A CASE STUDY OF IMPACT ANALYSIS:
TÜBİTAK RESEARCH SUPPORT PROGRAMMES

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ABSTRACT

A CASE STUDY OF IMPACT ANALYSIS:
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The Scientific and Technological Research Council of Turkey is the major academic research management and funding agency in Turkey. As a policy-maker, the council has undertaken very important responsibility in designing a science and technology policy of Turkey. By means of impact analysis, evaluating the ongoing research support programmes is important for designing more effective ones. However, impact of academic research are widely disseminated, journal articles being published and cited, number of academic staff involved in the supported projects, patents, and prototypes could be used as an evaluation instrument for impact analysis. In this study first time, we have figured out the social benefits (in 2008 TL fixed prices) of academic research projects, specifically physics academic research projects that were supported during 1998-2008 by TÜBİTAK. Return of funds of TÜBİTAK supported physics projects during 2005-2008 was calculated as 142%, when rate of return was taken 28%.

Keywords: Impact Analysis, Social Benefits, Academic Research Supports, TÜBİTAK Supports, R&D Supports

ÖZ

ETKİ ANALİZİ DURUM İNCELEMESI:
TÜBİTAK ARAŞTIRMA DESTEK PROGRAMLARI

Tanrıkulu Erden, İlkay

Yüksek Lisans, Fizik Bölümü

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Türkiye Bilimsel ve Teknolojik Araştırma Kurumu, Türkiye`nin akademik araştırmalara yön veren ve araştırmaları destekleyen en önemli kurumudur. Politika yapıcı olarak, Türkiye`nin bilim ve teknoloji politikasını belirlemek Kurumun sorumluluğundadır. Etki analizi yöntemlerini kullanarak, devam eden programların değerlendirilmesi, daha etkili programların oluşturulabilmesi için önemlidir. Akademik araştırmaların etkileri geniş alanlara yayılmış olmasına rağmen, etki analizi yapabilmek için, yayınlanmış dergi makaleleri ve bu makalelere yapılan atıflar, projelerde yer alan akademik personel sayısı, patentler ve prototipler değerlendirme araçları olarak kullanılabilir. Bu çalışmada ilk defa, TÜBİTAK tarafından 1998-2008 yılları arasında desteklenen, akademik araştırma projelerinin (özelinde fizik projelerinin) sosyal faydasını (2008 TL sabit fiyatları cinsinden) ortaya koyduk. Geri dönüş oranı %28 olarak alındığında, 2005-2008 yılları arası TÜBİTAK destekli fizik projelerinin, destek geri-dönüşü yaklaşık %142 olarak hesaplandı.

Anahtar kelimeler: Etki Analizi, Sosyal Fayda, Akademik Araştırma Destekleri, TÜBİTAK Destekleri, Ar-Ge Destekleri

To my family

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INTRODUCTION

1.1 The Scientific and Technological Research Council of Turkey

The Scientific and Technological Research Council of Turkey (TÜBİTAK) is the major academic research management and funding agency in Turkey. It was established in 1963 with a mission;

> to develop scientific and technological policies in line with our national priorities and in cooperation with all sectors and related establishments; to contribute to establishment of infrastructure and instruments to implement said policies; to support and conduct research and development activities; and to play a leading role in the creation of a science and technology culture with the aim of improving the competitive power and prosperity of the country (BTYK, 2005).

The vision is “to be an innovative, guiding, and cooperating institution in the fields of science and technology, which serves for improvement of the life standards of our society and sustainable development of our country.” (BTYK, 2009).

On July 7th 2005 regarding the Law Number 5376, the name of the institution which was The Scientific and Technical Research Council of Turkey, was changed as The Scientific and Technological Research Council of Turkey.

TÜBİTAK is an autonomous institution. *Science Board*, whose members are chosen from senior pundits from universities, industries and research units of our country, is the administration unit of TÜBİTAK. The chair of the Science Board is the President of TÜBİTAK.

In 1983, the Supreme Council for Science and Technology (SCST) was established to give a direction to Turkish science policy. SCST is the highest council about science policy of Turkey and TÜBİTAK is the secretariat of the Council. The main functions of the Council is defined as "to organize, coordinate and encourage basic and applied researches especially in natural sciences, to support academic researches and to encourage young researchers" (TÜBİTAK, 2009). SCST is headed by Prime Minister of Turkey. After the establishment of SCST, development science and technology policies for our country had been one of the important issues of TÜBİTAK. 1983-2003 document was the first work established on the Turkish Science Policy, *Vision 2023* project is thought as the extension of this mission for the next twenty years (BTYK, 2000).

TÜBİTAK has also undertaken the responsibilities of presentation of potential of Turkish researchers, institutes, universities, and industries in international platforms. To achieve these responsibilities, EU Framework Programs, bilateral and multilateral projects programs are main objects of TÜBİTAK. For these purposes International Cooperation Department (UİDB) is settled. UİDB has the responsibilities of carrying out international collaborations function by develop, set, and apply policy proposals and programmes.

In addition to academic based function of TÜBİTAK, industrial based research and technology development activities is supported. Technology and Innovation Funding Programs Directorate (TEYDEB) is established with this purpose. TEYDEB's mission can be stated as to increase the global competitiveness of Turkish private companies that are equipped with R&D capabilities and play a leading role in the creation of enterprise culture to improve prosperity of the country. Companies' attention to R&D studies is trying to be increased by the different types of support programme. As expected, major part of the support investment has been allocated for industrial based research projects.

Besides supporting the research all over the country, TÜBİTAK have an active role in research, through the established R&D institutes, which are Marmara Research Centre (MAM), National Research Institute of Electronics and Cryptology (UEKAE), Defense Industries Research and Development Institute (SAGE), Space Technologies Research Institute (UZAY), National Metrology Institute (UME), Research Institute for Basic Sciences (TBAE), Turkish Institute for Industrial Management (MEB-TÜSSİDE) (TÜBİTAK, 2007).

Another scope of TÜBİTAK is to encourage the academic staff or scientists for improving and increasing their attention to academic activities. Through a set of funding programmes under Science Fellowships and Grant Programmes Department (BİDEB), attraction of Turkey for scientists has been increasing.

To establish scientific culture on the society is another activity area of TÜBİTAK. Society-oriented programs are designed by Science and Society Department (BTDB). Main classifications of the programmes could be listed as; academic publications, popular science books, popular science magazines, science and society activities and funding programmes (TÜBİTAK, 2007).

As a summary, TÜBİTAK not only supports academic and industrial R&D studies but also gives a direction to scientific and technological policies and manages R&D institutes, and boosts research, technology and development studies in line with national priorities. Furthermore, TÜBİTAK funds research projects carried out in universities and other public and private organizations, conducts research on strategic areas, and develops support programmes for public and private sectors, publishes scientific journals, popular science magazines and books, organizes science and society activities and supports undergraduate and graduate students through scholarships (TÜBİTAK, 2009).

Established headquarters to satisfy all the purposes are given in Figure 1.1 (TÜBİTAK, 2007).

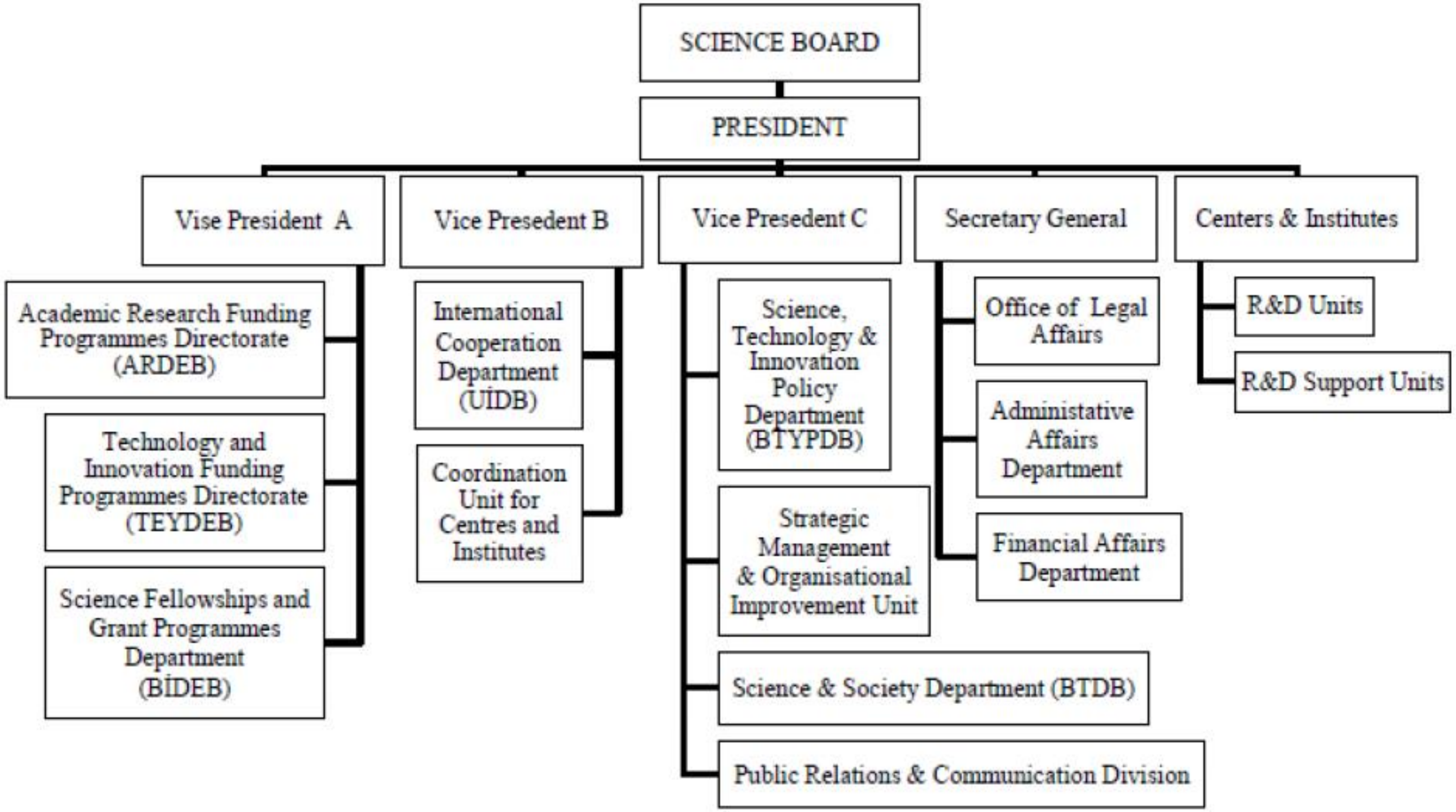


Figure 1.1: TÜBİTAK Organization Chart

In our study, we will focus on academic research projects supported by Academic Research Funding Programmes Directorate (ARDEB). For this reason, ARDEB structure, project evaluation methods and funding programmes under ARDEB will be explained in the following parts of the chapter. In addition, the topic of our study is the issue of Science, Technology and Innovation Policy Department (BTYPDB), for this reason, we will summarize the purposes and activities of BTYPDB.

