects and similar criteria of the program.

It is pointed out that amount of proposed and supported projects are ranging within very large interval for different calls. Even, these values are so few for some technology areas with the low rate of passing first stage. This may be due to the lack of qualified researchers having project experience. Such experience is required to write a qualified project proposal contributing to the targets of related call. This situation could also emerge as a result of not having knowledge on the bureaucratic issues according to the views of project coordinators involved in the interview exercise.

Effects of project characteristics on output amounts change with PTAs. Funding amount ranging within the large scale for different calls is inefficient and ineffective for some technology areas according to the results of econometric analysis and the opinions of interviewees. Similarly, scaling is ineffective and inefficient in terms of output additionality. Even, most of proposed and supported projects, even the ones having output, are small-scaled, according to the program indicators. In addition, although having sub-projects and larger team size have an increasing effect on the funding amount, these are inefficient and ineffective in terms of getting support and output additionality, as inferred from the program indicators and econometric analysis. Besides, the qualification of supported projects, represented by their peer-review grades and minimum grade of supported projects, is also ineffective. All these facts infer

the requirement of applying different rules on these issues for different PTAs, which will serve as reallocation of funding resources.

Interest of researchers from different institution types and different provinces are quite different. Researchers from public and private institutions do not prefer 1003 program as much as those from universities, even for the areas with which they intensely engage. In addition, majority of the proposed and supported projects are from few provinces, which are the most developed ones in terms of trade, industry and education. Although, those regional and institutional disparities can be eliminated by defining different priorities for different provinces and institution types, more analysis are required to decide this, which is out of the scope of this thesis.

Capability of the supported projects and their outputs in terms of serving for the targets of the program, such as promoting university-industry cooperation, improving product-oriented outputs having high competence in global market, and contributing to economic growth and social welfare, is insufficient, as stated by interviewees. Moreover, most the outputs are at basic research level and far-away from being converted to real product according to results of both analysis of program indicators and interviews. In addition, researchers mostly prefer applying this program only for its high funding amount instead of the opportunity of conducting R&D study with university-industry cooperation under the scope of a call-specific and more product-oriented program. In addition, existence of researchers from private sector, which is required to provide university-industry cooperation and to create product-oriented outputs, is also ineffective, according to the results of econometric analysis.

CHAPTER 6

POLICY RECOMMENDATIONS AND CONCLUSION

Turkey aims to reach the level of developed countries and compete with them by improving its level of economic growth and development. STI policies have positive impact on the development of scientific and technological knowledge, which contributes to social welfare and economic growth. Therefore, Turkey implements such policies via various governmental institutions, including TUBITAK to reach its stated aim.

Along with the Vision 2023 project, Turkey has also begun to prioritize its STI polices by 2010. In this direction, TUBITAK developed new funding programs in 2011, with which project proposals are taken by means of the specific calls. These calls are launched in the technology areas prioritized by SCST and SB of TUBITAK. 1003 Priority Areas R&D Grant Program of TUBITAK is one of these programs. Scope of its calls are determined by considering the SCST decisions, development plans, results of the Technology Foresight Project and STI policies and strategies.

Within the scope of this thesis, 1003 Grant Program is evaluated with the examination of its qualitative and quantitative effects for different PTAs. It aims to figure out the ineffectiveness and inefficiencies in terms of output, input, behavioral and project additionalities of the program. To achieve this, both quantitative and qualitative methods, which are descriptive statistics of program indicators, econometric analysis and interviews, are conducted. As a result of these analyses, some ineffective and inefficient points, affecting the application amount, success rate, output amount and quality of the outputs negatively, are detected. These are related to not only the characteristics of projects and researchers, but also rules and specific issues of the program and calls.

Table 6.1: Summary of policy recommendations and policy tools to obtain effective and efficient 1003 Prioritized Grant Program

INCREASING EFFECTIVENESS AND EFFICIENCY OF 1003 PRIORITIZED R&D GRANT PROGRAM OF TUBITAK IN TERMS OF ITS CONTRIBUTION TO VISION 2023		
POLICY LEVEL	**POLICY RECOMMENDATIONS**	**POLICY TOOLS**
Micro-Level Policies for Researchers and Their Institutions	• Increase the level of knowledge on R&D definition with rules, requirements and classification of R&D studies • Increase the level of knowledge on the targets, regulations and features of 1003 Program • Prepare for the call before it is launched by pursuing call plans	• Have deep knowledge on Frascati Manual, regulations of writing R&D projects and the target sand regulations of 1003 program • Conduct basic research studies on the subjects stated as prioritized in STI Strategy Documents and Development Plans and derive prospective project idea about these subjects • Cooperate with other researchers, especially from other institution types, having competence on prioritized areas and institution of whom have required infrastructure
Mezzo-Level Policies Related to the Processes of 1003 Prioritized R&D Grant Program	• Reallocate funds to PTAs • Increase the quality of proposed and supported projects • Increase the direct and indirect social and economic impacts of 1003 Program • Provide qualified applications from all institution types within cooperation • Make application easier to increase application amount • Increase contribution of obtained outputs to Vision 2023 target and aims of 1003 Program	• Apply different evaluation and supporting criteria for different PTAs and different calls • Apply different restrictions on scaling, budget, sub-project amount and team size for different PTAs and different calls • Integrate stakeholders from public and private institutions to writing of call text and evaluation processes • Set starting and target TRL considering the existing situation and targets of prioritized areas with qualification of existing R&D infrastructure and personnel • Reduce the bureaucratic procedures and shorten processes by simplification of rules and regulation
Macro Level Policies at National Level	• Promote education of qualified R&D personnel on the areas studied less • Promote the generation of basic research knowledge on the prioritized subjects • Convert outputs of 1003 projects to real products and services having high competence in global basis • Make university-industry-public institution cooperation more effective	• Support basic research activities on the subjects which could be prioritized in the future • Share outputs of 1003 projects with public and industrial institutions, which are likely to commercialize them as a real product and service; and subsidize these institutions by an additional mechanism

Considering these results, some policies, summarized in Table 6.1, are suggested to obtain more effective and efficient 1003 Program. These policies could be classified as micro, mezzo and macro level policies. Micro-level policies are suggested for the applicants and their institutions while mezzo-level ones should be applied on the processes and regulations of 1003 Program by TUBITAK. Macro-level polices, on the other hand, require national intervention which could be achieved with general tools out of 1003 program.

As stated in the previous chapter, lack of qualified researchers applying for 1003 program and their lack of knowledge not only on the requirement of R&D studies and 1003, but also on the bureaucratic issues cause inefficiencies. To solve the problem of insufficient knowledge on R&D, 1003 Program and bureaucracy, the briefings which will be given by experts from TUBITAK on these issues could be provided by the related institutions, as a micro level policy. Simplification of rules and regulation to eliminate their discouraging impact could also be suggested as a mezzo level policy tool. In addition, there is also need for the policy aiming to raise R&D personnel and increase their competences on the prioritized areas before launching call to solve this problem. As such a policy tool, basic research activities on the subjects which will be prioritized in the future could be supported by additional funding mechanisms at macro level. Conducting such activities could also help researchers to prepare the prospective calls which will be launched in the future at micro level.

Characteristics of both projects and calls need to be more efficient and effective in terms of output additionality, as inferred from the conducted analyses, in order to increase the quality of proposed and supported projects. To improve the effectiveness of sub-projects and team size for both supporting situation and output additionality, different restrictions on these issues could be applied for ach PTA, even for each call, at mezzo level. Moreover, to increase the efficiency and effectiveness of peer-review in terms of output additionality, grading system including evaluation and supporting criteria should be revised to support projects. Participation of the project coordinators in peer-review panels could also be provided to increase the efficiency and the effectiveness of the evaluation process. With an interactive discussion of the prospective changes in the project, the projects which will be supported could be made more effective and efficient. Similarly, some of the projects which will not be supported in the current system could also be supported by eliminating the unclear points and

deficiencies in the proposal as a result of such a discussion. These recommendations about the evaluation process will also eliminate the disparities on the supporting rate between PTAs, and create positive impact on the effects and so quality of supported projects.

At mezzo level, reallocation of financial resources to PTAs could also be suggested. These could be provided by applying different restrictions on scaling and funding limits for each PTAs. Simplification of rules and regulations, especially those for medium and large scaled projects, also promotes this policy.

Moreover, to convert the outputs of 1003 projects to real products having high competence in global basis, university-industry cooperation should be provided more effectively. To achieve this, outputs of 1003 projects should be shared with the industrial and public sector institutions, which are capable enough to commercialize them as a real product. In addition, these institutions should be subsidized by an additional funding mechanism. Moreover, related public and private institutions, which can be convert the outputs of 1003 projects to the final expectations of Vision 2023, should also be included in CPCB, and so both evaluation and call text writing processes. This will also promote to the aim of increasing the quality of both proposed and supported projects.

Lastly, quality of outputs obtained from supported 1003 projects should also be increased. To achieve this, more contribution of these outputs to social, scientific and economic targets of Vision 2023 and 1003 Program should be provided. Setting starting and target TRLs as application criteria, which could be directing projects to these aims, could be used for this aim, as a mezzo level policy tool. However, if basic research of a subject does not exist, this decreases the amount of proposed projects. To eliminate this, the generation of basic research knowledge before the calls which will be launched on that subject should be provided. The basic research activities on the areas and subjects detected as not having such knowledge by SCST with the foresight studies could be subsidized by additional funding mechanisms at macro level. These subjects could reach the expected starting TRL with these subsidies.

International cooperation supports for the prioritized areas could also be a beneficial tool at macro level to increase the speed of improvements in these areas. The cooperation with the countries which are competence enough in an area for which acceleration is required in Turkey could be helpful to increase the

quality and knowledge level of R&D personnel studying on this area. This could also contribute to the process of converting knowledge-based outputs to real products with the help of the advanced R&D infrastructure in more developed countries. For the side of the areas on which innovation capacity of Turkey is strong, having the researchers in less developed countries conduct the relatively more basic level research activities could have could be promoted with such a support mechanism. This provides saving time for more advanced and product oriented researches in those areas.

Despite the importance and benefits, impact analysis and program evaluation are not preferred so much due to their high costs, requirement of long time, and difficulties in obtaining data. Even, most studies classified as impact assessment in the literature are, in fact, output analysis since they do not consider other impacts including input, and behavioral additionality. This fact is also valid for the studies on resource allocation. Most of these studies are at project selection level and allocation of funding resources for different technology fields or different R&D policy programs is not studied extensively. Therefore, the analyses conducted in this thesis and the policies recommended as a result of them contribute to the literature from many aspects.

