IMPACT ANALYSIS OF INDUSTRIAL RESEARCH AND DEVELOPMENT SUBSIDY PROGRAMS IN TURKEY: AN APPRAISAL OF QUANTITATIVE APPROACHES

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Approval of the Graduate School of Social Sciences

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I certify that this thesis satisfies all the requirements as a thesis for the degree of Doctor of Philosophy.

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Doctor of Philosophy in Science and Technology Policy Studies.

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ABSTRACT

IMPACT ANALYSIS OF INDUSTRIAL RESEARCH AND DEVELOPMENT SUBSIDY PROGRAMS IN TURKEY: AN APPRAISAL OF QUANTITATIVE APPROACHES

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This thesis has two objectives in the field of policy evaluation that recently received extensive attention from international science and technology community. First, an attempt is made to examine, in the Turkish context, the effects of public subsidies on private research and development (R&D), selecting and implementing a suitable empirical methodology. Second, in the context of emerging economies, it aims to contribute to the existing impact analysis literature by providing an evaluation study for the period during which public incentives in business R&D have gained momentum with increased resources for diversified policy measures in Turkey since 2004.

In the dissertation, three quantitative studies examining the causal relations between direct public support and private R&D are presented. The first study, which uses the Tobit model, indicates that receiving a subsidy is an important determinant of private R&D intensity. In the second study, adopting the propensity score matching and difference-in-differences methods and using a panel dataset, effectiveness of receiving a grant from the TUBITAK industrial R&D support program is examined. The results indicate program-induced input additionality in (i) R&D personnel, (ii) R&D intensity and (iii) R&D expenditure per employee of the beneficiary firms during 2004-2006. The analysis with the propensity score matching using the data from Turkish Community Innovation Survey 2006 is repeated and similar results are obtained.

The results validate that engagement in public R&D programs in Turkey is beneficial for private R&D. Sufficient evidence was obtained to conclude that TUBITAK's industrial R&D project support program has encouraged most private firms to increase their R&D spending and R&D personnel in the period of 2003-2006.

Keywords: Evaluation, impact analysis, government intervention, R&D subsidies, treatment effect

ÖZ

TÜRKİYEDEKİ SANAYİ ARAŞTIRMA VE GELİŞTİRME DESTEK PROGRAMLARININ ETKİ ANALİZİ: NİCEL YAKLAŞIMLARIN DEĞERLENDİRİLMESİ

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Bu tez, uluslararası bilim ve teknoloji topluluğunun son zamanlarda oldukça yoğun ilgisini çeken politika değerlendirmeleri çerçevesinde iki ana amaç doğrultusunda oluşturulmuştur. Bu amaçlardan ilki, Türkiye bağlamında, özel sektör araştırma ve geliştirme (Ar-Ge) çalışmalarında kamu sübvansiyonlarının etkisini ölçmek için uygun olabilecek nicel yöntemi seçmek ve uyarlamaktır. İkinci amaç ise, gelişmekte olan ülkeler bağlamında, 2004 yılından bu yana önemli ölçüde çeşitlendirilerek artan miktarda kaynak sağlanan kamu Ar-Ge ve yenilik desteklerinin özel sektörün Ar-Ge faaliyetlerine etkisini inceleyerek etki analizi literatürüne katkıda bulunmaktır.

Çalışmada, doğrudan kamu destekleri ve yararlanıcı firmaların Ar-Ge faaliyetleri arasındaki nedensellik ilişkileri iki ayrı veri seti ile üç nicel çalışma kullanılarak sunulmaktadır. Ekonometrik yaklaşımla, Tobit modeli kullanılarak yapılan ilk çalışmada, Ar-Ge yardımı sağlanmasının özel sektörün kendisinin gerçekleştirdiği Ar-Ge yatırımları için çok önemli bir belirleyici olduğunu göstermektedir. İkinci çalışmada, yarı-parametrik eğilim skoru eşlemesi ve farkların farkı kestirimi yöntemleri ve bir panel veri seti kullanarak benimseyerek, TÜBİTAK Sanayi Ar-Ge desteği programından hibe alma etkinliği incelenmiştir. Sonuçlar, programdan 2004 yılında hibe desteği alarak yararlanan firmaların 2004-2006 yıllarında (i) Ar-Ge personeli, (ii) Ar-Ge yoğunluğu ve (iii) çalışan başına Ar-Ge harcamalarında girdi artımsallığı olduğunu göstermektedir. Araştırmanın son bölümünde, eğilim skoru eşlemesi yöntemi ile 2006 yılında gerçekleştirilen Topluluk Yenilik Anketi verileriyle hazırlanan ikinci bir veri seti kullanılarak analiz tekrarlanmış ve ilk çalışmaya benzer biçimde girdi artımsallığı bulunmuştur.

Gerçekleştirilen üç nicel analizin sonuçları Türkiye'de kamu tarafından sağlanan Ar-Ge desteklerinin özel sektörün Ar-Ge performansına yararlı olduğunu doğrulamaktadır. Özetle, 2003-2006 döneminde TÜBİTAK-DTM sanayi Ar-Ge projeleri destek programının özel sektörün Ar-Ge harcamalarının ve Ar-Ge personel istihdamının artmasını teşvik ettiği sonucuna ulaşmak için yeterli kanıt elde edilmiştir.

Anahtar Kelimeler: Değerlendirme, etki analizi, devlet müdahalesi, Ar-Ge teşvikleri, müdahale etkisi

Mehmet Tandoğan'ın anısına

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CHAPTER I

INTRODUCTION

"Learn truth from facts"
Deng Xiaoping
Chinese political leader

This dissertation is concerned with two complementary achievements in the research field of policy evaluation which have recently received extensive attention from the international science and technology community. First, an attempt is made to examine, in the Turkish context, the effects of public subsidies on private research and development (R&D), selecting and implementing a suitable empirical methodology. Second, in the context of emerging economies, the dissertation aims to contribute to the existing impact analysis literature by providing an evaluation study for the period since 2004 during which public incentives in business R&D have gained momentum in Turkey with significantly increased public resources for diversified policy measures, including grant and soft-loan programs for SMEs and international R&D projects, and generous R&D tax incentives. The share of direct support in total private R&D expenditure increased from less than 1% in 1996 to about 9% in 2008. The only quantitative ex-post evaluation of public support programs in Turkey is conducted by Özçelik and Taymaz (2008) for the period

1993-2001. Another round of evaluation is needed for the post-2001 period, given that a rapid increase in both economic growth and public support for private R&D has been observed.

In this study, enterprise-level data for the Turkish economy over the period 2003-2006[1] and a semi-parametric matching technique are used to scrutinize the effectiveness of R&D and innovation grants provided by the Scientific and Technological Research Council of Turkey (TUBITAK) and the Undersecretariat of Foreign Trade (DTM) to firms in the manufacturing and service sectors in Turkey.

1.1 EVALUATION OF PUBLIC INCENTIVES IN PRIVATE RESEARCH AND DEVELOPMENT: MOTIVATIONS AND CHALLENGES

Since the mid-twentieth century, the promotion and regulation of technological change have never dropped off governments' to-do lists. This is not only because the innovation stemming from technology is accepted as a crucial determinant of economic growth, but is also due to the growing consensus that government should play a facilitator role in the complex pattern of *national, regional or sectoral systems of innovation*. Among the various policy instruments of state aid, direct R&D subsidies and fiscal incentives turn out to be the two best-known and most frequently employed mechanisms by policy makers.

Increasingly, practitioners and researchers expend a great deal of effort on the evaluation of the impact of public incentives in private R&D and innovation, particularly at the after-treatment (i.e. ex-post evaluation) stages, in order to assess

[1] When the research was conducted, the latest firm level data available at the Turkish Institute of Statistics (TUIK) was from the Structural Business Survey conducted for 2006.

the achievements of the policy instruments in terms of the pre-defined goals and expectations. Although the key driving forces behind the evaluation efforts may vary depending on the stakeholders (i.e. who is evaluating and who will use the results) involved in the process, two arguments are worth mentioning. The first is the growing need to enhance the transparency and external accountability of public sector organizations. Governments need to provide an explanation or a justification to legislative bodies and the public for the transactions in which they are involved. Evaluation results may offer the means to fulfill such responsibilities. An expansion of this argument points to a paradigm shift in public decision making: Policy makers are increasingly forced to make decisions based on evidence-based justification instead of story-based rationalization because of accountability obligations imposed by the national and international community (UNESCO, 2010; World Bank, 2009; OECD, 2006).

The second motivation for policy evaluation is that the assessment results can provide valuable input for the improvement of the implemented strategies and policy instruments, such as programs and projects. Furthermore, a reliable evaluation study carried out before the implementation of the policy tool (i.e. ex-ante evaluation) may contribute to the approval of its legitimacy. In South Korea, for example, more than 250 policy instruments for promoting R&D and innovation are assessed periodically through a sophisticated meta-evaluation program for performance rating according to their pre-treatment objectives[2]. These rating scores

[2] The evaluation process of the national and regional programs in South Korea is designed and coordinated by the Korean Institute of S&T Evaluation and Planning (KISTEP), which has its legal basis in the R&D Performance Based Evaluation Law enforced in 2005 (Yoo, 2007).

are then used to assist the Korean government in its budget coordination and allocation, as well as in program improvement and re-planning.

The generic flow of an evaluation which is basically a social process consists of five consecutive phases. In the first phase, after the organization or the program to be evaluated is selected, the objectives (e.g. improvement of a program, input to decision making, protection of the public interest, and the like), participants and time constraints (e.g. before or after the treatment) of the evaluation process are defined. This task is undertaken by considering the needs and expectations of all the stakeholders, who may include commissioners, policy makers, program owners and incentive beneficiaries. At this stage, it is crucial to achieve a consensus between the stakeholders on the possible outcome of the process since each group of participants may interpret the evaluation process from its own perspective.

Second, an evaluation methodology (or a set of mixed methods) which fits for the objectives based on accessible data is selected from a wide range of qualitative and quantitative approaches. This is the stage where several important decisions should be taken for building an evaluation model based on appropriate approaches. This may include measuring the effect of a treatment by observing before-and-after or with-and-without situations; whether or not a control group is to be used, and so on.

In the third step, the data requirements of the selected methodology are satisfied. In this phase, the evaluator is involved in the collection and clearance of new data (surveys, interviews, questionnaires, and the like) and/or consolidation of existing data (national statistics or administrative data from previous operations). It is particularly important to obtain a relevant, noise-free and representative dataset that will yield a valid and reliable analysis.

In the fourth phase, the constructed data are analyzed employing the selected methodology. Evaluation at different levels employing a variety of methods provides multiple lines of evidence, which helps in gaining a deeper understanding of the treatment[3] effect. For example, an econometric study on public funding may reveal some additionality in the economic performance of the beneficiary firms, and further deep interviews with the R&D managers may provide valuable insights into the change in the firms' R&D behavior due to the subsidies. One of the objectives of this thesis is to provide an overview of qualitative and quantitative methods for measuring the effects of subsidy programs on private R&D, addressing their advantages and problems related to their implementation. Special attention will be given to empirical approaches with detailed classification and examples from the literature.

In the last phase, the evaluation findings are disseminated internally and externally to the stakeholders. This might become a challenging task for the evaluator, due to the complexities of the evaluation process to be explained, and political expectations, which are difficult to fulfill with findings most of the time. Through the first four phases, communication between the actors of the evaluation process, via workshops and interim reporting, may help the successful dissemination of the final results.

[3] Treatment, in the context of this study, can be defined as the techniques or actions customarily applied to a specific individual or a group of individuals in a specified situation. Therefore, any government intervention in private R&D activities can be regarded as a treatment.

As Luo's (2010) compilation of terms for defining the roles of an evaluator implies, a person who is involved in evaluation may become "*a judge during the phase of selecting criteria of merit, a methodologist when collecting data, a program facilitator during the program implementation, and an educator during the results dissemination*" (Luo, 2010, p.42). Nevertheless, it could be argued that, in addition to the technical qualifications, the objectivity and transparency of the evaluator seem to be the crucial virtues necessary for the attainment of an acceptable level of credibility from the beneficiaries of the evaluation output.

1.2 RESEARCH QUESTIONS

This research is confined to explore two essential questions: (i) Which quantitative method best fits for evaluating effects of direct R&D subsidies? (ii) Do public R&D subsidies in Turkey cause substitution or complementary effect on private R&D investment (over the period 2003-2006)?

Based on these questions, the major objective of this dissertation is to identify and analyze, by using quantitative methods, a set of key issues related to the evaluation of public subsidies on private R&D in Turkey. The specific research objectives guiding this study can be outlined as follows:

1. What is the role of R&D subsidies in firms' R&D investments compared with other determinants such as firm size, sales, exports, foreign ownership and technology transfer?
2. What are the available evaluation methods used for measuring the effects of public R&D policies and which one might be the best approach to illustrate the

causal relationship between the treatment and treated in the evaluation of Turkish R&D subsidy programs?

3. In the absence of subsidies, would the recipients of incentives have (i) carried out the same amount of R&D expenditure per employee (ii) employed the same number of R&D personnel and (iii) had the same share of R&D expenditure in total output? In other words, is there any input additionality?
4. In the absence of subsidies, would the recipients of incentives have had the same (i) recorded growth rates, (ii) exports and imports and (iii) level of employment? That is to say, is there any output additionality?

1.3 ORGANIZATION OF THE DISSERTATION

This dissertation is organized as follows: In Chapter 2, the theoretical framework of public incentives in private R&D and the evaluation process will be presented. First, based on the existing literature, an economic analysis of government intervention in technological change will be carried out, firstly by illustrating some historical highlights, then by presenting the rationale behind these involvements, and lastly by reconciling various taxonomies of such interventions. In Chapter 2, qualitative and quantitative evaluation approaches and their rationales will be examined via an extensive examination of the related literature. The chapter will close with an investigation of the theoretical and methodological background of the treatment effect and matching techniques that will be used to address the search for input and output additionality of public funding in our thesis. The selected evaluation model includes measuring the with-and-without treatment effect adopting a semi-parametric propensity score method (PSM). Because of a selection bias occurring for several reasons (preferences of the public agency in allocating grants, characteristics of those firms which apply, peculiarities of the grant process itself) during the funding process, comparing the R&D expenditures of recipient firms with those of non-recipients does not reveal appropriate information about the true impact of the support programs. Unless it is possible to identify what a subsidized firm would have spent on its R&D activities in the absence of any subsidy – which is unknowable since an enterprise cannot be observed in both states simultaneously – an appropriate counterfactual must be constructed to assess the additionality effect.

In order to construct a valid control group for recipient firms, an appropriate method would be to condition on observables and then match each recipient firm with a non-recipient firm that is highly similar to it except for its subsidy status. To remove the so-called "curse of multidimensionality", a scalar, called *propensity score* (i.e. the probability that a firm receives an R&D grant) is used together with the *Mahalanobis distance* to carry out the matching procedure. Once the control group for subsidy recipient firms is selected, the average impact of treatment on the treated is calculated by subtracting the average R&D expenditure (intensity) of support recipients from those recorded for the firms in the control group. As it is commonly used for producing standard errors in matching methods, bootstrapping[4] is also used in the estimation of the subsidy impact. One shortcoming of the matching method is that it checks only for observables but not for time-invariant, firm-specific non-observables, as well as common macroeconomic shocks which might cause the selection bias. The difference-in-differences (DiD) estimator will be used to deal with this issue.

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[4] Bootstrapping is a common *resampling method* which can be used as an alternative to asymptotic approximation for producing standard errors, t-statistics and-p-values (Wooldridge, 2001).

In Chapter 3, there will be a review of the available studies based on econometric studies on the measurement of incentive-generated *additionalities* which have been published since the late 1970s. In the reviews carried out by Capron (1992), David et al., (2000) and Klette et al. (2000), there is a highly comprehensive overview of the results concerning empirical evaluation studies. This chapter will include a brief appraisal of the pioneer studies in this domain. However, the main focus will be on the empirical evaluation studies which use firm-level data and have been published during the last fifteen years. Through a review of the literature, there will be an assessment of empirical findings which have been obtained from various recent evaluation approaches. During this period, theoretical evaluation studies based on earlier work have now achieved a level of maturity that makes them an essential instrument in many areas of empirical research in economics for the assessment of causal effects (Imbens and Wooldridge, 2009). The principal problem in studies related to government intervention is that of measuring the effect on a certain outcome of the exposure of a collection of individuals (e.g. people, firms or countries) to a treatment (e.g. subsidy program or tax incentive regulation). Unlike the earlier studies, taking care of the selection bias problem, and considering subsidy as an endogenous variable are the common characteristics of recent literature on subsidy evaluation. Different researchers utilize various statistical and econometric methodologies to address program selection and missing data problems in counterfactual situations. Depending on available data and the choice of dependent variable(s), (i) *matching methods* (Czarnitzki, 2001; Aerts and Czarnitzki, 2004; Duguet, 2004; Ebersberger and Lehtorante 2005; Chudnovsky et al., 2006; Lööf and Hesmati, 2005; Görg and Strobl, 2007; Özçelik and Taymaz, 2008; Cerulli and Poti, 2008; Aerts and Schmidt 2008; Gonzales and Pazo 2008),

(ii) *two- or three-stage selection models* (Busom, 2000; Wallsten, 2000; Janz, 2003; Hussinger, 2003, 2008; Negri et al., 2006; Takalo et al., 2008), (iii) *difference-in-difference methods* (Lach, 2002; Chudnovsky et al., 2006; Negri et al., 2006; Aerts and Schmidt, 2008) and (iv) *instrumental variable methods* (Bloom et al., 2002; Ali-Yrrkö, 2004; Clausen, 2009) have been adopted extensively during the last decade.

In Chapter 4, a chronological account of science, technology and innovation (STI) policies and incentives in Turkey since the 1960s will be presented in order to provide a historical perspective. Then, the public R&D support programs implemented during the period of analysis examined in this thesis, i.e. 2003-2006, will be presented and analyzed. The beginning of public incentives in business R&D in Turkey dates back to the early 1990s. However, until recently, governments' financial involvement was low and the range of such policy tools was limited. Since 2004, both a significant increase in resource allocation and the diversification of the policy instruments for promoting private R&D and innovation has observed both as presented in Table 6. The key organizations supporting private R&D during this period are TUBITAK, DTM, the Technology Development Foundation of Turkey (TTGV) and the Small and Medium-sized Industry Development Organization (KOSGEB). In addition to the direct incentives provided by these organizations, the Ministry of Finance introduced a fiscal incentive of 40% tax allowance for private R&D expenditure by adopting the existing Tax Law No 5520 in 2005. In the last section, the evolution of key STI indicators in Turkey will be examined with reference to national and international data. According to the latest figures, annual public expenditure in US dollars for R&D support programs in Turkey rose from by more than 34% in four years from $877 million in 2005 to $1.176 million in 2008.

Chapter 5 contains the findings of the analysis obtained from three quantitative studies based on econometric and semi-parametric methods. For these analyses, two different datasets are constructed. The first one, a panel dataset, is consolidated using data from the Structural Business Survey and the R&D Survey conducted by Turkish Statistical Institute (TUIK) and administrative data from TUBITAK over the period 2003-2006. The second -cross-sectional- dataset is sourced from Innovation Survey conducted in Turkey by TUIK for the period 2004-2006. The first section in Chapter 5 explains the construction of the datasets and provides a descriptive analysis. Then, the results of the first study examining the impact of direct R&D subsidies on firm's R&D investment will be analyzed. Using the Tobit model, possible determinants of the firm's R&D investment, beside the R&D subsidies, will be examined. These variables are foreign and state ownerships, capital intensity, sectoral and the firm's own R&D intensities, technology transfer and export status, market share, import penetration and wage rate. In the second study, adopting the semi-parametric propensity score matching and difference-in-differences methods and using the panel dataset, the effectiveness of receiving a grant from the TUBITAK industrial R&D support program is examined. The analysis with propensity score matching using the cross-sectional dataset is repeated to validate the methodology and results obtained from the previous empirical examination with a completely different data source.

The last chapter is devoted to conclusive remarks, policy implications and guidelines for further studies. The final point suggests that this study is not a complete assessment of a selected public policy instrument, but may rather be seen as a modest contribution to the debate on the use of empirical methods for the assessment of the public interventions in industrial R&D and innovation activities in Turkey.

CHAPTER II

THEORETICAL BACKGROUND: EVALUATION OF RESEARCH AND DEVELOPMENT SUPPORT

> *"In summary, evaluation persuades rather than convinces, argues rather than demonstrates, is credible rather than certain, is variably accepted rather than compelling"* House (1980).

The global impact of science, technology and innovation (STI) is conceived as a major driving force for economic growth. One of the main targets agreed by the European Council (EC) in Lisbon in 2003 was to improve and boost the innovation performance of the European Union (EU). The EC suggested that EU member countries' expenditure on research and development (R&D) should reach 3% of their gross domestic product (GDP) and spending on private R&D should increase to exceed two-third of gross expenditure on research and development (GERD) by 2012[5]. These objectives urge governments to develop appropriate policies and

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[5] Table D1 in Appendix D presents the variations of GERD as a percentage of GDP in European and other selected countries since 1995. From 1995 to 2007, the increase in GERD as a percentage of GDP is 2.05 to 2.28 in all the OECD countries, 1.66 to 1.77 in EU-27, 2.50 to 2.66 in the USA, 2.92 to 3.41 in Japan and impressively 0.57 to 1.44 in China. Pottelsberghe (2008) emphasizes the sizeable difference in the variations between the EU, the USA and Japan by presenting industry- and government-funded GERD separately (Table D2, Appendix D). He criticizes EU policies for failing to fulfill the Lisbon requirements by "missing the wrong targets". In order to stimulate European

measures in order to be able to stimulate private research and improve innovation performance. Among the various approaches of public intervention in the field of R&D, direct subsidies and tax incentives are two well-known policy instruments for governments. While an increasing amount of public resources was allocated for these policy implementation in advanced economies, the causal relationship between public funding of private R&D and firms' own R&D expenditure has become an important issue and investigated by many researchers since the 1970s (Howl and Fetridge, 1976; Lichtenberg, 1987; Wang et al., 1998; Wallsten, 2000; Klette, et al., 2000; Czarnitzki and Licht, 2006; Görg and Strobl, 2007).Today, it is rather implausible to design and implement policy instruments without taking into account the effectiveness of policy instruments. This should include not only assessing the general impact of the supported projects such as the amount of additional R&D input/output generated, but also focusing on "the *type* of R&D conducted by firms or the *ways* in which such R&D is conducted" (OECD, 2006:10).