1.2 Academic Research Funding Programmes Directorate (ARDEB)

The mission of ARDEB that understood from the name of it can be stated as; in the line with the county priorities, and in light of universal developments, design academic research funding programmes and improve them to encourage scientists and institutions to perform R&D; and with financial support increase the production of knowledge and technology and their availability to the public (TÜBİTAK, 2007).

To cover needs of academic society, public sectors, and military, ARDEB establishes new support programmes for academic R&D projects, public agencies, defense and space technologies research projects in accordance with worldwide research tendencies. Moreover, scientific meetings are funded and to create a network among universities, industry and the public sector support programmes are established. International projects are supported to achieve the part of TÜBİTAK mission in international platforms. On the other hand, financial support incentives for patents are provided to increase the number of patents (TÜBİTAK, 2007).

ARDEB provides mentioned supports through the constellation of grant committees given in Figure 1.2.

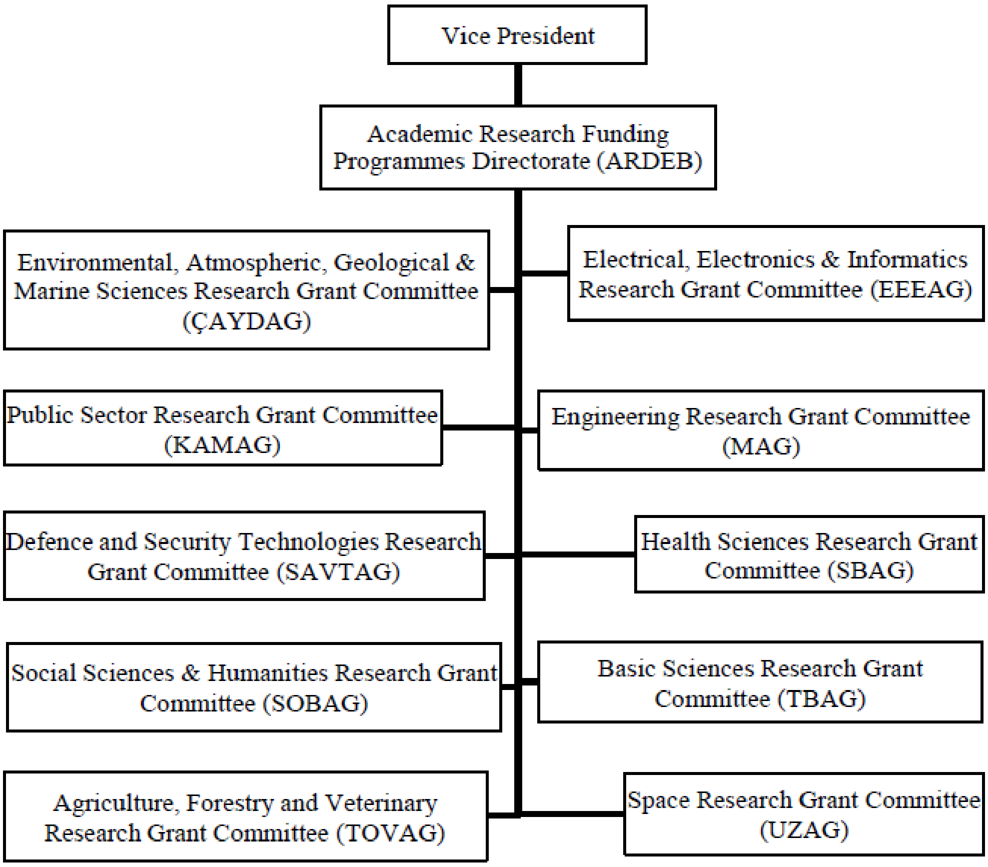


Figure 1.2: Academic research funding groups of Academic Research Funding Programmes Directorate (ARDEB).

1.2.1 ARDEB Support Programmes

ARDEB funds qualified academic-based projects with the programmes which are explained below. It is important to note that, every programme is designed to cover academic research communities with different status or attitudes.

1.2.1.1 The Support Programme for Scientific and Technological Research Projects (Programme No: 1001)

This programme is established to support research projects that have intellectual merit, broader impact, and feasibility. Main purposes of the support programme can be summarized as to support academic research projects which could produce new information, do scientific interpretation or solve technological problems in our country, increase national competitive capacities in international academic platform, in compliance with scientific basis and within the accordance with prioritized areas.

Application of researchers from universities, public and private sectors are accepted. Since January 2009, calls for application are reduced two times a year, at March and September. Support duration is maximum 3 years for this programme. (For detailed information, see TÜBİTAK, 2009)

This programme is main support programme of ARDEB. The number of application of this programme is more than the number of application of other programmes. As expected, the number of funded projects in this programme is more than the number of funded projects in others.

1.2.1.2 The Support Programme for Short-Term R&D Projects (Programme No: 1002)

Urgent and short-term R&D projects, which are executed in mainly universities, research hospitals and institutes, are supported with this programme.

If applicants are the university personnel, it is required to have at least PhD degree. If applicants are from public or private sectors, at least graduation from university is needed.

For this programme, application is possible all through the year and project duration is maximum 12 months. (For detailed information, see TÜBİTAK, 2009)

1.2.1.3 The Support Programme for Public Sector Research and Development (Programme No: 1007)

This programme is designed to satisfy public institution requirements and to solve their problem by means of R&D projects. According to scope of the project, project proposals could be assigned to one of the following support units:

- Public Research Grant Committee (KAMAG)
- Defense & Security Technologies Research Grant Committee (SAVTAG)
- Space Research Grant Committee (UZAG)

Applications are possible two times a year. There is no budget limit and maximum support duration is 48 months. (For detailed information, see TÜBİTAK, 2009)

1.2.1.4 Patent Application Promotion and Support Programme (Programme No: 1008)

Patents are one of the important outputs of academic research. While supporting R&D research projects, TÜBİTAK design patent programme for patents arise from these projects and from other research projects in universities, private firms or public R&D institutions.

Overall, programme is initiated to increase the number of national and international patent application. Moreover, it promotes people to make patent application and increases the consciousness of people for registering their intellectual and industrial property rights. (For detailed information, see TÜBİTAK, 2009)

1.2.1.5 Global Researcher Programme (Programme No: 1010)

Global researcher programme is designed to benefit from global researchers' knowledge in a specific research area. In this programme, support is only available when the participation of global researcher is critical for the success of the project and there are not qualified researchers in Turkey in the respective research area.

Universities, public and private corporations can apply to this programme. (For detailed information, see TÜBİTAK, 2009)

1.2.1.6 The Participation Programme for International Scientific Research Projects (Programme No: 1011)

This programme is to support participation of Turkish researchers in international project associations that are executed by multiple research groups and organizations from different countries. (For detailed information, see TÜBİTAK, 2009)

1.2.1.7 The Support Programme for the Initiative to Build Scientific and Technological Cooperation Networks and Platforms (Programme No: 1301)

Besides supporting individual research projects, another important point is the supporting cooperation networks and platforms. For this purposes, "The Support Programme for the Initiative to Build Scientific and Technological Cooperation Networks and Platforms (1301)" is established. Mainly, network and platform corporations about the areas such as basic sciences, engineering, health and social sciences are supported in order to develop our country is science and technology foresight. (For detailed information, see TÜBİTAK, 2009)

1.2.1.8 The National Career Development Programme for Young Researchers (Career Programme) (Programme No: 3501)

Young scientists are encouraged to do academic research at the beginning of their academic career. Application is possible to this programme, in the first five years after holding PhD degree. Young scientists are going to take the academic leadership properties and maintain their career as a researcher and lecturer. (For detailed information, see TÜBİTAK, 2009)

1.2.1.9 The Support Programmes for International Projects

Main issue of this programme is to develop international collaborations by supporting bilateral projects which satisfy some certain criteria. This programme contains three divisions; bilateral programmes, multilateral programmes and European Union Framework Programmes. According to the agreement between TÜBİTAK and parity counsel or agency of partner countries, annual funding limits per projects, call times for application are determined. (For detailed information, see TÜBİTAK, 2009)

1.2.2 Evaluation and Funding Process of Research Projects

The general structure of the TÜBİTAK proposal review and evaluation process for ARDEB is depicted in Figure 1.3. After proposals submission to ARDEB, all proposals are undergone formal pre-evaluation. Different than scientific and technological research projects (1001), career projects (3501), etc., bilateral & multilateral projects are submitted to UİDB and their formal pre-evaluation is done by UİDB. Academic research project proposals and bilateral & multilateral academic research projects proposals, which pass pre-evaluation, are sent to related academic research funding group according to their fields of research by ARDEB.

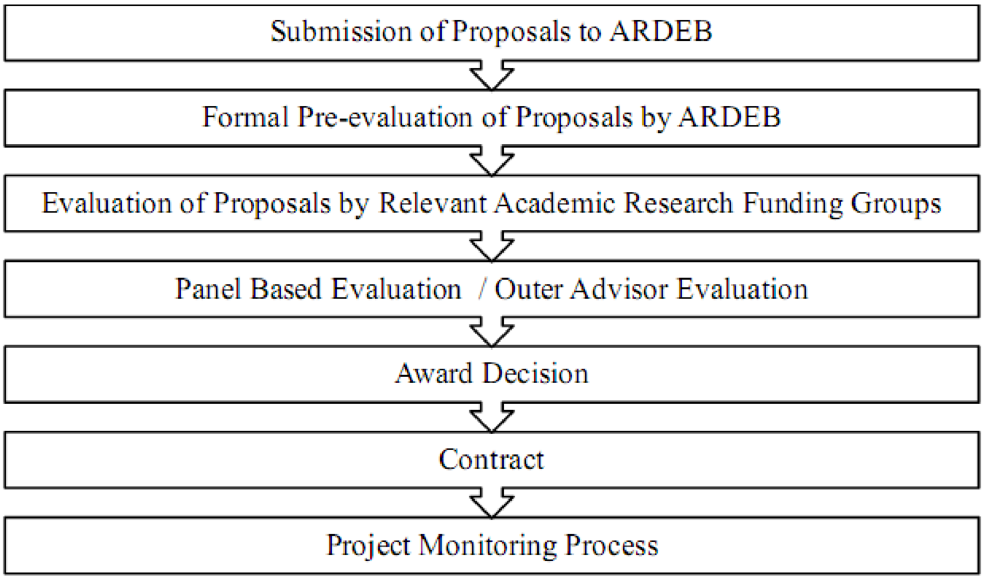


Figure 1.3: Proposals review and evaluation process of ARDEB. Source: TÜBİTAK (2009).