The policies recommended by considering the results of this study will also be helpful to obtain more efficient and effective prioritized R&D Support mechanism. Despite the prospective positive impacts of these policies on 1003 program, some further studies are required to maximize the benefit of not only the prioritized but also whole R&D supports. Firstly, such impact assessment and evaluation studies should be conducted for other R&D support mechanisms to increase their effectiveness and efficiency. While doing this, their effect on the 1003 program should also be analyzed. Moreover, contribution of the 1003 outputs to 1511 Program of TUBITAK, which is another prioritized program, as input should be investigated in order to find out the indirect product-oriented impacts of the 1003 Program.

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APPENDICES

APPENDIX A: INTERVIEW QUESTIONS

This interview is conducted for the impact analysis study of TUBITAK 1003 Program. The study aims to make funding mechanism more efficient and effective by detecting the current impacts of funded 1003 projects and their PTAs in terms of output and behavioral additionality. During the interview; you will be asked questions about both the pre-funding, funding and post-funding processes of your 1003 project, as well as your opinion about the program itself.

a. Information About Background of 1003 Project and Current Situation

The purpose of the questions in this section is to get information about both your opinions on the 1003 program and other TUBITAK supports before your 1003 project as well as the features of the 1003 project you are funded.

1. When did you graduate from Ph.D./Bachelors Program?

2. When did you start working in the institution where you propose this project? Have you worked at another institution / organization before / after this institution, and where did you work if yes? Is there any project team member you have worked together in your previous/next institutions?

3. Did you have a joint work / TUBITAK project together with these institutions / organizations?

4. If you had worked work in another institution before and/or after the projects, which are these institutions? Is there anybody in the Project team working in these institutions? Is there any study/TUBTIAK Project you conduct together with anybody whom you have studied with in these institutions?

5. How many people are there in the research team?

6. Is there any project you propose to TUBITAK and/or supported before your 1003 project? If yes, is there anybody being in the team of both 1003 and previous projects?

7. What are your studies on call subject before your 1003 project?

8. Did you have the idea of your 1003 project before the call?

9. How did you hear 1003 and the related call? Why did you prefer 1003 Program to get support for your project?

10. How much did the basic research idea of the project evolve when you applied for 1003?
    a. There was no proof-of-concept / basic research before my project. (or equivalent to this)
    b. Proof-of-concept/basic research studies partially existed while applying to 1003. (or equivalent to this)
    c. The concept was just proven and supported by basic researches before my project. (or equivalent to this)
    d. I have no idea.

11. How much is the budget of your project?

12. What are the outputs of your project, if they exist?

b. Impact and SWOT Analyses of the Project

Aim of the questions in this part is learning your opinions about both the application-evaluation-operation processes of 1003 program and the support you get with its outputs and impacts.

1. Could you evaluate application process of 1003 in terms of procedures, bureaucracy, duration and transparency? Could you need consultancy for bureaucratic issues or Project writing while applying?

2. What do you think about the expected university-industry cooperation and application of all public/foundation universities, public institutions and private sector to the same calls? To what extent university-industry cooperation can be provided via 1003 Program? How could your project and overall 1003 Program contribute to bringing the new technologies based on information produced in universities and research centers into use of industry and public institution?

3. Is your 1003 project has any of the following social, economic and scientific impacts?
    a. Reducing foreign-dependency in technology /increasing global competence of the country (reducing current account deficit)
    b. Contributing to economic growth
    c. Contributing to structural reforms which could be reduced fragilities in the economy
    d. Contributing to social welfare
    e. Contributing to conscious use of the technology
    f. Contributing to an area studied relatively less
    g. Formation of R&D projects within the frame of university-industry cooperation
    h. Creating employment and contributing to raise of qualified R&D personnel (reducing unemployment)

4. Is there any contribution of your 1003 project to the literature? If yes, choose these contributions from the following cases?
    a. Improvement/Use of a new approach
    b. Improvement/Use of a new dataset
    c. Improvement/Use of a new theory
    d. Improvement/Use of a new method/model
    e. Improvement/Use of a new process
    f. Improvement/Use of a new material/product

5. Did/Will your supported 1003 project significantly contribute to aims and targets stated in the text of related call? What are these contributions? If you think that, expected impact did not/may not be produced, what are the factors causing this situation?

6. Could you evaluate the outputs obtained from the Project activities and your expectation while applying? If you think that you could not/may not able to create outputs and impacts you desired, what are the factors causing this situation?

7. Which opportunities are emerged for you, project team members and your institutions as a result of 1003 support you get?

8. Is there any opportunity cost of the 1003 support you get for you, project team members and your institutions? If yes, what are these costs?

9. Is the funding amount sufficient? Is there any difference between requested and given fund? If yes, how has this revision affected your project? What do you think about the scaling applied for 1003 Program?

10. If you had not been supported in the scope of 1003, what would have you thought about conducting this Project? Would there be any changes in your Project when you conducted this project without 1003 support?

11. Are evaluation and tracing processes of 1003 program sufficient? Are the performance indicators suitable and objective?

c. About the Policy Behind the 1003 Program

The aim of the questions in this part is getting your opinion about the policy and 1003 program and your improvement suggestions.

1. Has the support you get from 1003 Program met your expectation? If you design this program, how would you change it?

2. Which of the technology areas would you prioritize, except your area, in the scope of 1003? For which subject would you prefer to launch call in your area? Why?

3. If you prepared the text of the call you applied, how would you change it in terms of aims, targets, content, specific issues, and etc.?

4. Is there any need for a new national or international support mechanism following the 1003 program or at the same time with it? If yes, what kind of support mechanism should it be?

5. Are information activities about TUBITAK supports and 1003 program sufficient?

6. Would you recommend other scientists in your area to apply for the 1003 program and other TUBITAK supports?

7. Please, evaluate the importance of output types given below in terms of your field of study and PTA of the call you get support

   a. Scientific paper
   b. Presentation
   c. Book/Book Chapter
   d. Prize
   e. Patent Application/Registration
   f. Product/Model
   g. Company
   h. Dissemination
   i. Thesis
   j. New Projects
   k. Others

8. Please, evaluate the importance of output types given below in terms of the 1003 program *(Please, answer this question considering all PTAs, general characteristics and targets of 1003.)*

   a. Scientific paper
   b. Presentation
   c. Book/Book Chapter
   d. Prize
   e. Patent Application/Registration
   f. Product/Model
   g. Company
   h. Dissemination
   i. Thesis
   j. New Projects
   k. Others

d. About the Future Studies

The aim of this part is getting information about your (planned) scientific studies after your supported 1003 project and their relation with this.

- Is there any project proposed to TUBITAK by you or anyone from project team after your 1003 project? If yes, is there anybody being in the team of both 1003 and following projects and is this project is related to your 1003 project? If no, do you think conducting such project? If no, why?

e. Conclusion

The aim of this part is getting your opinion about this interview.

- If you conducted this study instead of us, would you have any other questions to ask?

APPENDIX B: WEIGHTS OF OUTPUT TYPES FOR DIFFERENT PTAS

Table A.1: Weights of output types for Energy, ICT and Health projects

Output Type	Energy	ICT	Health
Presentation (Verbal/Poster)	12	10	9.5
Scientific paper	13	15	10
Book Chapter	9	8	5
Dissemination	9.5	9.5	9
New Project	14	11	9
Thesis (Master, PhD)	15.5	15.5	11
Patent Application	9.5	11.5	7.5
Registration	9.5	11.5	7
Prize	4	4	5.5

APPENDIX C: LIST OF LAUNCHED 1003 CALLS WITH THEIR PTAS, YEARS AND SUB-TECHNOLOGIES

Table A.2: List of launched calls for 1003 R&D Grant Program

Call Acronym	PTA	Sub-Technological Field	Year
GD0101121	Agriculture	Arable Crops	2012
GD0102121	Agriculture	Arable Crops	2012
OT0101121	Automotive	Electric and Hybrid Electric Vehicle Technologies	2012
OT0102121	Automotive	Electric and Hybrid Electric Vehicle Technologies	2012
OT0103121	Automotive	Electric and Electric Vehicle Technologies	2012
BR0101121	Energy	Boron Technologies	2012
EN0101121	Energy	Coal Technologies	2012
EN0102121	Energy	Coal Technologies	2012
EN0103121	Energy	Coal Technologies	2012
TC0101	Health	Medical Devices	2012
BT0101121	ICT	Fatih Project	2012
GD0201	Agriculture	Food Security	2013
GD0202	Agriculture	Food Security	2013
SB0101	Energy	Vaccine	2013
BR0101122	Energy	Boron Technologies	2013
EN0401	Energy	Energy Efficiency	2013
EN0402	Energy	Energy Efficiency	2013
EN0403	Energy	Energy Efficiency	2013
EN0404	Energy	Energy Efficiency	2013
EN0301	Energy	Solar Energy	2013
EN0302	Energy	Solar Energy	2013
EN0303	Energy	Solar Energy	2013
EN0201	Energy	Hydrogen and Fuel Cell Technologies	2013
EN0202	Energy	Hydrogen and Fuel Cell Technologies	2013
BM0101	Health	Bio-Material	2013
BM0102	Health	Bio-Material	2013
BM0103	Health	Bio-Material	2013
SB0201	Health	Biomedical Equipment	2013
SB0202	Health	Biomedical Equipment	2013
SB0203	Health	Biomedical Equipment	2013
SB0103	Health	Medicine	2013
SB0104	Health	Medicine	2013
SB0102	Health	Medical Diagnostic Kits	2013
BT0102	ICT	Fatih Project	2013
BT0103	ICT	Fatih Project	2013
BT0301	ICT	Graphene	2013

Table A.2 (continued)

Call Acronym	PTA	Sub-Technological Field	Year
BT0401	ICT	Human Brain	2013
BT0201	ICT	Mobile Communication Technologies	2013
BT0202	ICT	Mobile Communication Technologies	2013
SU0101	Water	Membrane Technologies	2013
SU0102	Water	Membrane Technologies	2013
SU0103	Water	Membrane Technologies	2013
GD0301	Agriculture	Food Additives/Inactive Ingredient	2014
GD0302	Agriculture	Food Additives/Inactive Ingredient	2014
GD0303	Agriculture	Food Additives/Inactive Ingredient	2014
GD0101	Agriculture	Arable Crops	2014
GD0102	Agriculture	Arable Crops	2014
GD0103	Agriculture	Arable Crops	2014
GD0104	Agriculture	Arable Crops	2014
GD0105	Agriculture	Arable Crops	2014
GD0106	Agriculture	Arable Crops	2014
GD0107	Agriculture	Arable Crops	2014
GD0108	Agriculture	Arable Crops	2014
OT0103	Automotive	Electric and Hybrid Electric Vehicle Technologies	2014
OT0104	Automotive	Electric and Hybrid Electric Vehicle Technologies	2014
OT0201	Automotive	Internal Combustion Engine Technologies	2014
BR0101	Energy	Boron Technologies	2014
EN0401	Energy	Energy Efficiency	2014
EN0304	Energy	Solar Energy	2014
EN0101	Energy	Coal Technologies	2014
EN0102	Energy	Coal Technologies	2014
EN0103	Energy	Coal Technologies	2014
SB0101	Health	Vaccine	2014
SB0204	Health	Biomedical Equipment	2014
SB0105	Health	Epidemiology	2014
SB0102	Health	Medical Diagnostic Kits	2014
BT0601	ICT	Electric - Electronic	2014
BT0501	ICT	Electronic Microelectromechanical Systems and Smart Screens	2014
BT0502	ICT	Electronic Microelectromechanical Systems and Smart Screens	2014
BT0203	ICT	Mobile Communication Technologies	2014