This chapter is organized as follows: In the next section, based on the existing literature, an economic analysis of government intervention in technological change will be carried out first by illustrating some historical highlights, then presenting the rationale behind these involvements and lastly by reconciling various classifications of such interventions. In the second section, qualitative and quantitative evaluation approaches and their rationales will be presented by an extensive examination of the related literature. The chapter will end with a section on the concept of causality

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business R&D, he demonstrates the importance of having (i) more and better academic research and (ii) an integrated market for innovation (Pottelsberghe, 2008:223-224).

and theoretical and methodological background of treatment effect and matching techniques that will be used in the empirical part of the study.

2.1. ECONOMIC ANALYSIS OF GOVERNMENT INTERVENTION IN TECHNOLOGICAL CHANGE

Every government policy should carry an attribute of public interest. The public policy intervention in the process of technological change is no exception. However, the priorities of public interest in such policies might show significant differences in time and geography (Nelson, 1983); (Freeman & Soete, 2003). In time of war, governments obviously give the highest priority to defense and national security issues. In peacetime, although the defense industry is kept high in the list, the primary concern is macroeconomic issues, including improvement in growth, efficiency, productivity and so on. Policies driven by country-specific weaknesses also have crucial importance. An African country suffering from droughts, for example, is expected to invest in acquiring new technologies such as those related to clean water production and dry-farming.

Public intervention in technological progress occurs through incentives and regulations. Government attempts to promote or control technology-related activities by means of policies such as R&D subsidies, tax incentives, corrective or distortionary taxations[6], or regulations of property rights, and the like. Authorities often try to achieve the optimum mixture of different policies. Almost every economic activity is somehow regulated by government. The form and level of

[6] Corrective (e.g. environmental) taxes charge people for activities that have harmful consequences, whereas distortionary (e.g. earned income) taxes charge people mostly for their beneficial activities. Depending on its (recent) policy objectives, government may opt for the appropriate tax scheme.

intervention might depend on how well the public interest should be protected against private benefits, avoiding free-rider problems. In the following sub-sections, examples of public intervention in technological progress throughout history will first be presented, and then an investigation of a variety of incentives and regulations with their features and consequences related to economy will be carried out.

2.1.1. Government intervention in technology: Historical highlights

There are several strands of public intervention in technological progress that will be elaborated later in this chapter. Here, a few instances will be referred to, in order to illustrate the historical background.

Alchemists, astronomers and philosophers, under the auspices of ancient kings and medieval emperors, might be acknowledged as the first beneficiaries of public incentives for private research. However, the consequences of their success or failure must have been more dramatic than those seen today. Since ancient times, depending on the interaction between countries, the rulers have encouraged technology transfer and imitation, especially for military purposes. It is worth mentioning Britain’s Royal Society, inspired by Francis Bacon, established in 1660 and given royal approval by King Charles II, as one of the earliest institutions providing public funds for basic research (Ingham, 2010). On the other hand, in order to sustain and improve food production, agriculture has always been publicly subsidized, which presents a sample case of support for applied research and development.

After the First World War, pervasive utilization of substantive public subsidies initiated a transformation from curiosity-driven individual research to a “utilitarian”

(Schmookler, 1965) development of science and technology in the US and Europe. This trend accelerated during the Second World War and Cold War period. Although the support for small solitary research continued in some countries, the US and Soviet governments' competitive intervention in defense-originated industries such as aviation, semiconductors and telecommunications was "massive as well as directive" (Nelson, 1983:505). This era was the beginning of the distinction between "big science" and "small science" (Freeman et al., 2003). Big science was associated with being collaborative, interdisciplinary, financed by both public and private resources, and containing both basic and applied research activities. A classic example of big science would be the Manhattan Project, which was directly and strongly funded by the US government during the Second World War (Gossling, 1999). The project was not only successful in terms of accomplishing its primary mission of producing an atomic bomb, but it also introduced new technology for an alternative energy source, and initiated an exhausting international competition in nuclear arsenals as well. The consequences of this type of international competition concerning national security issues can be seen in the context of introducing new products and technologies in civilian life, as well as providing strong justification for governments to institutionalize interventions for the promotion and control of technological change.

After the war, two influential reports triggered public policies for science and technology in the USA: Vannevar (Bush, 1945) declared that new knowledge which can only be obtained by scientific research is needed for new products, industries and more jobs. This report initiated a series of important public displays of support for higher education and basic research in the USA (Bush, 1945). Later, in 1963, the Economic Report of the President (CEA, 1963) recommended a technology support program for non-defense industries. Industrial subsidies, especially in computers, semiconductors and aerospace, and including energy saving, environment-conscious policies, were seen pervasively in many countries by the late 1970s. R&D contracts and other indirect state aids became common in OECD countries in the 1980s. It has been reported that 1,479 industrial support programs were employed by OECD countries between 1989 and 1993, of which 282 were for R&D and technological innovation (OECD, 1998, p.27). Figure 1 presents the variations in the R&D investment patterns by the federal government and industry for basic and applied R&D from 1950-2006 in the USA (NSB, 2008). As a result of both various government interventions in science and technology and global competition within the USA, the federal government funded about 59% of basic research and 16% of development, while industry funded about 17% of basic research and 83% of development in 2006 (NSB, 2008).

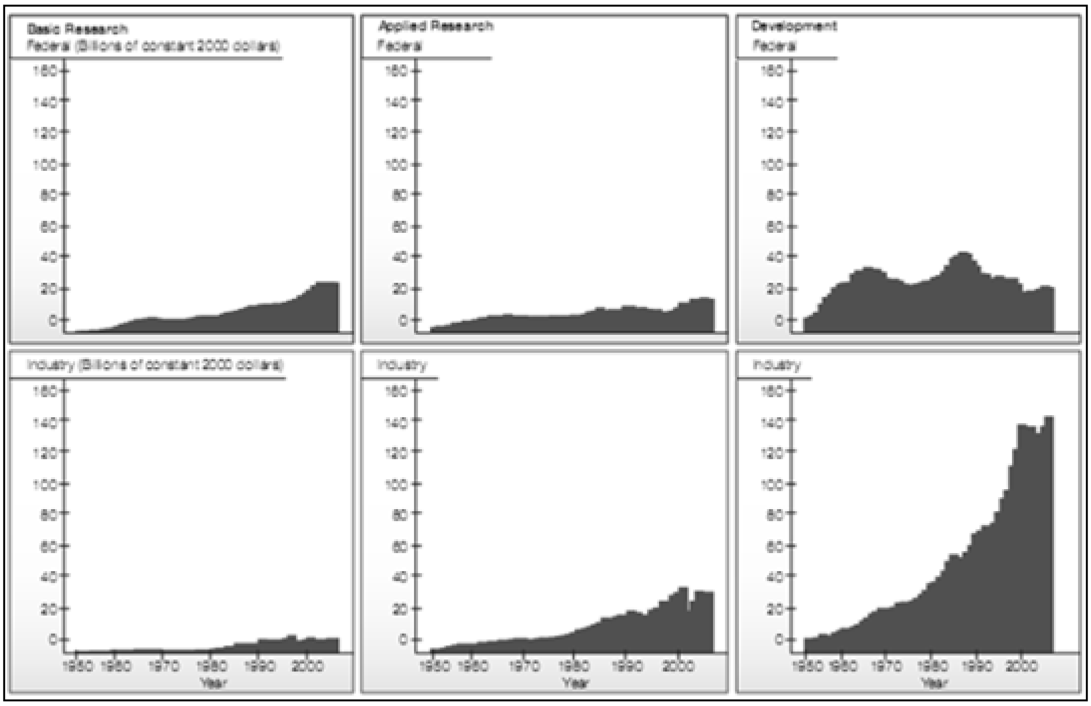

Figure 1 R&D investment patterns by the federal government and industry for basic and applied research and development in the USA: 1950-2006

Source: NSB, 2008

Another strand of government intervention which started relatively early in the history of world industrial development was the regulation of property rights. Although the oldest examples of the granting of exclusive rights to inventors date back to the 15th Century (Machlup, 1958)[7], the adoption of IPR regulation as we understand it today started at the beginning of the 1800s in Europe and the USA. Lamoreaux and Sokoloff (2007) emphasized the importance of the proper design of a state-controlled appropriability for innovation and the profitable trading of

[7] One of the first examples of granting privileges to inventors was enacted by the Republic of Venice in 1474.

technology. They demonstrated how the USA, at the beginning of the 20^{th} Century, gained competitive advantage over Europe by employing a more effective patent system to promote innovation and to facilitate increasing private returns on research and development. Lerner (2002) examined and compared the patent systems of 60 countries during the last 150 years. By using Penrose's study (1951), he observed that wealthier and more democratic countries adopt more effective patent protection. While the developing countries adopted strong IPR measures at the beginning of 20^{th} Century, they weakened them in the 1960s (Lerner, 2002).

An alternative to the western model of intervention, which is based on public-private interactions, existed in the Soviet Union from the 1930s to the 1980s. By employing a strong centralized planning system, the state controlled and financed almost all the scientific and technological activities with no consideration of any market requirements. In such a system, the state owned and exploited all the R&D outcomes and therefore no IPR regulation was needed. As Yegorov (2009) states, researchers in natural sciences, generously encouraged by the Soviet leaders and relatively less dependent on the state[8], were able to compete with their western colleagues. However, due to communication and mobility restrictions, the Soviet developers and specialists had to rediscover everything which was available outside the country. Deviation from the international standards, excessive control and central planning of technology, combined with an absence of entrepreneurship,

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[8] He explains the difference in the general atmosphere for social and natural scientists thus "Entrepreneurship was banned, while social sciences or arts required a high level of loyalty to the dominant ideology. Specialists in natural and technical sciences had a higher degree of freedom in the selection of topics for their research" (Yegorov, 2009, p.601).

caused the Soviet Union to lag behind in certain crucial areas, such as electronics and biotechnologies (Yegorov, 2009).

2.1.2. Why does government intervene? The economic perspective

The existing literature on rationales for government intervention in private R&D revolves around a number of themes. The first theme constitutes a theoretical justification of such intervention based on the concept of market failure due to unwanted leakages of knowledge. Nelson (1959) and Arrow (1962) identify the existence of market failure in private R&D activity from the incomplete appropriability of the outcome of research, which is knowledge. Private enterprises tend to underinvest in R&D because there are technological and commercial uncertainties, and because the R&D outcome has a more beneficial effect in the public domain[9]. This leads to the private sector's failure of fully utilizing the R&D output due to its being partially non-excludable and non-rival (Romer, 1990). Knowledge resulting from research is partially non-excludable since others may capture and benefit from at least a part of its value generated by the originator, even under appropriability regulations. Usher (1964) demonstrated the sub-optimality characteristics of the patent system and stated that society may benefit from any invention regardless of its commercial success. Knowledge is also non-rival because it is not subject to exhaustion when it is used by others. Arrow (1962) pointed out that the increasing returns of information generated by research and

[9] Bernstein and Nadiri (1988) analyze social and private rate of returns in high-tech industries in the US during 1958-1981 and find that social returns of R&D investments are 2-10 times the private rate due to inter-industry R&D spillovers. In a recent study, Lang (2009) examines the R&D returns in the German manufacturing sector over 45 years and observes that the private return of R&D investments declined dramatically by two-thirds within the period of analysis.

invention (especially by basic research) is one of the main causes of firms' reluctance to invest in research.

Besides the market failure caused by those characteristics of knowledge beneficial to the public, Cerulli (2010) points out that other types of market failure, such as barriers to entry and exit, capital market imperfections, or coordination and organizational failures might result in insufficient private return on business R&D. To summarize, the market failure rationale concerning private R&D investment suggests that the social rate of return[10] would be greater than the private rate due to spillovers and other market externalities, such as environmental issues. Jones and Williams (1997, 2000) questioned whether economies engage in too much or too little R&D, so they developed an endogenous growth model for measuring the social rate of return on R&D. In line with examples from previous literature (Mansfield, 1977; Bernstein and Nadiri, 1988; Griliches, 1992), their results, derived analytically from existing empirical studies, showed that optimum R&D investment should be at least four times greater than actual spending. These evidence-based arguments justify government efforts at mediation of information spillovers, such as IPR regulations, and for optimum allocation of resources within society. Public incentives are expected to stimulate private R&D, which otherwise tends to remain reluctant due to the gap between social and private profitability.

The second theme is related to the evolutionary school of technological change. Arrow's argument on easy transferability of knowledge, which Nelson (1959 and

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[10] Peterson (1976, p.324) defines the R&D related social rate of return as "the value of additional output that is forthcoming because of the research". Georghiou et al. (2003, p.17) relate social returns to social surplus to the level of investment, and describe it as the surplus captured by parties other than the R&D performer him/herself.

1961) assumed to be the primary output of R&D activities, is challenged by evolutionary scholars. The first argument relies on capital market imperfection for R&D projects due to the asymmetric-information problem of the *lemon market*[11]. Since the investor (e.g. funding agency) does not have the same level of information about a project as the project owner (funded firm) does, the risk and cost of external R&D investment is higher than that of internal financing (Leland and Pyle, 1977; Metcalfe 1994, Hall, 2002). Another issue that is related to the asymmetric information problem between the investor and R&D performer is defined as *moral hazard* arising from the separation of ownership and management of innovating firms (Hall, 2002). The risk of an R&D investment that is ready to be taken by the owner of the firm would be avoided by the manager as a result of possible conflict in their goals as referred to in economics as a *principle-agent problem*.

The second argument emerges due to the *sticky* and *cumulative* characteristics of knowledge as the output of an R&D activity. By coining the term sticky information, Hippel (1994, pp.429-430) argues that when the cost of acquiring information is high, which is mostly the case in research activities, it is equally costly to transfer and use that information as well. This argument challenges the view of earlier scholars such as Arrow on the easy transferability of information[12]. On the other

[11] The asymmetric information problem was first elaborated by Akerlof (1970) using an analysis of the car market. A car owner in a used-car market would have better knowledge of whether a particular car is good or bad than the potential buyers, causing the bad cars (called "lemons" in the US) to drive the good cars out of the market. Such a market is called a "lemon market".

[12] Arrow states that the cost of transmitting information is often very low and reaches the conclusion that, "In the absence of special legal protection, the owner cannot [...] simply sell information on the open market. Any one purchaser can destroy the monopoly, since he can reproduce the information at little or no cost" (Arrow, 1962, p.614).

hand, as described by Hippel (1994) and based on Rosenberg's analysis (1976), much technological knowledge is difficult to acquire and disseminate since it consists of a large number of increments which may have tacit parts. The relocating of such a cumulative body of knowledge generated by research and technological development might be costly and not a trivial task most of time due to the low learning ability, or the absorptive capacity, of the potential recipient (Cohen and Levinthal, 1989). Even though recent analyses (Hyvärinen and Rautiainen, 2007; Autio et al., 2008) do not always assume the market failure rationale due to spillovers to be the single most significant factor in justifying public intervention in technological innovation, governments, relying more and more on the evidence obtained from policy evaluations, continue to support private R&D with subsidies, fiscal incentives and appropriability measurements. A study conducted by Levin et al. (1987) highlights the discrepancies in the efficiency of appropriability conditions in different industries. Conducting an inter-industry survey, they find that patents raise imitation costs by 40% in new drugs and 7-15% in electronics[13]. However, they concluded that firms in the US do not consider patent either as the most efficient or even the only way of appropriation.

Malerba (1992) explored firm-level learning, concluding that firms have various learning processes, and different learning structures result in different patterns of innovation. Therefore, any public R&D policy with the objective of supporting a distinct technological innovation in an industry should selectively target those

[13] Similarly, Mansfield et al., (1981) found using survey data that about 60% of the patented innovations were imitated within 4 years, and on average, such imitation could cost 50-75% of the cost of the original innovation. Such evidence will alleviate but not completely remove the underinvestment problem.

specific learning processes which are best suited to that technological progress. Moreover, Clarysse et al. (2009) recently found evidence that learning effects decrease with the number of supported R&D projects. These approaches and arguments dispute the earlier justification of subsidies made by the market failure rationale. The last thirty years of experience in the implementation of technology policies in different countries shows that, occasionally, such policies fail to achieve efficient results because of either *government failures* or *systemic failures*. Government failure may occur for various reasons, such as conflicting political concerns, effective lobbying of stakeholders, inadequate priority settings, insufficient market information, and the like. Cohen and Noll (1991) demonstrate numerous examples of failures of government while implementing technology policies in the US from the 1960s to the 1990s. Systemic failure on the other hand, is often related to "... the lack of coherence among institutions and incentives. This occurs when there are mismatches between the different components of innovation systems (such as conflicting incentives of markets and non-market institutions)" (OECD, 1998b: p.21)

Although there are several arguments concerning the cause-and-effect relationship between market failure, government failure and systemic failure (Larosse, 2004; Papaconstantinou and Polt, 1997), diminishing the gap between social benefits and private returns of the private R&D is the basic criterion of success for any market intervention by governments, and hence the justification of what should be regarded as the key evaluation benchmark.

2.1.3. How does government intervene? A broad classification of technology policies

Classifying technology policies is a challenging task since such policies, in general terms, are highly complex and multidimensional involving numerous stakeholders at different stages. Moreover, policy objectives may be regional, national or international, occasionally holding global ambitions. Policy instruments related to technology and innovation may be embedded in other incentives and measures. For example, structural public funds aimed at high technology areas such as nanotechnology or space technology naturally include state aid for related research infrastructure. A generic labor market intervention may involve a higher education incentive that directly affects the supply side of private R&D activities. Sometimes the same intervention tool can be employed differently to achieve different objectives in two or more countries, since their governments might not have similar opinions concerning the best focus and locus of the similarly targeted technological change.

In this section, by investigating the existing literature a self-effacing attempt will be made to identify government interventions in technological innovation according to their four distinct features. These features are, (i) Intervention domain (promotion or regulation), (ii) Intervention objective (demand or supply side), (iii) Intervention strategy (direct or indirect) and (iv) Intervention specificity (specific or generic). A brief description of these features will be presented below:

(i) Intervention domain: This describes whether the policy provides an incentive, i.e. R&D grants or tax credits for the promotion of private R&D activities, or mandates a regulation, i.e. measures concerning intellectual property rights or public procurements. Policy instruments and measures from two categories are generally adopted simultaneously as being complementary to each other rather than substitutes, whereas a number of policies in the same group can be used as alternatives to each other[14].

(ii) Intervention objective: This describes whether the policy instrument targets the demand or supply side of the R&D activities in question. While R&D subsidies and contract-based public procurements are accepted as demand side interventions, policies for skilled personnel availability aim to promote the supply side. One common characteristic of R&D activities is that roughly half of their costs consist of personnel expenditure (Goolsbee, 1998). Therefore, it is not surprising that many empirical studies identify a positive impact of R&D subsidies on R&D employment (Levy and Terleckyj, 1983; Irwin and Klenow, 1996; Lerner, 1999; Taymaz and Üçdoğruk, 2007). However, a few scholars, such as Wallsten (2000), evaluating the Small Business Innovation Research (SBIR) program in the US, and Suetens (2002), estimating the impact of Flemish R&D support programs, reach the conclusion that R&D grants have no effect on either firms' R&D activities or employment. There is an ongoing debate over whether greater R&D expenditure leads to more R&D output, i.e. new/better products and lower cost production, or whether it merely leads to a rise in researchers' wage due to inelasticity in the supply of scientists and engineers (Goolsbee, 1998; David and Hall, 2000; and Aerts and Schmidt 2008).

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[14] For example, Lahiri and Ono (1999) studied the effects of subsidy versus taxation policy on private R&D investment and concluded that a firm with initial cost advantages should have its R&D activities subsidized, whereas a firm without such advantages should face with discriminatory taxation.

(iii) Intervention strategy: This describes whether the policy treatment is *direct,* as in the subsidization of R&D costs or research collaborations between firms and universities and public financing of selected technologies, or *indirect,* as in public research and the networking and coordination subsidies of European framework programs, whose outputs could be exploited by industry through spillovers. Direct intervention policies generally contain well-defined and more measurable objectives and goals than indirect policies and hence, until now, better methodologies have been developed to evaluate the effect of direct support instruments. (For a detailed comparison between direct and indirect public supports, see OECD, 1998a.) An alternative yet similar taxonomy related to intervention strategies was proposed by Ergas (1986), namely mission-oriented and diffusion-oriented technology policies. Mission-oriented policies concentrate on building nationwide technological capabilities in those industries selected by the policy makers in the given countries. These policies are also related with the central plans of major projects of national importance, including radical innovations in new technologies. According to Ergas (1986), the US, the UK and France are the countries that mostly adopt mission-oriented policies. Among these countries, it is argued that France is the most successful in obtaining efficient results from the implementation of such policies, whereas the UK is claimed to be the least successful. On the other hand, Ergas (1986) classifies Germany, Switzerland and Sweden as diffusion-oriented countries, while Japan is said to be a country unique in this respect, since its government employs both mission and diffusion-oriented policies.

Diffusion-oriented countries adopt policies to disseminate existing technological capabilities throughout industry and promote supportive institutional mechanisms, such as education systems and technical standardization. In these countries, technological preferences are decentralized and fulfilled by industry (Ergas, 1986:28). Inspired by Ergas's suggestion of the mission/diffusion-oriented categorization, an integrated policy framework is suggested by Hahn and Yu (1999) to comprise simultaneously both technology generation and diffusion (see also OECD, 1998b for the different technology policy schemes of the OECD countries).

(iv) Intervention specificity: This defines whether intervention is adopted through specific policies such as regional, sectoral, SME-targeted measures, or general policies such as legislation for technology development zones or support for R&D intermediary institutions (OECD, 1998a). A parallel policy feature suggested by Folster (1991) is *selectivity,* which is frequently and interchangeably used to mean specificity. However, it should be noted that there is a discrepancy between specificity and selectivity: while selective policies contain a preference or favor, specific policies indicate a sort of exclusivity. An R&D subsidy program for example, is always *selective* by nature but might be either *specific,* such as a program for funding exclusively for nanotechnology firms, or a *general* program available for any firm in industry that satisfies the general requirements of the funding agency.

There may be different classifications in terms of technology policy instruments with respect to the variety of intervention features; however, the drawbacks of any kind of classification should be kept in mind. A summary of technology policy instruments having the above-mentioned intervention features can be seen in Table 1. Among the eleven intervention categories in Table 1, direct support for business R&D and fiscal incentives have been the two principle instruments adopted and evaluated extensively by numerous countries during the last three decades and therefore they deserve more detailed explanation.