Evaluation method has the critical importance to support qualified projects. In ARDEB, there are two methods used for evaluation of academic research projects proposals. First one is panel-based evaluation system and the other one is outer advisor evaluation system. Panel-based evaluation system has been used for evaluation of academic research project proposals since 2004, regardless of their programme type. According to application date of the proposals and project budget, appropriate type of evaluation is chosen.

Bilateral & multilateral projects are classified in two parts according to their budget which only demands support for common scientific meetings, exchange of scientists, scientific visits, etc. or demands support for academic research in addition to support for scientific visits.

Short-term R&D projects and bilateral & multilateral projects that only demand support for scientific visits are evaluated by outer advisor evaluation.

Bilateral & multilateral projects that demand support for academic research in addition to support for scientific visits can be evaluated at panels or evaluated by outer advisors. Since, application date of multilateral & bilateral project proposals are different from other proposals, generally there is time limitation to declare evaluation results of these projects. This means that, evaluation periods of these projects must be completed as quickly as possible. For this reason, if there is enough time to evaluate proposals at panels, panel-based evaluation is preferred. If proposals are sent to research groups out of panel period then they are evaluated by outer advisor.

All the time, scientific and technological research projects (1001), and career projects (3501) are evaluated at panels, since their application dates are defined by TÜBİTAK. It should be noted that, most of the proposals are in these categories.

1.2.2.1 Panel-Based Evaluation System

Experts within each research group further divide the proposals according to their topics. Up to ten project proposals are evaluated at one panel session. Each panel is composed of five to nine panelists.

Once a panel is determined for a group of proposals, panelists whose expertise can cover the research topics of the proposals in each such group are identified. Up to 10 proposals can be evaluated at panels. They evaluate proposals with respect to three categories; intellectual merit, broader impact, and feasibility. This review process is generally concluded within four weeks of a scheduled panel meeting. Then the panel convenes to evaluate all the proposals collectively.

Panelists are selected in accordance with the subjects of the proposals. One of the most difficult problems in proposal evaluation is how to compose a panel for a given set of proposals. There are several constraints that must be simultaneously satisfied.

- Panel should cover the subject of each proposal,
- the cost of panels should be optimized,
- conflicts and coincidence of interests should be eliminated,
- panel should ensure a reliable and objective evaluation.

These constraints are tried to be satisfied by related academic research funding group experts.

During the panel meeting, after discussing proposal, each of them are graded with respect to the three criteria; intellectual merit, broader impact, and feasibility, which contains sub-criteria: method, team, and equipment separately. Final score for proposals could be between 0 and 9. It is important that, these criteria are used for scientific and technological research projects (1001), evaluation criteria for different type of support programs are generally specialized depending on the purpose of the support program. For example, international cooperation projects evaluation criteria are different; they are evaluated with respect to their importance of scientific cooperation, intellectual merit and feasibility, and effects on country/community.

1.2.2.2 Outer Advisor Evaluation System

This method is generally used for evaluating short-term R&D projects and bilateral & multilateral project proposals. Outer advisors are determined by related academic research funding group *Grant Committee*. The constraints which are satisfied while choosing the panelist should also be satisfied while choosing the outer advisor. Every advisor evaluates the proposals according to specified evaluation criterias, and gives a score between 0 and 9 just like panelist.

Proposals are funded according to their weighted scores and availability of funds.

After evaluation process, for projects which are decided to support, contracts are signed between TÜBİTAK and projects' coordinators. Ongoing projects are monitored by relevant academic research funding group. The outputs of projects could be ranging from scientific outputs such as publications, intermediate outputs such as patents and prototypes, and final outputs such as new or improved products, processes or services.

TÜBİTAK who must decide how much to fund in academic research, impact analysis of outputs primary significance. As Mansfield said that, past investments in academic research are sunk costs, and social rate of return from next year`s investment is what counts (Mansfield, 1990).

1.3 Science, Technology and Innovation Policy Department (BTYPDB)

Science, Technology and Innovation Policy Department (BTYPDB) is built to monitor and evaluate national and worldwide STI policies. To propose STI policy, Department search and examine policy-making formulation methods. As a result of such studies, best tools are identified and proposed for improving the existing policies (TÜBİTAK, 2007).

Accordance with the purposes, "National Science and Technology Strategy" spanning the timeframe between 2005 and 2010 is developed in collaboration with the relevant public agencies, academia, private sector and the non-governmental organizations.

As the main modality for this strategy, a Turkish Research Area (TRA) was defined composing of all private and public entities that either perform, fund or demand R&D activities. Main objectives of TRA can be defined as

- to increase the quality of life in Turkey,
- to find solutions to social problems,
- to increase the competitive capability of our country,
- to create awareness and interest in STI in the society.

Increase the share of R&D expenditures in Gross Domestic Product (GDP), increase the demand for R&D, and increase the number and the quality of R&D personnel can be listed as the basic targets of TRA.

Specifically, for the year 2010, two significant targets have been established in "the National Science and Technology Strategy", that are to increase the Rate of Gross Domestic Product to 2% during the period from 2005 to 2010, and to raise the number of full-time equivalent R&D personnel up to 40,000 in 2010 (BTYK, 2004).

The science and technology policies, which are covering for the next 20 years of Turkey, is called *Vision 2023* project. It is thought as further step of identifying science and technology policies of our country. "Possesses the skill of converting technological developments into social and economic benefits; in the 100th Anniversary of our Republic in line with the target pointed out by Atatürk as reaching the level of modern civilizations." is one of the main theme of Vision 2023 project (BTYK, 2000).

CHAPTER 2

EVALUATION OF RESEARCH PROGRAMMES
AND
IMPACT ANALYSIS

Programme Evaluation is defined in the study of Lengrand (2006) as a learning process helping to design better programmes in the future, and as a consequence save taxpayers money while achieving important socioeconomic objectives. The need to evaluate programmes is becoming widely recognised. However, in many environments this is not the case. Even more opinion that is prevalent has a very narrow view of what evaluation could be and what it should contribute. There are relatively few environments where a “culture of evaluation” has been well-established.

2.1 What is Research Programme Evaluation?

Lengrand (2006) stated that most of the R&D programmes especially into information technology (IT) dealt with new topics that could not easily be categorized in the traditional dichotomy of pure and applied research. The performance of semiconductors and optical fibers, the ways in which software could be structured and processed, the nature of user interfaces, and a host of new fields like mechatronics, chematronics, optronics, and some other new topics became prevalent in the 1980’s. Beyond the scientific curiosity, new knowledge, which has gotten from new topics, was generated in response to requirements from technology suppliers and users.

It was driven by rapid application in practical purposes; of course, it needs to basic scientific research. To describe such work, the term *strategic research* became popular.

Evaluation studies in strategic research came across with two-sided problem. One side, it was evaluated in terms of contribution of the expenditure of funding to scientific knowledge – journal articles being published and cited, etc. The other side is the practical effects of studies – application of results in commercial technologies. "Strategic research was being funded by governments more in order to achieve innovation objectives than those of pure science." (Lengrand, 2006).

To understand the impacts of research programmes more clearly, it has been necessary to develop new approaches to evaluation. "The assessment of impacts on the behavior of economic agents is a major focus of evaluation activity." (Lengrand, 2006).

Impact analysis is part of the research programme evaluation. According to Lengrand (2006), the demand for impact analysis can be seen as one element of knowledge-based society. Policy-makers need to know what the results of their past policies have been, and to have a better idea of what possible results of future policies will be. The idea of impact analysis is an obvious response to this demand.

2.2 What is Impact Analysis?

Impact analysis (IA) differs in all sorts of ways – in the methods used, in their scale, their scope, and in the extent to which results are disseminated and used. Therefore, there are many definitions of impacts, depending on;

- The nature of the impact: economic, scientific, technological, cultural, social, environmental, etc.
- The scope of the impact: systematic, organizational, and firm-based.
- The timing of the impact: estimated, contemporary, ex-post (Bilbao, 2008).

IA has been practiced in various forms for years, yet there is no consensus definition. For example, according to the paper of Arnold and Bohner (1993) the definition of IA is the activity of identifying what to modify to accomplish a change, or of identifying the potential consequences of a change. Rome Air Development Center (1986) defined IA as “an examination of an impact to determine its parts or elements.". Pfleeger (1991) defined IA as "the evaluation of the many risks associated with the change, including estimates of the effects on resources, effort, and the schedule."

2.2.1 Dimensions of Impact

The paper of Bach and Georghiou (1998) contains several dichotomies about the dimensions of impact; some of the dichotomies are listed below:

- Artefact vs. knowledge and skills - concerning whether what is produced is tangible or embodied (product, process, service) or intangible in terms of knowledge and skills;
- Output vs. impact – concerning with differentiation between outputs from RTD, and impacts arise from interaction between the outputs and the society.
- Short term vs. long term – dealing with time profiles of impact.
- Intended vs. unintended – concerning with the programme goals as the basis for evaluation, they can be intended or unintended.

2.2.2 Taxonomies of Impacts

As well as the dimensions given in previous section, almost every evaluation, generates its own list of impacts (Bach and Georghiou, 1998). The paper of Bach and Georghiou (1998) contains a Table 2.1 that shows a list derived from the COMEVAL Toolkit.

Table 2.1: Evaluation and its own list of impacts. Source: Bach and Georghiou (1998).

Outputs		Impacts/effects	
Intermediate outputs	Prototypes, technological sub-systems, demonstrations, models/simulators, integration of technologies, tools/techniques/ methods, intellectual property, decisions on further RTD,	Competitiveness	Sales, market share, open up markets, create new markets, lower costs, faster time to market,
		Employment	jobs created, jobs in regions of high unemployment, jobs secured, jobs lost,
		Organisation	formation of new firm, new technological networks/contacts, new market networks/contacts, improved capacity to absorb knowledge, core competence improvement, further RTD, change in strategy, reorganization of firm to exploit results,
Products	new products, improved products,		
Processes	new processes, improved processes,		
Services	new services, improved services, processes for delivering, new services,		
Standards	reference, conformance, memoranda of understanding, common functional specification, identified need for regulatory change,	Quality of life	healthcare, safety, social development & services, support for cultural heritage,

Table 2.1: (continued)

Outputs		**Impacts/effects**	
Knowledge and skills Dissemination	management &organization, technical training activities, workshops/ seminars/ conferences, technology transfer activities, knowledge & skills transfer, publication/ documentation	Control & care of the environment	reduced pollution improved, information on pollution & hazards, reduced raw material use, reduced energy consumption, positive impact upon global climate, decrease in pollutants,
		Development of infrastructure	transport telecommunications urban development rural development
		Production & rational use of energy	energy savings renewable sources nuclear safety assurance of future supply distribution of energy
		Industrial development	development of internal market, development of large organizations, support for trade,
		Regulation & policy	national regulations or policy, world-wide regulations or policy, co-ordination between national & community RTD programmes

Bach and Georghiou (1998) are commented for this table that it contains rough taxonomy, on the other hand, taxonomy that is actually more precise should be context sensitive, and this taxonomy is designed to be operational at the project level however almost all of the effects on the table are shown at the organization level or above.