Table A.2 (continued)

Call Acronym	PTA	Sub-Technological Field	Year
BT0204	ICT	Mobile Communication Technologies	2014
BT0205	ICT	Mobile Communication Technologies	2014
SU0301	Water	Integrated Watershed Management	2014
SU0302	Water	Integrated Watershed Management	2014
SU0303	Water	Integrated Watershed Management	2014
SU0304	Water	Integrated Watershed Management	2014
SU0104	Water	Membrane Technologies	2014
SU0105	Water	Membrane Technologies	2014
SU0201	Water	Water Saving Technologies	2014
SU0202	Water	Water Saving Technologies	2014
1003-HVU-HAVA-2015-2	Aerospace	Aeronautics	2015
1003-GDA-BHCE-2015-2	Agriculture	Horticultural Crops	2015
GD0401	Agriculture	Increasing Animal Production By Genetic And Technological Methods	2015
GD0402	Agriculture	Increasing Animal Production By Genetic And Technological Methods	2015
GD0403	Agriculture	Increasing Animal Production By Genetic And Technological Methods	2015
GD0501	Agriculture	Fisheries	2015
1003-GDA-TRLA-2015-2	Agriculture	Arable Crops	2015
1003-OTO-BTRY-2015-2	Automotive	Battery Technologies	2015
1003-OTO-MALZ-2015-2	Automotive	Material Technologies	2015
1003-KMY-KMYM-2015-2	Chemistry	Chemicals	2015
BR0101	Energy	Boron Technologies	2015
EN0401	Energy	Energy Efficiency	2015
EN0402	Energy	Energy Efficiency	2015
1003-ENE-KOMR-2015-2	Energy	Fossil Fuels: Coal	2015
1003-ENE-GUNS-2015-2	Energy	Solar Energy	2015
EN0201	Energy	Hydrogen and Fuel Cell Technologies	2015
EN0202	Energy	Hydrogen and Fuel Cell Technologies	2015
1003-ENE-HPIL-2015-2	Energy	Hydrogen and Fuel Cell Technologies	2015
1003-ENE-YENI-2015-2	Energy	Renewable Energy Sources	2015
SB0205	Health	Biomedical Equipment	2015
SB0206	Health	Biomedical Equipment	2015
SB0207	Health	Biomedical Equipment	2015
SB0104	Health	Medicine Technologies	2015

Table A.2 (continued)

Call Acronym	PTA	Sub-Technological Field	Year
1003-SAB-ILAC-2015-2	Health	Medicine Technologies	2015
1003-SAB-UIDB-2015-2	Health	Immunodeficiency (Bilateral Cooperation)	2015
1003-SAB-KLNK-2015-2	Health	Clinic Researches	2015
1003-SAB-TTIP-2015-2	Health	Basic and Clinic Medical Sciences	2015
1003-SAB-ASIT-2015-2	Health	Vaccine Technologies	2015
1003-BIT-BGUV-2015-2	ICT	Information Security	2015
1003-BIT-BBIL-2015-2	ICT	Cloud Computing	2015
BT0602	ICT	Electric - Electronic	2015
BT0503	ICT	Electronic MEMS and Smart Screens	2015
1003-BIT-FOTO-2015-2	ICT	Photonics	2015
1003-BIT-GNBT-2015-2	ICT	Wide-Band Technologies (Including Cabled / Wireless Communication Technologies and IP Technologies)	2015
1003-BIT-MNOE-2015-2	ICT	Micro/Nano/Opto-Electronic Technologies (MEMS, NEMS, MOEMS) and Semiconductor Technologies	2015
1003-MAK-TSRM-2015-2	Machine-Production	Machine Design	2015
1003-MAK-OTOM-2015-2	Machine-Production	Automation Technologies	2015
1003-SBB-EGTM-2015-2	SSH	Education	2015
1003-SUA-ARTM-2015-2	Water	Refinement Technologies	2015
1003-OTO-HEAT-2016-1	Automotive	Electric and Hybrid Electric Vehicle Technologies	2016
1003-OTO-MALZ-2016-1	Automotive	Material Technologies	2016
1003-KMY-KMYM-2016-1	Chemistry	Chemicals	2016
1003-ENE-BORT-2016-1	Energy	Boron Technologies	2016
1003-ENE-EVKN-2016-1	Energy	Energy Efficiency	2016
1003-ENE-EVSA-2016-1	Energy	Energy Efficiency	2016
1003-ENE-KOMR-2016-1	Energy	Fossil Fuels: Coal	2016
1003-ENE-GUCD-2016-1	Energy	Power and Storage Technologies: Electric Power Transformation, Electricity Transmission and Distribution	2016
1003-ENE-GUNS-2016-1	Energy	Solar Energy	2016
1003-SAB-BMLZ-2016-1	Health	Bio-material	2016
1003-SAB-BMED-2016-1	Health	Biomedical Equipment	2016
1003-SAB-TANI-2016-1	Health	Diagnostics	2016
1003-SAB-TTIP-2016-1	Health	Basic and Clinic Medical Sciences	2016
1003-BIT-BGUV-2016-1	ICT	Information Security	2016

Table A.2 (continued)

Call Acronym	PTA	Sub-Technological Field	Year
1003-BIT-GNBT-2016-1	ICT	Wide-Band Technologies (Including Cabled / Wireless Communication Technologies and IP Technologies)	2016
1003-BIT-GOMS-2016-1-2	ICT	Embedded Systems	2016
1003-BIT-GOMS-2016-1-1	ICT	Embedded Systems	2016
1003-BIT-MNOE-2016-1	ICT	Micro/Nano/Opto-Electronic Technologies (MEMS, NEMS, MOEMS) and Semiconductor Technologies	2016
1003-BIT-MILT-2016-1	ICT	Mobile Communication Technologies	2016
1003-BIT-ROME-2016-1	ICT	Robotics-Mechatronics	2016
1003-BIT-VERI-2016-1	ICT	Data Mining and Data Storage	2016
1003-MAK-ROME-2016-1	Machine-Production	Robotics-Mechatronics	2016
1003-SBB-AILE-2016-1	SSH	Family	2016
1003-SBB-EKBY-2016-1	SSH	Economic Growth	2016
1003-SUA-YNTM-2016-1	Water	Sustainable Water Management	2016
1003-GDA-TGUV-2017-1	Agriculture	Food Security in Agricultural Production	2017
1003-GDA-TRLA-2017-1	Agriculture	Arable Crops	2017
1003-OTO-MALZ-2017-1	Automotive	Material Technologies	2017
1003-KMY-ANAK-2017-1	Chemistry	Main Chemicals	2017
1003-ENE-KOMR-2017-1	Energy	Fossil Fuels: Coal	2017
1003-ENE-HPIL-2017-1	Energy	Hydrogen and Fuel Cell Technologies	2017
1003-ENE-YENI-2017-1	Energy	Renewable Energy Sources	2017
1003-SAB-ASIT-2017-1	Health	Vaccine Technologies	2017
1003-SAB-ILAC-2017-1	Health	Medicine Technologies	2017
1003-SAB-KLNK-2017-1	Health	Clinic Researches	2017
1003-SAB-TTIP-2017-1	Health	Basic and Clinic Medical Sciences	2017
1003-BIT-AKAY-2017-1	ICT	Open Source Software	2017
1003-BIT-BGUV-2017-1	ICT	Information Security	2017
1003-BIT-BBIL-2017-1	ICT	Cloud Computing	2017
1003-BIT-EKRN-2017-1	ICT	Screen Technologies	2017
1003-BIT-GNBT-2017-1	ICT	Wide-Band Technologies (Including Cabled / Wireless Communication Technologies and IP Technologies)	2017
1003-BIT-GOMS-2017-1	ICT	Embedded Systems	2017
1003-BIT-ROME-2017-1	ICT	Robotics-Mechatronics	2017
1003-MAK-TSRM-2017-1	Machine-Production	Machine Design	2017

Table A.2 (continued)

Call Acronym	PTA	Sub-Technological Field	Year
1003-SBB-EGTM-2017-1	SSH	Education	2017
1003-SBB-EKBY-2017-1	SSH	Economic Growth	2017
1003-SBB-KENT-2017-1	SSH	Urbanization	2017

	OUTPUT	WOUTPUT	BUDGET	FINALIZATION	LARGE	MEDIUM	SMALL	PRIVATESECTOR	PROPORTIONALGRADE	SUBPROJECT	TEAMSIZE	YEARAFTERCALL	YEARAFTERSTART
OUTPUT	1.000000	0.986984	-0.252616	0.305798	-0.261875	0.026804	0.220560	-0.141857	-0.020180	-0.064499	-0.079737	0.360372	0.392738
WOUTPUT	0.986984	1.000000	-0.273010	0.315980	-0.269743	0.017496	0.235477	-0.154504	-0.043119	-0.077681	-0.100573	0.355513	0.386827
BUDGET	-0.252616	-0.273010	1.000000	-0.402291	0.827696	-0.073652	-0.706184	0.438570	0.114532	0.535760	0.551035	-0.304607	-0.363753
FINALIZATION	0.305798	0.315980	-0.402291	1.000000	-0.319351	-0.127623	0.400371	-0.110165	-0.152005	-0.191321	-0.230341	0.448065	0.506255
LARGE	-0.261875	-0.269743	0.827696	-0.319351	1.000000	-0.348818	-0.640212	0.480529	0.012643	0.539536	0.506244	-0.137703	-0.195994
MEDIUM	0.026804	0.017496	-0.073652	-0.127623	-0.348818	1.000000	-0.496631	0.022550	-0.004040	-0.026269	0.032800	-0.011363	-0.036551
SMALL	0.220560	0.235477	-0.706184	0.400371	-0.640212	-0.496631	1.000000	-0.463517	-0.008398	-0.478149	-0.495734	0.136845	0.211476
PRIVATESECTOR	-0.141857	-0.154504	0.438570	-0.110165	0.480529	0.022550	-0.463517	1.000000	-0.051953	0.410266	0.339139	-0.043721	-0.046152
PROPORTIONALGRADE	-0.020180	-0.043119	0.114532	-0.152005	0.012643	-0.004040	-0.008398	-0.051953	1.000000	0.027015	0.030328	-0.160370	-0.128590
SUBPROJECT	-0.064499	-0.077681	0.535760	-0.191321	0.539536	-0.026269	-0.478149	0.410266	0.027015	1.000000	0.588575	-0.028828	-0.082075
TEAMSIZE	-0.079737	-0.100573	0.551035	-0.230341	0.506244	0.032800	-0.495734	0.339139	0.030328	0.588575	1.000000	-0.035791	-0.048060
YEARAFTERCALL	0.360372	0.355513	-0.304607	0.448065	-0.137703	-0.011363	0.136845	-0.043721	-0.160370	-0.028828	-0.035791	1.000000	0.897862
YEARAFTERSTART	0.392738	0.386827	-0.363753	0.506255	-0.195994	-0.036551	0.211476	-0.046152	-0.128590	-0.082075	-0.048060	0.897862	1.000000