Table 1 Categories of government interventions in technological progress

FEATURES: Policy Instrument	**DOMAIN** Promotion or Regulation	**PURPOSE** Demand side or Supply side	**STRATEGY** Direct or Indirect	**SPECIFICITY** Specific or Generic
Subsidies for business R&D: Public R&D&I Grants, loans, credits, and rent discounts	**P**	**D**	**Dir**	**S / G**
Income tax exemption and reimbursement of social security contribution for R&D personnel	**P**	**D**	**Dir**	**G**
Fiscal Incentives: R&D Tax credits and allowances	**P**	**D**	**Ind**	**G**
Public research, government laboratories	**P**	**D**	**Ind**	**S**
Public procurement: defense and civilian contracts	**P**	**D**	**Ind**	**S / G**
National/international collaborative scientific research support programs	**P**	**D / S**	**Dir**	**S / G**
Higher education support for skilled personnel availability	**P**	**S**	**Dir**	**S / G**
Public support for intermediary R&D institutions	**P**	**S**	**Ind**	**S**
Legislation for Intellectual Property Rights	**R**	**D**	**Ind**	**G**
Incentives for technology development zones, science parks, etc.	**R**	**D**	**Ind**	**G**
Public R&D legislative measures	**R**	**D / S**	**Dir / Ind**	**S / G**

P: Promotion, R: Regulation; D: Demand, S: Supply; Dir: Direct, Ind: Indirect; S: Specific, G: Generic

Source: Author’s elaboration

2.1.3.1. Direct support for business R&D

In Table 1, the direct support for business R&D is presented with the characteristics of promotion type direct incentive for demand side of R&D which can either be provided to general or specific target groups. Public subsidies in the form of direct state aid are expected to mitigate country- specific weaknesses by stimulating academic and industrial R&D activities. In general, they are implemented by funding agencies and ministries using specific support programs financed from the national budget. Such programs, through grants, loans and contributions, are intended to reduce the cost of investment for either basic, i.e. scientific, research or experimental development[15]. However, there are criticisms related to governments' selection policies, which claim that they are based on *picking the winners* to subsidize rather than supporting projects that carry higher levels of risk and uncertainty (Hall and van Reenen, 2000; OECD, 2002a). This might mean that such selective policies are not always shaped by technological preferences and national priorities, but rather by political concerns and stakeholders' lobbying activities, and therefore they might have the potential to have partial or full crowding out effects on industrial R&D investment.

As a common intervention policy, governments might either opt to be selective in choosing the beneficiaries of an R&D subsidy program, with respect to the type of industry or technological area (e.g. mission-oriented policies), or to design a non-

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[15] Madore (2006, p.2) emphasizes the difference between research and development as "[B]asic research, work performed for the advancement of knowledge and science without any practical application in mind; applied research, carried out for the advancement of science, but with a specific application in mind; and experimental development, aimed at achieving technological progress. In experimental development, the results of basic and applied research are used to create new products or processes, or to improve those that already exist."

specific program that would be open to any candidate satisfying the criteria set by the funding agency (i.e. diffusion-oriented policies). Most of the instruments in the former category are program-based, while the latter is project-based, these projects being run by small countries (OECD, 1998b). Actually, direct support for private R&D is a continuous learning process for both the funding agency and the beneficiary.

Teubal (1996), inspired by Israel's accumulated R&D subsidy experience, presents the characteristics of two stages of government support for newly industrialized countries in the early and the late subsidizing periods; he calls these the *infant* and *mature* stages. In the infant stage, the main objective is to introduce R&D processes as a routine activity in the industry by funding a targeted number of good quality projects. Funding decisions, in this early stage, are taken autonomously for each project with respect to general criteria designed to develop and disseminate industrial research capabilities. Teubal (1996) suggests that, for between five and ten years from the start of the infant stage, government should continue to support private R&D, although the mature stage has been reached considering the following strategy: In this last stage, mission-oriented policies should be launched; aiming at higher potential benefits for society is encouraged, as are more risky projects and research competitions. However, in a given country, the success rate of such a policy sequence would be strongly correlated not only with the existence of a suitable "policy environment" (Teubal, 2002, p.247), but also with other institutional and legislative support mechanisms for technological change and innovation (Nelson, 1983).

2.1.3.2. Fiscal incentives for industrial R&D

An equally popular incentive mechanism for stimulating private R&D investment is the provision of fiscal incentives. Guellec and van Pottelsberghe de la Potterie (2003) concluded in their study that subsidies and tax incentives are substitutes since increasing the intensity of one reduces the effect of the other. They find also that a positive effect on R&D performer firms can be observed if these policies are stable over time. As predicted by Hall and Reenen (2000), an increasing number of countries are progressing towards fiscal incentives that are more lenient, and include non-selective policies in addition to R&D subsidies. In fact, while direct subsidies are mostly known to be centralized, mission-oriented and selective-treatment, tax incentives are de-centralized, neutral with respect to area of industry or technology area, mostly diffusion-oriented, and hence provide equal-treatment intervention in industrial R&D (OECD, 2002a; Czarnitzki, et al., 2004; Lhuillery, 2005).

Fiscal incentives consist of several distinct mechanisms that can be employed either collectively or individually:

<u>R&D tax credit</u>: is defined as the dollar for dollar cutback from the firm's tax payment based on its qualified in-house R&D expenditure and outsourced research payments (with some limitations). Tax credit does not depend on the tax rate, and hence it has the same value for the firm, regardless of the firm's income level. Tax credits are one of the most common fiscal policies used to reduce the marginal cost of industrial R&D in OECD countries.

<u>R&D tax allowance</u>: or tax deduction, is defined as the incremental or leveled reduction from the firm's taxable income based on its qualified R&D expenditure

and outsourced research payments. Expenditure on R&D is capitalized (as investment) and is assumed to depreciate at higher rates than other fixed assets such as plant and machinery (GIB, 2009). Tax deduction is not as valuable as tax credit for beneficiaries since it varies with the tax rate and taxable income.

Reimbursement of employees' social security contributions: is targeted to facilitate employment of skilled personnel required for R&D activities. In many countries, such reimbursements are adopted as a general policy tool in industry, intended to reduce unemployment.

Income tax exemption: allows rising of salaries for R&D personnel.

The US was one of the pioneer countries, adopting a generous R&D tax credits incentive in 1981. As an indirect R&D co-financing measure for industry, this incentive became a favorite intervention policy in the 1990s; while there were just 12 OECD countries subsidizing private R&D investments through tax incentives in 1996, this had increased to 21 countries in 2008 (Mohnen and Lokshin, 2009). Appendix A presents the summary of the R&D tax incentives schemes of 23 countries in 2008-2009.

2.2. ASSESSMENT OF THE EFFECTS OF PUBLIC SUPPORT ON PRIVATE R&D

This section provides a brief review of the methods and concepts applied in the evaluation of the impacts of public policies on the stimulation of industrial research and development for technological innovation. The effect of government intervention in private R&D can be viewed from various perspectives. David and Hall (2000) provide a black box model for R&D, in which they try to establish the "static" and "dynamic" effects of "contract R&D", which is related to research on government projects conducted either by government labs or by firms which have been awarded contracts, and "grant R&D", which is publicly supported. They define static effects as the immediate impact on research inputs (e.g. rise in demand for researchers in supported technology areas, alteration of firms' decisions on R&D investment due to preferences of support programs, and the like), and dynamic effects as the time-lagged consequences of funded research (e.g. unwanted disturbances in academic research resulting from a rise in the demand for researchers in industry).

One may find other types of classification concerning *temporal* (immediate/lagged, short-term/long-term), *diametric* (firm, own/other industry, societal levels) or *domain specific* (scientific and technological, economic, commercial, political or organizational) aspects of the impact. The assessment of public policy may extend on the micro or macro level; in regional or nationwide economic performance figures such as growth, employment, productivity, export and import might be affected by publicly-funded R&D. The change in total factor of productivity (TFP)[16] caused by various intervention policies such as tax incentives, public procurement and R&D grants is yet another important issue to which researchers pay attention (Griliches, 1979; Capron, 1992; Hall and Reenen, 2000; Niinnien, 2000; Harris et al., 2009).

[16] TFP in its most general terms can be defined as the effects in total output which do not have direct causal relation with input such as capital or labor. A typical TFP source could be human capital or *useable knowledge* (Kuznets, 1966). There is an ongoing debate, however, on defining TFP and its relation to growth (For review refer to Prescott, 1997; Hulten, 2000). As for the well-known definitions of TFP used in evaluation of the effects of R&D on productivity and growth, see also Mansfield (1980) and Nadiri and Mamuneas (1994).

Before continuing with the assessment of approaches for measurement of the effects of government intervention, two points related to the meaning of evaluation need to be clarified. First, it should be noted that the concept of evaluation is a social research practice, which Rossi et. al. (1999, p.20) define thus: "*Program evaluation is the use of social research procedures to systematically investigate the effectiveness of social intervention programs that are adapted to their political and organizational environments and designed to inform social action in ways that improve social conditions*". They also elucidate what they mean by *social research procedures*: that they are the latest social science methods of continuous observation, measurement, sampling, research design, and data analysis "*for producing valid, reliable and precise characterizations of social behavior"* (Rossi et. al., 1999, p. 22). Second, the terms *evaluation, assessment*, and *measurement* are frequently used interchangeably with little attention given to the differences in their meanings. The confusion in the alternate usage of these terms is clarified by Huitt et al. (2001) as

> "Assessment, measurement, research, and evaluation are part of the processes of science and issues related to each topic often overlap. Assessment refers to the collection of data to describe or better understand an issue, measurement is the process of quantifying assessment data, research refers to the use of data for the purpose of describing, predicting, and controlling as a means toward better understanding the phenomena under consideration, and evaluation refers to the comparison of data to a standard for the purpose of judging worth or quality. …Collecting data (assessment), quantifying that data (measurement), making judgments (evaluation), and developing understanding about the data (research) always raise issues of reliability and validity. Reliability attempts to answer concerns about the consistency of the information (data) collected, while validity focuses on accuracy or truth. The relationship between reliability and validity can be confusing because measurements (e.g., scores on tests, recorded statements about classroom behavior) can be reliable (consistent) without being valid (accurate or true). However, the reverse is not true: measurements cannot be valid without being reliable. "(Huitt et al., 2001, p.1).

However, in most of the recent studies, scholars' use of *evaluation* or *assessment* covers the meaning of both making judgments and developing understanding about the data. In this thesis, *evaluation* will be used to describe those two meanings. In the next section, evaluation methods in various categories will briefly be overviewed.

2.2.1. Axes of evaluation categories

The measurement and evaluation methodologies of the effects of public policies can be scrutinized in three distinct classification approaches. The first approach is based on the evaluation time (i.e. when to evaluate), the second is related to qualitative and quantitative methodologies, and the third approach is built on the concept of additionality.

2.2.1.1. Evaluation choice in the time domain

The evaluation of government intervention strongly involves practice-driven approaches and methods creating suitable information with which to understand the effectiveness of the relevant policies before, during and after the intervention cycle. Therefore, three types of evaluation can be identified regarding the temporal dimension[17]:

1) *Ex-ante evaluation* is conducted before the implementation of the intervention. Such evaluations are aimed at assessing likely future performance in order to assist policy planning, i.e. design of the relevant

[17] Polt and Rojo (2002) classify and give detailed descriptions of the different evaluation types. Most of the definitions in this section are borrowed from their study. The table in which they summarize the characteristics of eleven distinct evaluation methods can be seen in Appendix B.

policy. Simulations (i.e. scenario modeling to investigate socio-economic outcomes), expert panels/peer reviews (i.e. perceptions of scientists and scholars in estimating scientific and technological outcomes), cost efficiency and cost-benefit analysis (i.e. examining the economic efficiency of the policy) and foresights (i.e. expert assessment of the policy's potential for technological and socio-economic advances) are the most common methods used for ex-ante evaluation. The success criteria of an ex-ante evaluation study is its ability to demonstrate the link between the intervention policy with benefits and merits, as well as its capacity to analyze the rationale of the intervention, considering all the expectations of the stakeholders.

2) *Intermediate evaluation and monitoring* are conducted during the intervention period. This type of evaluation provides useful information for the observation of the progress and immediate effects of the relevant policy. Monitoring, including managerial, technical and economic issues, enables a continuous feedback mechanism to make corrective adjustments to the intervention policy when it is necessary with regard to the initial requirements.

3) *Ex-post evaluation* is concerned with assessment of both the expected and unexpected effects of the intervention on the targeted organizations and individuals. When the intervention terminates, it is of critical importance to choose the right time to conduct the evaluation. While an early attempt is unable to reveal all the effects, the outcome of a late evaluation might be unreliable due to the possible involvement of other factors affecting the results. The most frequently used ex-post and intermediate evaluation

approaches are as follows: Innovation surveys (questionnaires for basic innovation data such as Community Innovation Surveys (CIS) based on Oslo manuals), macro and micro econometric studies (such as parametric and non-parametric empirical studies, control group approaches, etc.), interviews and case studies, benchmarking (i.e. comparison of related indicators such as innovation indicators and performance criteria across the individuals and organizations), cost-benefit analysis, expert panels/peer reviews, productivity analysis (impact analysis of the intervention on productivity growth at micro or macro level), network analysis (examining the structures of cooperation, and analyzing the impact of the intervention on the present and future; existing and potential collaborative relations of targeted individuals and organizations), and foresights and technological assessments. Ex-post evaluation methods are mostly used to quantify the impact, to estimate the efficiency (i.e. the level of effectiveness) and efficacy (i. e. the power or capacity to create an effect) of interventions. In ex-post evaluation of public R&D support policies, Polt and Rojo (2002) argue that most of the methodologies attempt to examine a specific relevant aspect of an R&D process such that, while a micro-econometric analysis focuses on capturing the private rate of return of the intervention, a cost-benefit study attempts to transform all the benefits and costs of a project or program of intervention policy into monetary values for purposes of comparison.

2.2.1.2. Qualitative versus quantitative methods

From the methodological perspective, the measurement of the effects of government R&D policies can be grouped into two broad categories, namely qualitative and quantitative evaluation approaches.

Qualitative methods such as surveys, interviews and case studies, provide evaluators with more detailed information on the multidimensional impacts of technology intervention policies. Policy makers, employing such methods, may have a better insight into the effects which, although important, are difficult or impossible to measure with quantitative methods. For example, case studies used to measure the effects of The Advanced Technology Program (ATP) on advanced refrigerator technology in the US between 1995 and 1999, revealed several qualitative benefits including improved food safety in the food processing and food service industries, improved cross-industry knowledge transfer and enhanced organizational capacity with joint venture associates (Ruegg, 2003).

Among the various qualitative methods, peer reviews have become popular, especially for ex-ante evaluation. Peer reviews are relatively simple and cost-effective, but open to local lobbying of related stakeholders; they are sometimes criticized for being too scientific, failing to recognize the wider social and economic effects (Piric & Reeve, 1997). For a successful peer review evaluation, selecting the individuals with the most suitable qualifications in the field for the (external or local) *expert panel* is an important issue to be considered.

Another qualitative method used typically in priority and goal setting practices is technological forecasting procedures. Capron (1992) identified three distinct types of technological forecasting, namely (i) scenario generation for the future developments which is similar to Delphi-based techniques, (ii) cross-impact identification or interdependency table creation for different research fields and (iii) morphological analysis merging assessment methods with creativity techniques. Their course of estimating future technological enhancements might fail due to misleading assumptions and the subjectivity of the experts (Piric and Reeve, 1997)[18].

Quantitative methods, on the other hand, can be reviewed in five groups:

(i) Econometric analysis: By merging micro or macro economic theories with methodologies in statistics and mathematics, econometric evaluation studies define models to verify certain economic hypotheses and attempt to estimate parameters to reveal the magnitude and direction of the relationships between the related entities in question.

(ii) Cost benefit analysis (CBA): This methodology, as an analytical tool, is used to examine the social and economic effects of an intervention policy mostly, when possible, in monetary terms[19]. Costs and benefits can be investigated in categories of direct and indirect effects, including tangible and intangible components. For example, sales resulting from the output of a funded project can be regarded as a direct (and tangible) benefit, whereas the increase in health problems in the users of project output may be evaluated as an indirect and intangible cost for society.

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[18] See Grupp and Linstone (1999) and Sarıtaş, Taymaz and Tümer (2007) as two examples of national technology forecast and foresight studies.

[19] The various techniques for monetizing cost and benefits are summarized by Polt and Woitech (2002).

According to Polt and Woitech (2002), uncertainty is the most significant technical difficulty in CBA. It could be simplified by converting *uncertainty* to *risky situations* by using risk analysis approaches.

(iii) Control group analysis (CGA): This method can be used to evaluate the profiles of treated and untreated groups, assuming the government intervention as the treatment. While CGA is widely accepted as a successful tool for measuring the effects of non-randomized treatments such as public R&D subsidy programs, the difficulty of establishing an accurate control group is the major drawback of this approach. CGA will be elaborated in detail in the next section, since it is one of the major methods employed in this thesis.

(iv) Financial methods: As a relatively older approach, financial methods including the calculation of internal rate of return and net current value, ratio methods, cost-effectiveness analysis, portfolio models, risk profiles and programming models are identified by United Nations (UN, 1980). As an evaluation tool, financial methods are considered inflexible and limited since they focus only on a few economic indicators and targets (Piric and Reeve, 1997).

(v) Efficiency Assessment: In the context of evaluation methods, the efficiency assessment (Farrel, 1957 cited by Cincera et al., 2007) is a well-known approach which has been used in economics for decades. It can be classified as technical efficiency (maximum output for a given input), allocative efficiency (optimal mix of input for a minimum cost of given output) or overall efficiency. Two non-parametric methods, Free Disposal Hull (FDH) and Data Envelopment Analysis (DEA) are widely used to examine technical and allocative efficiency in various industries. The primary drawback of non-parametric methods is their strong dependence on the accuracy of the data, and noise or error intolerance. The alternative approach that includes the effect of error term is the Stochastic Frontier Estimation (SFE) method. In this method, by employing stochastic frontier models (instead of deterministic frontier models as in FDH and DEA), the sensitivity to outliers and extreme values can be minimized (Simar, 2007).

Table 2 summarizes the strengths and weaknesses of efficiency assessment methods.

Although efficiency assessment provides an important indicator for the policy makers, their expectations concerning the impact analysis of public R&D incentive programs foster the employment of more comprehensive evaluation methods, which will be discussed later (Cincera et al., 2007).

Table 2 Strengths & weaknesses of alternative methods to assess efficiency

Method	Strengths	Weaknesses
1. Composite performance indicators		
	• Evaluation of public spending in its entirety	• Not suited to assess the efficiency of particular policies e.g. health, education, R&D policies
2. Data Envelopment Analysis (DEA)		
	• Allow one to directly compare the efficiency of countries (ranking) • No need to define the relative importance of the various inputs employed and output produced (due to the absence of weights or prices attached to each outcome) • No need to specify a functional relationship between inputs and outputs • Not subject to simultaneous bias and/or specification errors • Allow to deal with the simultaneous occurrence of multiple inputs and outputs	• Heavy reliance on the accuracy of the data • Difficult to distinguish between output and outcomes • Efficiency scores attributed to inputs while other factors may also contribute • Frontier depends from the set of countries considered (Inefficiences can be underestimated)
3. Stochastic Frontier Estimation (SFE)		
	• Error term with 2 components: conventional error term + term representing deviation from frontier (relative inefficiency) • Allow for hypothesis testing, confidence interval • Allow to explain inefficiency	• Assume functional form for the production function • Assume distributional form of the technical efficiency term • Single output dimension • Frontier depends from the set of countries considered (Inefficiences can be underestimated)

Source: Cincera et al., 2007

Scrutinizing the results obtained by qualitative and quantitative methods, it can be claimed that there exists no single perfect methodology to fulfill the complete set of requirements of a specific evaluation process. Each method has its own pros and cons. Depending on the available data and the unit of analysis (i.e. firm, industry or national/global economy), evaluators choose to employ one or more methods from a selection of approaches in the qualitative or quantitative groups. In fact, Capron (1992) describes the evaluation process as consisting of complementary rather than substitute methods. Often, in order to increase the credibility of results, the evaluator begins with a quantitative method of estimating the impact of an intervention policy and seeks to confirm the estimated results with a qualitative method such as case studies or interviews. The table 38 in Appendix B briefly describes all the above-mentioned evaluation methods, namely those belonging to qualitative, quantitative or both groups.

As a particular implementation of the above mentioned methodologies, Georghiou and Roessner (2000, pp. 658-661), summarize distinct types of method for evaluating the impact of research in universities and public laboratories:

1. Retrospective: historical investigation of the knowledge generated by R&D, searching for the relative contribution of basic vs. applied research. They note that historical tracing studies, besides being costly, ignore the indirect effects of research, including spillovers and knowledge acquired from unseccessful R&D activities (i.e. dead ends).
2. Measurement of research outputs generated by activities in research projects and programs using patent and citation counts; surveys of sales, licenses and contracts; bibliometrics studies, and the like. Such methods can be successfully adopted for benchmarking in order to measure and compare the research performance of individuals, institutions or countries, but they often fail to demonstrate the actual impact on socioeconomic change as Leydesdorff et al. (1994) argued that scientific research outputs and economic change are only loosely coupled (Leydesdorff et al., 1994).
3. Macroeconomic production function models for evaluating the impact of the technological change resulting from the related R&D activity on national or regional economy and productivity growth.
4. Microeconomic models for estimating the changes in user and producer surpluses caused by the related technological change. A selection of micro

and macroeconomic studies for evaluating the effect of public support on private R&D in different countries from 1999-2009 is summarized in Table 4 in Chapter 3.

Micro and macro evaluations do not necessarily converge to the same results. Capron and Cincera (2002) state that the positive effect of subsidies on firm- level R&D investment observed via micro evaluation may not be seen at the industry level because of the additional responses of the non-beneficiary firms in the same industry.