2.3 Challenges of Impact Analysis

According to the study of Lengrand (2006), impact analysis face with a number of challenges, and below there is a discussion on major challenges to impact analysis in research programmes: complexity and multiple causality, time lags, indirect impacts, and multiple objectives.

Complexity and Causality: to set up true experiment, or to control all major variables in relating causes and effects and to apply scientific experimental methods are nearly impossible in many cases. From the innovation programmes perspective, it is difficult to construct true control groups. Control groups are necessary to match or compare the organizations that were or were not involved in the programme. They are assigned in a random fashion. Comparisons between programme participants and non-participants will need to be made with caution – matching them on as many variables as possible.

Causality problem can be represented with the question: "What is the relationship between research inputs, outputs, outcomes and impacts?" (Bilbao, 2008).

Another difficulty to analyzing programme impacts is *over determination*. The term over determination is used for the case in which changes in the innovation performance may or may not only be related to the programme itself, it may be part of a wider complex of changes.

Time Lags: to get desired impacts may take a long time. The intended impact of innovation policies are generally long-term ones, the economic pay-offs of innovation can be seen perhaps over 10 to 15 years. Long term effects of innovations are very difficult to measure and mostly full range of impacts could not be measurable (Lengrand, 2006).

To make precise impact analysis, and to get valuable results, it is important to gather intermediate impacts, long-term impacts, and indirect impacts that are plausibly related to programme activities.

Indirect Effects: it was described in a study of Lengrand (2006) as "as we move on from those directly involved in a programme to those which are in one way or another affected by the behavior of the participants."

Generally, important account of innovation is not for the initial producers, but for its users. Most of the case, tracing impacts on users can be very difficult.

To solve this problem, offered solution is to use econometric or input-output models. These models give an opportunity to estimate the knock-on effects of chance at a one point in a system. These models are useful in simple flows of products and changes in performance as recorded in financial terms. *Modelling* could be another solution to assess less tangible factors. By empirical tools, it is also possible to trace impacts through a system – for instance, looking at the diffusion of a specific innovation or practice through survey techniques, asking informants in specific locations about their knowledge and practices (Lengrand, 2006).

Multiple and Complex Objectives: Multiple objectives pose a challenge for impact assessment. Lengard (2006) propose a set of solution to these problems:

- determining the key impacts on which to focus;
- determining whether some impacts can be assessed in some instances and others in separate evaluations, either later in time or of similar programmes;
- determining whether it is possible to examine certain indicators in depth in a limited sample of cases, and more indirectly or partially in others;

- preparing different reports on sub-programmes or on particular classes of impact.

Some other challenges faced with up while analyzing R&D impacts are figured out in the work of Bilbao (2008). He represents these problems under following titles: attribution problem (What portion of the benefits should be attributed to initial research and not to other inputs?), internationality problem (Role of spillovers), evaluation time scale problem (At which time should we measure the impacts?), and definition of appropriate indicators problem.

Overall, all the problems discussed here is also an opportunity. For what the problems do is force us to examine more closely what is meant by innovation and what are the intended objectives of Innovation Programmes; and to understand more fully the innovation system within which interventions are being made. This understanding is vital for constructing a knowledge-based rationale for interventions (Lengrand, 2006).

2.4 Additionality

Additionality is the key dimension of research programme evaluation (Georghiou, 2002). This means that, it is an important element while considering the impacts of a programme. Therefore, to understand impact analysis, additionality concept should be clarified.

Additionality can be described as the change due to the activity, as compared to what would have happened had the activity not been undertaken at all. Simply, it is the change that can be attributed to the existence of the programme – what the additional effect of the programme is, as compared to what would have happened in the absence of the programme (Lengrand, 2006). This means that, additionality can also be described as observable, measurable or non-measurable effects of any kind of support. Conceptually, additionality appears relatively simple on superficial examination, it involves comparison with the null hypothesis or counterfactual – What would have happened if no intervention had taken place (Georghiou, 2002).

In his paper, Georghiou (2002) treated additionality in four manifestations:

Input additionality: According to paper of Streicher (2004) input additionality is defined primarily in a contemporaneous way: what is the immediate effect of a subsidy an R&D expenditures?

Input additionality is a concern with whether resources provided to a firm are additional. That is to say, whether for every Turkish Liras provided in subsidy or other assistance, the firm spends at least an additional Turkish Liras on the target activity. Three scenarios are worthy of note,

- Subsidy causes increase in R&D investment done by firms (Positive effect).
- Subsidy causes decrease in R&D investment done by firms. This is known as crowding out (Negative effect).
- Subsidy cause no change in R&D investment done by firms (No effect).

In terms of academic research, input additionality can be interpreted as a concern with whether resources provided to academicians are additional.

Output and Outcome Additionality: *Output additionality* concerns with the proportion of outputs that would not have been achieved without any/public support (Streicher, 2004). In line with Streicher (2004), output additionality can be defined as what is the effect of the subsidies on a firm’s turnover, profit, etc. This definition can be rephrased as for academic research, what is the effect of the funding on number of articles, patents, and the number of academic staffs who contribute to the mentioned academic research.

With a minor but important difference; *Outcome additionality* concerns with the improved business performance as a result of new or improved products, process, or services (Georghiou, 2002).

While stating output additionality in evaluation process, evaluators are faced with two main obstacles. One is that, business plans, new partnership; number of articles, patents, and prototypes, can be classified as intermediate achievements. Actually, they do not directly contribute in innovation. On the other hand, contribution of outcome additionality to innovation is much more difficult to state. Because it also contains all types off spilover problem and assessment time problem (Georghiou, 2002).

Behavioral Additionality: is that how firms' research decisions are effected from the existence and availability of funding (Streicher, 2004). It means that, how funding changes the academic researchers' attitude toward new research.

According to Georghiou (2002), The UK Department of Trade and Industry has articulated these changes in three sub-divisions:

- *Scale additionality*, when the activity is larger than it would otherwise have been as a result of government support (perhaps creating economies of scale).
- *Scope additionality*, where the coverage of an activity is expanded to a wider range of applications or markets than would have been possible without government assistance (including the case of creating a collaboration in place of a single-company effort).
- *Acceleration additionality*, when the activity is significantly brought forward in time, perhaps to meet a market window.

As Bach and Matt (2002) stated that, behavioral additionality has a further dimension in capturing permanent or persistent changes in firm behavior as a result of the policy intervention. Bach and Matt (2002) have sought to extend this dimension of additionality by introducing a further category, that of cognitive capacity additionality.

- *Cognitive capacity additionality*, whether the policy action changes the cognitive capacity of the agent. It covers permanent or persistent changes in firm behavior to move into a new area of activity or to alter its business process, as a result of the policy intervention.

Normally, there are some criticisms about the additionality concepts. Luukkonen (2000) state that additionalty concept is not enough to decide whether public support is useful or not. She argued that success of the project is separate value than whether a project is additional or not. High additionality bring together with high failure risk, because a firm may be undertaken more risky projects than usual or undertaken projects beyond its capacity. Another case is that the firms move in the wrong direction of technology by policymaker incentive.

As a result, to develop scientific and technological policies in line with our national priorities, to establish instruments to implement said policies; to support and conduct research and development activities; and to improve competitive capability of the country, TÜBİTAK, as a science and technology policy-maker of Turkey, needs to know what the results of their past policies have been, and needs to know what possible results of future policies will be. At this point, impact analysis is beneficial source.

CHAPTER 3

BASIC THEORY ON RETURN OF ACADEMIC RESEARCH FUNDINGS

Up to now, few detailed studies have been carried out on the contribution of academic research to industrial innovation. Mansfield (1990) comments that most of them seem to have focused on the drug industry. Edwin Mansfield pioneering work on academic research and industrial innovation has detailed information about the social rate of return from academic research.

Mansfield (1990) state his purpose as

> To estimate the extent to which technological innovations in various industries have been based on recent academic research, and the time lags between the investment in recent academic research and the industrial utilization of their findings.

In his paper, however, the results are subject to many limitations, they probably pique interest of public policy-makers concerned with science and technology, economists, and others that study the process of technological change (Mansfield, 1990).

To estimate the social rate of return from academic research, he is concerned primarily with academic research occurring within fifteen years of the commercialization of whatever innovation is being considered. He ignore long-term (more than fifteen years) effects of academic research because (as mentioned in previous chapter under the title of “2.3 Challenges of Impact Analysis) benefits occurring many years after the relevant investment in research are very difficult to measure, and because the effects of relatively old science may not be a reliable guide to the present situation (Mansfield, 1990).

In his survey, he used a random sample of 76 American firms in seven manufacturing industries: information processing, 25; electrical equipment, 14; chemicals, 15; metals, 6; instruments, 7; drugs, 6; and oil, 3 industries. These firms were chosen randomly from the list of major firms in these industries in Business Week, 23 June 1986. He stated that, the firms in his sample are accounted for about one-third of the total sales in the population of firms in these industries in 1985. Data were obtained through questionnaires and interviews from top R&D executives. Information on new products and processes based on recent academic research was collected from firms' executives. Mansfield classified these data under two categories;

- New products and processes that could not have been developed (without *substantial delay*) in the absence of recent academic research.
- New products and processes that were developed with very substantial aid from recent academic research.

First category covers direct effect of academic research on new products and processes. "Substantial delay" means that a delay of a one year or more. In the absence of the relevant academic research, non-academic researchers might provide information to produce new products and processes. However, Mansfield (1990) stated that according to firms, this is unusual way for producing the new products and process on this category. Firms believed that in the absence of academic research, necessary information might be provided (by other sources) at least 9 years longer.

Second category covers this case; sometimes new products and processes could have been developed without the findings of recent academic research, they could have been found by scientist and engineers in firms (but it would have been much more expensive and time-consuming to do so). On the other hand, scientists and engineers in firms can use the results of academic research in new techniques that enable to carry out R&D in particular areas more cheaply, quickly, or accurately. For example, high resolution nuclear magnetic resolution spectroscopy, which was based on research at Stanford and Harvard Universities, has become indispensable in many chemical laboratories (Mansfield, 1990).