Figure A.1: Correlation Matrix of Variables Used for Project-Based Regression Analysis

	MEANWOU...	TIMEAFTER...	FINALIZATI...	FINALIZED...	MAINPROJ...	MEANFUND	MEANPRO...	MEANTEAMS...	MINPROPO...	PRIVATEPA...	SCALEREST
MEANWOU...	1.000000	0.480214	0.190074	0.284150	0.382300	-0.370003	-0.005285	-0.107291	-0.156508	-0.064916	0.133088
TIMEAFTER...	0.480214	1.000000	0.374548	0.434994	0.383332	-0.376111	-0.288908	0.053330	-0.398705	-0.046362	0.247609
FINALIZATI...	0.190074	0.374548	1.000000	0.709374	0.226855	-0.290094	-0.220480	-0.140676	-0.272362	-0.076297	0.073955
FINALIZED...	0.284150	0.434994	0.709374	1.000000	0.555396	-0.222950	-0.068821	-0.102836	-0.244007	0.056779	0.141861
MAINPROJ...	0.382300	0.383332	0.226855	0.555396	1.000000	0.026958	0.219919	0.084420	-0.278599	0.014757	0.009182
MEANFUND	-0.370003	-0.376111	-0.290094	-0.222950	0.026958	1.000000	0.139628	0.534017	0.029668	0.291934	-0.269706
MEANPRO...	-0.005285	-0.288908	-0.220480	-0.068821	0.219919	0.139628	1.000000	-0.078745	0.805554	0.120426	-0.271308
MEANTEAMS...	-0.107291	0.053330	-0.140676	-0.102836	0.084420	0.534017	-0.078745	1.000000	-0.175708	0.223141	-0.034648
MINPROPO...	-0.156508	-0.398705	-0.272362	-0.244007	-0.278599	0.029668	0.805554	-0.175708	1.000000	0.127957	-0.262929
PRIVATEPA...	-0.064916	-0.046362	-0.076297	0.056779	0.014757	0.291934	0.120426	0.223141	0.127957	1.000000	-0.147497
SCALEREST	0.133088	0.247609	0.073955	0.141861	0.009182	-0.269706	-0.271308	-0.034648	-0.262929	-0.147497	1.000000

Figure A.2: Correlation Matrix of Variables Used for Call-Based Regression Analysis

APPENDIX E: RESULTS OF CHOW BREAKPOINT TESTS APPLIED DURING ECONOMETRIC ANALYSIS

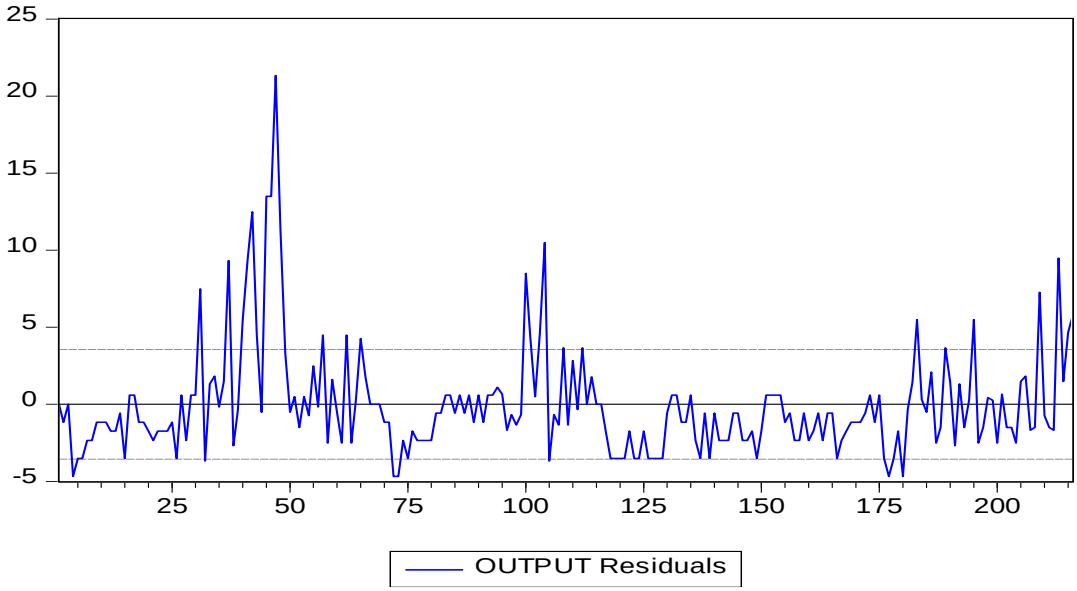

Figure A.3: Residual graph for project-based regression of "output" on selected variables

Chow Breakpoint Test: 65
Null Hypothesis: No breaks at specified breakpoints
Varying regressors: All equation variables
Equation Sample: 1 216

F-statistic	13.29531	Prob. F(2,212)	0.0000
Log likelihood ratio	25.52318	Prob. Chi-Square(2)	0.0000
Wald Statistic	26.59061	Prob. Chi-Square(2)	0.0000

Chow Breakpoint Test: 112
Null Hypothesis: No breaks at specified breakpoints
Varying regressors: All equation variables
Equation Sample: 1 216

F-statistic	9.932161	Prob. F(2,212)	0.0001
Log likelihood ratio	19.34628	Prob. Chi-Square(2)	0.0001
Wald Statistic	19.86432	Prob. Chi-Square(2)	0.0000

Figure A.4: Results of Chow Breakpoint Test at the points where PTAs change for the project-based regression of "output"

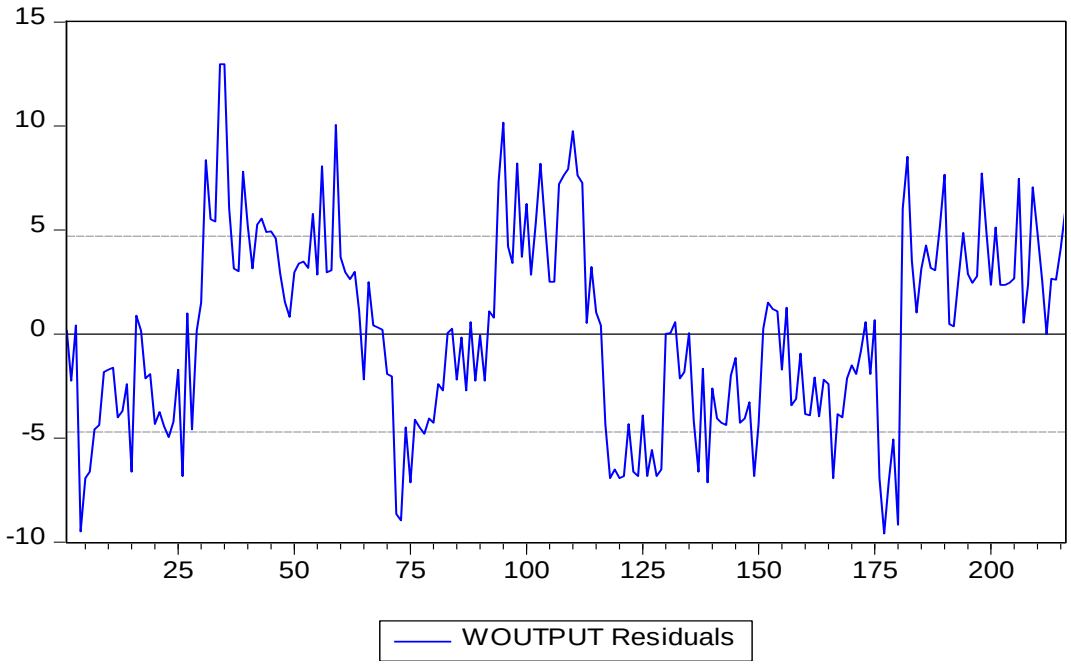

Figure A.5: Residual graph for project-based regression of "woutput" on selected variables

Chow Breakpoint Test: 65			
Null Hypothesis: No breaks at specified breakpoints			
Varying regressors: All equation variables			
Equation Sample: 1 216			
F-statistic	2.231738	Prob. F(3,210)	0.0856
Log likelihood ratio	6.779006	Prob. Chi-Square(3)	0.0793
Wald Statistic	6.695213	Prob. Chi-Square(3)	0.0823
Chow Breakpoint Test: 112			
Null Hypothesis: No breaks at specified breakpoints			
Varying regressors: All equation variables			
Equation Sample: 1 216			
F-statistic	5.126595	Prob. F(3,210)	0.0019
Log likelihood ratio	15.26675	Prob. Chi-Square(3)	0.0016
Wald Statistic	15.37979	Prob. Chi-Square(3)	0.0015

Figure A.6: Results of Chow Breakpoint Test at the points where PTAs change for the project-based regression of "woutput"

Chow Breakpoint Test: 23
Null Hypothesis: No breaks at specified breakpoints
Varying regressors: All equation variables
Equation Sample: 1 62

F-statistic	3.126325	Prob. F(3,56)	0.0328
Log likelihood ratio	9.600640	Prob. Chi-Square(3)	0.0223
Wald Statistic	9.378975	Prob. Chi-Square(3)	0.0247

Chow Breakpoint Test: 41
Null Hypothesis: No breaks at specified breakpoints
Varying regressors: All equation variables
Equation Sample: 1 62

F-statistic	2.830979	Prob. F(3,56)	0.0465
Log likelihood ratio	8.754650	Prob. Chi-Square(3)	0.0327
Wald Statistic	8.492937	Prob. Chi-Square(3)	0.0369

Figure A.7: Results of Chow Breakpoint Test at the points where PTAs change for the call-based regression of "meanwoutput"

APPENDIX F: PROJECT EVALUATION FORM USED FOR 1003 PROGRAM

Project Number	
Project Coordinator	
Project Title	

1- ORIGINALITY

JUSTIFICATION / EXPLANATION

2- METHODOLOGY

JUSTIFICATION / EXPLANATION

3- PROJECT MANAGEMENT, TEAM AND RESEARCH FACILITIES

JUSTIFICATION / EXPLANATION
a. <u>Project Management</u>:
b. <u>Project Team</u>:
c. <u>Research Facilities</u> (existing infrastructure/equipment**):**

4-CONTRIBUTION TO AIMS AND TARGETS OF CALL PROGRAM

JUSTIFICATION / EXPLANATION

5-WIDESPREAD IMPACT

JUSTIFICATION / EXPLANATION

VIEWS AND SUGGESTIONS REATED WITH THE SUITABLILITY OF PROJECT DURATION

VIEWS AND SUGGESTIONS RELATED TO THE SUITABILITY OF PROJECT BUDGET AND ITS JUSTIFICATION

OTHER OPINIONS

APPENDIX G: TURKISH SUMMARY / TÜRKÇE ÖZET

Bilim Teknoloji ve Yenilik (BTY) çalışmaları, hem sosyal refah hem de ekonomik büyümeye katkıda bulunan bilimsel ve teknolojik bilginin üretilmesine katkı sağlar. Hükümetler politika araçlarını ve ilgili kurumları kullanarak, sosyal ve ekonomik hedefleri doğrultusunda, ülkenin BTY sistemini geliştirmeye ve iyileştirmeye çalışırlar. Türkiye'de Ar-Ge ve yenilik faaliyetleri ve ilgili politikalar Türkiye Bilimsel ve Teknolojik Araştırma Kurumu (TÜBİTAK) ve Bilim ve Teknoloji Yüksek Kurulu (BTYK) aracılığıyla yürütülmekte ve yönetilmektedir. Türkiye'nin Ar-Ge ve yenilik politikası araçlarından biri de TÜBİTAK'ın 1003 Öncelikli Alanlar Ar-Ge Destek Programı'dır.