2.2.1.3. Additionality assessment

It can be argued that, for an effective evaluation process, to question “what is going to be evaluated”, in other words, “what is to be expected as *additionality* due to intervention” is of crucial importance. The concept of additionality (i.e. the observed change caused by an intervention) has been studied and classified by a number of scholars (Buisseret et al., 1995; Clarysse et al., 2009; Falk, 2004, 2007; OECD (Leydesdorff et al., 1994), 2006) in a range from a simple input-output additionality to more complex definitions, such as “project additionality” or “cognitive capacity additionality” (Bach and Matt, 2002). According to Clarysse et al. (2009), *input additionality*, which is the additionality of one Euro of public subsidy on private R&D investment, and *output additionality*, which is the part of R&D output –however measured- that would have been missing without the subsidy (Georgiou, 2002), are explained through neo-classical approaches. In this *input-blackbox-output* model, additionality, which is the direct effect on input, output or both, is observed and analyzed for impact analysis. Increase in the firm’s own R&D investment or R&D personnel due to public incentives are considered as input additionality, and additional products, services or processes are expected as output additionality. Input additionality is known to be the most common, and also rather straightforward to measure, type of indicator evaluated in numerous studies, as presented in Table 4 in Chapter 3. Evaluating input additionality includes the search for whether subsidies have a complementary (crowding in) or substitution (crowding out, or deadweight) effect on private R&D investment.

Output additionality, on the other hand, is less easy to measure for two reasons. First, evaluation horizon is critical, and should be estimated taking into account various criteria, such as type of industry, characteristics of the innovation system of region or country, or macroeconomic instabilities. For example, it might not be possible to observe the effect of R&D funding on both exports of beneficiaries in a low-tech industry in a developing country, and in a high-tech industry in a developed country in a given time period after the treatment.

The second reason is associated with *proximity* or *relatedness* of the treatment process to the potential outcomes. The causal relationship between public funding and firms' own R&D expenditure is stronger than the correlation concerning public funding and sales (or employment or exports). There could be further causalities, if market changes, intra/inter industry spillovers and the like, which affect the changes in firms' sales, are taken into consideration.

The outcome of an innovation process is more than those concrete outputs, even if it fails to achieve its initial goal (OECD, 2006). The major weakness of the input-output evaluation methods is that the effects on the black box (i.e. firm or institution) that is actually performing the innovation process are not taken into consideration. For the policy makers, effectiveness, the "attainment of the given goals" of an intervention program, is more important than efficiency, the “use of given resources” (Larosse, 2004). In order to measure effectiveness, one should observe the “behavior” of the black box in the linear innovation model. *Behavioral additionality* (first mentioned by Buisseret et al., 1995) is defined as “the difference in firm behaviour resulting from the intervention” (Georghiou, et al., 2004:7). While the funding agency’s expectation from the funded firm is often limited to contracted deliverables, the actual contribution of subsidy could expand beyond the funded project to the firm’s broader objectives. Behavioral additionality studies in numerous OECD countries, including Japan, Germany, Ireland and Finland (OECD, 2006) show that funding creates much R&D-related additionality in firms’ behavior, such as more challenging research, acceleration of R&D projects, increased scale and complexity, and improved management and selective collaboration. In a recently completed study for the European 6th Framework program (FP6), the following behavioral additionality was observed across the participant countries (EU, 2009):

- Access to state-of-the-art knowledge and skills
- Getting to know the right people /networking
- Visibility, and the ability to expose skills to an international audience
- Bringing a networking culture and project management skills into the organization
- Increased prestige attached to research performers part of FP6.

It is possible to find more detailed and meticulous classifications of additionality concerning direct R&D subsidy programs in the literature of behavioral additionality. According to Falk (2007), inspired by Davenport (1998), one of the most significant subjects in the context of public funding is “the question of implementation/non-implementation in the (hypothesized) situation of no public assistance” (Falk, 2007, p.67). This type of effect is called “project additionality”, which exists if the project is withdrawn unless it is awarded public funding. However, in many cases without public support, the project is conducted, but with size or scope or timeframe changes[20]. These changes can be identified as scale or scope or acceleration additionality. Hence, Falk proposes a classification of additionality in three -sometimes overlapping- categories: 1) Resource-based concepts including project and input additionality 2) result-based concepts including output and strategic additionality 3) process-based concepts such as scope and score additionality (parallel to previous classification of behavioral additionality). Figure 2 shows the range of additionality from resource-based to result-based concepts (Falk, 2007). This approach was used in a recent evaluation study for IWT R&D grants in Belgium (IWT, 2006).

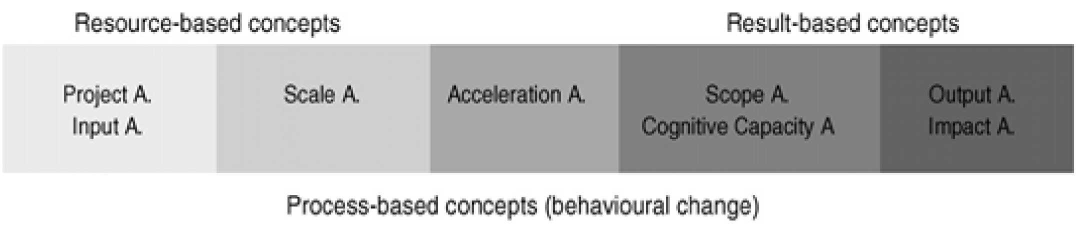

Figure 2 Additionalities in resources, processes and results

Source: Falk, 2007, p.668

[20] For example, a publicly funded project would be finished with fewer accomplishments then planned (scope) or in a longer period of time (timeframe) or realizing a smaller budget (size) if it would not been subsidized.

2.3. QUASI-EXPERIMENTAL SEARCH FOR CAUSAL RELATIONSHIP

The key feature common to all evaluation practices is the search for some form of causality. Causality or a casual relationship is an association between two events, namely cause and effect. One of the earliest definitions of these two events was provided by John Locke in 1690[21] where he argued that "*a cause is that which makes any other thing, either simple idea, substance, or mode, begin to be; and an effect is that which had its beginning from some other thing*".

The "basic idea of causation" is well elaborated by Mackie (1974:29) as being "*the belief that a cause is necessary in the circumstances for the effect*", He argued that the *necessity* in the circumstances is any distinguishing characteristic of causal as opposed to non-causal others. From the introduction of circumstances, i.e. a set of conditions, into the picture emerges an issue of the need to discover the distinction between causes and conditions[22].

As an interesting exercise, if Mackie's idea of causation is applied to evaluation theory of government intervention (GI) in private R&D change (PRDC), it could be simply postulated that GI is necessary in the circumstances (a sequence of

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[21] An Essay Concerning Human Understanding: Book 2: Chapter 26, http://www.ilt.columbia.edu /publications/Projects/digitexts/locke/understanding/chapter0226.html

[22] Mackie (1974) makes several suggestions as to how causes can be distinguished from conditions, but they are beyond the scope of this study. He claims that most causes are identified as "Insufficient but Non-redundant part of Unnecessary but Sufficient", i.e. INUS conditions (ibid, p.62). It would be an interesting exercise to attempt introducing the concept of INUS conditions as a new set of independent variables into econometric models in the future evaluation studies.

observations and assumptions of the evaluator) for PRDC in the case of the following logical sequence:

(i) GI and PRDC are two separate events, and

(ii) GI occurs and PRDC occurs, and

(iii) In the circumstances where GI had not occurred, PRDC would not have occurred[23].

Since Francis Bacon's innovative ideas on *experimental science* spread across Europe in the early 1600s, the common feature of any experiment is to intentionally change one factor in order to find out what subsequently happens to other factors, i.e. to envisage the effects of presumed causes (Shadish et al., 2002). In many cases such as health and agriculture research studies, *randomized experiments,* in which random selection of experimental units (i.e. individuals, groups, organizations, etc.), are used to discover causal relationships. When it is not possible to assign units of experiment to test conditions randomly however, quasi-experimental methods should be employed. Most of the research studies in social sciences use such methodology due to their non-random natures. Table 3 gives a brief definition of different experiments.

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[23] Cases (ii) and (iii) imply that the observed correlation between GI and PRDC does not simply prove that GI causes PRDC. This is because correlation studies give no information about which variable comes first and whether there exist alternative causes for the presumed effect.

Table 3 Vocabulary of experiments

Experiment:	A study in which an intervention is deliberately introduced to observe its effects.
Randomized Experiment:	An experiment in which units are assigned to receive the treatment or an alternative condition by a random process such as the toss of a coin or a table of random numbers.
Quasi-Experiment:	An experiment in which units are not assigned to conditions randomly.
Natural Experiment:	Not really an experiment because the cause usually cannot be manipulated; a study that contrasts a naturally occurring event such as an earthquake with a comparison condition.
Correlational Study:	Usually synonymous with non-experimental or observational study; a study that simply observes the size and direction of a relationship among variables.

Source: Shadish et al., 2002 p.12

The studies by Splawa-Neyman (1990, originally published in 1923) and Fisher (1935) are accepted as the earliest examples concerning the analysis of causal effects in randomized experiments. Inspired by these studies, Rubin developed a causal effect methodology for non-randomized experiments (see *correlational study* in Table 3) which is appropriate for observational studies (Rubin, 1974, 1977). His method, which is called the *Rubin Causal Method* (RCM) by Holland (1986), is now acknowledged as one of the leading approaches adapted for program evaluation studies. In the next section, fundamentals and key elements of RCM will be depicted.

2.3.1. The Rubin Causal Method

Lechner (1999, p.13) calls RCM as the *"working horse in the evaluation literature"*. Rubin's influential proposal for dealing with the causality assessment is based on two key elements: A potential outcomes framework and a treatment assignment mechanism. With these two notions, RCM provides a flexible approach to reveal the heterogeneity in the effects of the treatment[24].

The first element of RCM, potential outcomes framework consists of a pair of outcomes $Y_i(W_i)$ for each individual i where $i = 1,\ldots N$ and W_i is the binary treatment indicator taking the value of 1 in the presence of the treatment, 0 otherwise. $Y_i(1)$ is the outcome realized by the unit i if it is exposed to the treatment and $Y_i(0)$ is the realized outcome if it is not exposed. As mentioned before, only one the two potential outcomes can be realized by individual i and the other one is left as a *counterfactual* outcome pointing out what would have happened in the absence of the treatment. The relation between the potential outcomes $Y_i(W_i)$ and the realized outcome Y_i is illustrated by Imbens (2004) as

$$Y_i = Y_i(W_i) = \begin{cases} Y_i(0) \; if \; W_i = 0 \\ Y_i(1) \; if \; W_i = 1 \end{cases} \qquad (1)$$

He argues that potential outcome framework, by taking the difference or the ratio of $Y_i(1)$ and $Y_i(0)$, reveals the causal effect at the unit of interest level before specifying an assignment mechanism. On the other hand, *realized output* can be shown in a structural equation as

$$Y_i = \alpha + \tau W_i + \varepsilon_i \qquad (2)$$

where α, τ and ε_i denote the constant, the treatment (causal) effect and the unobserved component respectively. Equation (2), as a control function model,

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[24] The RCM is proposed for measuring the causal effects of a single treatment. Lechner (1999) extend the model to the case of multiple mutually exclusive treatments regarding the European labor market programs.

specifies the joint distribution of assignment rule and treatment. As will be explained in chapter 3, different versions of this model are widely used in evaluation studies adopting early structural methods and Heckman's selection methods. Blundell and MaCurdy (1999) discuss the details of the relationship between control function approaches with other evaluation methodologies in the field of labor supply and welfare programs. In their comprehensive review study of program evaluation, Imbens and Wooldridge (2009) state that the potential outcome approach separates the effects of treatment and the effects of assignment by allowing the researcher to define casual effect without regarding probabilistic properties of the outcomes or assignment. Hence, this approach handles the modeling of potential outcomes separately from the assignment mechanism, this being easier than directly defining a model for the realized outcome Y_i which is defined in Equation (2).

The second key element of RCM, treatment assignment mechanism, is defined as the *conditional probability* of receiving the treatment (i.e. cause) for a given set of characteristics (i.e. observed covariates) of the participants (Rosenbaum and Rubin, 1983). The simplest treatment assignment is that of randomized experiments in which the probability of receiving the treatment depends only on covariates and is independent of the potential outcomes. Imbens and Wooldridge (2009) suggest that Fisher's (1935) method related to analysis of randomized experiments should be used more often in social sciences as it is in educational research, biostatistics and healthcare. However, they argue that in economics, such analyses are seldom adopted when searching for causality since experimental evaluation cases are rarely seen in this field[25]. On the other hand, analyses based on observational (i.e. nonrandomized) data are widely used by economists. The main difference between the two approaches is in the assignment mechanisms. Although both assignment probabilities are independent of potential outcomes[26], in contrast to the situation in randomized experiments, in nonrandomized experiments, probability of assignment to treatment is not a known function of the covariates vector X_i. Moreover, probability distribution of the average treatment estimation may show different characteristics depending on the size of X_i. See Abadie and Imbens (2006) who examine the large sample properties of matching estimators including the differences in the effects of discrete and continuous covariates on the asymptotic properties of the estimators.

Estimating the treatment effect in observational studies in which a selected group of individuals are exposed to a treatment is not as straightforward as in randomized experiments and needs particular matching methods for gathering non-experimental comparison groups. Blundel and Costa Dias (2006) state the principle characteristics of matching to be that it "attempts to reproduce the treatment group among the non-treated, this way re-establishing the experimental conditions in a non-experimental setting, but relies on observable variables to account for selection". In the next section, basics of matching process with required

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[25] Imbens and Wooldridge (2009:20) exemplify studies on analysis of causality for randomized experiments in a limited number of areas in economics including income tax experiments and job training programs.

[26] This critical assumption is first articulated by Rosenbaum and Rubin (1983) as *unconfounded assignment*. It can be denoted as $(Yi\,(0), Yi\,(1)) \;\square\; Wi \mid Xi$ i.e. potential outcomes are conditionally independent (denoted by $\square$) of treatment for a given (denoted by |) covariate vector. The same assumption is also called *selection on observables* by Heckman, Ichimura and Todd (1997).

assumptions and different algorithms in the context of evaluation framework will be explained.

2.3.2. Basics of Propensity Score Matching (PSM)

In the search for a causal relationship between treatment[27] and the impact on the treated, the principle question is: What would the treated individual act or be like, if it had not been treated, i.e. what is the additionality caused by the treatment? The difficulty in answering such a question emerges from the hypothetical or *counterfactual* characteristic of the outcome observation (Winship and Morgan, 1999). As it is impossible to observe both the treated and the untreated cases using the same unit of analysis in the same time interval, a suitable control group should be selected for comparison. Heckman et al. (1998) argue that counterfactual problem should be handled at the population level since it is impossible to solve it in the individual (i.e. firm) level. The other important limitation related to R&D subsidies is the existence of selection bias, since neither program application by the firm nor the acceptance program by the funding agency is a randomized event. Firms may opt to engage in R&D activities according to their pre-defined policies. In fact, the characteristics of R&D performers and non-R&D performers often show significant differences. Regarding such restrictions, instead of adopting simple OLS models (which requires random variables for unbiased estimates) the use of propensity score matching (PSM) *which involves pairing treatment and comparison units that are similar in terms of their observable characteristics* (Dehejia and

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[27] Treatment, in the context of this study, can be defined as the techniques or actions customarily applied to a specific individual or a group of individuals in a specified situation. Therefore, any government intervention in private R&D activities can be regarded as treatment.

Wahba, 2002, p. 151) seems to bring certain advantages for correcting the sample selection bias problem.

Since the influential studies on PSM by Rubin (1974, 1977) and Rosenbaum and Rubin (1983), numerous scholars have further developed and exploited the model (Heckman and Robb, 1985; Holland, 1986; LaLonde, 1986; Heckman, Ichimura and Todd, 1998; Dehejia and Wahba, 1999, 2002; Lechner, 1999; Imbens, 2000, 2004; Smith, 2000; Blundel and Costa Dias, 2000, 2006; Sianesi, 2004: Zhao, 2004; Caliendo and Kopeinig, 2008; Imbens and Wooldridge, 2009).

Many examples of PSM analysis exist in measurement of effects of government interventions in private R&D in a range of countries (Czarnitzki, 2001; Aerts and Czarnitzki, 2004; Duguet, 2004; Ebersberger and Lehtorante 2005; Chudnovsky et al., 2006; Lööf and Hesmati, 2005; Görg and Strobl, 2007; Özçelik and Taymaz, 2008; Cerulli and Poti, 2008; Aerts and Schmidt 2008; Gonzales and Pazo 2008). A selection of recent PSM studies will be overviewed in chapter 3.

The main incentive for using PSM would be the problem of dimensionality of the covariates: In most of the cases, the number of pre-treatment characteristics of the individuals which is used to determine comparison groups is too high for manual operation the so-called "curse of dimensionality". As a practical solution to this problem, Rosenbaum and Rubin (1983) suggest using a function of all relevant covariates, X_i, and a so-called balancing score, $b(X_i)$ such that the conditional distribution of X_i given $b(X_i)$ does not depend on treatment assignment[28]. The

[28] Therefore, such a function of related covariates creates a natural weighting scheme which provides an unbiased estimate of treatment effects.

balancing score that provides the probability of being exposed to a treatment given observed covariates is called *propensity score* and the matching method adopting such a balancing score is therefore called PSM. The following section will give the general definitions of assumptions under which the practical usage of PSM is possible.

2.3.2.1. Identification of PSM Assumptions

The key assumption in PSM, mentioned above, is identified by Rosenbaum and Rubin (1983) as the *unconfoundedness* characteristic of treatment assignment. Presenting the independence of potential outcomes $Y_i(0,1)$ and treatment W_i given set of covariates X_i, it can be defined as

Assumption 1 (Unconfoundedness):

$$(Y_i(0), Y_i(1)) \perp W_i \mid X_i \qquad (3)$$

Where $\perp$ is the symbol for independence. This strong assumption implies that besides the potential outcomes, available data should include all the variables that influence the probability of exposure to treatment (i.e. selection of observables). If the available data cannot provide this condition, an alternative method such as difference-in-differences (Lach, 2002; Chudnovski et al., 2006) or instrumental variable (Wallsten, 2000; Bloom et al., 2002) should be adopted to include selection on unobservables.

The second assumption on joint distribution of covariates and treatment can be defined as

Assumption 2 (Overlap):

$$0 < P(W_i = 1 | X_i = x) < 1, \text{ for all } x \qquad (4)$$

This indicates that individuals with the same set of covariates X have a positive probability of both participant and nonparticipant. That is, for all possible values of covariates, there are both treated and control units which is called the *common support* condition.

Assumptions (1) and (2) together are called *strong ignorability* by Rosenbaum and Rubin (1983, p.43). By assuming independence only for control group a weak unconfoundedness can be defined as

Assumption 3 (Unconfoundedness for control):

$$Y(0) \perp W \mid X = x \qquad (5)$$

Similarly, a weak overlap assumption is

Assumption 4 (Weak overlap):

$$P(W = 1 | X = x) < 1 \qquad (6)$$

To put this into words, probability of receiving treatment is less than 1, given the same set of covariates indicating a weaker overlap condition than Assumption (2). Assumptions (3) and (4) are sufficient to estimate average treatment effect for the treated (ATT) which is one of the most commonly studied estimands in PSM. In the next section, a number of different treatment effect estimators will be identified.

2.3.2.2. Identification of PSM Estimands

An important discussion concerning PSM is related to the choice of treatment parameter (i.e. estimand) to be measured due to the distinction between homogenous and heterogeneous treatment responses (Blundell and Costa Dias, 2006). If the impact of the treatment is not the same for all the treated individuals (i.e. if there is a heterogeneous response), a variety of treatment parameters can be measured across which the results may differ[29].

The most frequently used treatment parameters are *population average treatment effect*, ATE and *average treatment effect on the treated*, ATT. If τ denotes the treatment effect,

$$\tau^{ATE} = E(\tau) = E[Y(1) - Y(0)] \qquad (7)$$

[29] For review of the definition of different treatment effect parameters, see Imbens, (2004); Blundell and Costa Dias, (2006) and Imbens and Wooldridge (2009)

Equation (7) gives the difference of the expected outcomes after participation and nonparticipation. Alternatively, parameter of interest can be ATT and formulated as

$$\tau^{ATT} = E(\tau) = E[Y(1) - Y(0) \mid W = 1] \qquad (8)$$

Equation (8) indicates that ATT is the difference between expected outcomes with and without treatment for those individuals who actually received treatment. In this case, a counterfactual condition as explained before should be considered in the model.

The outcome pertaining to treated individuals is directly observable, whereas direct observation for potential outcome of treated individuals is not possible, hence estimation is required. In case of matching, the potential outcome for treated individuals is generated from a group of untreated individuals. Obviously, this counterfactual effect cannot be estimated as the average outcome of non-participants due to possible selection bias. In order to overcome the selection bias, the following equation is proposed:

$$E(Y(0)|W = 1, X = x) = E(Y(0)|W = 0, X = x) \qquad (9)$$

Equation (9) indicates that the outcome of non-treated individuals (i.e. left side of equation 9) can be used to estimate the counterfactual outcome of the treated individuals in case of non-treatment (right side of equation 9), provided that no systemic difference exists between these groups[30]. From Equations (8) and (9), the population average treatment effect can be written as:

$$\tau^{ATT} = E(Y(1)|W = 1, X = x) - E(Y(0)|W = 0, X = x) \text{ for all } x \qquad (10)$$

For non-experimental studies, holding the weaker assumptions (3) and (4) is sufficient to estimate τ^{ATT} (Caliendo and Kopeinig, 2008). One possible problem in Equation (10) would be dealing with high number of variables in the covariate vector X. As discussed in the previous section, Rosenbaum and Rubin (1983) suggest using propensity score $P(X_i)$ for dimensionality reduction where $P(X_i)$ is the probability of individual i having been exposed to treatment, defined as

$$P(X_i) \equiv \Pr(W_i = 1| X_i = x) = E(W_i|X_i = x) \qquad (11)$$

Hence, replacing the covariate vector in Equation (10) by the propensity score, $P(X)$, ATT for PSM denoted as τ_{PS}^{ATT} (i.e. PSM estimator) will be

$$\tau_{PS}^{ATT} = E(Y(1)|W = 1, P(X)) - E(Y(0)|W = 0, P(X)) \qquad (12)$$

[30] In evaluation of R&D subsidies using PSM method, Equation (9), based on conditional independence assumption suggested by Rubin (1974, 1977), implies that for each subsidized firm, a firm having the same X characteristics as the treated one must be searched for in the group of non-subsidized firms.