Table 3.1: Percentage of new product and process based on recent academic research, seven industries, United states, 1975-85. Source: Mansfield (1990).

Industry	Industry Percentage that could not have been developed (without substantial delay) in the absence of recent academic research		Percentage that were developed with very substantial aid from recent academic research	
	Products	Processes	Products	Processes
Information processing	11	11	17	16
Electrical	6	3	3	4
Chemical	4	2	4	4
Instruments	16	2	5	1
Drugs	27	29	17	8
Metals	13	12	9	9
Oil	1	1	1	1
Industry mean *	**11**	**9**	**8**	**6**

* Unweighted mean of industry figures

As indicated in Table 3.1, about 11 percent of these firms' new products and about 9 percent of their new processes (these products and processes has been carried out within 15 years of the first introduction of the innovation.) could not have been developed (without substantial delay) in the absence of recent academic research. In addition, about 8 percent of these firms` new products and about 6 percent of their new processes have been developed with very substantial aid from recent academic research. By the way, given industry figures in Table 3.1 are weighted means of the firm percentages for each industry, the weights being the 1985 sales of the firms (Mansfield, 1990). Nevertheless, the industry mean figure is un-weighted mean of all seven industries.

Table 3.1 tells us nothing about the economic importance of these new products and new processes. The figures being shown in Table 3.2 are about the economic importance of these new products and new processes. Mansfield state that data were obtained from each firm concerning the 1985 sales/saving of its new products/new processes first commercialized in 1982-85 that could not have been developed (without substantial delay) in the absence of recent academic research. These data were used to estimate the total 1985 sales and saving for such new products and new processes (first commercialized in 1982-85). To make the estimation for total sales or total saving, the number of major firms in each industry (in the list of Business Week) was multiplied by the mean 1985 sales or savings from such products or processes of the firms in the sample.

Table 3.2: Estimated sales of new products based on recent academic research and estimated savings from new processes based on recent academic research, seven industries, United States, 1985*. Source: Mansfield (1990).

Sales or Savings	Innovations that could not have been developed (without substantial delay) in the absence of recent academic research	Innovations that were developed with very substantial aid from recent academic research
Total 1985 sales by major firms of new products first commercialized in 1982-85 and based on recent academic research:		
Billions of dollars	24.0	17.1
Percent of total sales of major firms	3.0%	2.1%
Total 1985 savings by major firms due to new processes first commercialized in 1982-85 and based on recent academic research:		
Billions of dollars	7.2	11.3
Percent of total costs of major firms	1.0%	1.6%

* The seven industries that are included are listed in Table 3.1.

The seven industry total sales are about 24 billions of dollars and total savings are about 7.2 billions of dollars.

As mentioned in Chapter 2, time lag is critical issue for impact analysis. Mansfield worked on time lag to understand the relationship between academic research and industrial innovation based on academic research findings. Data, concerning the mean time interval between academic research findings and the commercialization of the products or processes, were collected from the firms.

If more than one such research finding was required for the development of the innovation, this time interval was measured from the year when the last of these findings was obtained.

Table 3.3: Average time lag between academic research finding and the first commercial introduction of a new product or process based on this finding, seven industries, 1975-85. Source: Mansfield (1990).

Industry	Innovations that could not have been developed (without substantial delay) in the absence of recent academic research (mean number of years)	Innovations that were developed with very substantial aid from recent academic research (mean number of years)
Information processing	7.0	6.2
Electrical	5.3	4.9
Chemical	6.8	7.3
Instruments	4.2	4.2
Drugs	8.8	10.3
Metals	9.8	5.1
Oil[a]	N.A.	N.A.
Industry mean[b]	7.0	6.4

[a] Reliable data could not be obtained for a sufficiently large number of innovations to allow us to present figures for this industry.

[b] Unweighted mean of industry figures.

Mansfield (1990) stated that the results of his work and results of Gellman (1976) are about the same. In Gellman (1976) study, average time lag for academic –research-based innovations in 1953-73 is 7.2. Similarly, in the Table 3.3, Mansfield founded time lag as 7 years. He pointed out that Gellman's data are not comparable with his data in many regards. For example, in Gellman's sample, the lag can be longer than 15 years for innovations; this cannot be the case in Mansfield's. Moreover, Gellman's data pertain to all industries, not just to those included Mansfield's study. Nonetheless, he figured out that Gellman's results are so close to his results.

"Because of the cumulative nature of science, total investment may have extended over decades or centuries. Nonetheless, for policy-makers who must decide how much to invest next year in academic research, rate of return is of primary significance. Past investments in academic research are sunk costs, and the social rate of return from next year's investment is what counts." (Mansfield, 1990).

To calculate the social rate of return from the investment in academic research, Mansfield tried to find the answer of the question; what would happen if the resources devoted to academic research were withdrawn-and not allowed to do the same or similar work elsewhere?

Mansfield set up a basic model to find an answer. He stated that without the investment in academic research in year t, the findings of this research would not be available; therefore, the development and introduction of the new products and processes based on these findings can be prevented or delayed. Firms believe that in the absence of academic research it would have taken at least 9 years longer, on the average, for providing necessary information to introduce related products and processes. At that point, Mansfield made a conservative assumption that it would have taken 8 years for this to occur. Therefore, time lag is taken 7 years. In other words, if the investment in academic research is done in year t, the new products and processes could be introduced 7 years later (that is, in year t`, where t` = t+7). The social benefits from the innovations commercialized in year t` that are based on academic research in year t are assumed to continue up to year t`+7 (and no longer). Since, after 8 years or more (in year t`+8 and more), non-academic research finding (through industrial, governmental, or other researchers) could affect the introduction of the new products and processes. Therefore, benefits 8 years or more after commercialization are so heavily discounted. In addition to this assumption, they also accepted the very conservative assumption that the social benefits from the innovations commercialized in year t` continue up to year t`+7 at their average annual level in the first four years after commercialization, and to be zero before year t`. Last assumption is based on Figure 3.1. The dotted line is used for time form of social benefits and costs in year t.

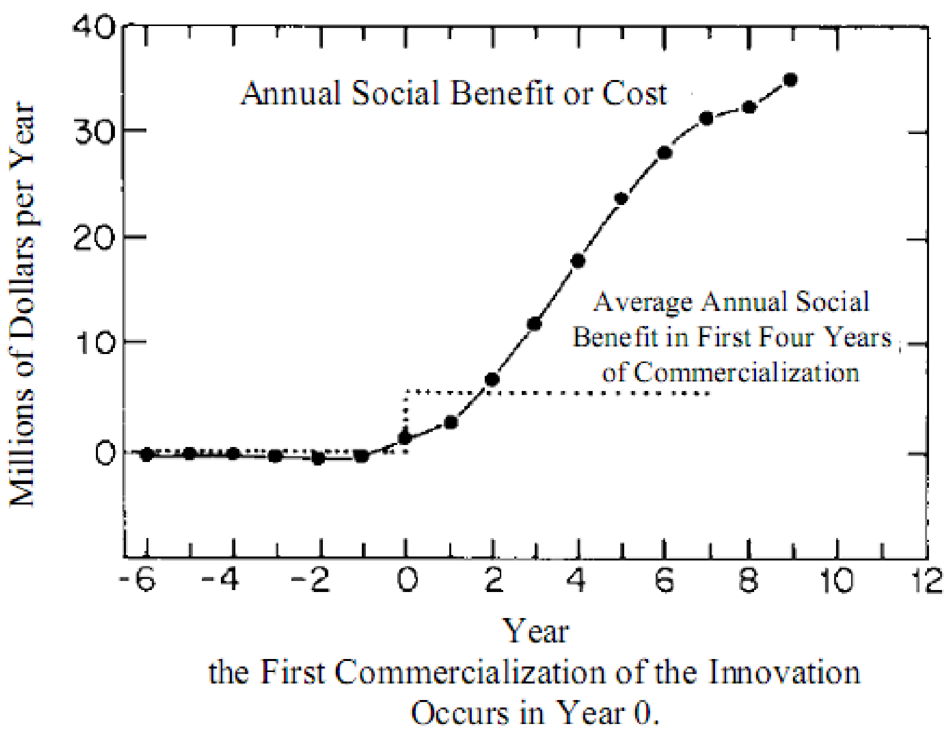


Figure 3.1: Annual social benefit or cost, by year, from first commercialization of innovation, mean for 53 industrial innovations. Source: Mansfield (1990).

This means that the dotted line represents the average social benefits in the years after the commercialization of the innovation (between years t` and t`+7), this line is also underestimates the social costs (due to investment in applied R&D, plant and equipment, and startup activities) prior to year t`.

Under conservative assumptions, to estimate the social rate of return (i) from the annual investment in academic research (C) during 1975-78 and the annual social benefit from this investment (X), he used Equation 3.1.

$$\mathrm{X}\left[\frac{1}{(1+\mathrm{i})^{7}}+\frac{1}{(1+\mathrm{i})^{8}}+\ \ldots+\frac{1}{(1+\mathrm{i})^{14}}\right]=\mathrm{C} \tag{3.1}$$

To solve Equation 3.1 for i, the values of C and X are needed. With regard to C which is fixed 1985 dollars, OECD data and Campbell (1978 and 1983) were used in the OECD countries and the Soviet Union (data other than the social sciences and psychology). Mansfield stated that according to the National Science Foundation (NSF), these countries had carried out almost all of the world's scientific and technological activities.

Because of the 7-year time lag, the investment in academic research during 1975-78 results in new products and processes commercialized in 1982-85. To estimate X (fixed 1985 dollars) during years 1982-85, B(t`) is defined as;

$$\sum_{\mathrm{i}}\sum_{\mathrm{j}=0}^{3}\left(\mathrm{b}_{\mathrm{ij}}\right)/4 \tag{3.2}$$

Where b_{ij} be the social benefit during year t`+j (where j = 0,. . ., 3) from the ith new product or process (based on academic research) commercialized in year t`.

All of the new products and processes commercialized (that were based on academic research) in year t` is covered with the first summation, therefore B(t`) is the sum of the social benefits accruing annually from the new products and processes commercialized in year t`.

One should bear in mind that, the annual social benefit was assumed to equal their average annual level in the first four years after commercialization. Under this very conservative assumption, X equals the mean value of B(t`) during 1982-85.