1003 Programı sonuç odaklı, gözlemlenebilir hedefleri olan ve ilgili bilim ve teknoloji alanlarının dinamiklerini gözeten yurtiçi Ar-Ge projelerinin desteklenmesi ve koordine edilmesi amacıyla 2012 yılında başlatılmıştır. Program kapsamında; kalkınma planları ile bilim teknoloji ve yenilik stratejileri dikkate alınarak BTYK ve TÜBİTAK Bilim Kurulu (BK) tarafından belirlenmiş olan 10 öncelikli teknoloji alanında (ÖTA) Ar-Ge projeleri desteklenmektedir.

1003 Programı çağrılı bir program olup, proje başvuruları yıl içerisinde belirli tarihlerde açılan çağrılar aracılığıyla kabul edilmektedir. 2012 yılından Mayıs 2017'ye kadar, bu program kapsamında 166 adet çağrı açılmıştır. 1003 Programı için 2 aşamalı başvuru ve değerlendirme süreci uygulanmaktadır. Çağrı amaç ve hedeflerine uygun olan ve Ar-Ge niteliği taşıyan araştırma projeleri 2. aşama başvurusuna hak kazanmaktadır. 2. aşamada ise her bir değerlendirme kriteri (özgün değer, yöntem, proje yönetimi ekip ve araştırma olanakları, program amaç ve hedeflerine katkı ve yaygın etki) için ve toplamda önceden belirlenen destek limitlerinin üzerinde puan alan projelerin desteklenmesine Başkanlık Onayı ile karar verilmektedir.

Üniversitelerde, araştırma enstitülerinde/merkezlerinde, kamu kurumu ve özel kuruluşlarda tam zamanlı olarak çalışan araştırmacılar, yürütücü veya araştırmacı olarak bu programa proje önerebilirler. Bu projeler bütçelerine göre küçük, (500.000 TL'ye kadar), orta (1.000.000 TL'ye kadar) ve büyük (2.500.000 TL'ye kadar) olmak üzere 3 farklı ölçeğe ayrılmaktadır. Orta ve

büyük ölçekli projeler, çağrıya özel bir kısıt bulunmaması halinde, en fazla 3 alt projeye sahip olabilirler. Küçük ölçekli projelerin süresi en fazla 24 ayken diğer projelerde bu süre en fazla 36 aydır.

Bu tez çalışması kapsamında;

"1003 TÜBİTAK Hibe Programı'nın niteliksel ve niceliksel etkileri nasıl geliştirilebilir ve bu etkiler farklı ÖTA'lar için farklı mıdır?"

sorusu araştırılmaktadır. Bu araştırma ile

"Desteklenen 1003 projelerinden daha fazla fayda sağlanabilir ve 1003 fonlarını (alt) ÖTA'lar ve desteklenen projeler arasında yeniden tahsis eden yeni bir politikayla ülkenin kalkınmasına ve büyümesine daha fazla katkıda bulunulabilir."

şeklindeki tez cümlesi kanıtlanacaktır. **Bu çalışmanın temel amacı;** TÜBİTAK tarafından uygulanan Ar-Ge politika araçlarından birini daha verimli ve etkili bir hale getirmektir. Bunun sonucunda, programın misyonuna (ekonomik kırılganlıkları, dışa bağımlılığı ve bütçe açığını azaltırken, ekonomik büyüme ve sosyal refahı artırarak gelişmiş ülkelerin seviyesine ulaşmak ve onlarla rekabet edebilmek) daha etkili bir şekilde katkı sağlanabilecektir.

Uluslararası pazarlarda rekabet artmaktadır. Bununla birlikte, bir ülkenin araştırma yapmak için kullandığı mevcut teknolojik, mali ve insan kaynakları kısıtlıdır. Bu nedenle, sadece uluslararası eğilimleri değil, aynı zamanda ulusal ihtiyaçları, sosyo-ekonomik yapıları, araştırma altyapısını ve yeterliliklerini de göz önünde bulundurarak, araştırma faaliyetleri için öncelikli alanların seçilmesine ihtiyaç duyulmaktadır. Literatürde önceliklendirme için hem gelişmiş hem de gelişmekte olan ülkeler tarafından uygulanan için iki yaklaşım vardır: tematik önceliklerle tepeden aşağı yaklaşım ve fonksiyonel önceliklerle tabandan tepeye yaklaşım. Tepeden aşağı yaklaşımda, öncelikler hükümet organları tarafından dikte edilirken, tabandan epeye yaklaşımda öncelikler hakkında görüş birliğine varmak için tüm paydaşların katılımıyla, öngörü çalışmaları, anketler ve grup tartışmaları yürütülmektedir. Tablo A.3.'te farklı ülkelerin BTY öncelikleri ve bunların altında yatan amaç ve hedeflerle karar sürecinde kullanılan yöntemler özetlenmektedir.

Tablo A.3: Farklı ülkelerde uygulanan önceliklendirme politikaları

Ülke	Yöntem	Yıl	Öncelikli Alanlar	Seçim Kriterleri
Japonya	Tepeden Aşağı Yaklaşım	2001, 2006	Yaşam Bilimleri, BIT, Nanoteknoloji/Malzeme, Çevre, Enerji, İmalat, Sosyal Altyapı, Uzay ve Deniz Bilimleri	-
ABD	Tabandan Tepeye Yaklaşım	-	Sadece fonksiyonel öncelikler	Araştırmacıların tercihleri
Hollanda	Sistemik bir model ile Tabandan Tepeye Yaklaşım	-	Sadece fonksiyonel öncelikler	• Araştırmacıların ilgileri • Günün önemli hususları
Avrupa Birliği	Fayda-maliyet modeli ile Tepeden Aşağı Yaklaşım	1994, 1998, 2002, 2007, 2014	Sağlık (İlaç, Biyoteknoloji), BIT, Enerji, Yaşam Kalitesi, Çevre (sıfır atık), Üretim Teknolojileri (Nanoteknoloji), Gıda, Ulaşım, Sosyal Bilimler	• Avrupa'ya katma değeri • AB politikalarına katkı • Avrupa'nın Ar-Ge potansiyeline etkisi
Yeni Zelanda	İstişare ile Tepeden Aşağı Yaklaşım	-	Doğal Kaynaklar ve Biyoloji, Yeni Fizik Teknolojileri, Geleceğin İnsan Teknolojileri	• Görece üstünlük ve güçlülük • Çevre ve toplumsal hedeflerle ilişki
Kanada	Tepeden Aşağı	1996, 2001	Yaşam Bilimleri ve Sağlık, BIT, Uzay, Çevre, Su ve Doğal Kaynaklar, Gıda	• Ekonomik rekabet gücüne katkı • Kanadalıların sosyal faydası
İrlanda	Öngörü çalışmaları ile Tepeden Aşağı Yaklaşım	-	Biyoteknoloji, BIT, Fonksiyonel öncelikler	-
Birleşik Krallık	Öngörü çalışmaları ile Tepeden Aşağı ve Tabandan Tepeye Yaklaşım	-	Fonksiyonel öncelikler Her ajans tarafından belirlenen tematik öncelikler	• Uluslararası trendler • Ulusal ve toplumsal ihtiyaçlar
Çin	Politika yapıcılar ve paydaşlar arasında fikir birliği	2006	Enerji, Su, Çevre, Gıda, İmalat, Ulaşım, Bilgi Bilimleri, Sağlık, Kentleşme, Kamu Güvenliği, Ulusal Savunma	• Sanayi ihtiyaçları • Dünyadaki BT gelişmeleri
Kore	Tepeden Aşağı	2003	BIT, Biyoteknoloji, Yaşam Bilimleri, Nanoteknoloji, Çevre, Malzeme, Uzay, Ulusal Güvenlik, Nükleer Enerji, Sağlıklı Toplum	-

Türkiye'de bu iki önceliklendirme yaklaşımı entegre bir şekilde uygulanmaktadır. Tematik öncelikler, yani ÖTA'lar, tepeden aşağı yaklaşımla TÜBİTAK BK ve BTYK

tarafından ilan edilmektedir. 1003 programı kapsamında, Türkiye'nin Ar-Ge kapasitesinin yüksek olduğu Bilgi ve İletişim Teknolojileri (BİT), Otomotiv ve Makine/İmalat alanlarının yanı sıra ivme kazanılması gereken Enerji, Su, Tarım, Sağlık ve Havacılık alanlarında çağrılar açılmaktadır. Ayrıca, TÜBİTAK BK tarafından ÖTA olarak seçilen Kimya ve Sosyal ve Beşeri Bilimler (SBB) alanlarına yönelik çağrılar da mevcuttur. ÖTA'ların alt alanları ile 1003 programı kapsamında açılacak çağrıların başlığı, kapsamı, amaçları ve özel hususları belirlemek için ise tabandan tepeye yaklaşımla öngörü çalışmaları yürütülmektedir.