Equation (12) simply indicates that, in the boundaries of common support (i.e. when assumption (4) holds); the PSM estimator is the mean difference in outcomes, weighted by propensity score distribution of the treated individuals. At the point of arrival with Equation (12), selection bias seems to be minimized; the dimensionality problem of -possible- large covariate vector and counter-factuality dilemma is taken care of by introducing a propensity score distribution into the picture. Yet, as the PSM approach completely depends on the selection of observable data, the effects of unobservables cannot be observed in the PSM estimands, which is assumed to be the main weakness of the method. Fortunately, using hybrid methods such as adopting PSM in conditional DiD (Heckman 1998; Aerts and Schmidt, 2006), the non-parametric matching approach may become a powerful instrument in evaluating the effects of both observables and unobservables.

In the next section, the general framework on matching algorithm issues will be discussed.

2.3.2.3. PSM Algorithms

Dehejia and Wahba (2002) raise three issues in the implementation of unit matching with treated and control groups;

(i) Matching with or without replacement: When the matching algorithm allows an individual in the control group to be used more that once as a match (i.e. matching with replacement), the bias will reduce and the matching quality will increase. This is because matching with replacement minimizes the distance of estimated propensity score between the matched pair of individuals. Matching with replacement is particularly useful if there is a high level of dissimilarity (i.e. minimum overlap) in the propensity score distribution of treatment and control groups. It causes, however, an increase in variance of the estimates since observations of a few untreated individuals will be *overused* in the matching algorithm (Lechner, 1999). On the other hand, using untreated individuals only once for matching will reduce the quality of the matching and increase the bias, while a lower variance may be achieved. Before choosing whether the matching will be done with or without replacement, researcher should consider the trade-off between bias and variance.

(ii) The number of control units to match with a treated unit: In order to increase the precision of the estimates, one may match multiple untreated individuals with the same treated individual. When there are many good matches available for the treated individual, the method of multiple control units could be chosen at the cost of bias increase.

(iii) Choosing a matching algorithm: The PSM estimation using Equation (11) is not a straightforward process since the propensity score $P(X_i)$ used for matching is a continuous variable and hence there is no exact match with the same value for treated and control units. Among the numerous approaches to solve this problem, four popular matching algorithms are as follows:

The first algorithm, *Nearest Neighbor Matching* consists of choosing an individual from the control group as a matching partner for a treated individual that has the *nearest* distance of estimated propensity score. When each treated individual is matched with its nearest neighbor, the difference between the outcomes of treated and untreated units is calculated to be used for computing the average treatment effect of the treated (ATT). This algorithm guarantees that every treated unit matches, but, the matching quality might show great varieties depending on the level of difference in the propensity score values of units in treated and control groups. If that difference is high, that is, pre-treatment characteristics of treated and control units are very different, matching with replacement may improve the matching quality in the nearest neighbor algorithm.

The second algorithm, *Stratification Matching* is based on the idea of partitioning the range of variation of the propensity score in intervals (i.e. strata) such that within each stratum the average propensity scores of treated and untreated units are the same. Dehejia and Wahba (2002) argue that, within the common support[31], partitioning should be done so that covariates in each stratum are balanced across the treated and untreated units. Using a simple mathematical model, the effectiveness of stratification in removing bias is estimated by Cochran (1968) such that for the number of matching stratum, n = 2, 3, 4, 5, 6; the percentages of bias removed are approximately 64%, 79%, 86%, 90%, 92%. Based on Cochran's (1968) calculation, Imbens (2004) suggests that five strata would be sufficient for most of the cases.

The third algorithm is *Kernel Matching,* which is associated to outcome Y_i of treated individual i, a matched outcome provided by a *kernel-weighted average* of the outcome of all non-treated individuals in a control group. The weight, given to the non-treated individual j, is in proportion of the distance between i and j. The major advantage of kernel matching is the lower variance achieved because more information is used for each matching. On the other hand, the possibility of including observations that are bad matches seems to be an important drawback

[31] That is, discarding the control units with an estimated propensity score greater than the maximum or less than the minimum propensity score for treated units

for this algorithm, but, can be avoided by enforcing an appropriate common support condition (Caliendo and Kopeinig, 2008).

The risk of bad matches in the nearest neighbor algorithm, which occurs when the nearest neighbor is unacceptably distant, can be avoided by setting a maximum propensity range, i.e. a *caliper,* which is then, as the fourth algorithm, called Caliper Matching[32]. While the matching efficiency increases in this algorithm which only uses better matches, so does the variance of the estimates due to the lower number of treated individuals that could match. Moreover, one should note that selecting a suitable tolerance level in advance might not be a trivial task.

The choice of matching algorithm depends on the available data and hence this should be scrutinized cautiously for each evaluation case. In the study that will be presented in the next chapter, after testing different algorithms, the decision was made to use the nearest neighbor algorithm with replacement, since the matching quality was the same for any algorithm (all the treated firms within the given common support are matched), and hence the simplest algorithm is selected[33]. On the other hand, following Dehejia and Wahba's (2002) suggestion, matching with replacement is preferred because there is a high level of discrepancies in the covariates of the program participant and non-participant firms. Fortunately, the risk

[32] Dehejia and Wahba (2002) propose a variant of caliper matching which is known as radius matching. In this case, all the non-treated individuals within the same caliper or *radius* are used for matching instead of using only the nearest neighbor.

[33] Moreover, Smith (2000) argued that asymptotically all PSM estimators should yield the same results, because with growing sample size they all become closer to comparing only exact matches. The selection decision of matching algorithms in small samples, however, may be crucial. Our dataset is rich enough to allow choosing any matching algorithm.

of high variance due to overusing the same control unit for many treated units has not been observed since, in almost all matching cases, a new control unit is used.

2.4. CONCLUSION

In this chapter, first the historical evolution and economic rationale of the government intervention in technological change were elaborated. Then, a variety of public involvements, from science-driven policies provoked by national security concerns to industrial subsidies and fiscal incentives for diminishing the gap between social and private returns, were examined. Based on a feature set of domain, objective, strategy and specificity; intervention policies were classified and their rationales and goals were illustrated.

Second, the measurement and evaluation methodologies of the effects of public policies are elaborated with different classification approaches which are built on additionality (input, output, behavioral, etc.), evaluation time (ex-ante or ex-post) and qualitative vs. quantitative methods. The advantages and challenges of these approaches are exemplified. It should be noted that each method may illuminate a different part of the picture and hence adopting several evaluation methods, when it is possible, can provide a better understanding of the actual treatment effect.

Third, the theoretical framework of empirical evaluation approaches was reviewed. In this part, identifying the distinction between correlation and causality, quasi experimental (or nonrandom) search techniques for causal relationship is explained by investigating the Rubin Causal Method. The essential elements of matching methods such that counterfactual outcome, treatment and control groups, conditional probability of receiving the treatment (i.e. cause) are clarified. Then, within the context of Rosenbaum and Rubin’s framework (1983), the theoretical aspects of propensity score matching which eliminates dimensionality problem of covariates (control variables used for matching) are explained. The chapter is ended with clarifications of different matching algorithms employed in PSM applications.

CHAPTER III

REVIEW OF EMPIRICAL EVIDENCE

In the previous chapter, the acknowledged rationale for and the classification of government intervention in private R&D was elaborated and numerous evaluation methodologies based on different theoretical approaches are reviewed. It has been observed that direct R&D subsidies and R&D tax incentives are the most common intervention tools and that most of the impact assessment studies are concentrated in these two public policies. This chapter aims to present samples of previous econometric studies on the measurement of incentive-generated *additionalities* which have been published since the late 1970s. Three seminal review studies, Capron (1992a), David et al., (2000) and Klette et al., (2000) summarize the results presented by the literature in this field. In the following sections, after a brief introduction with examples of early papers, more attention will be paid to the examination of the empirical evaluation studies published during the last fifteen years.

3.1. EARLY MODELS AND ANALYSES

In this section, a few examples of the first generation models attempting to evaluate the effects of public subsidies on private R&D will be presented. Although government intervention in private R&D activities started after the end of the Second World War, very few evaluation studies can be found before the 1970s (e.g. Blank and Stigler, 1957; Minasian, 1969). In an excellent review focused on those early evaluation studies conducted before 1992 Capron (1992a) distinguishes them based on their dependent variables and types of empiric model[34]. Cerulli (2010) reviews a wide range of economic methods used to evaluate the impact of government R&D subsidies, extending from simple structural models to the recent methods rooted in dynamic models of imperfect competitions.

In one of the pioneering studies on public R&D support, Howe and Fetridge (1976) conclude that current sales, cash flow and government incentive grants[35] are the principle determinants of private R&D expenditure regardless of a firm's number of employees. In the cross-section and time series analyses that were conducted separately, they observed that R&D incentive grants significantly increase total R&D expenditure of firms in the electrical industry but not in chemical or machinery industries.

Griliches (1979), in search of the actual contribution of public R&D activities to a firm's productivity growth, raised several important questions namely: What are the similarities in returns between public and private R&D investments? How can we measure the output in R&D intensive industries? How can we measure the R&D

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[34] Capron's summary tables that presented micro and macro econometric studies focusing on estimating the effect of public subsidies on productivity and private R&D investment are attached in Appendix C

[35] In this study, Howe and Fetridge (1976) analyzed the micro data from 81 Canadian firms which had benefited from The Program for the Advancement of Industrial Technology, the Industrial Research Assistance Program, the Defense Industry Productivity Program and the Defense Industrial Research Program over the period 1967-71.

capital? What are the spillover effects of government financed R&D? Does public R&D investment substitute for or complement company-financed R&D? He demonstrated the limited effectiveness of the available data in answering those questions and suggested expanding the existing database related to public and private R&D interactions. He found later that the effect of private R&D investments on private productivity growth is considerably larger than the effect of publicly financed R&D (Griliches, 1986)[36].

Levy and Terleckyj (1983), in their macroeconomic study, use the Generalized Least Square (GLS) method to estimate the role of *contract R&D,* i.e. government R&D expenditure on private R&D investment and productivity, using the time series data from 1949-1981 in the USA. They found that, on average, a one-dollar increase in government R&D spending is associated with a 27-cents increase in industry financed R&D expenditure. This result was in line with several other empirical studies using similar methodologies in early 1980s.

One of the pioneering studies emphasizing the importance of distinguishing government subsidy from the total R&D investment of a firm was carried out by Lichtenberg (1987). He argued that a number of previous studies, neglecting this distinction, identified an upwardly biased positive effect of subsidies on private R&D. His simple model in reduced form[37] for estimating the effect of federally

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[36] Capron (1992a) argued that Griliches's findings were mitigated and unstable. In a recent econometric study, Hussinger (2008) found that publicly invested R&D is as effective as privately invested R&D concerning a firm's productivity.

[37] Refer to Lichtenberg (1987 pp. 98-100) for building details of the model.

funded industrial R&D (FRD) expenditure on a company's own R&D (CRD) expenditure can be presented as

$$CRD = \beta_0 + \beta_1 FRD + \beta_2 GOVSALES + \beta_3 OTHSALES + \mu \quad (1)$$

where GOVSALES and OTHSALES are sales to the government and to the other companies respectively, β_0, β_1, β_2 and β_3 are coefficients and μ is the uncorrelated error term. The impact of FRD on CRD, in this model, can easily be estimated by using Ordinary Least Square, OLS or GLS (in case of heteroscedasticity and/or autocorrelation). Lichtenberg's model is based on the assumption that all the independent variables are exogenous i.e. the covariance between each control variable with the error term is zero. Such an assumption may be acceptable for *observable-to-analyst variables* (Cerulli, 2010 p.7) such as sales, firm size or industry dummies, but is difficult to justify for the subsidy related variables used in the model because of the *selection bias problem* explained in previous chapter. The acceptance of the subsidy as an exogenous variable is found to be the weakest point in all three of the above-mentioned models. Since the government selects subsidy beneficiaries according to pre-defined strategies from those nominees that decide to apply to the subsidy program, there are unobservable factors causing subsidy to be an endogenous variable in the model[38]. Various methodologies attempt to solve the problem of the endogeneity of control variables, including more

[38] For example, a funding agency may prefer to subsidize firms with higher private R&D expenditure resulting in nonzero covariance between CRD and FRD in equation (1)

complex structural models[39] (Lichtenberg, 1988; Wallsten, 2000, Fox, 2002) and non-parametric matching methods which will be explained in the next section.

3.2. RECENT EMPIRICAL METHODOLOGIES

During the last 15 years, it has been possible to observe a steady evolution of both structural and non-structural evaluation methodologies in the econometric literature aiming to measure the effect of government R&D intervention. Recent theoretical studies based on earlier work have now achieved a level of maturity that makes them an essential instrument in many areas of empirical research in economics for the assessment of causal effects (Imbens and Wooldridge, 2009). The principle problem in studies related to government intervention is that of measuring the effect on a certain outcome of the exposure of a collection of individuals (e.g. people, firms or countries) to a treatment (e.g. subsidy program or tax incentive regulation). Unlike the earlier studies, taking care of the selection bias problem, and considering subsidy as an endogenous variable are the common characteristics of recent literature on subsidy evaluation.

Researchers in a range of countries utilize various statistical and econometric methodologies to address program selection and missing data problems in counterfactual situations. Depending on available data and the choice of dependent variable(s), (i) *matching methods* (Czarnitzki, 2001; Aerts and Czarnitzki, 2004; Duguet, 2004; Ebersberger and Lehtorante 2005; Chudnovsky et al., 2006; Lööf and Hesmati, 2005; Görg and Strobl, 2007; Özçelik and Taymaz,

[39] Structural models such as Two Stage Least Square (2SLS) estimations are also called simultaneous equation models or multivariate/multi-equation regression models. Variables in such models are used to present reciprocal causal relationships with each other (Fox, 2002).

2008; Cerulli and Poti, 2008; Aerts and Schmidt 2008; Gonzales and Pazo 2008), (ii) *two or three stages selection models* (Busom, 2000; Wallsten, 2000; Janz, 2003; Hussinger, 2003, 2008; Negri et al., 2006; Takalo et al., 2008), (iii) *difference-in-difference methods* (Lach, 2002; Chudnovsky et al., 2006; Negri et al., 2006; Aerts and Schmidt, 2008) and (iv) *instrumental variables methods* (Bloom et al., 2002; Ali-Yrrkö, 2004; Clausen, 2009) have been employed extensively during the last decade.

In Table 4, a collection of recent empirical literature including the above mentioned studies is presented by distinguishing them through the following attributes:

1) Name of the researcher(s) and the year of publications.
2) Type of data used and period of study: Panel or cross-section data collected in which years and from which countries.
3) Type of intervention policy: Whether the policy is a direct R&D subsidy or a fiscal incentive.
4) Methodology and dependent variable(s) used: Macro or micro econometric, parametric or non-parametric models; choice of dependent variables for direct or indirect effects.
5) Main findings of the study.

Table 4 Collection of previous studies on measuring the effects of public R&D subsidies using econometric methodologies

Study	Country, Sample and Period (1)	Type of Intervention Policy	Dependent Variables and Methodology (2)	Results (3)
Mamuneas and Nadiri (1996)	USA; NSF and Bureau of Labor Statistics; 1956-1988;	Publicly financed R&D and R&D tax incentives in 15 industries	Private R&D; MAE;	Publicly financed R&D crowds out private R&D
Branstetter and Sakakibara (1998)	JAPAN; Data from Japanese Research Consortia and US Patent Office; 1983-1989; 226 OBS	Government support for Japanese Research Consortia in semiconductor industry	Private R&D spending, patents granted; MIE; OLS	Consortia membership creates significant positive effect on private R&D spending and raises patenting by 5%
Klette and Møen (1999)	NORWAY; Statistics Norway and RCN data 1987-1990; 6000 OBS	Government subsidy program for IT industry	Private R&D spending, growth in sales, employment and productivity; MIE and MAE(OECD comparison); OLS	No significant contribution of the program in the IT related manufacturing plants in Norway
Diamond (1999)	USA; NSF Database; 1953-1995; 43 OBS	Federal spending on basic research	Private spending on basic research; MAE; OLS	Significant (at 95%) positive effect: $1 federal spending on basic research results $0.08 rise in academic, $0.62 in industry spending in basic research
Brouwer and Kleinknecht (1999)	NETHERLANDS; 1988 SEO National Survey on R&D and Innovation, and CIS 1; 441 OBS	Participating in an EC R&D funding program in 1991 or in 1992	Private R&D person-years; MIE; OLS	Significant (at 90%) positive effect
Busom (2000)	SPAIN; 1988; 147 OBS	National and EU funding	R&D investment; MIE; 2 step Heckman selection Probit model	No full substitution, partial substitution in 30% of beneficiaries

Table 4 (Continued)

Wallsten (2000)	USA; NSF Database 1990-1992; 367 OBS	Small Business Innovation Research, SBIR funding	R&D investment and employment; MIE; IV and 3SLS model	Positive correlation between subsidies and employment, direct evidence of substitution for private R&D investment
Lach (2002)	ISRAEL; 1990-1995; 1098 OBS	R&D subsidies granted by Ministry of Industry and Trade	R&D investment; MIE; DiD	$1 subsidy induces $11 in SMEs (significant) and $0.23 in LSEs (not significant).
Mohnen and Therrien (2002)	CANADA, FRANCE, GERMANY, IRELAND, SPAIN; CIS 2; 1999 Canadian Survey of Innovation; 4404 OBS in CA, 10407 in EU	Government support for innovation	Categorical shares of innovative sales MIE; Probit	Canadian firms are more innovative, Gov. Supp. significant (at 95%) in European countries
Bloom, Griffith and Van Reenen (2002)	AUSTRALIA, CANADA,FRANCE, GERMANY, ITALY, JAPAN, SPAIN, UK, USA; OECD database; 1979-1997; 165 OBS	R&D Tax credits	R&D investment; MAE; OLS and IV	10% fall in user R&D cost due to tax credit causes 1% (10%) rise in R%D investment in short (long) term
Janz, Lööf and Peters (2003)	GERMANY, SWEDEN; CIS 3; 1049 OBS	Financial support for Innovation	Innovation expenditure and sales; MIE; Pooled and individual 2SLS	Ineffective in both countries
Aerts and Czarnitzki (2004)	BELGIUM (Flanders); CIS 3, EPO and Belfirst database; 776 OBS	Regional, national and EU funding	R&D intensity; MIE; OLS, PSM	No full substitution, significant positive effect of subsidies
Ali-Yrrkö (2004)	FINLAND; enriched TEKES database 1996-2002; 441 OBS	TEKES industrial grants	Private R&D investment; MIE; Pooled OLS, IV	No substitution, significant positive effect of subsidies, more in large firms
Duguet (2004)	FRANCE; Database from Ministry of Research; 1985-1997; 1300-1600 OBS per year	Government support for private R&D	Private R&D investment; MIE; PSM	No full substitution, heterogeneous effect of subsidies
Wu (2005)	USA; NSF and SSTI conducted surveys in 13 States, 1979-1995; 117 OBS	R&D Tax credits, Public investments in higher education (HE), Federal R&D Funds	R&D investment; MAE; two-way FE model	Significant positive effect of tax credits and HE investments, insignificant effect of federal funds

Table 4 (Continued)

Ebersberger and Lehtorante (2005)	FINLAND; R&D survey 1985-2000 and CIS for 1991, 1996 and 2000	Industrial R&D subsidies	R&D output and labor demand; MIE PSM methods	Positive impact on generating R&D output (patent) and employment growth
Lööf and Heshmati (2005)	SWEDEN; CIS 3 and firms' register data	Public R&D subsidies	Internal R&D investments; MIE; PSM	Significant only in SMEs
Negri, Lemos and Negri (2006)	BRAZIL; National Industrial surveys, PIA and PINTEC (CIS); 1996-2003; 80000 OBS per year	National Technological Development Support Program	R&D investment, productivity and growth; MIE; PSM, 2 step Heckman and DiD	Positive: R&D investment of funded firms is 28% to 39% more than non-funded firms, insignificant effect on productivity, Significant (at 99%) positive effect on sales and employment
Görg and Strobl (2007)	IRELAND; Annual Business Survey; 1999-2002; 4192 OBS	R&D grants from Industrial Development Agency Ireland and Forbait	Total and per employee R&D spending; MIE; PSM	Small R&D grants increase R&D spending of domestic firms, substitution if the grant is too large (nonlinearity). R&D Grants have no effect on foreign firms
Chudnovsky, Lopez, Rossi and Ubfal (2006)	ARGENTINA; Survey from National Statistics Bureau; 2001-2004; 414 OBS per year	R&D subsidies from national agency FONTAR	Innovation intensity, new sales and productivity; MIE; PSM and DiD methods	Substitution only if firm is already innovative, positive insignificant effect on output and productivity
Aerts and Schmidt (2008)	GERMANY and BELGIUM; CIS 2 and CIS 3; 3902 German, 1471 Flemish firms.	Public R&D subsidies	R&D intensity, MIE; PSM and CDiD	Positive: R&D intensity of funded firms is 64% to 100% more than non-funded firms
Özçelik and Taymaz (2008)	TURKEY; TUIK and Turkish Funding Agencies' databases; 1993-2001 96984 OBS	Industrial R&D grants and loans	R&D Intensity; MIE; Parametric and PSM models	Significant positive effect on R&D intensity, more in SMEs.
Hussinger (2008)	GERMANY; Mannheim innovation panel, Patent data; 1992-2000; 3744 OBS, 723 of which funded.	Subsidies for manufacturing firms by Federal Ministry of Education and Research	R&D intensity, new product sales; MIE; Heckman two step model	R&D investment increases 30% in funded firms. Public subsidies are as good as private investment for new product sales

Table 4 (Continued)

Schneider and Veugelers (2008)	GERMANY; CIS 4; 1715 OBS	Government support for innovation	Innovative sales of young innovative companies (YIC); MIE; OLS and Tobit	No effective increase in sales of YICs
Cerulli and Poti (2008)	ITALY; CIS 3; 2540 OBS	Regional, national and EU level industrial R&D Subsidies	R&D expenditure and intensity, employment and innovative turnover; MIE; OLS and PSM	No full substitution in general except in very small firms, low knowledge intensive service and automotive industries
Gonzales and Pazo (2008)	SPAIN; Survey data from Spanish Ministry of Industry; 1990-1999; 9455 OBS	Industrial R&D Subsidies	Private R&D Investment; MIE; PSM model	Significant positive effect on R&D investment, more in SMEs and low-tech sectors.
Takalo, Tanayama and Toivanen (2008)	FINLAND; Datasets from Tekes and Asiakastieto Ltd.; 2000-2002; 915 OBS	Industrial R&D grants and loans from Tekes	Private R&D Investment; MIE; Continuous treatment effect model (2SLS)	Agency-specific treatment effect (TE) is less than private TE. Treated firms internalize 60% of total TE.
Clausen (2009)	NORWAY; CIS 3	"Far from the market, FMS" and "close to the market, CMS" subsidies	Internal R&D investments and R&D personnel; MIE; IV models	FMS causes additionality for R&D investments and personnel; CMS causes substitution for both dependent variables.
Harris, Li and Trainor (2009)	UK - Northern Ireland; Business Enterprise R&D annual data and Annual Respondents Database; 1998-2003 2063 OBS	Regional R&D Tax Credit	R&D stock and productivity; MIE; GMM panel	12.4% fall in user R&D cost due to tax credit results 2.6% (16.9%) rise in R%D stock in short (long) term.