He stated that according to Mansfield (1977), “the social benefits from a new process consist of the savings to the innovator plus whatever net benefits accrue to others, and the social benefits from a new product consist of the increased gross profits of the innovator plus the net benefits to users.”(Mansfield, 1977)

According to statement given in previous paragraph, conservative estimate of B_{85} was stated. (For detailed information, see Mansfield, 1990)

By using the resulting estimates of X, together with estimate of C, the estimated social rate of return (i) values were found. These values are given in Table 3.4.

Table 3.4: Estimated rate of return from worldwide investment in academic research in 1975-78, based on alternative assumptions. Source: Mansfield (1990)

Assumption	**Rate of return (%)**
Including half of innovations developed with substantial aid from academic research	
Including estimated benefits to users from new products	28
Excluding benefits to users from new products	10
Excluding all innovations developed with substantial aid from academic research	
Including estimated benefits to users from new products	23
Excluding benefits to users from new products	5

As shown in Table 3.4, the estimated social rate of return is 28 percent when half of innovations developed with substantial aid from academic research (with the estimated benefits to users from new products) is added to sum of savings from the new processes and gross profits (sales) from the new products (in the left-hand column of Table 3.2). The estimated rate of return is 23 percent, even if all social benefits from innovations developed with substantial aid from academic research are excluded. In extreme cases, the figures are estimated as 10 percent and 5 percent.

CHAPTER 4

ESTIMATED SOCIAL BENEFITS OF TÜBİTAK SUPPORTED ACADEMIC RESEARCH PROJECTS

In this study, our purpose is to estimate the social benefit of the investment on academic research during 1998-2008. We looked at the social benefit of academic research projects that are supported by TÜBİTAK under Academic Research Funding Programmes Directorate (ARDEB), and under Basic Sciences Research Funding Group (TBAG), and specifically social benefit of physics projects supported by TÜBİTAK. Note that we focus on the social benefits from funding on academic research projects supported by TÜBİTAK not the social benefit from the entire academic research investment all over the Turkey.

It is good to recall that, TBAG, which is administered by Grant Committee, is located under ARDEB (see Chart 1.2). With other basic science projects (such as, chemistry, biology etc.) physics projects are also monitored by TBAG.

Because the results of academic research are widely disseminated and their effects are so widespread, it is difficult to identify and measure the links between academic research and its' social benefits. To get reasonable relation between the funding on academic research projects supported by TÜBİTAK and its' social benefits in terms of industrial innovations, results of Mansfield's (1990) study is used.

His paper figured out, as deeply mentioned in theory part of our study, the results of the rate of return ratios that were calculated by using annual investment (C) and annual adjusted social benefit (X) figures.

As a summary, in Mansfield (1990) work, the annual investment (C) figure during years 1975-78 were stated according to data that were derived from 76 American firms which were in study sample. The result was extrapolated by using OECD data and Soviet Union data with some assumption to get annual investment (C) figure for all over the world during years 1975-78. To get the worldwide annual adjusted social benefit (X) during years 1982-85, the data that were derived from firms were adjusted by some assumption (laying on previous work of Mansfield and the others). By using these figures, he stated the rate of return ratios for different case of assumptions.

In light of findings of Mansfield study, we try to estimate the annual social benefit (X) during 2005-2008, 2006-2009,…, 2011-2014, and 2012-2015 periods, separately. The rate of return figures (i) in Table 3.4 were used. To get the annual investment (C) figure during 1998-2001, 1999-2002,…, 2005-2008 periods, TÜBİTAK database was used. While creating our data list to get the annual investment figures, some constraints are settled down, that are;

- Project finish date are between 01 January 1998 and 01 January 2009,
- Project whose status is registered as “finished”.

In addition to above constraints, specifically, we only deal with the academic research projects funded under the programmes: ‘Scientific and Technological Research Projects Programme (1001)’, ‘Young Researchers National Career Development Programme (Career Programme) (3501)’, and ‘International Projects Support Programmes’.

All projects (monitored by ÇAYDAG, EEEAG, SBAG, SOBAG, TBAG, TOVAG, and MAG) were called as *ARDEB projects*. Obtained data list contained 3886 ARDEB projects. In Table 4.1 we classified these projects according to their finish date. By the way, all through this study we used "finish date-based" classification for projects. In other words, for example, in the Table 4.1 number of projects in 2005 is given as 313, this means that in 2005, 313 projects were finished (no matter when they had been started).

Moreover, we have to clarify some possible misconception about ARDEB projects in our data list and total ARDEB projects. According to our data list, only 888 of ARDEB projects were finished in 2008. However, total number of finished ARDEB projects in 2008 is about 1269. The difference between the number of ARDEB projects in our data list and the number of total ARDEB projects occurs because of the support programme types. That is to say, 381 of total ARDEB projects are not in our interest, because their support programme types are different from our concern. As stated previously, in this work, only projects which are proposed under 'Scientific and Technological Research Projects Programme (1001)', 'Young Researchers National Career Development Programme (Career Programme) (3501)', and 'International Projects Support Programmes' are included.

Table 4.1 contains also the total number of academic staff who are involved in ARDEB projects as coordinator, advisor, researcher or research assistant.

Moreover, there are funding figures of projects in Table 4.1. These figures are expressed in fixed 2008 TL values. To convert funding figures of projects to 2008 TL values, we used "Other Services" column of "Public Fixed Capital Investment and Foreign Exchange Deflator" published by T.R. Prime Ministry State Planning Organization (DPT) (DPT, 2008).

It is important to state that, there may be some missing data in our data list, because of the change of research funding groups name under ARDEB. To prevent this unwanted situation, we collect all projects under present research funding groups name. That is, research funding groups under ARDEB are ÇAYDAG, EEEAG, SBAG, SOBAG, TBAG, TOVAG, and MAG (see Chart 1.2).

To find annual investment, Mansfield counted the annual investment other than the social sciences and psychology. However, in our study funds on the social sciences are counted. According to Mansfield, about 11 percent of academic R&D in the United States in 1975-1978 went for the research not concerned with the engineering or the physical, environmental, mathematical, or life science. However, SOBAG was founded at 2000 and the total budget of SOBAG projects during 2000-2008 is about 8% of the total budget of ARDEB projects during same period. This may cause the results of social benefits from ARDEB projects to be higher than it should be, but it does not affect the social benefits of TBAG projects and Physics projects.

There is one more problem to solve before starting to examine the data, some projects are not monitored by its related research group. If there is a “grant committee member of related research founding group” among the project staff, they are monitored by another research founding group. This case created a question, should we count these projects into related research funding groups or into monitoring research funding groups? Fortunately, only 42 of 3886 projects (almost 1 percent) were in this situation, this is negligible number. As a result, we count the projects in this situation into its monitoring research group.

Table 4.1: Number of ARDEB projects, their budgets, and involved academic staff figures (according to finish date of projects).

ARDEB	Number of Projects	Total Budget *	Budget per Projects*	Number of Academic Staff	Budget per Academic Staff*
1998	247	1,215,411	4,920	755	1,609
1999	226	1,209,401	5,351	660	1,832
2000	184	1,199,709	6,520	542	2,213
2001	182	1,222,530	6,717	495	2,469
2002	218	2,126,589	9,755	649	3,276
2003	281	4,321,452	15,378	915	4,722
2004	347	6,804,434	19,609	1,103	6,169
2005	313	9,684,703	30,941	1,057	9,162
2006	413	16,802,530	40,684	1,386	12,123
2007	587	52,667,121	89,722	2,453	21,470
2008	888	109,292,411	123,077	4,379	24,958
TOTAL	**3886**	**206,546,296**		**14,394**	

* 2008 TL fixed prices

Table 4.1 displays the change in the number of projects, total funding amount on these projects, and number of academic staff involved in these projects during years 1998 and 2008. To estimate the social benefits of these projects, we focused on the average values of funding sequential groups of four; we made same thing for C values in Table 4.2 and Table 4.3.

Table 4.2: Number of TBAG projects, their budgets, and involved academic staff figures (according to finish date of projects).

TBAG	Number of Projects	Total Budget*	Budget per Projects*	Number of Academic Staff	Budget per Academic Staff*
1998	48	369,488	7,697	205	1,802
1999	50	339,685	6,793	198	1,715
2000	36	348,206	9,672	134	2,598
2001	48	370,112	7,710	153	2,419
2002	45	582,122	12,936	166	3,506
2003	65	923,799	14,212	266	3,472
2004	83	1,796,228	21,641	347	5,176
2005	79	3,203,095	40,545	375	8,541
2006	115	5,317,366	46,238	513	10,365
2007	121	10,976,889	90,718	567	19,359
2008	207	24,258,376	117,190	1,073	22,608
TOTAL	**897**	**48,485,371**		**3997**	

* 2008 TL fixed prices

If the values on Table 4.1 and Table 4.2 are compared, during years 1998 and 2008, 897 of 3886 ARDEB projects monitored by TBAG (which supports the academic research projects on physics, chemistry, biology, mathematics and statistics), that is about 23% of ARDEB projects. In addition, about 23% of total investment was assorted for TBAG projects.

Table 4.3: Number of Physics projects, their budgets, and involved academic staff figures (according to finish date of projects).

Physics Projects	Number of Projects	Total Budget*	Budget per Projects*	Number of Academic Staff	Budget per Academic Staff*
1998	16	186,545	11,659	100	1,865
1999	17	113,420	6,671	82	1,383
2000	11	173,768	15,797	42	4,137
2001	9	179,339	19,926	25	7,173
2002	10	143,063	14,306	40	3,576
2003	9	97,106	10,789	34	2,856
2004	12	274,113	22,842	44	6,229
2005	11	547,216	49,747	66	8,291
2006	16	681,036	42,564	94	7,245
2007	21	1,839,821	87,610	100	18,398
2008	45	5,095,990	113,244	241	21,145
TOTAL	**177**	**9,331,422**		**868**	

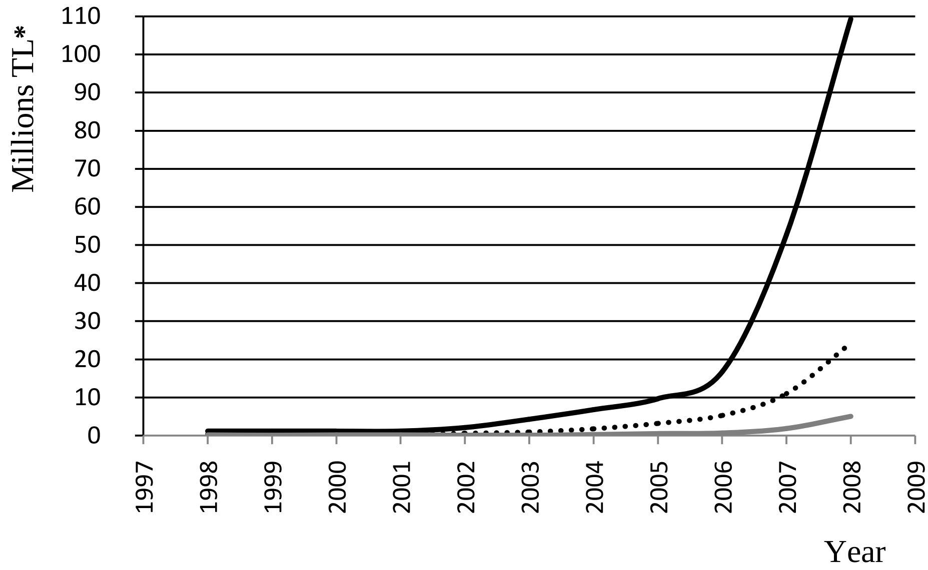
* 2008 TL fixed prices

As seen from Table 4.2 and Table 4.3, 177 of 897 TBAG projects were physics projects. This means that about 20% of all TBAG projects were physics projects during years 1998 - 2008. Moreover, about 19% of funding was used for supporting physics projects.