Türkiye'nin ÖTA'ları ve alt teknoloji alanları, diğer ülkelerin tematik öncelikleri ile karşılaştırıldığında, çoğunluğunun, uluslararası eğilimlere benzer olduğu görülmektedir. BİT, Sağlık, Tarım, SBB, Su ve Enerji, gelişmiş ve gelişmekte olan ülkelerin neredeyse tamamı tarafından önceliklendirilmiş olan alanlarken, Üretim Teknolojileri sadece daha az gelişmiş ülkeler olan Çin ve AB tarafından öncelikli alan olarak seçilmiştir. Öte yandan Havacılık-Uzay, gelişmiş ülkelerden yalnızca iki tanesi (Japonya ve Kanada) tarafından önceliklendirilmiştir. Bununla birlikte, Otomotiv, incelenen ülkeler tarafından öncelik verilen alanlar arasında bulunmazken, diğer birçok ülke tarafından öncelikli olarak belirlenmiş olan, Ulaştırma, Milli Savunma, Kamu Güvenliği, Atık ve Çevre gibi alanlar Türkiye tarafından doğrudan önceliklendirilmemiştir.

Ulusal BTY politikalarının ekonomik büyüme ve sosyal refah açısından başarısını tespit etmek için, Ar-Ge ve yenilik faaliyetlerinin doğrudan ve dolaylı kısa süreli ve uzun vadeli etkileri ölçülmelidir. Bunu başarmak için, üç farklı analiz entegre ve ardışık olarak uygulanmalıdır: hedefleri belirlemek için ön-değerlendirme, süreçleri izlemek için ara-değerlendirme ve faaliyetlerin başarısını değerlendirmek için nihai-değerlendirme. Literatürde, bu analizler için kullanılan çeşitli nicel ve nitel yöntemler bulunmaktadır.

Tobit model tahmini, Veri Zarflama Analizi (DEA), Stokastik Sınır Analizi (SFA), ve Maksimum Olabilirlik Tahmini (MLE) yöntemlerini içeren ekonometrik analizler kantitatif yöntemlerdendir. Diğer taraftan, akran değerlendirmeleri ve grup analizi nitel analiz yöntemlerine örnek olarak verilebilirken literatürde etki değerlendirmesi için bu tip yöntemler kullanan çalışmalar oldukça sınırlıdır. Bunlara ek olarak, kullanılan veri özelliklerine göre, eğilim skoru eşleştirme

(PSM) ve fark içinde fark (DiD) gibi hem niceliksel hem de niteliksel olabilecek yöntemler de vardır. Literatürde bu yöntemler kullanılarak yürütülmüş olan çalışmaların örnekleri Tablo A.4'te görülmektedir.

Tablo A.4: Etki değerlendirmesi ve kaynak dağılımı üzerine literatürde yer alan çalışmalar

Yazar(lar)	Yıl	Çalışmanın Amacı	Kullanılan Yöntem
Czarnitzki & Hussinger	2004	Yenilik çalışmaları ve çıktıları için verilen Ar-Ge desteklerinin etkilerinin tespit edilmesi	PSM (nicel)
Feldman & Kelley	2006	Ekonomik ve toplumsal göstergeler üzerindeki muhtemel etkisi en yüksek olan projelerin tespit edilmesi için bir ön-değerlendirme sistemi geliştirilmesi	MLE ile çok değişkenli LOGIT modeli
Falk	2007	Avusturya yenilik politikasının etkilerinin ölçülmesi Firma özelliklerinin artımsallıkla olan ilişkisini tespit edilmesi	Grup analizlerinin karşılaştırması
Conte ve ark.	2009	Farlı AB üyesi ülkelerin yenilik performanslarının ölçülmesi ve karşılaştırılması	SFA
Tandoğan	2011	Türkiye'deki kamu teşviklerinin özel sektör Ar-Ge aktiviteleri ve yatırımlarına olan etkisini ölçülmesi	Tobit modeli PSM (nitel) DiD
Fedderke & Goldschmidt	2014	Güney Afrika'daki Ar-Ge fonlamasını etkisinin değerlendirilmesi	PSM Akran değerlendirmesi
Eilat ve ark.	2008	Kaynakların farklı aşamalardaki Ar-Ge projelerine optimum dağılımı	DEA İşletme Karnesi
Linton ve ark.	2002	Optimum bir proje portföyü seçmek için r-Ge çalışmalarının potansiyelinin ölçülmesi	DEA Değer yaratma Modeli
Wonglimpiyarat	2008	Kaynakların farklı teknoloji alanlarına optimum dağıtılması için bir sistem geliştirmek	Çıktı, sonuç ve etki değerlendirmesi
Garrison ve ark.	2011	Maliyet etkinliği yüksek yenilik aktivitelerinin seçilmesi	Maliyet etkinliği analizi
Volinskiy ve ark.	2011	Kanada'nın kamu araştırma destek mekanizması için kaynak dağılımı	Fayda-maliyet analizi Seçim deneyi
AB Komisyonu	2011	Desteklenmesi daha iyi olan alan ve politikaların tespit edilmesi için etki analizi Kaynakların seçilen programlara dağıtılması	BTY göstergeleri analizi Ekonometrik analizler Çıktıların tanımlayıcı istatistikleri Uzman ve paydaşlarla panel tartışması

Ar-Ge faaliyetlerinden elde edilen faydaları arttırmak için kıt kaynaklar bu faaliyetlere etkin ve verimli bir şekilde dağıtılmalıdır. Literatürde bu amaç için kullanılan nitel ve nicel yöntemleri derinlemesine açıklayan çeşitli çalışmalar bulunmaktadır. Heidenberger ve Stummer (1999), çalışmalarında Ar-Ge projelerinin seçimi kaynak dağıtımı için kullanılabilecek yöntemleri incelemektedir. Bu yöntemler arasında Analitik Hiyerarşi Süreci (AHP), indirgenmiş nakit akımlarının net bugünkü değeri, Delphi yöntemi, matematiksel programlama modelleri, oyun teorisi yöntemleri ve karar ağacına ek olarak sezgisel ve stokastik yaklaşımlar yer almaktadır. Ayrıca, Chuller (n.d.) de çalışmasında Delphi yöntemi avantajları ve dezavantajları ile tanımlamıştır. Bu yöntemlerin kullanıldığı vaka çalışmalarının literatürdeki örneklerine Tablo A.4'te yer verilmiştir.

Etki değerlendirmesi ve analizi; önemine ve faydalarına rağmen; yüksek maliyeti, uzun zaman gereksinimi ve veri elde etmedeki zorluklar nedeniyle çok fazla tercih edilmemektedir. Dolayısıyla, bu tür çalışmaların literatürdeki örnekleri sadece küresel vakalar değil, aynı zamanda Türkiye için de sınırlıdır. Hatta, TÜBİTAK'ın destek mekanizmaları ve 1003 Programı'nın etki değerlendirmesi hakkında literatürde herhangi bir çalışmaya rastlanmamıştır. Ayrıca, literatürde etki değerlendirmesi olarak sınıflandırılan çalışmaların çoğu aslında çıktı analizidir. Bu çalışmalarda etkiyi ölçmek için sadece Ar-Ge çalışmalarının çıktıları dikkate alınmakta iken etkin ve etkili bir etki değerlendirmesi diğer etkiler de dikkate alınmalıdır. Literatürdeki kaynak tahsisine ilişkin çalışmaların çoğunun ise proje seçim seviyesinde olduğu dikkate alınmalıdır. Literatürde farklı teknoloji alanları veya farklı Ar-Ge politika araçları için finansman kaynaklarının dağıtılması konusunda da kapsamlı bir çalışma bulunmamaktadır.

Bu tez çalışması kapsamında; TÜBİTAK'ın 1003 Destek Programı'nın, çıktı, girdi ve davranışsal artımsallıkları farklı ÖTA'lar için karşılaştırılarak değerlendirilmektedir. Bu değerlendirmenin amacı, yeni politikalar önererek programın etkinliğini ve etkinliğini arttırmaktır.

Bu değerlendirme çalışması için, program göstergelerinin tanımlanması ve analizi ile bu göstergelerin çıktı miktarı ile ilişkisini tahmin etmeyi amaçlayan ekonometrik analizler nicel yöntem olarak seçilmiştir. Diğer taraftan nitel yöntem olarak, desteklenen projelerin yürütücülerinden oluşan bir örneklem ile mülakat çalışması yapılmıştır. Program göstergelerinin tanımlayıcı istatistikleri tüm ÖTA'lar için incelenirken, diğer iki yöntem sadece Enerji, BİT ve Sağlık için uygulanmıştır.

İlk aşama olarak; program göstergelerinin incelenmesi kapsamında, açılan çağrılar; önerilen, desteklenen, sonuçlanan projelerin toplam ve ortalama sayıları ile bunların proje ölçeği, yürütücü kuruluş türü, yürütücünün cinsiyeti, alt-proje sayısı ve projenin yürütüldüğü ile göre dağılımları; talep edilen ve verilen fon miktarları ile bunların yürütücü kuruluş türü ve yürütücünün cinsiyetine göre dağılımı; ve çıktılar ile bunların proje ölçeği, çıktı türü ve elde edilme zamanlarına göre dağılımı tanımlayıcı istatistiklerden faydalanılarak analiz edilmiştir.

Bu çalışma, durum tespiti ve nihai değerlendirme amacı ile yürütülmektedir. Bu analizler sonucunda, 1003 Destek Programının verimsiz ve etkisiz noktaları ile mevcut durumu tespit edilecektir. Ayrıca; proje sayısı, proje özellikleri, çıktılar ve fon miktarlarının dağılımı açısından ÖTA'lar arasındaki farkın ortaya çıkarılması beklenmektedir. Bunlara ek olarak, bu göstergeler, yapılacak ekonometrik analizler sırasında bağımsız değişkenlerin seçimi için bilgi sağlayacaktır.

Bu çalışmadan aşağıdaki sonuçlar elde edilmiştir:

• Bazı teknoloji alanlarında çalışan araştırmacı sayısı az olması sonucu Havacılık ve Uzay gibi alanlarda önerilen ve desteklenen projeler de az sayıdadır. Bu nedenle, bu alanlarda nitelikli araştırmacı yetiştirmek ve bu kişileri programa çekmek için bir politika aracına ihtiyaç vardır.

• Havacılık ve SBB projeleri için ilk aşama değerlendirmesini geçme oranı düşüktür. Bu, Havacılık çağrılarına başvuran ve daha çok teknik konulara yoğunlaşmayı tercih eden araştırmacıların bürokrasiden uzak olmasından kaynaklanıyor olabilir. Mülakat yapılan yürütücülerin özellikle başvuru

sürecindeki bürokrasinin yoğunluğu ve karmaşıklığı ile ilgili görüşleri ile Bürokrasiden uzak olan özel sektörden Havacılık alanı için önerilen projelerin yüksek oranı da bu iddiayı desteklemektedir. SBB için ise, bu durumun nedeni, bu alandaki proje yürütücülerinin Ar-Ge çalışmasının ve 1003 çağrılarının gereksinimleri konusundaki derin bilgi eksiklikleri olabilir. SBB alanında açılan çağrıların kapsamı oldukça geniş olması ve bu konuların doğrudan tüm toplumun günlük sosyal sorunları ile ilgili olması nedeniyle, başvuru şartlarını sağlayan herhangi biri AR-GE faaliyetleri ile ilişkisinin önemi olmaksızın bu alandaki çağrılara proje önerebilir. Tüm bu sonuçlar, Frascati Kılavuzunda anlatılan Ar-Ge faaliyetlerinin ve 1003 Programının özellikleri ve gereksinimleri konusunda proje yürütücülerinin ve paydaşların bilgilendirilmesinin gerekliliğini göstermektedir

• Tüm ÖTA'lar için, önerilen ve desteklenen projelerin neredeyse tamamı üniversitelere aittir. Ayrıca, önerilen ve desteklenen projeler için alt projeye sahip olma oranı da düşüktür. Bu bulgulardan, 1003 Programı kapsamında üniversite-sanayi işbirliğini sağlama girişimlerinin amaçlandığı kadar başarılı olmadığı sonucuna varılabilir.