(1) Shaded cells: Studies that use CIS data
(2) Shaded cells: Macro econometric studies
(3) Dark shaded cells: Full substitution is observed, light shaded cells: partial substitution is observed
MAE: Macroeconomic, MIE: Microeconomic, PSM: Propensity score matching, FE: Fixed effect, RE: Random effect, GMM: Generalized method of moments, IV: Instrumental variable, OLS: Ordinary Least Square, 2SLS: Two-stage Least Square, 3SLS: Three-stage Least Square, DiD: Difference-in-difference, CDiD: Conditional DiD, OBS: Observation, CIS 1: Community Innovation Survey covering 1990-1992 period, CIS 2: 1994-1996, CIS 3: 1998-2000, EPO: European Patent Office.
Source: Author's elaboration

By examining the studies in Table 4 and comparing them with Capron's (1992) collection of earlier studies reproduced in Appendix C, one can observe the following pattern of changes in evaluation methodologies, data in use and findings:

1) Macroeconomic studies which were frequently seen in the 1980s and 1990s are replaced with microeconomic analyses since the available data are enriched in variety with longer time series.

2) New and advanced methods such as difference-in-differences and propensity score matching are widely preferred and often more than one method is used in the same study for comparative reasons. Linear regressions yielding biased estimates due to the endogeneity characteristic of public R&D subsidies are almost never used after 2005.

3) Previous findings obtained from early structural and non-structural analyses report more substitution effect of public funding on private R&D investment than the recent studies. A collection of summary distribution of econometric studies reviewed by David et al. (2000) and Garcia-Quavedo (2004) together with the summary figures coming from Table 4 is shown in Table 5. In the firm level studies, David et al. (2000) reviewed 19 studies performed between 1966 and 1998 in which nine of the cases report that public R&D funding behaves as a substitute for private R&D investment. Similarly, Garcia-Quavedo (2004) observes that in 38 micro level evaluation studies performed during the period of 1966-2002, 11 of the cases report substitution and 10 studies report no significant results. On the other hand, in our literature survey, we observe only two cases resulting full crowding out and three cases showing insignificant or variable effect of public subsidies among the 24 microeconomic studies performed during the period of 1996-2009.

Table 5 Summary of evaluation studies for the impact of public R&D support using econometric methodologies: 1966-2009

Level of analysis	Review study	Substitution effect	Insignificant or variable effect	Complementary effect	Total number of studies
Firm	1966-1998 (1)	9	n/a	n/a	19
	1966-2002 (2)	11	10	17	38
	1998-2009 (3)	2	3	19	24
Industry or country	1966-1998 (1)	2	n/a	n/a	14
	1966-2002 (2)	6	9	21	36
	1996-2005 (3)	1		4	5

(1) Source: David, Hall and Toole, 2000, p.526
(2) Source: Garcia-Quavedo, 2004, p.92
(3) Source: Author's elaboration, based on Table 4.

In the following sections through the rest of this chapter, noteworthy examples of the implementation of the recent methodologies for the evaluation of public R&D funding on private R&D investments will be presented and discussed.

3.2.1. Structural models

Busom (2000) was among the first to question the public funding decision. She states that the decision process makes subsidy an endogenous variable, possibly correlated with the error term in linear regression causing inconsistent estimates. She also points out that the agency's preference for subsidizing R&D projects which might have more spillover potential results in underinvestment in such projects by the beneficiary firms since firms have insights on the difficulties to appropriate the returns of their projects. In her study, Busom (2000) first established a participant (treated) and a non-participant (control) group from a sample of Spanish firms.

Then, by using Heckman's selection model[40] and introducing a binary subsidy variable, she found that small firms have more chance to benefit from subsidy programs, and although it was not possible to reject full crowding out effect for 30% of the beneficiaries, subsidies encourage more private R&D effort (Busom, 2000).

Takalo et al. (2008) adopted a similar 2SLS model with continuous subsidy variable to examine the effects of both being beneficiaries of the subsidy program and the amount (i.e. level) of subsidy received by the manufacturing firms on their own R&D investment in Finland. Although the funding agency, TEKES provides grants and low interest loans for the R&D projects of manufacturing firms, they introduce them into the model as a single subsidy instrument. Using the project level data, they estimate the agency's funding decision, the cost of application and firms' R&D investment as the dependent variables. In their study, using a semi-parametric selection model,[41] they find a considerable degree of treatment effect heterogeneity. They estimate that large firms produce larger rate of return on technically more challenging projects funded by TEKES. Moreover, they observed that firms prefer not to participate in the subsidy programs with their most profitable projects. In general, they estimate that the average treatment effect of the agency's funding is about the 40% of the firm's total R&D investment.

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[40] Heckman and Robb (1985) utilized this model to estimate the effects of training programs on wages. They took into account the non-random characteristic of program enrolment for cross-section, repeated cross-section and panel types of data.

[41] Takalo et al. (2008) actually use two Tobit models in their estimation of treatment effects. This is because, when the subsidy is assumed as a continuous variable and not a binary treatment variable, a Tobit model in which it has either zero value (for non-subsidized firms) or an amount of subsidy value (a positive continuous variable for subsidized firms) seems more appropriate.

Wallsten (2000) explored whether government grants for industry increase private R&D; he did this by using a multiple equation selection model and instrumental variables with data collected from the Small Business Innovation research (SBIR) program in the USA. Inspired by Lichtenberg (1987), he defines *BUDGET*[42] as the instrumental variable for his model in order to control the endogeneity of the subsidy. Wallsten finds that although the program helps the beneficiary firms to keep sustainability in their R&D and innovation activities, the SBIR grants substitute private R&D investment dollar for dollar. Moreover, he observes that grants do not create additionality in employment, but firms with higher numbers of employees and more research activities have a higher probability of being rewarded. Wallsten's (2000) findings show significant dissimilarity to another evaluation study of the same program using matching and OLS methods (Lerner, 1999), which concludes that SBIR grants led to higher employment and growth for the beneficiary firms. A possible reason for such conflict is the selection bias problem in OLS methodologies used by Lerner (1999).

Hussinger (2008) investigates the effect of federal subsidy programs on private R&D investment and new product sales by using Heckman's two-stage selection model with German data from 1999-2002. In her parametric and semi-parametric model, she first estimates the probability of receiving public fund by using a probit

[42] The instrumental variable *BUDGET* is defined as "the total SBIR budget of all agency-years in which the firm won an award. …the variable budget thus approximates the SBIR funds available for each firm given the type of research it does which should be uncorrelated with firm's unobserved innovativeness" (Wallsten, 2000, s. 94). He admits that it is not a perfect instrument since the exogeneity of the instrument remains untested in his model.

model and then, by adopting four different selection models[43], she estimates firms' R&D investment. She concludes that subsidy beneficiaries increase their R&D investments by 30% and public subsidies are as effective as private R&D investments on leading to new product sales. Hussinger (2008) further notes the nonlinear effects of firm size, firm age and past public subsidies in the models.

3.2.2. Difference-in-differences and instrumental variable models

In the empirical evaluation literature, scholars usually adopt more than one method for the same dataset for comparison reasons. The studies that will be reviewed in this section start with simple OLS regression and then use more sophisticated approaches such as instrumental variable (IV) or difference-in-differences (DiD) models. Lach (2002), for example, adopted different estimators for treatment effect including DiD and dynamic panel models to measure the impact of publicly provided R&D subsidies on Israeli manufacturing firms from 1990-1995. Assuming positive correlation between the determinants of private R&D and subsidy program participation, he finds large additionality effects in small firms, but almost none for large firms receiving about 70-80 % of all subsidies. Lach's interpretation of the results is that large firms receive funding for projects that would have been carried out anyway (i.e. displacement of funding) whereas for small firms subsidies are so critical that their projects would not been taken into consideration without public support. About the model, he notes that while the DiD approach is successful in handling the selection bias due to the fact that better R&D performers through the

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[43] She employs different selection models used by previous researchers. These models are all based on Heckman's two-step selection approach yet can be differentiated from each other by their approximation methods of selection correction term. See Hussinger (2008) for details.

funding period may receive more subsidies, it fails to compensate for bias when a firm's R&D expenditure jumps due to the unexpected development of a good idea (which makes the DID estimator upwardly biased).

In a macroeconomic study, using a structural equation model with IV regression, Bloom et al. (2002) examine the effects of tax credits on the cost of private R&D investments in nine OECD countries for the period 1979-1997. The application of IV estimators reduces the selection bias and improves the upwardly biased OLS estimates caused by the possible endogeneity of the user cost of R&D. They introduce current and lagged values of the only tax component of the user cost and first and second lag of output as instrumental variables into a simple OLS model; from this, they find that tax changes considerably affect the level of R&D investments. The study also demonstrates the short and long term differences in price elasticity of R&D cost in different industries and countries.

Chudnovsky et al. (2006) employ both PSM and DiD methodologies to analyze the effects of the Argentinean Technology Fund, FONTAR on private innovation activities in Argentine for the period 2001-2004. Using the rich data set of the funding agency, the outcomes of interest in the models are total and private innovation intensity, new product sales and labor productivity. They also adopt DiD estimators combined with a PSM approach using the whole sample and a subset consisting of the firms which remain inside the common support boundaries. The results, consistent in all models, show (i) a significant positive effect of subsidies on total innovation intensity, (ii) an insignificant positive effect on privately funded innovation intensity and (iii) no significant additionality of subsidies on innovative outcomes or firm performance, although the authors comment that such additionalities might need several years to materialize.

While most of the evaluation studies measure the effect of subsidies provided for "R&D" projects, in Norway, Clausen (2009) distinguishes "research" and "development" subsidies by differentiating support programs for projects "far from" and "close to" the market and analyze their effectiveness separately. He uses the data from Community Innovation Survey, CIS 3, conducted on Norwegian manufacturing and service firms for the period 1999-2001. He adopts an IV regression model to estimate private R&D investment and R&D personnel. Based on Lichtenberg's (1984) suggestion that public R&D can be assumed as an exogenous factor at the industry level, Clausen carefully choose the total amount of public funding at industry level (two variables, one for far from and another for close to the market industry funding) as the IV in his model. Surprisingly, he finds that far from the market (i.e. research) subsidies have significant positive effects on private research expenditure and the private R&D investment budget whereas close to the market (i.e. development) subsidies reduce the amount of private expenditure on development, and therefore crowd out private R&D spending. These results seem to contrast with the findings of similar research conducted by Aerts and Thorwarth (2008) in Flanders (Belgium). Adopting parametric treatment and IV regression models, they find that R&D subsidies are the main source of additionality in development spending, and yet in their IV regression model, they cannot reject the crowding out effects of R&D grants on private research expenditure.

3.2.3. Matching models

During the last 10 years, the matching models, especially propensity score matching have been widely used in the evaluation of policy interventions. The main reasons for the increasing number of scholars preferring the PSM methodologies in measuring effects of public R&D subsidies are (i) the identification of endogeneity problems in parametric models (such as selection bias) explained in Chapter 2, (ii) accessing larger and better databases in many countries related to public funding and private R&D and innovation activities acquired through administrative data of funding agencies, Community Innovation Surveys and further R&D surveys at national or regional levels and (iii) availability of PSM-related computer programs written for the major econometric software packages. In this section, four sample studies have been selected to illustrate PSM deployment in evaluation studies.

Aerts and Czarnitzki (2004), pointing out the lack of awareness of the selection bias problem in previous studies on evaluation of the effects of R&D subsidies in Flanders, adopt non-parametric nearest-neighbor matching to test crowding-out effect of public funding for innovation projects on the Flemish manufacturing sector and computer services. They find no evidence of substitution of subsidies for the private R&D investments of 180 beneficiary firms. On the contrary, their study shows that fund recipients would have invested much less in R&D activities if they had not been subsidized. They used probit model on the receipt of subsidies and observe that patent stock, firm size and export have significant positive effects, whereas foreign ownership has a significant negative effect on the probability of receiving public funding. In addition to propensity score, they follow Lechner's (1998) *hybrid matching method*[44] and include firm size (i.e. log of employment) as a second argument in the matching function. As stated by the authors, the missing

[44] Lechner (1998) suggests including one or more variables together with propensity score in the matching function in order to increase matching efficiency. This approach, as an extension of Rosenbaum and Rubin (1983)'s proposed matching method, is called the hybrid matching method and has been used extensively since then in PSM studies.

time-series dimension of the R&D and innovation activities (The Flemish CIS-3 cross-section data is used) and failure to introduce the amount of subsidies into the model might be considered the main shortcomings of the study.

In our second study, performing a careful analysis of the public funding process in France, Duguet (2004) uses both a control function model (i.e. *naïve estimator* as he calls it) and the Nadaraya-Watson[45] non-parametric estimator of the average effect. He uses the panel dataset from the French Ministry of Research collected in the period 1985-1997 and introduces into a logit model variables that affect both the probability of receiving subsidy and the investment in private R&D, including the amount of subsidy and indication of past public support. He finds that probability of receiving subsidy increases with lagged values of firm size, R&D intensity and debt-to-sales ratio, as well as the existence and importance of past R&D public support. After applying the common support boundaries for each year, the firms remaining for the matching vary from 80% to 93% of the initial sample. The results of the PSM estimation confirm the absence of full or partial crowding out effects, which is in line with other studies applying similar methodologies (Czarnitzki and Fier, 2002; Aerts and Czarnitzki, 2004; Lööf and Heshmati, 2005). An interesting observation is that the negative effect of the subsidy on private R&D investment is seen for 1987 which was the year of highest average subsidy over the research period. This incidence of

[45] Duguet (2004) follows the kernel matching method proposed by Heckman, Ichimura and Todd (1998) in which, by adopting a kernel weighting function, the Nadaraya-Watson estimator is used to calculate a locally weighted average.

crowding out is interpreted by the author as “likely to have occurred from too much generosity” (Duguet, 2004: 270)[46].

In Brazil, the public R&D subsidies for industry started rather early in the 1970s, but the national support programs were not evaluated at the firm level until the De Negri et al. (2006) study. They use difference-in-differences, Heckman’s two stage selection models and propensity score matching method to measure the impact of the National Technological Development Support Program (ADTEN), which was accessed by only 0.07% of Brazilian industrial firms in the period 1996-2003. In this study, R&D intensity, R&D continuity, size (in terms of number of employees), age, export performance and foreign ownership (negative and significant coefficient) of firms and being in a technology-intensive industry are found to be the significant determinants of the probability of program participation. Through all three methods, they find enough evidence to reject the crowding-out hypothesis of ADTEN’s R&D loans for the firms’ private R&D expenditure which is in line with the empirical results from Hall and Maffioli’s (2008) evaluation study of technology development funds in Latin America. De Negri et al. (2006) also find strong indications that beneficiaries of the program perform better in terms of rate of increase in both net turnover in sales and number of employees. Moreover, they observe a positive but insignificant impact on firm productivity and patent application which seems to require longer period of time to obtain conclusive results.

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[46] The causal relationship between the amount of subsidy and crowding-out effect is examined in a study by Görg and Strobl (2007) in which similar results are obtained: For domestic firms in Ireland, grant provision on a small or medium scale does not substitute private expenditure, whereas large sums of subsidies may behave as financing for R&D projects that would have been realized anyway.

The last study that will be examined in this section was carried out by Özçelik and Taymaz (2008) for the evaluation of Turkish public R&D support programs. In the first econometric analysis in this field in Turkey, they examine the determinants of R&D intensity of (i) all firms in Turkish manufacturing industry, (ii) all the R&D performers and (iii) all the R&D grant and loan recipients using a panel dataset built from different data sources collected in the period 1992-2001. Firm size (in terms of real output), public support (both grants and loans), previous R&D intensity, technology transfer and sectoral R&D intensity are observed to be significant factors positively affecting the private R&D intensity in Turkish manufacturing industry. Adopting propensity score matching and difference-in-differences methods, Özçelik and Taymaz (2008) also calculate the average treatment effects of public support on private R&D investment and find strong evidences to support the crowding-in effect of public R&D loans and grants. The period in which the research was conducted could be described as the *"infant stage"* (Teubal, 1996) of government R&D intervention policy in Turkey, since the first R&D loan was provided by the Technology Development Foundation of Turkey (TTGV) in 1992 and the first large scale R&D grant program was started by the Scientific and Technical Research Council of Turkey (TUBITAK) in 1995. Since 2003, there has been a considerable increase in the resource allocation to public R&D support as well as the number of beneficiary firms in Turkey (see Chapter 4 for more information). Therefore, one of the reasons to initiate a new evaluation study for the period 2003-2006 that will be presented in Chapter 5 is to identify the discrepancies and similarities of the findings obtained for these two periods.

CHAPTER IV

GOVERNMENT INTERVENTION TO PRIVATE R&D IN TURKEY: POLICIES, INCENTIVES AND SUBSIDIES

> *".. Elsewhere, countries less well-known for their scientific endeavour, such as Turkey, are emerging on the international scene. Science may not yet be a global enterprise but the circle of players is definitely widening. International cooperation is not only helping countries to 'catch up' but is also becoming indispensable to the very exercise of science. We live in exciting times."* (Koïchiro Matsuura, Director-General of UNESCO, 2005 p. ix)

In the last decade, the importance of innovation and diffusion of technology through business R&D has been strongly acknowledged in Turkey, and besides allocating more resources to the current intervention instruments, new policy measures and programs have been introduced[47]. The outcome of these incentives can be observed in some of the key indicators: The share of public R&D subsidies in enterprise R&D expenditure in Turkey soared from 1% in 1996 to 9% in 2008 (Taymaz, 2009). The gross domestic expenditure on R&D (GERD) in Turkey increased by 108% between 2001 and 2006, from €1.17 billion (purchasing power parity, PPP) to €2.43 billion (PPP) (EUROSTAT, 2009). This reveals an average

[47] In the period 2006-2008, Turkish government introduced 15 new policy measures aimed at increasing private R&D, strengthening the links between universities and industry and promoting the development of Turkish Research Area, TARAL (WorldBank, 2009).

annual growth rate of 15.7%, a substantially higher growth rate than the EU-27 average (3.6%). The share of business expenditure of R&D (BERD) in GERD rose by 18 % between 2001 and 2007, from 41% to 48%. Nevertheless, with 2007's figures, 0.72% of GERD as a percentage of GDP in Turkey is lower than the EU-27 average of 1.85%. Similarly, Turkey's share of BERD in GERD of 48% remains behind the EU-27 average, which was 63% in 2007[48]. Although these figures indicate that public policies and incentives seems to induce a series of positive effects on R&D activities in Turkey, the key questions, such as whether increasing private R&D expenditure contributes to the innovation value chain of industry or facilitates employment expansion in Turkey, need further analysis. In this manner, one of the important research areas, which is also the subject of this study, is to find out if R&D subsidies substitute (i.e. crowding-out) for private R&D spending.

In this chapter, first a brief overview of science, technology and innovation (STI) policies and incentives in Turkey since 1960 will be presented in a historical perspective. In Section 4.2, the significant public R&D support programs during the period of analysis (i.e. 2003-2006) will be explained. In Section 4.3, the evolution of important STI indicators in Turkey will be presented and examined.

4.1. SCIENCE, TECHNOLOGY AND INNOVATION POLICIES IN TURKEY, A BRIEF OVERVIEW IN HISTORICAL PERSPECTIVE: 1960-2010

In 1960, the State Planning Organization (*Devlet Planlama Teşkilatı, DPT*) was established to provide indicative and systematic incentives to economic

[48] In 2009, the share of GERD in GDP further increased to 0.85% in Turkey. The latest figures of the key STI indicators in Turkey for the years between 2004 and 2009 will be presented in Table 10.

investments and development in Turkey. One of the important activities of the DPT was the preparation of indicative development plans for Turkey in five-year periods. In the first Five Year Development Plan, a special section was dedicated to research issues and 0.4% of GDP was allocated to research expenditure. In that plan, based on the situation at the time[49], new incentives and policy measures were suggested for the promotion of researchers and encouragement of scientific activities, including the creation of a research environment and the organization of research by establishing a scientific and technical research council in Turkey. Indeed, following that suggestion, the Scientific and Technological Research Council of Turkey (*Türkiye Bilimsel ve Teknolojik Araştırma Kurumu, TÜBİTAK*) was established in 1963 , with financial and administrative autonomy, and since then it has operated to coordinate, organize, promote and develop basic and applied research and technological development in Turkey. According to Türkcan (2009), the foundation of TUBITAK was a key milestone in the institutionalization of modern science and technology policies in Turkey. Until the mid-1970s, import substitution policies were successfully implemented and an average of 6% annual growth was reached. During this period, the largest part of the limited research resources were spent in the mineral and agricultural industries by the state and universities, and research demand from industry was insignificant[50].

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[49] In the report, the DPT presented a survey finding on forecasting the number of R&D personnel needed in public research activities during the period of 1963-1967. The total number was forecast to be 3,300 for five years in which 162 scientists were required for agriculture, 519 for medical sciences and 252 for social sciences (DPT, 1963).

[50] In 1967, TUBITAK carried out a survey with a sample of 167 firms from different industries and none of them reported any research activities, mostly because they either predicted insufficient market conditions or preferred technology transfer for economic reasons (Türkcan, 1974).

In 1980, Turkey left the import-substitution model as the main economic policy and opened its economy to the operation of market forces. During the period 1980-1993, export-oriented growth due to the high devaluation of the Turkish Lira, relatively low wages and public subsidies of exports were observed. A few STI policies were announced in the 1980s, but were largely ignored in the implementation phase. For example, the highest ranking organization for the identification and coordination of STI policies in Turkey, the Supreme Council of Science and Technology (BTYK) was founded in 1983 with a schedule of two meetings annually, but it did not become active until 1989. Since 2004, BTYK has held its two meetings annually and become an important instrument for Turkey's STI policy coordination[51].