Table 4.4 represents the distribution of projects and the number of academic staff involved in these projects according to research funding groups. 868 academic staff (about 22% of TBAG projects) has involved in physics projects as coordinator, advisor, researcher or research assistant. Total number of academic staff who has been involved in TBAG projects is 3997, that is more than the numbers of academic staff involved in the projects supported by all other research funding groups separately.

Table 4.4: Distribution of ARDEB projects, and involved academic staff figures, according to research funding groups.

Research Founding Group	**Number of Projects**	**Number of Academic Staff**
ÇAYDAG	560	2282
EEEAG	204	557
SBAG	494	2385
SOBAG	223	680
TBAG	897	3997
TOVAG	862	2478
MAG	646	2015
ARDEB	**3886**	**14394**

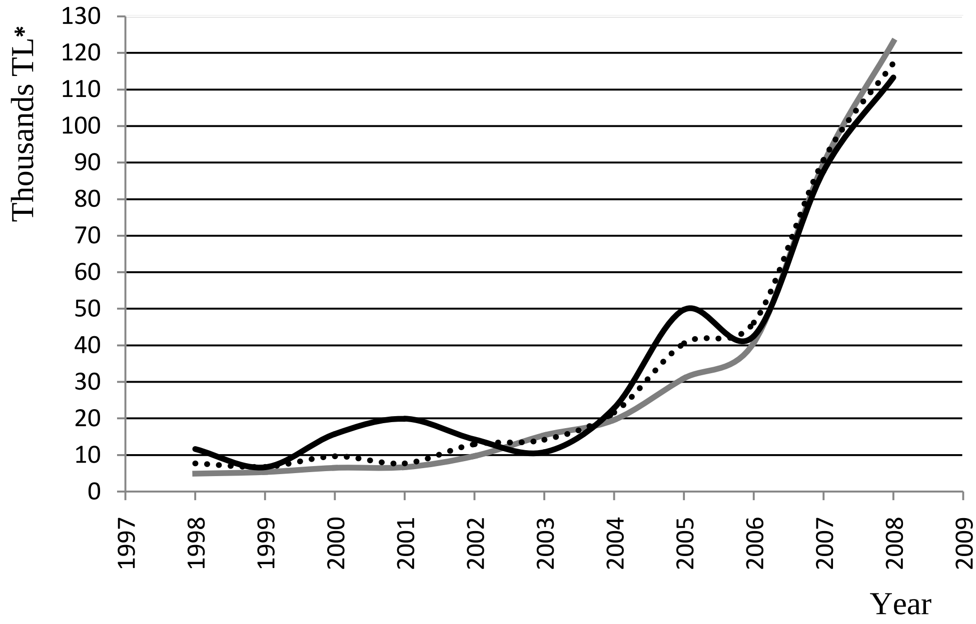


* 2008 TL fixed prices

Figure 4.1: Total annual budgets of academic research projects, during 1998-2008. Total annual budget of ARDEB projects, Total annual budget of TBAG projects, Total annual budget of Physics projects.

Figure 4.1 displays the dramatic increase in the total annual budget of ARDEB projects, TBAG projects and Physics projects after 2006. Actually, this result is because of the change in the country's S&T strategy in 2004. As stated in Chapter 1, one of the significant targets have been established in September 2004, is to increase GERD to 2% during the period from 2005 to 2013 (BTYK, 2004). According to TÜİK statistics, in 2004, the share of R&D expenditures in the GDP was about 0.67% and in 2008 the share of R&D expenditures in the GDP was about 0.73%.(TÜİK, 2006 and 2009)

Overall, in accordance with the increase in the share of R&D expenditures in the GDP, trend of annual budget figures that are used for funding academic research projects are meaningful.



* 2008 TL fixed prices

Figure 4.2: Average annual budgets of Physics projects; TBAG projects; and ARDEB projects during 1998-2008. ARDEB Avarage Annual Projects Budget, TBAG Avarage Annual Projects Budget, Physics Projects Avarage Annual Budget.

By the help of Figure 4.2, average budget of ARDEB projects, TBAG projects, and physics projects can be compared. During 1998-2002 and during 2004-2006, average budget of physics projects is more than that of TBAG projects and ARDEB projects. Between 2002 and 2004, and during 2006-2008, the investment per physics projects is slightly less than that of TBAG projects and ARDEB projects. However, it could be easily said that average budget distribution of projects are nearly same after 2006.

As a summary, to be on the safe side and to make a precise estimation (as could as possible) for social benefits, we used the average annual investment (C) values during 1998-2001, 1999-2002,…, 2004-2007, and 2005-2008 periods. By this way, average annual investment values are obtained. On the other hand, with regard to social rate of return values (i); the rate of return figures (i) in Table 3.4 is used. Therefore, we get estimation on annual social benefit from the innovations commercialized in the corresponding time interval, such as 2005-2008 (that are the effect of the investment during 1998-2001), or 2012-2015 (that are the effect of the investment during 2005-2008).

Table 4.5, Table 4.6 and Table 4.7 contain estimated average social benefit values for different i values for ARDEB projects, for TBAG projects, and for Physics projects respectively.

Table 4.5: Estimated average annual social benefits (X) from funding of ARDEB projects during periods of 1998-2001, 1999-2002,…, 2004-2007, 2005-2008 result in new products and processes commercialized in corresponding time interval for four different rate of return (i) values.

Corresponding Time Interval	Social Benefits* of ARDEB projects for four different "i" values			
	28%	23%	10%	5%
2005-2008	1.7	1.2	0.4	0.3
2006-2009	2.1	1.4	0.5	0.3
2007-2010	3.2	2.2	0.7	0.5
2008-2011	5.2	3.6	1.2	0.8
2009-2012	8.2	5.6	1.9	1.2
2010-2013	13.4	9.3	3.1	1.9
2011-2014	30.7	21.2	7.1	4.5
2012-2015	67.4	46.4	15.6	9.8

* In Millions 2008 TL fixed prices

Table 4.6: Estimated average annual social benefits (X) from funding of TBAG projects during periods of 1998-2001, 1999-2002,…, 2004-2007, 2005-2008 result in new products and processes commercialized in corresponding time interval for four different rate of return (i) values.

Corresponding Time Interval	**Social Benefits* of TBAG projects for four different "i" values**			
	28%	**23%**	**10%**	**5%**
2005-2008	0.5	0.4	0.1	0.1
2006-2009	0.6	0.4	0.1	0.1
2007-2010	0.8	0.5	0.2	0.1
2008-2011	1.3	0.9	0.3	0.2
2009-2012	2.3	1.6	0.5	0.3
2010-2013	4.0	2.8	0.9	0.6
2011-2014	7.6	5.2	1.8	1.1
2012-2015	15.6	10.8	3.6	2.3

* In Millions 2008 TL fixed prices

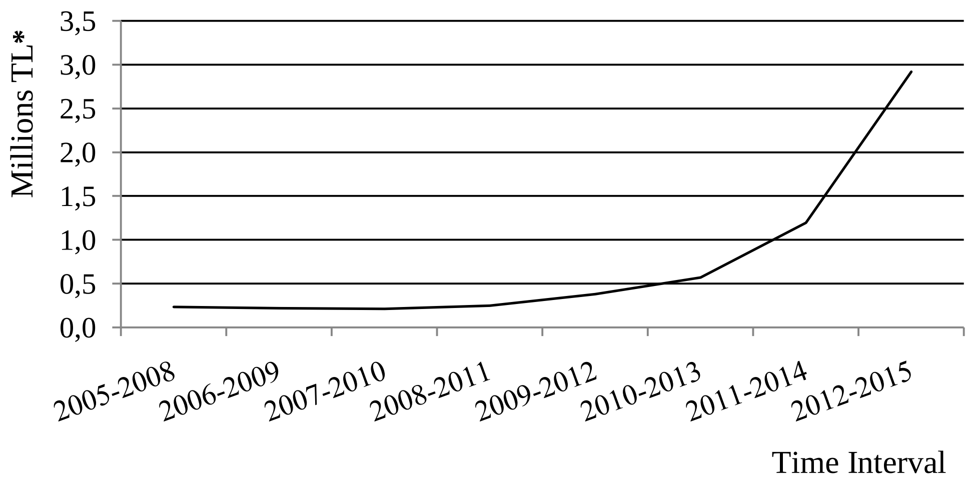
Table 4.7: Estimated average annual social benefits (X) from funding of Physics projects during periods of 1998-2001, 1999-2002,…, 2004-2007, 2005-2008 result in new products and processes commercialized in corresponding time interval for four different rate of return (i) values.

Corresponding Time Interval	Social Benefits* of Physics projects for four different "i" values			
	28%	**23%**	**10%**	**5%**
2005-2008	0.23	0.16	0.05	0.03
2006-2009	0.22	0.15	0.05	0.03
2007-2010	0.21	0.15	0.05	0.03
2008-2011	0.25	0.17	0.06	0.04
2009-2012	0.4	0.26	0.09	0.06
2010-2013	0.6	0.39	0.13	0.08
2011-2014	1.2	0.82	0.28	0.17
2012-2015	2.9	2.01	0.68	0.42

* In Millions 2008 TL fixed prices

If we look at the last three tables (Table 4.5, Table 4.6 and Table 4.7), they give us a chance to compare social benefits of TÜBİTAK supported academic research projects.

The estimated average annual social benefits from funding in academic research during 2005-2008, result in the new products and processes commercialized in 2012-2015. In terms of social benefit, contribution of ARDEB projects is estimated as 67.4 Millions TL, contribution of TBAG projects is estimated as 15.6 Millions TL, and the contribution of physics projects is estimated as 2.9 Millions TL at maximum (when i is taken 28%). On the other hand, for the minimum i value which is 5%, contribution of ARDEB projects is estimated as 9.8 Millions TL, contribution of TBAG projects is estimated as 2.3 Millions TL, and the contribution of physics projects is estimated as 0.42 Millions TL.