• Havacılık ve Makine-İmalat alanlarındaki düşük kadın yoğunluğunun bir göstergesi olarak, bu alanların çağrıları için önerilen projelerin yürütücüleri ağırlıklı olarak erkektir. Öte yandan, kadın araştırmacıların önerdiği projelerin birinci aşama değerlendirmesini geçme ve desteklenme oranları erkeklerin önerdiği projelere oldukça yakındır. Bu, bazı teknoloji alanlarındaki kadın araştırmacı yoğunluğunun ve 1003 Programına olan ilgilerinin iyileştirilmesi gerektiği anlamına gelir.

• Bazı çağrılardaki orta ve büyük ölçekli projeler için alt projelere sahip olma şartına rağmen, alt projelere sahip olan projelerin sayısı düşüktür. Çünkü neredeyse tüm ÖTA'lar için önerilen ve desteklenen projelerin çoğu küçük ölçeklidir. Ayrıca, araştırmacılar orta ve büyük ölçekli projeler için mümkün olan en düşük alt proje sayısı ile proje önermeyi tercih etmektedir. Araştırmacılar, bu tür projeler önermeyi tercih etmelerinin sebebi alt projeleri olan ve olmayan projelerin destek oranın neredeyse aynı olmasıdır. Buna ek olarak, alt proje sayısındaki artış ile birlikte, bürokratik süreçlerin artarak karmaşıklaşması ve proje yönetiminin zorlaşmasına rağmen projelerin destek oranında önemli bir

değişiklik olmamaktadır. Üniversite-sanayi işbirliğindeki başarısızlık, küçük ölçekli ve daha az alt projeye sahip olan projelerin tercih edilmesinin de bir sonucu olabilir.

• Türkiye'nin hemen hemen tüm şehirlerinden önerilen ve desteklenen projeler olmasına rağmen, bu projelerin çoğu sadece nüfusun değil aynı zamanda ekonomik ve endüstriyel faaliyetlerin de yoğun olduğu illerde bulunan kuruluşlardandır. Başvuru miktarındaki bu bölgesel eşitsizliği gidermek için bölgesel önceliklendirme politikaları; destek oranlardaki farklılık için ise, bölgesel seçim mekanizmaları önerilebilir. Buna ek olarak, daha az projeye sahip bölgelerdeki araştırmacılar ile daha aktif ve başarılı illerden gelen araştırmacılar arasındaki işbirliğini artıracak mekanizmalar da, bölgesel eşitsizliğin ortadan kaldırılmasına yardımcı olabilir.

• Özel sektörden teklif edilen projeler için yarısı yürütücü kuruluş tarafından sağlanan makine ve ekipman maliyetleri proje bütçesini domine etmesi nedeniyle özel sektör projelerine verilen fonlar, yüksek personel maliyetlerine rağmen, diğer kuruluşlarınkinden daha yüksek değildir. Bunun bir diğer göstergesi olarak, daha kısıtlı Ar-Ge altyapısına sahip olan kamu kurumlarına ait projelerin fonlama bütçeleri daha yüksektir. Bu durum, bazı kurumlar ve teknoloji alanları için ek bir makine ve ekipman altyapısı sağlama mekanizmasının gerekliliğine işaret etmektedir.

• Çıktı elde etme süresinin Her bir ÖTA için farklı olmasına rağmen, çıktıların büyük çoğunluğu, tüm ÖTA'lar için, proje sonuçlanmadan ve başladıktan sonraki 2 yıl içerisinde elde edilmektedir. Ayrıca, çıktıya sahip olma ihtimali, çıktı miktarı ve çıktının elde edilme zamanı hem ÖTA'nın hem de projenin başlangıç ve hedef Teknoloji Hazırlık Seviyesi (THS) gibi özellikleri ile değişebilir.

İkinci aşama olarak, 1003 Programının çıktı artımsallığı açısından daha etkin ve verimli hale getirilmesi için politika önerileri oluşturmak amacıyla ekonometrik analizler yürütülmektedir.

Çıktı miktarlarının hem projelerin hem de çağrıların özellikleriyle ilişkisini göstermek için iki farklı model kullanılmıştır. Program göstergeleri üzerinde yapılan analizler sonucunda, ÖTA'lar arası dengesizliklerin tespit edildiği proje

ölçeği, fonlama miktarı, alt proje sayısı ve desteklenen proje sayısı gibii proje ve çağrı özellikleri, bağımsız değişken olarak seçilmiştir. Ayrıca, literatürdeki benzer çalışmalarda kullanılan bazı özellikler de modellere eklenmiştir. Bunlar, Fedderke & Goldschmidt (2015) tarafından kullanılan akran değerlendirme puanları ilgili değişkenler ile Tandoğan (2011) tarafından kullanılan alt proje sayısı ve özel sektör katılımı ile ilgili değişkenlerdir.

İlk model olarak, desteklenen projelerin toplam çıktı miktarı, program göstergeleri üzerindeki tanımlayıcı analizler sonucunda dengesiz dağılım gözlenen proje özellikleri üzerinden tahminlenmektedir (Bkz. Denk. 1). Bu regresyon için kullanılan örneklemde Enerji için 65, BİT için 47 ve Sağlık için 103 olmak üzere toplam 216 proje mevcuttur. Örneklemde yer alan projeler, veri alındığı sırada desteklenmiş ve başlatılmış olanlardır.

(Ağırlıklı) Çıktı Miktarı = f (proje özellikleri vektörü) + u (Denk. 1)

Bu model için, hem orijinal hem de ağırlıklı toplam çıktı miktarı tahminlenmiş ve mevcut bağımsız değişkenlerle daha iyi açıklanabilen ağırlıklı değer bağımlı değişken olarak seçilmiştir.

Ağırlıklı çıktı miktarını hesaplamak için ise, her bir ÖTA'daki çıktı türlerine farklı bir ağırlık verilir. Ağırlıklar, sadece çıktıların farklı ÖTA'lar için türlerine göre dağılımı değil, aynı zamanda mülakatlara katılan proje yürütücülerinden alınan cevaplar da dikkate alınarak belirlenmiştir.

Bir projenin toplam ağırlıklı çıktı miktarı, Denk.2'deki gibi hesaplanır:

Ağırlıklı çıktı miktarı=$\sum_i Ağırlık_{ij} * (Çıktı\ Miktarı)_i$/Toplam Çıktı Miktarı (Denk. 2)
(i: çıktı türü j: ÖTA)

Diğer yandan, ikinci modelde, her bir çağrı için desteklenen projelerin ortalama ağırlıklı çıktı miktarı, hem çağrı özellikleri hem de eğer mevcutsa önceki modelde kullanılan değişkenlerin ortalaması üzerinden tahminlenmektedir (Bkz. Denk. 3). Bu regresyon için, Enerji için 23, BİT için 18 ve Sağlık için 21 olmak üzere toplam 62 çağrının bulunduğu bir örneklem kullanılmıştır Örneklemdeki çağrılar, destek kararı verilen ve projeleri başlamış olan çağrılardır.

Ortalama(Ağırlıklı) Çıktı Miktarı = f (çağrı özellikleri vektörü) + u (Denk. 3)

Bahsi geçen bu iki model, Olağan En Küçük Kareler (EKK) yöntemi kullanılarak tahmin edilmiştir. Bu doğrultuda, her iki model için de EKK yönteminin gereksinimlerinin karşılandığı kabul edilmiş ve bunu doğrulamak için, seçilen modellere tanı testleri uygulanmıştır. Testler sonucunda herhangi bir eksiklik veya hata gözlemlenmesi durumunda, seçilen doğrusal modellerde gerekli düzenlemeler yapılmıştır.

Ekonometrik analizler sonucunda elde edilen regresyon modellerinden aşağıdaki çıkarımlar yapılmıştır:

- Proje ve çağrı bazlı özellikler çıktı miktarları üzerinde farklı ÖTA'lar için farklı etkilere sahiptir. Bu nedenle, ÖTA'ların nitelikleri ve gereksinimlerine göre farklı uygulama, değerlendirme ve destekleme kriterleri kullanılmalıdır.

- Fonlama miktarı ile çıktı sayısı arasındaki negatif ilişki nedeniyle, desteklenen projelere verilen destek miktarının çıktı artımsallığı açısından verimsiz olduğu sonucuna varılabilir. Büyük ölçekli bir proje olmanın, yani daha uzun zaman aralığı için daha yüksek miktarda fon almanın negatif etkisi de bu iddiayı desteklemektedir. Bu sonuç aynı zamanda, mülakat çalışmasının çıktı artımsallığına fonlama tutarının etkisine ilişkin sonuçları ile de uyumludur.

- Alt proje sayısının çıktı miktarına etkisinin anlamsız olması, minimum alt proje sayısı ile ilgili çağrı kısıtlarını verimsiz kılmaktadır.

- Enerji çağrıları için önerilen projelerin ölçeğine ilişkin kısıtların çıktı miktarı açısından anlamsız oluşu bu kısıtları etkisiz hale getirirken, büyük ölçekli bir proje olmanın negatif etkisi ile küçük veya orta ölçekli bir proje olmanın anlamsız olması ölçeklendirmeyi çıktı artımsallığı açısından etkisiz ve verimsiz kılmaktadır. Program göstergelerinden elde edilen çıktısı olan projelerin çoğunun küçük ölçekli olması bilgisi ile mülakat yapılan araştırmacıların ölçeklendirme hakkındaki görüşleri de bu iddiayı desteklemektedir.

- Desteklenen projelerin akran değerlendirmesi puanın ile bir çağrıda desteklenen projelerini minimum değerlendirme puanının çıktı miktarına olan

anlamsız etkisi nedeniyle değerlendirme ve destekleme kriterlerinin çıktı artımsallığı açısından etkisiz olduğu görülmektedir.

• Proje ekibinin büyüklüğünün çıktı miktarına olan negatif ve anlamsız etkisi onu çıktı artımsallığı açısından etkisiz ve verimsiz hale getirir. Buradan, alt projeli projelerin teşvik edilmesinin anlamsız olduğu sonucuna varılabilir.