After 1993, economic turbulence and political instabilities caused frequent interruptions in policy identification and implementation. The Turkish economy in this period could be identified as having several boom and bust cycles in which the most severe occurred in 2001. In response, a series of essential institutional, monetary and fiscal changes were implemented. The reform package and the positive effects of a favorable global economy, combined with the starting of negotiations for EU membership triggered rapid growth in GDP, achieving an average growth rate of 7% during 2001-2007. During the same period, private R&D expenditure also significantly increased and the inflation rate dropped rapidly from 100% in 1998 to almost 6.5% in 2010 (see Figure 3 and 4)).

[51] See Goren (2008) for a chronological review of BTYK resolutions and their consequences for S&T policies in Turkey.

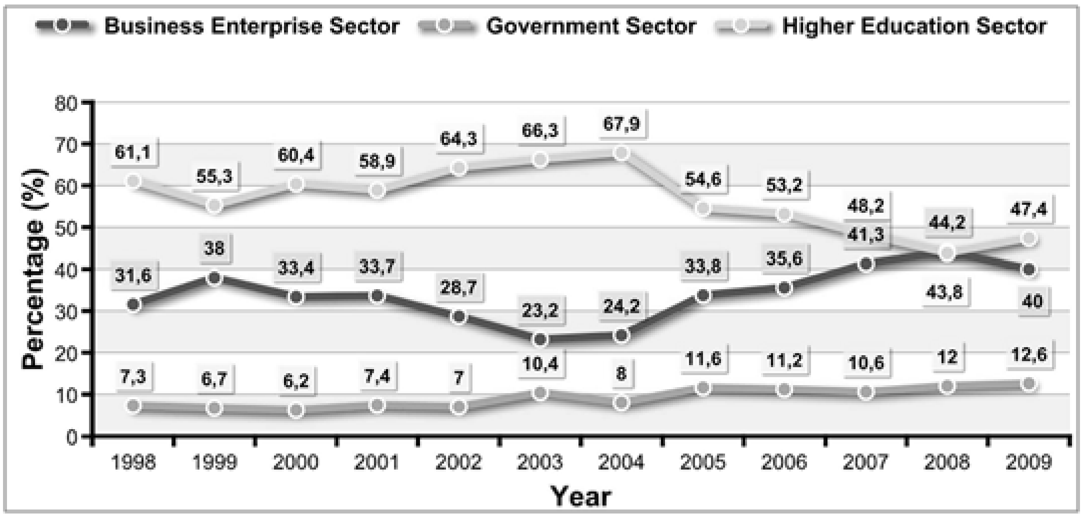

Figure 3 Evolution of GERD by sector of performance in Turkey 1998-2009

Source: TUIK

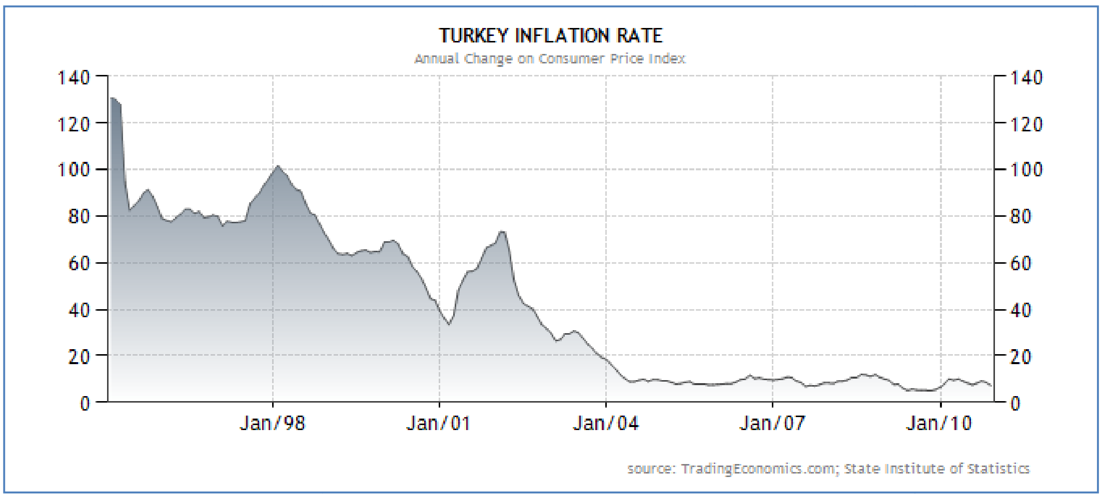

Figure 4 Evolution of inflation rate in Turkey 1995-2010

Source: TUIK

As a brief overview, Table 6 is organized chronologically, indicating the significant milestones of the political and institutional changes in science and technology in Turkey during the last 50 years.

Table 6: Evolution of STI policies and national innovation system in Turkey since 1960

YEAR	EVENT or ACTIVITY
1960	State Planning Organization (DPT) was founded to provide indicative and systematic incentives on economic investments and development in Turkey.
1961	Turkey entered to the OECD as one of the 18 founder member countries.
1962	First five year state plan for 1963-1967 was published by DPT.
1963	The scientific and Technological Research Council of Turkey (TUBITAK) was established by Law No 278.
1972	The Marmara Research Institute (TUBITAK-MAM) was founded to conduct basic and applied (industrial) research according to the priorities set by Science Boards of TUBITAK and approved by DPT.
1981	The Council of Higher Education was established. It is a fully autonomous supreme corporate public body responsible for the planning, coordination, governance and supervision of higher education within the provisions set forth in the Higher Education Law (Law No 2547). While there were 19 universities in Turkey in 1981, there are, at present, 139 universities, 45 of which have foundation status.
1983	Based on statutory Decree No 77, The Supreme Council for Science and Technology (BTYK) was formed but did not become active until 1989. Chaired by the Prime Minister and having TUBITAK as the general secretariat, the BTYK was in charge of designing, monitoring and coordinating national STI policies including target identification, priority setting and resource allocation (see Goren, 2008 for an analysis on the BTYK activities and resolutions between 1989-2008).
1983	"Turkish Science Policy: 1983-2003" was published as the first official document in the area of science policies in Turkey. One of its targets was to have R&D expenditure of 1% as a percentage of GDP by 1993. This strategic document was never implemented (Taymaz, 2001).
1990	The Turkish Statistical Institute (TUIK), in line with OECD standards, started to collect data on R&D activities in Turkey.
1990	The Small and Medium-sized Industry Development Organization (KOSGEB) was established as an affiliate of the Ministry of Industry and Trade to develop SME policies and promote entrepreneurship.

Table 6 (Continued)

1991	The Technology Development Foundation of Turkey (TTGV) was founded in accordance with the international loan agreement signed between Turkey and the World Bank. TTGV launched an R&D support program to provide soft loans to selected industrial projects on technological production or process innovation.
1992	The National Metrology Institute (UME) was founded in 1992, as part of TUBITAK to establish national measurement standards and provide measurement, calibration and consultancy services.
1993	The "Turkish Science and Technology Policy: 1993-2003" was prepared by TUBITAK and accepted by the BTYK. In this document, the expected increase in GERD as a percentage of GDP was from 0.33 in 1993 to 1.0 in 2003, and the expected increase in the share of private R&D expenditure from 18% to 30% of GERD.
1993	The Turkish Academy of Sciences (TUBA) was founded to establish the criteria of scientific excellence in Turkey, to encourage and foster scientific endeavours, to ensure that scientific principles be applied in all spheres and to create an environment of debate so that basic social strategies may be defined in the light of scientific and technological data
1994	The Turkish Patent Institute (TPE) was established by TPE Decree No 544 to enforce a revised legislative IPR regime in Turkey.
1994	The Turkish Competition Authority (RK) was established by Law No 4054 to form a national competition policy in markets for products and services in Turkey.
1995	The Turkey–EU Association Council adopted its resolution on the completion of the Customs Union between Turkey and the EU in industrial and processed agricultural goods as stated in the Ankara Treaty which was signed between Turkey and the European Community in 1963. The immediate outcome was that in 1996, Turkey's exports to EU increased by 3.6% compared to 1995, whereas its imports from EU rose by 34.7% (ABGS, 2007).
1995	TUBITAK launched an R&D support program to provide grants for industrial R&D projects in accordance with a decree issued by the Board of Money Credit and Coordination (PKK).
1998	PKK put into force Decree No 98/10 to commission the Undersecretariat of the Prime Ministry for Foreign Trade (DTM) for industrial R&D support. It was decided that TUBITAK and TTGV would be in charge of designing and running support programs.

Table 6 (Continued)

1998	The Turkish Statistical Institute (TUIK) carried out the first Community Innovation Survey (CIS) in Turkey for the period of 1995-1997.
1999	The Turkish Accreditation Agency (TURKAK) was established by Law No 4457 to assess private and public organizations applying for accreditation working in the field of calibration, inspection testing and certification of products, systems and personnel.
2001	The Technology Development Zone Law No 4691 came into force to support R&D in techno-parks and organized industrial zones. Affiliated to the Ministry of Industry and Trade, there are 37 techno-parks around Turkey, of which 21 are active with a total of 1178 firms by 2009.
2003	TUBITAK was officially assigned as the contact organization for the EU Framework Programs (FP) by the Turkish government, and Turkey was associated with the 6th FP, which is assumed to be significant progress in the integration of the Turkish research area with Europe.
2004	"Vision 2023: Science and Technology Strategies" was published as a result of Turkey's first institutional foresight exercise at the national level conducted by TUBITAK. It includes S&T vision of Turkey, declares strategic technologies and R&D priorities and suggests policy recommendations (TÜBİTAK, 2004; see Sarıtaş et al., (2007) for a critical review).
2004	The Turkish Research Area, TARAL was created with a dedicated public budget in the 10^{th} meeting of BTYK. TARAL aims to mobilize private and public sectors for reaching national R&D related short and long term targets. The collaboration between the European Research Area, ERA and TARAL was also one of the objectives in the BTYK decision (BTYK, 2004).
2005	The Ministry of Finance introduced a 40% tax allowance for private R&D expenditure in the existing Tax Law No 5520.
2006	The Ninth Development Plan for 2007-2013 establishes revised STI targets for 2013 including an increase in R&D expenditure to 2% of GDP; an increase in the share of private R&D expenditure to 60% of GERD and the raising the number of researchers to 80,000 (revised again in 2008 to 150,000 since the target figure had already been reached).
2006	In the framework of EU accession negotiation, the screening and negotiation phases of Chapter 25 on Science and Research was completed and closed as Turkey's adoption of the acquis and its degree of implementation in the fields of science and research were seen as sufficient by the Commission (see Screening Report Turkey Chapter 25, (EC, 2006)).

Table 6 (Continued)

2007	Five Technology Platforms were established in the automotive, electric and electronics, metal and textiles sectors, in line with the policies for European Technology Platforms, to provide public-private partnership for suggesting sectoral STI policies and strategic research agendas.
2007	TUBITAK launched two new R&D support programs: The Techno-entrepreneurship grant program (aiming to support young entrepreneurs who have innovative project ideas with commercial potential) and an R&D funding program for SMEs (to provide direct support for the first two R&D projects of SMEs).
2007	The Ministry of Industry and Trade published a revised SME strategy and SME Action Plan for the period of 2007-2009 which largely followed EU policies, including the Lisbon strategy.
2007	TUBITAK signed a memorandum of understanding with the European Joint Research Centre (JRC) with a view to promoting JRC collaboration with major R&D organizations in Turkey.
2008	A generous R&D tax law for a range of R&D fiscal incentives including up to 150% tax allowance for R&D expenditure, income tax and social security premium exemptions for researchers was adopted (GIB, 2008).
2008	Turkey assumed a full role in EURAXESS, the European research mobility network, which increases mobility of researchers and investment in research and international cooperation. TUBITAK became the bridgehead organization and put the EURAXESS-Turkey web portal into service.
2009	The National Nanotechnology Research Center (UNAM) was established at Bilkent University with a structural fund provided by DPT.
2010	KOSGEB launched an SME support program for R&D, innovation and industrial applications which provides a mixture of grants and soft loans.
2010	The Turkish Government signed an agreement with the European Investment Bank to receive a loan of €450 million in order to boost research capacity in Turkey.
2010	A new law (No 6015) was enacted by the Undersecretariat of the Treasury establishing the State Aid Council for regulation of state aid, including public R&D incentives based on EU state aid regulations.

Source: Author's elaboration

4.2. PUBLIC SUPPORT PROGRAMS FOR PRIVATE R&D IN TURKEY

The beginning of public incentives in business R&D in Turkey dates back to the early 1990s. However, until recently, governments' financial involvement was low and the range of such policy tools was limited. Since 2004, a significant increase has been seen both in resource allocation and diversification of the policy instruments for promoting private R&D and innovation as presented in Table 6. In this section, however, only the public support programs and other incentives which have been in force for supporting industrial R&D activities in Turkey during the period of the study will be explained[52]. The key organizations supporting private R&D from 2003-2006 were DTM, TUBITAK, TTGV and KOSGEB. In addition to the direct incentives provided by these organizations, the Ministry of Finance introduced a fiscal incentive of 40% tax allowance for private R&D expenditure by adopting the existing tax law No 5520 in 2005.

4.2.1. TUBITAK – DTM Industrial R&D Projects Support Program

During the period of 2003-2006, the most important public R&D incentive[53] was the Industrial R&D Projects Support Program that was launched by DTM and the Technology and Innovation Support Programs Directorate (TEYDEB)[54] of TUBITAK in 1995. In the context of the program, while DTM provides funding, TUBITAK serves as the referee institution. TUBITAK's grant committees distribute funds

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[52] For an overview of national STI implementation plans, recent policy measures and support programs for private R&D in Turkey, see TÜBİTAK (2005, 2010), WorldBank (2009).

[53] For example, 88% of total public funding for industrial R&D in Turkey was provided by TUBITAK and DTM through the industrial R&D Project Support Program in 2005 (see Table 14).

[54] The directorate TEYDEB was called TIDEB from 1995 to 2004.

across a wide range of technological fields. The evaluation of applicants' R&D projects for grants and the assessment of the legitimacy of beneficiary firms' R&D expenditure were made by external evaluators selected by the related grant committee members.

The applicants, which are either large firms or SMEs, select one of the following technology groups according to their projects' focus of interest: (i) Machinery and manufacturing technologies, (ii) Electrical and electronics, (iii) Information technologies, (iv) Materials, metallurgical and chemical technologies, (v) Biotechnology, agriculture, environmental and food technologies. The distribution of the technological fields of proposed projects between 1995 and 2009 is shown in Figure 5 which indicates that more than 30% of the total number of project proposals is in the technology field of machinery (medium technology) whereas projects related to high technology are limited. The qualified projects are supported by means of non-reimbursable grants covering 50-60% of their eligible expenses in a matching fund scheme[55].

[55] The beneficiary firm reports project expenditure including personnel costs, consultancy and outsourcing fees, cost of equipment and material used in the project at six months intervals. TUBITAK conducts an evaluation and transfers 50-60% of eligible costs which have already been incurred by the firm..

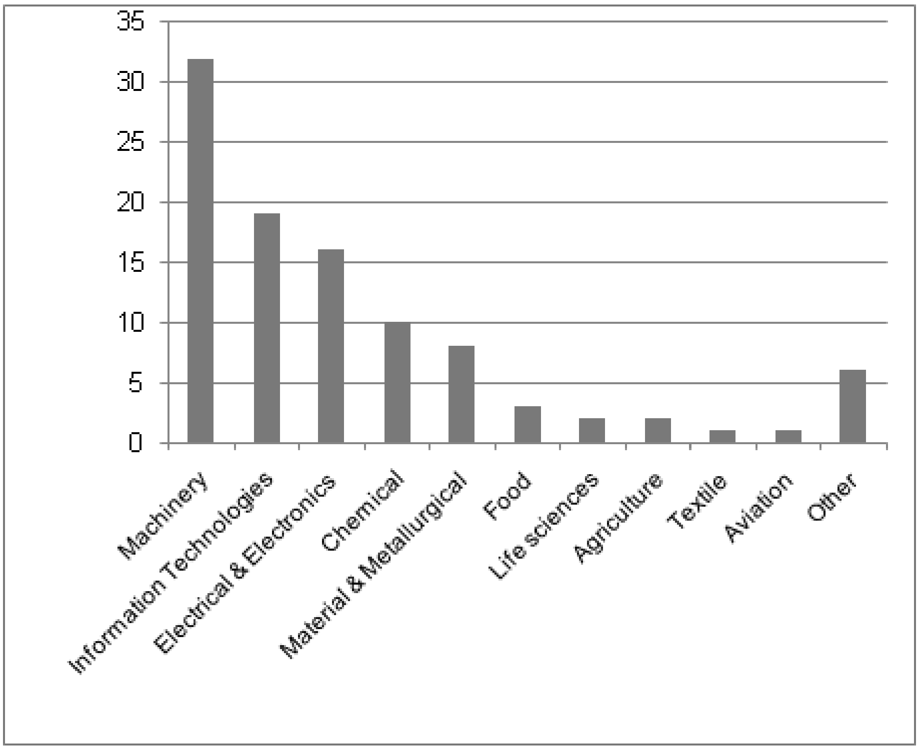

Figure 5 TUBITAK-TEYDEB project proposals by technology field in percentage: 1995-2009

Source: TUBITAK

Given the mission of increasing the international competitiveness of industrial companies in Turkey through R&D and innovation, the program supports the R&D phases of product and process innovations until prototype formation, excluding any production investments or marketing and organizational innovations. In the years 1995-2009, 4,752 firms applied to the program with 10,161 R&D projects, of which 6,122 were granted. The total amount paid to the beneficiary firms was 1.07 Billion USD, of which more than 80% was spent after 2005. The total amount of R&D expenditure realized during this period was 2.13 Billion USD. As illustrated in Figure 6, acceleration started in 2004, which is selected as the reference year for the current evaluation study. The amount of average subsidy per supported project also increased more than threefold, from 80,000 USD in 2002 to 270,000 USD in 2007 (see Figure 7).

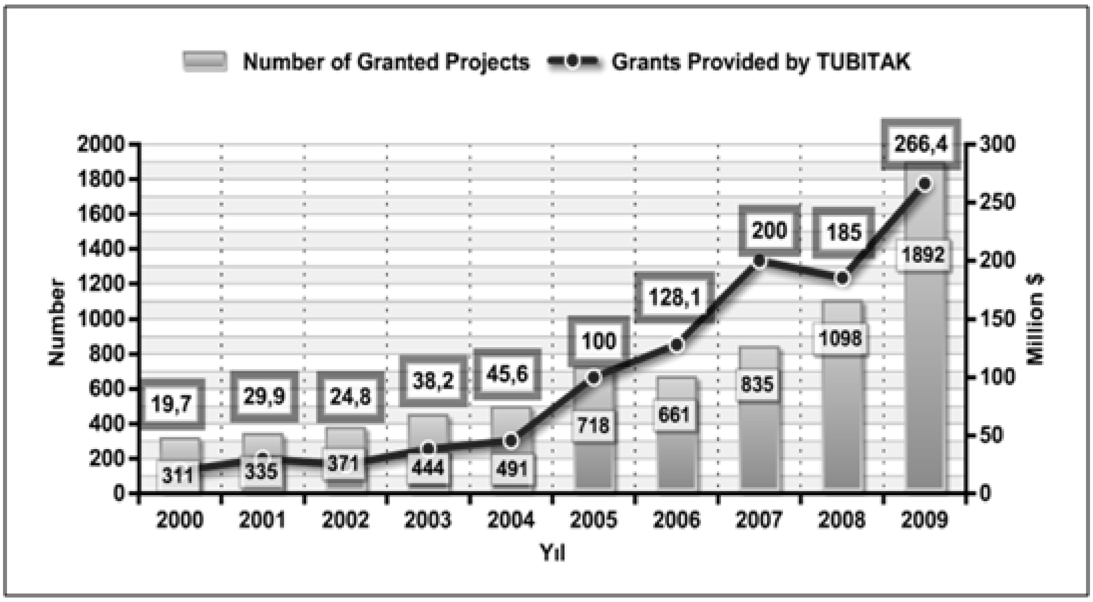

Figure 6 Evolution of total industrial R&D grants by TUBITAK-TEYDEB: 2000 - 2009

Source: TUBITAK

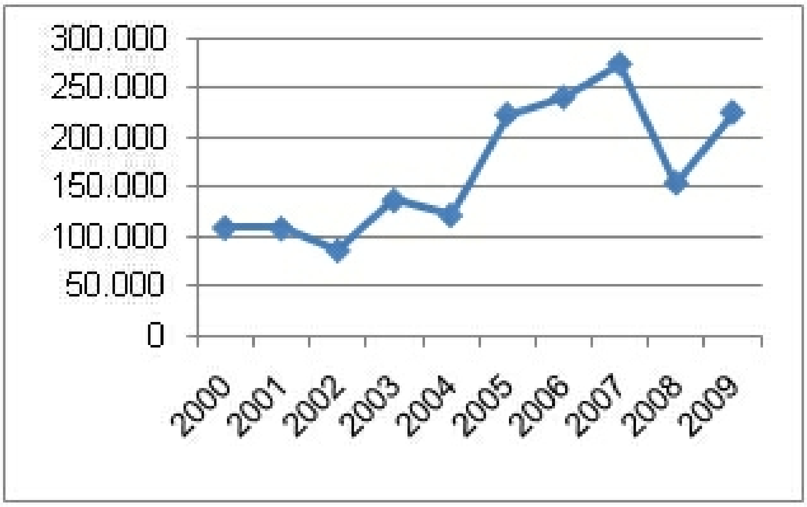

Figure 7 Average subsidy (in USD) per project supported by TUBITAK-TEYDEB: 2000 – 2009

Source: TUBITAK

Both large firms and SMEs can apply to the Industrial R&D Support Program. In order to facilitate the R&D activities of SMEs, TUBITAK launched a new R&D funding program only for SMEs in 2007. In this program, TUBITAK provides grants up to 75% of the expenditure of eligible SMEs' first two R&D projects. As depicted in Figure 8, the SME program helped to boost significantly the share of SMEs in the total number of applicants. The decrease in the number of proposals in 2009 was mostly believed to be caused by the global economic crisis which started in 2008.