* In Millions 2008 TL fixed prices

Figure 4.3: Estimated average annual social benefits (X) of physics projects supported by TÜBİTAK, based on investment during 1998-2008 for 28% of "i".

Figure 4.3 brings out the estimated social benefits from funding in physics academic research projects what we tried to figure out in this study. As expected, figure of estimated social benefits of supported physics projects shows the same trend with the figures of the projects budget.

Average budget of physics projects during 2005-2008 is about 2 million TL, and the estimated social benefits from funding in physics projects during 2005-2008 (result in 2012-2015) is about 2.9 million TL, when the rate of return (i) is taken as 28% (at maximum). This result implies that return of funds on physics projects is about 142 percent. It is important to memorize that, the rate of return (i) is 28%, when related social benefit (X) contains “savings & sales of innovations that could not have been developed in the absence of recent academic research”, “half of the savings & sales of innovation developed with substantial aid from academic research” and “benefits to users from new products”.

When the rate of return is taken as 5% (at minimum), the return of funds on physics projects during 2005-2008 is about 21 percent. As an important note, this result covers only social benefits from products and processes (that could not have been developed (without substantial delay) in the absence of recent academic research). Social benefits from innovations developed with the substantial aid from academic research, and benefits to user from these products and processes are not included. This is an extreme case but as information, it is good to be known.

Moreover, for the rate of return that is taken as 23% (excluding benefits to users from new products) and 10 % (excluding all social benefits from innovations developed with substantial aid from academic research), return of funds on physics projects during 2005-2008 are about 98% and 33%.

CHAPTER 5

DISCUSSION

As a major academic research management and funding agency, The Scientific and Technological Research Council of Turkey has undertaken very important responsibilities to design a science and technology policy in Turkey. To evaluate the academic research programmes success and to have an idea about the contribution of funding on academic research projects to country economy, it is necessary to know something about social benefits of supported projects. This study presents the social benefits of the investment on academic research projects during 1998-2008.

Nonetheless, it is good to be in mind that our results are rough in many aspects. Most important issue is the sample difference between the study of Mansfield (1990) and ours. Mansfield rate of return values were based on many assumptions. Some of them may show difference for the case of Turkey. Such as; the time lags between academic research findings and commercialization of the innovations based on these findings. Nevertheless, 7 years time lag is OECD average and it is safe to use for Turkey.

In addition, to find worldwide savings and gross profits from new product and processes, Mansfield used the results of American firms. Then by using some estimation; NSF figures of proportion of innovations based on academic research of OECD countries, worldwide savings were founded. However, Turkey is one of the founding members of the organization; it is not one of the high income countries. This may cause the difference on the saving figures (which are used to calculate social rate of return values). This means that, estimated rate of return values in the paper of Mansfield could be high for our country. For that reason, we find social benefits for four different cases, and we create a possible range for estimated social benefits.

On the other hand, Mansfield counted the annual investment other than the social sciences and psychology. However, in our study funding on the social sciences are counted. Nevertheless, this does not affect the figures of social benefits from physics projects and TBAG projects.

Less important issue is related with our data list, we used the funding (C) values from the TÜBİTAK database; there is a possibility of missing information in our data list.

Overall, our findings imply that funds distribution over projects has been nearly same since 2006. Our findings contain valuable data related with the number of academic staff who involved in physics projects. For physics projects, number of academic staff was increasing between 2000 and 2008. As stated on Chapter 1, one of the scopes of TÜBİTAK is to encourage the academic staff or scientist about improving and increasing their attention to academic activities by means of directories and ARDEB is one of them. Figures about staff who involved in physics projects give us a clue about the achievement of the scope. However, this is endless scope. Needless to say, academic staff profile could be another work concept. From such a work, very useful impact analysis figures can be obtained.

Most important findings of this study are about social benefits of supported projects. Return of funds on physics projects during 2005-2008 is about 142%. By using different tentative rate of return values, we found different figures for return of funding on physics projects that are 21%, 33%, and 98%. It is important that these figures be treated with proper caution. This is because social rate of return values were constructed with many assumptions and simplifications. Moreover, social benefits figures contain some assumption too. When we think all four figures together, hopefully, they create a secure estimation range between 21% and 142% for return of funds on physics projects according to assumptions (rather than exact estimation values).

However, for the policy maker, past investments in academic research are sunk costs; what counts is that the social rate of return (Mansfield, 1990). Therefore, social benefits figures in this study have a great significance.

Despite the facts that, to evaluate and measure the social impact of academic research funding programme, and to make a future estimation of social benefit of funds, this study can be thought as an introductory study. Analysis of academic staff involved in the supported projects, their distribution over universities, analysis of journal articles being published and cited, analysis of patents, and analysis of prototypes are all possible working area for impact analysis concepts.

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APPENDIX A

DATA LISTS AND CALCULATIONS

In chapter 4, to find social benefits figures of Physics Projects, TBAG Projects, and ARDEB Projects, we used Table A.1.

Table A.1: Total Budget of Physics Projects, TBAG Projects, and ARDEB Projects according to finish data of the projects.

Years	Total Budget* of		
	Physics Projects	**TBAG Projects**	**ARDEB Projects**
1998	186,546	369,489	1,215,412
1999	113,421	339,686	1,209,402
2000	173,769	348,206	1,199,709
2001	179,340	370,113	1,222,531
2002	143,064	582,123	2,126,590
2003	97,107	923,799	4,321,452
2004	274,114	1,796,229	6,804,434
2005	547,217	3,203,096	9,684,703
2006	681,036	5,317,366	16,802,530
2007	1,839,822	10,976,889	52,667,121
2008	5,095,990	24,258,376	109,292,412

* 2008 TL fixed prices

To find average annual budget (C) of Physics Projects, TBAG Projects, and ARDEB Projects, average annual budget (C) of sequential four years were taken. In Table A.2, there are average annual total budget of Physics Projects, TBAG Projects, and ARDEB Projects during sequential four years periods from 1998 to 2008.

Table A.2: Average Annual Total Budget (C) of Physics Projects, TBAG Projects, and ARDEB Projects.

	Average Annual Total Budget (C)* of		
During Years	**Physics Projects**	**TBAG Projects**	**ARDEB Projects**
1998-2001	163,269	356,873	1,211,763
1999-2002	152,398	410,032	1,439,558
2000-2003	148,320	556,060	2,217,570
2001-2004	173,406	918,066	3,618,752
2002-2005	265,375	1,626,312	5,734,295
2003-2006	399,868	2,810,122	9,403,280
2004-2007	835,547	5,323,395	21,489,697
2005-2008	2,041,016	10,938,932	47,111,692

* 2008 TL fixed prices

$$X\underbrace{\left[\frac{1}{(1+i)^7}+\frac{1}{(1+i)^8}+\ \dots+\frac{1}{(1+i)^{14}}\right]}_{A}=C \tag{3.1}$$

In Equation 3.1, to find the value inside the parenthesis (A), we put four different rate of return (i) values that were founded by Mansfield (1990).

Table A.3: Resultant A values for corresponding rate of return (i) values.

Rate of Return (i)	**Resultant A Values**
0.28	0.70
0.23	1.02
0.10	3.01
0.05	4.82

Equation A.1 was solved for “Estimated Average Annual Social Benefits (X)” by using “Average Annual Total Budget (C)” figures and “Resultant A Values”, for corresponding time interval.

$$X\,[A]=C \tag{A.1}$$

Estimated average annual social benefits (X) figures were given in Table A.4, Table A.5 and Table A.6 for ARDEB projects, TBAG projects and physics projects respectively. Table 4.5, Table 4.6 and Table 4.7 contain also average annual social benefits (X) of mentioned projects in millions 2008 TL fixed prices.

Table A.4: Average annual social benefits (X) of ARDEB projects in 2008 TL fixed prices.

During Years	Average Annual Social Benefits (X)* of ARDEB Projects for			
	Rate of Return (i) is 28% (A=0.70)	**Rate of Return (i) is 23%** (A=1.02)	**Rate of Return (i) is 10%** (A=3.01)	**Rate of Return (i) is 5%** (A=4.82)
2005-2008	1,732,689	1,192,788	402,388	251,249
2006-2009	2,058,410	1,417,015	478,032	298,481
2007-2010	3,170,882	2,182,844	736,385	459,796
2008-2011	5,174,418	3,562,083	1,201,674	750,319
2009-2012	8,199,412	5,644,497	1,904,179	1,188,960
2010-2013	13,445,658	9,256,027	3,122,533	1,949,695
2011-2014	30,727,906	21,153,175	7,136,052	4,455,717
2012-2015	67,364,543	46,373,936	15,644,309	9,768,234

* 2008 TL fixed prices

Table A.5: Average annual social benefits (X) of TBAG projects in 2008 TL fixed prices.

During Years	Average Annual Social Benefits (X)* of TBAG Projects for			
	Rate of Return (i) is 28% (A=0.70)	**Rate of Return (i) is 23%** (A=1.02)	**Rate of Return (i) is 10%** (A=3.01)	**Rate of Return (i) is 5%** (A=4.82)
2005-2008	510,290	351,285	118,506	73,995
2006-2009	586,300	403,611	136,159	85,017
2007-2010	795,105	547,352	184,650	115,295
2008-2011	1,312,733	903,689	304,861	190,354
2009-2012	2,325,447	1,600,844	540,047	337,203
2010-2013	4,018,166	2,766,117	933,153	582,656
2011-2014	7,611,870	5,240,032	1,767,732	1,103,764
2012-2015	15,641,471	10,767,631	3,632,475	2,268,100

* 2008 TL fixed prices

Table A.6: Average annual social benefits (X) of Physics projects in 2008 TL fixed prices.

During Years	Average Annual Social Benefits (X)* of Physics Projects for			
	Rate of Return (i) is 28% (A=0.70)	**Rate of Return (i) is 23%** (A=1.02)	**Rate of Return (i) is 10%** (A=3.01)	**Rate of Return (i) is 5%** (A=4.82)
2005-2008	233,456	160,712	54,216	33,852
2006-2009	217,913	150,012	50,607	31,599
2007-2010	212,081	145,997	49,252	30,753
2008-2011	247,951	170,690	57,583	35,954
2009-2012	379,457	261,219	88,123	55,023
2010-2013	571,768	393,606	132,784	82,909
2011-2014	1,194,740	822,463	277,459	173,244
2012-2015	2,918,429	2,009,054	677,757	423,188

* 2008 TL fixed prices