• Proje ekibinde sanayi kuruluşlarından bir araştırmacının varlığının etkisizliği üniversite-sanayi işbirliğini arttırmaya yönelik girişimlerin mevcut koşullarda çıktı artımsallığı açısından anlamsız olduğunu göstermektedir.

Son aşama olarak, proje yürütücülerinden oluşan bir örneklemle mülakat çalışması düzenlenmiştir. Bu alıştırmanın ana hedefi, 1003 Destek Programının paydaşlar tarafından gözlemlenen girdi, çıktı, proje ve davranışsal artımsallıklarını farklı teknoloji alanları için tespit etmektir. Proje öncesinde ve sonrasında proje ekibinin işbirliği ile ilgili sorularla, proje sonucunda ekibin ve yürütücü kuruluşun karşılaştığı fırsat ve fırsat maliyetleriyle ilgili sorular davranışsal artımsallığı tespit etmek için kullanılmıştır. Yürütücülerin, 1003 projesinin öncesinde ve sonrasında, TÜBİTAK'ın destek programlarına önerdiği projeler ise proje artımsallığını bulmak için sorgulanmaktadır. Ek olarak, projenin hem uzun vadeli etkileri hem de literatüre olan bilimsel katkıları açısından çıktı artımsallıklarını ortaya çıkarmaya yönelik sorular da mevcuttur. Ayrıca, projenin yeni nitelikli araştırmacı yetiştirme kabiliyeti ile ilgili sorularla projelerin girdi artımsallıkları sorgulanmıştır. Son olarak, yürütücülerin programı geliştirmeye yönelik önerileri ile programın başarı ve başarısız olduğu noktalar ile ilgili tespitleri de sorgulanmıştır.

Görüşme sorularının özellikle proje öncesi, proje ve proje sonrası ile ilgili bölümleri; Tandoğan (2011), Kim & Oh (2002) ve Avrupa Araştırma Konseyi raporunda (2012) kullanılan anket ve görüşme soruları uyarlanarak hazırlanmıştır. Ayrıca bu çalışmada vakaya özel bazı ek sorular, özellikle de programın genel politikası hakkında sorular, da yer almaktadır.

Mülakat yapılan örneklem, çıktısı olan ve olmayan sonuçlanmış ve yürürlükteki 16 projenin yürütücülerinden oluşmaktadır. Örneklemde yer alan yürütücülerin

projeleri her bir ÖTA için, yürütücülerin cinsiyeti, kurumlarının türü ve bulundukları ile ilişkin program göstergeleri ile orantılı olarak dağıtılmaktadır.

Sonuç olarak; bu çalışmaya dahil edilen tüm alanlarda desteklenen projelerin proje artımsallığı sağlama, istihdam yaratma, nitelikli Ar-Ge personeli yetiştirerek ve mevcut Ar-Ge personelinin bilgi birikimini artırarak girdi artımsallığı sağlama ve ekonomik ve teknolojik dışa bağımlılığı azaltıp ülkenin rekabet gücünü artırarak çıktı artımsallığı sağlama konularında yüksek katkılarının olduğu tespit edilmiştir. Ayrıca BİT alanında olmasa da Enerji ve Sağlık alanlarında, davranış artımsallığına katkı da oldukça yüksektir. Ek olarak, verilen desteklerle yürütücü kuruluşların altyapısın geliştirme konusunda da orta düzeyde girdi artımsallığı sağlanmıştır. Bununla birlikte desteklenen projelerin, üniversite-sanayi işbirliğine katkısı oldukça düşük olup, bu durum proje ekibinde sanayi kuruluşlarından araştırmacı içeren projeler için de geçerlidir.

Fonlama tutarları BİT ve Sağlık projeleri için yeterli bulunurken, Enerji projeleri için bu durum tam tersi olmuştur. Destek miktarını yetersiz bulan proje yürütücüleri genellikle verilen destek tutarının bütçe kalemleri arasında aktarılamamasından ve bütçenin enflasyon ve kur değişimleri sebebiyle zaman geçtikçe değere kaybetmesinden yakınmışlardır. Proje ölçeklendirme sistemi BİT projeleri ve Enerji projelerinin yarısı için uygun bulunurken, Sağlık projeleri için uygunsuz olarak nitelendirilmiştir.

Yalnızca Enerji ve BİT projeleri için temel araştırma ve kavramsal çerçevenin öneri aşamasında var olduğu belirtirmiştir. Ayrıca, bu tür projelerin çıktı elde etme ihtimalinin yani çıktı artımsallıklarının daha yüksek olduğu tespit edilmiştir.

Bu çalışma kapsamındaki nicel ve nitel analizlerin sonucunda aşağıdaki ifadeler çıkarılmıştır:

- Desteklenen projelerin ve çıktıların; üniversite-sanayi işbirliğinin teşvik edilmesi, küresel pazarda yüksek yetkinliğe sahip ürün odaklı çıktıların geliştirilmesi ve ekonomik büyümenin ve sosyal refahın artırılması gibi program hedeflerine katkı kapasiteleri yetersizdir.

- Desteklenen projelerden elde edilen çıktıların çoğu temel araştırma seviyesindedir ve gerçek ürüne dönüştürülebilmekten oldukça uzaktır.

- Üniversite-sanayi işbirliğini sağlamak ve ürün odaklı çıktılar yaratmak için gerekli olan özel sektör katılımı etkisizdir.

- Teklif edilen ve desteklenen proje sayıları, farklı çağrılar için çok geniş bir aralıkta değişmektedir.

- Proje özelliklerinin çıktı miktarlarına etkileri ÖTA'larla birlikte değişiklik göstermektedir.

- ÖTA'larla birlikte çok fazla değişmeyen fonlama tutarı, bazı teknoloji alanları için verimsiz ve etkisizdir.

- Proje ölçekleri, çıktı artımsallığı açısından etkisiz ve verimsizdir. Hatta önerilen ve desteklenen projelerle, çıktı sahibi olan projelerin çoğu küçük ölçeklidir.

- Alt projelere ve daha geniş proje ekibine sahip olmak, fonlama tutarı üzerinde artan bir etkiye sahip olsa da, bu özellikler destek alma ve çıktı artımsallığı açısından verimsiz ve etkisizdir.

- Akran değerlendirme puanları ve desteklenen projelerin minimum puanı ile temsil edilen desteklenen projelerin nitelikleri de etkisizdir.

Bütün bu eksiklikleri çözmek için aşağıdaki politikalar önerilmektedir:

Ar-Ge çalışmalarının ve 1003 programının gereklilikleri ve bürokratik süreçler hakkında, araştırmacılar ilgili kurum ve kuruluşlar tarafından bilgilendirilmelidir.

Bürokrasinin caydırıcı etkisinin ortadan kaldırılması için kurallar ve yönetmelikler sadeleştirilebilir.

Gerekli olan nitelikli Ar-Ge personelinin yetiştirilmesi ve temel bilginin oluşturulabilmesi için, gelecekte önceliklendirilecek konularla ilgili temel araştırma faaliyetleri ek finansman mekanizmaları ile desteklenebilir.

Teklif edilen ve desteklenen projelerin kalitesinin arttırılması amacıyla, proje ve çağrı bazlı özelliklerin daha verimli ve etkili olmaları sağlanmalıdır. Alt proje sayısının ve proje ekibi büyüklünün destek alma ve çıktı artımsallığı açısından etkisinin artırılması amacıyla bu hususlarda her ÖTA, hatta her bir çağrı için farklı kısıtlar uygulanabilir. Ayrıca, akran değerlendirmesinin etkisinin ve etkinliğinin artırılabilmesi için değerlendirme ve destek kriterleri gözden geçirilmelidir. Proje yürütücülerinin proje değerlendirme panellerine katılımının sağlanması da değerlendirme sürecinin etkinliğine ve etkililiğine olumlu bir katkı sağlayabilir.

Fonlama kaynakların ÖTA'lara yeniden tahsis edilmesi, her bir PTA için ölçeklendirme ve destek bütçesi limitleri üzerinde farklı kısıtlar uygulanarak sağlanabilir.

1003 projenin çıktılarını küresel düzeyde yüksek yetkinliğe sahip gerçek ürünlere dönüştürmek amacıyla üniversite-sanayi işbirliğinin daha etkin bir şekilde sağlanabilmesi için 1003 projenin çıktıları, bunları gerçek bir ürün olarak ticarileştirebilecek kapasitede olan sanayi ve kamu sektörü kurumlarıyla paylaşılarak; bu ürünlerin ticarileştirme süreci ek bir destek mekanizması ile finanse edilebilir.

Son olarak, desteklenen 1003 projelerinden elde edilen çıktıların Vizyon 2023 ve 1003 Programının toplumsal, bilimsel ve ekonomik hedeflerine katıkısının artırılabilmesi için projeyi bu amaçlara yönlendirecek olan başlangıç ve hedef THS'leri başvuru kriterleri olarak kullanılabilir. Bununla birlikte, bir konunun temel araştırması mevcut değilse, bu tip kısıtlar, önerilen projelerin miktarını azaltabilir. Bunu ortadan kaldırmak için, bu tür konularla ilgili açılaca çağrıalrdan önce ek finansman mekanizmaları ile gerekli temel araştırma bilgisinin oluşturulması sağlanabilir.

Öncelikli alanlardaki gelişmelerin hızını artırmak için bu alanlarda verilebilecek uluslararası işbirliği destekleri de makro düzeyde bir politika aracı olarak uygulanabilir. Türkiye'nin ivme kazanması gereken bir alanda yetkin olan ülkelerle yapılan işbirliği, bu alanda çalışan Ar-Ge personelinin kalite ve bilgi düzeyini artırmaya yardımcı olacaktır. Türkiye'nin yenilik kapasitesinin güçlü olduğu alanlarda ise, nispeten daha temel düzeydeki araştırma faaliyetlerinin

daha az gelişmiş ülkelerdeki araştırmacılara yaptırılması, bu alanlarda yapılabilecek daha gelişmiş ve ürün odaklı araştırmalar için zaman tasarrufu sağlayabilir.

Sonuç olarak, bu çalışmanın sonucunda önerilen politikalar, daha verimli ve etkin bir öncelikli Ar-Ge destek mekanizmasının elde edilmesine katkı sağlayacaktır. Ayrıca bu tezde yapılan analizler ve sonuç olarak önerilen politikalar literatüre de katkıda bulunmaktadır.

APPENDIX H: TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ■

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : Gürbüz
Adı : Mürüvvet Kübra
Bölümü : İktisat

TEZİN ADI (İngilizce) : An Effective and Efficient R&D Funding Mechanism: An Evaluation Study on Prioritized R&D Grant Program (1003) of TUBITAK

TEZİN TÜRÜ : Yüksek Lisans ■ Doktora ☐

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