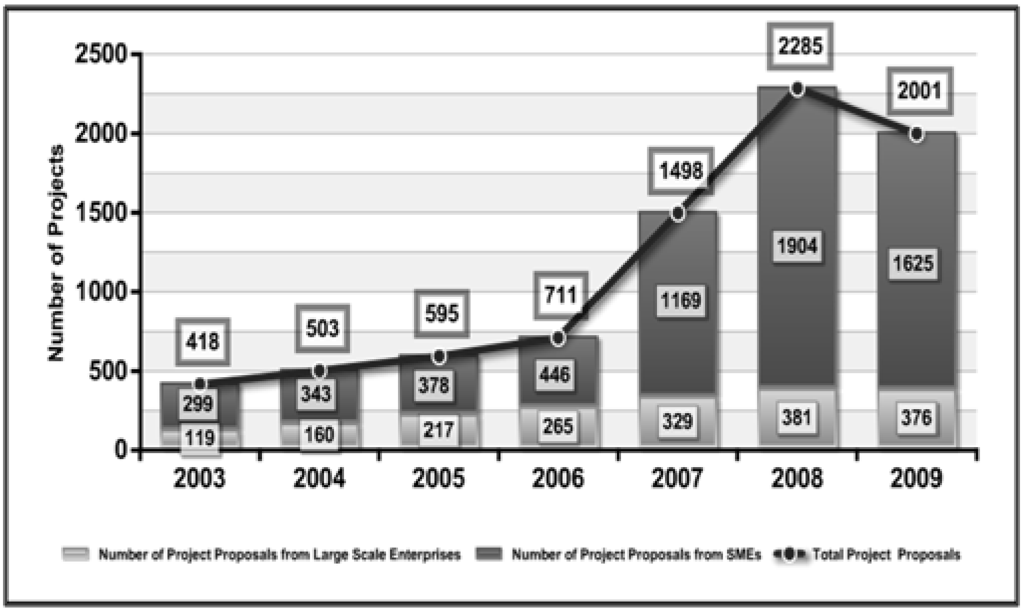

Figure 8 Distribution of project proposals for TUBITAK-TEYDEB based on firm size: 2000 - 2009

Source: TUBITAK

As the number of applications increased over the years, the acceptance rate of project proposals evaluated by the external evaluators decreased from 90% in 2000 to almost 50% in 2009 (Figure 11).

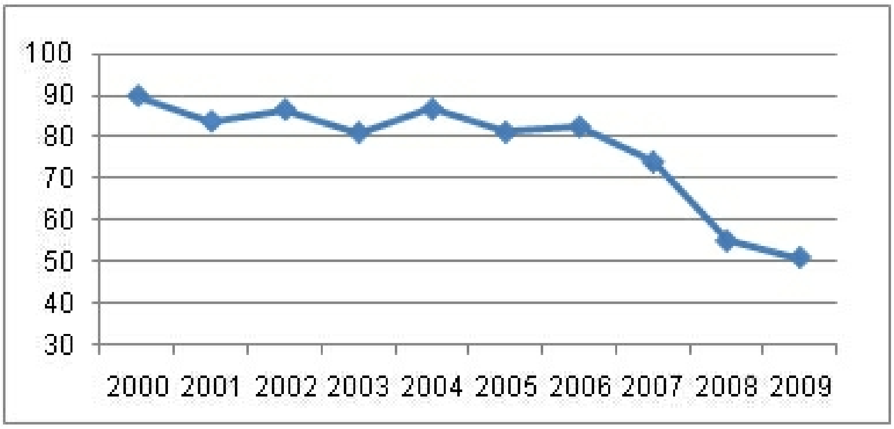

Figure 9 Acceptance rate of project proposals in TUBITAK-TEYDEB: 2000-2009

Source: TUBITAK

As it is presented in Figure 10, the evolution of TUBITAK grants via the Industrial R&D Projects Support Program soared more than tenfold in 10 years, thanks to the generous budget allocation from the government to TUBITAK for public R&D incentives since 2005.

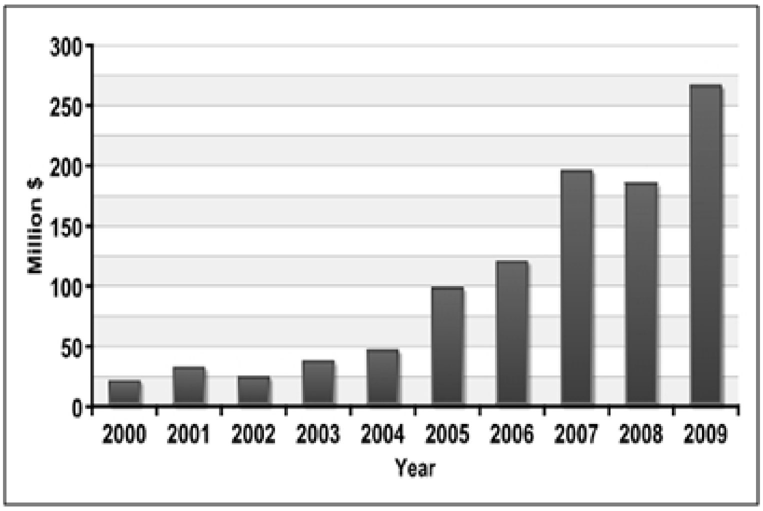

Figure 10 Evolution of grants provided by TUBITAK-TEYDEB: 2000-2009

Source: TUBITAK

4.2.2. TTGV – Technology Development Program

Initiated by a technology development program of the World Bank, the Technology Development Foundation of Turkey (TTGV) was established in 1991 by 56 founder organizations and individuals from both private and public sectors. Financed by the Undersecretariat of Foreign Trade, TTGV runs a technology development support program to provide interest-free loans for 50% of the budget of industrial R&D projects up to a maximum one million USD. In this program, the maximum project time is two years, and the loan should be paid back within four years, starting in the second year. To date, 76% of the program beneficiaries are SMEs (Telçeken, 2010). Table 7 summarizes the evolution of the technology development program since 1992.

TTGV also has two other groups of support programs: The first group includes support programs for start-ups, pre-incubation promotion and risk sharing facilities; the second group of incentives consists of programs for supporting environmental projects focusing on renewable energy, energy efficiency in industry and environmental technologies.

Table 7 Evolution of TTGV technology development Programme: 1992-2009

Years	92-99	00	01	02	03	04	05	06	07	08	09	Total
Number of applied projects	576	87	121	133	160	229	132	128	155	238	228	2187
Number of supported projects	179	55	32	51	67	64	25	101	88	116	113	891
Share of SMEs (%)	67	83	66	81	94	78	81	87	88	88	80	76
Total project budget (MUSD)	151	39	20	34	31	51	14	59	59	83	66	607
Total loan provided by TTGV (MUSD)	47	7	10	7	13	15	12	17	18	21	25	192
Number of completed projects	146	17	30	40	44	35	78	73	73	66	95	697
Total reimbursement (MUSD)	18	7	4	5	7	8	9	13	17	19	17	124

Source: TTGV

4.2.3. KOSGEB - SME Support Programs

The Small and Medium-size Industry Development Organization (KOSGEB) was established in 1990 as an autonomous public body affiliated to the Ministry of Industry and Trade. Authorized by Law 3624, KOSGEB implements a range of policy instruments for promoting entrepreneurship and improving the competitiveness of SMEs. Besides providing soft-loans and grants for the R&D and innovation projects of SMEs, KOSGEB assists co-operation between industry and universities by organizing the establishment of Technology Development Centers (TEKMER). TEKMERs provide basic means for technology-based start-up companies for up to four years. To promote technology diffusion, KOSGEB programs in TEKMERs support the upgrading of technology and the hiring of business and labor-training consultants[56]. Between 2000 and 2005, around 10% of KOSGEB's support budget was allocated to supporting the R&D projects of SMEs (Cansiz, 2008). Table 8 provides the budget allocation and number of supported projects by KOSGEB during the period 2000-2006. Cansiz (2008) offers the criticism that, by the end of 2006, of 400 supported and completed projects, only 29 of these projects had acquired a utility model certificate and the output from 21 projects (5%) were patented.

[56] For detailed description of KOSGEB's and TTGV's support programs in the period 1991-2003, see DPT (2004).

Table 8 Evolution of KOSGEB R&D Support Programme: 2000-2006

YEAR	Total support budget (thousand TL)	R&D support budget (thousand TL)	Realized R&D support (thousand TL)	Share of budget realization (%)	Number of supported projects	Number of completed projects
2000	4000	872	414	47	66	17
2001	3470	347	1585	457	89	20
2002	8000	800	1903	238	93	34
2003	128494	12714	4678	37	174	45
2004	228000	24497	19463	79	516	81
2005	248000	20000	12186	60	not reported	
2006	143000	16667	5457	33		

Source: Cansiz (2008)

4.3. KEY STI INDICATORS FOR TURKEY

In this section, recent key indicators related to R&D and innovation performance in Turkey will be illustrated. One of the most frequently used STI indicators, GERD as a percentage of GDP, is depicted in Table 9 comparing Turkey with EU-27 and some other countries. Although EU-27 did not show any progress despite the Lisbon criterion of targeting 3% growth, the improvement in GERD/GDP in Turkey during 2000-2008 still needs further acceleration to catch up with EU-27 average of 1.77%. The key STI indicators, which in general indicate steady progress in the last five years, are presented in Table 10[57]. While GERD per person rose from $51.4 in 2004 to $121 in 2009, the number of FTE researchers per 10,000 total employment increased from 18.1 to 34.6 during the same period.

[57] The difference between GERD/GDP figures depicted in Tables 9 and 10 is originated from TUIK's new method of calculation of GDP which is used in Table 10.

Table 9 Evolution of GERD/GDP in percentage: 2000-2008

	2000	2001	2002	2003	2004	2005	2006	2007	2008
EU-27	1.74	1.75	1.76	1.75	1.73	1.74	1.76	1.77	…
Turkey	**0.48**	**0.54**	**0.53**	**0.48**	**0.52**	**0.59**	**0.58**	**0.72**	**0.73**
Hungary	0.79	0.92	1.00	0.93	0.87	0.94	1.00	0.97	…
Poland	0.56	0.54	0.56	0.57	0.56	0.57	0.56	0.57	0.60
Romania	0.37	0.39	0.38	0.39	0.39	0.41	0.45	0.52	0.59
Spain	0.91	0.92	0.99	1.05	1.06	1.12	1.20	1.27	1.35
Korea	2.30	2.47	2.40	2.49	2.68	2.79	3.01	3.21	…
Mexico	0.34	0.36	0.40	0.40	0.40	0.41	0.39	0.38	…

Source: OECD MSTI 2009/1

Table 10 Evolution of basic STI indicators in Turkey: 2004-2009

	2004	2005	2006	2007	2008	2009
GERD / GDP in percentage	0.67	0.79	0.76	0.71	0.73	0.85
GERD (Million TL)	2 898	3 835	4 400	6 091	6 893	8 087
GERD (PPP* – Million USD)	3 653	4 373	4 883	6 578	7 034	8 819
GERD per person (PPP* – USD)	51.4	60.7	69.2	93.2	98.4	121.5
Sectoral share of GERD in percentage						
Higher Education	67.9	54.6	51.3	48.2	43.8	47.4
Private	24.2	33.8	37	41.3	44.2	40.0
Government	8.0	11.6	11.7	10.6	12.0	12.6
Total R&D personnel (FTE)	39 960	49 252	54 444	63 777	67 244	73.571
Total R&D personnel (FTE), sectoral share in percentage						
Higher Education	61.9	51.6	49.1	46.6	44.5	42.2
Private	22.1	30.4	33.1	38.3	40.8	42.8
Government	16	17.9	17.8	15.1	14.7	15.0
FTE researchers per 10,000 total employment	18.1	20.4	24.5	30.6	31.7	34.6
Number of scientific publications	15 443	16 718	18 928	21 961	22 995	24 916
Turkey's position in the world list of scientific publications	21	19	19	18	18	

Source: BTYK21, 2010 and TUIK

In recent years, the number of patent applications originating from Turkey has shown a considerable improvement. Table 11 shows that domestic patent applications rose from 170 in 1995 to 2,588 in 2009 with a highly variable rate of increase. On the other hand, foreign applications shifted from TPE to the European

Patent Convention. However, the success rate for acquiring granted patents from domestic applications has stayed at lower levels than foreign patent files since 1995 (Figure 11).

Table 11 Distribution of patent applications from residents in Turkey: 1995-2009

	Domestic					Foreign					General	
	TPE	**PCT**	**EPC**	**Total**	**Increasing Rate (%)**	**TPE**	**PCT**	**EPC**	**Total**	**Increasing Rate (%)**	**Total**	**Increasing Rate (%)**
1995	170	0	0	**170**	**-**	1520	0	0	**1520**	-	**1690**	-
1996	189	0	0	**189**	**11.18**	687	26	0	**713**	**-53.09**	**902**	**-46.63**
1997	202	1	0	**203**	**7.41**	598	730	0	**1328**	**86.26**	**1531**	**69.73**
1998	201	6	0	**207**	**1.97**	596	1680	0	**2276**	**71.39**	**2483**	**62.18**
1999	265	11	0	**276**	**33.33**	524	2220	0	**2744**	**20.56**	**3020**	**21.63**
2000	258	19	0	**277**	**0.36**	442	2714	0	**3156**	**15.01**	**3433**	**13.68**
2001	298	39	0	**337**	**21.66**	119	2756	2	**2877**	**-8.84**	**3214**	**-6.38**
2002	387	27	0	**414**	**22.85**	88	1335	37	**1460**	**-49.25**	**1874**	**-41.69**
2003	454	35	1	**490**	**18.36**	43	305	314	**662**	**-54.66**	**1152**	**-38.53**
2004	633	49	3	**685**	**39.80**	68	167	1342	**1577**	**138.22**	**2262**	**96.35**
2005	895	33	7	**935**	**36.50**	75	143	2308	**2526**	**60.18**	**3461**	**53.01**
2006	979	93	18	**1090**	**16.58**	71	89	3915	**4075**	**61.32**	**5165**	**49.23**
2007	1747	60	31	**1838**	**68.62**	71	139	4141	**4351**	**6.77**	**6189**	**19.83**
2008	2159	69	40	**2268**	**23.39**	68	107	4694	**4869**	**11.91**	**7137**	**15.32**
2009	2473	74	41	**2588**	**14.11**	69	105	4479	**4653**	**-4.44**	**7241**	**1.46**

TPE: Turkish Patent institute, PCT: Patent cooperation treaty, EPC: European patent convention.
Source: TPE

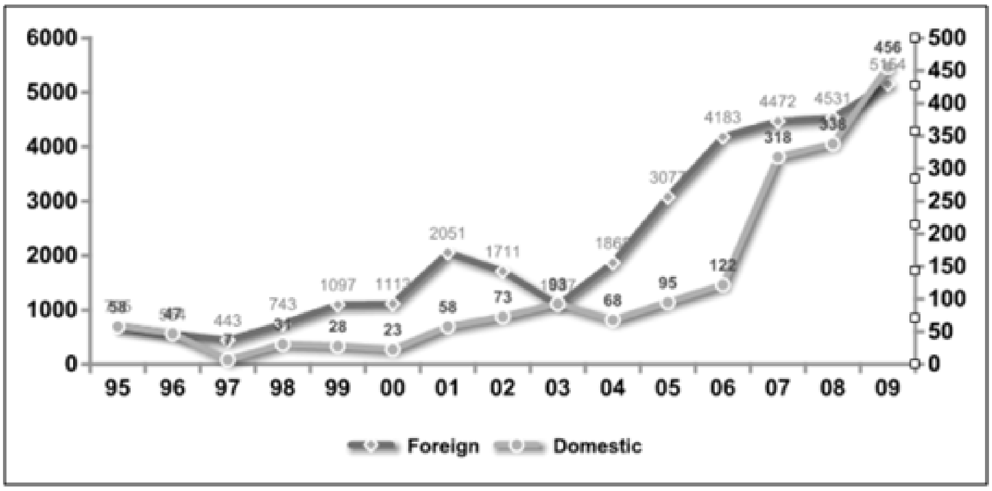

Figure 11 Distribution of total patents granted in Turkey: 1995-2009

Source: Prepared with TPE data

Another key STI indicator is related to human resources for science and technology. As illustrated in Figure 12, the rapid growth in Full Time Equivalent (FTE) R&D personnel and researchers in Turkey after 2002 resulted in a change in the national target for the number of FTE R&D personnel in 2013, from 80,000 to 150,000. However, comparing the number of FTE researchers per 10,000 total employed in Turkey with the EU-27 and certain other countries shows that the abovementioned progress needs to accelerate further (see Table 12).

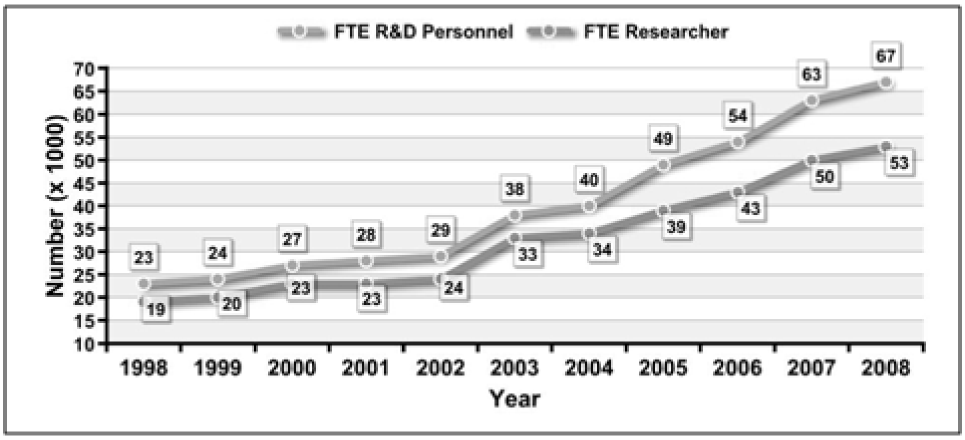

Figure 12 Number of FTE R&D personnel and researchers in Turkey: 1998-2008

Source: TUIK

Table 12 FTE researchers per 10,000 total employment in selected countries: 2000-2008

YEAR	Turkey	EU-27	Hungary	Poland	Romania	Spain	Korea	Mexico
2000	**13**	94	61	50	32	73	65	…
2001	**13**	95	60	54	31	74	77	11
2002	**14**	96	61	55	34	77	78	…
2003	**18**	97	60	57	36	85	84	15
2004	**18**	98	55	57	37	87	86	19
2005	**22**	100	56	55	36	91	94	21
2006	**24**	103	61	51	33	94	103	16
2007	**25**	104	62	50	31	98	115	16
2008	**…**	…	…	47	…	105	…	…

Source: OECD MSTI 2009/1

Table 13 Technological innovation activities in Turkey: 1995-2009

CIS	Manufacturing Sector (%)	Service Sector (%)
1995-1997	24.6	48.2
1998-2000	29.4	38.5
2002-2004	34.6	25.9
2004-2006	35.3	24.6
2006-2008	41.1	31.0

Source: TUIK

The technological innovation activities of the firms in the manufacturing and service sectors are measured through periodic CISs conducting by TUIK. According to the five most recent surveys, the share of firms in the manufacturing sector which perform innovation activities increased from 24.6% in 1995-1997 to 41.1% in 2006-2008 (Table 13) As depicted in

Figure 13, the proportion of innovative firms in Turkey is close to the average proportion of the EU-27 in 2006.

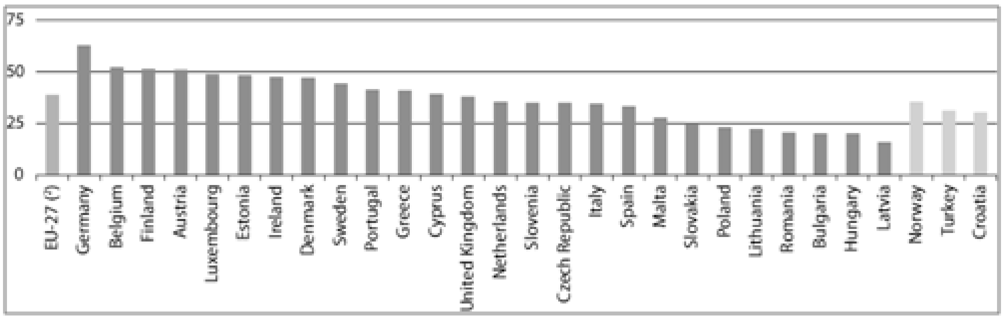

Figure 13 Proportion of innovative firms (percent of all firms): 2006

Source: EUROSTAT

Table 14 Public Expenditure on Innovation and Technology Programmes

Implementing Agency	2005	2006	2007	2008
Universities	274,2	278,7	256,3	253,5
TUBITAK (TUBITAK Research Centers)	108,8	155,0	141,8	183,3
TUBITAK (Turkey Research Area Programs) *	346,0	415,0	425,0	450,0
Academic Research Projects	90,0	80,0	85,0	105,0
Industrial Research Projects (of companies)	116,0	215,0	215,0	175,0
Research Projects of Public Institutions	50,0	50,0	50,0	65,0
Defense and Space Research Projects	50,0	60,0	65,0	80,0
Researcher Development	25,0	5,0	5,0	15,0
Science and Technology Awareness	15,0	5,0	5,0	10,0
Public Institutions (Outside TUBITAK)	36,2	49,3	80,2	78,2
Nuclear Energy Council (TAEK)	6,3	13,1	20,0	18,9
Ministry of Industry and Trade **	-	11,0	16,9	17,6
Ministry of Agriculture and Rural Affairs	2,2	2,5	4,0	3,6
Ministry of Health	0,1	6,2	5,2	4,9
National Boron Research Institute ***	0,1	3,0	6,0	6,3
Ministry of Energy ***	-	-	-	1,0
KOSGEB	12,5	5,4	4,6	6,5
TTGV	8,9	35,6	35,4	35,5
State Planning Organization (DPT),	1,1	10,0	18,0	18,0
Undersecretary of Foreign Trade (DTM)	40,0	42,0	63,5	n/a
TOTAL (TL)	**1182,4**	**1441,8**	**1501,9**	**1527,3**
TOTAL (USD)	**877,6**	**1002,6**	**1148,4**	**1175,5**

* TUBITAK funds the projects of other institutions' R&D projects

**Includes SAN-TEZ program that supports PhD students' theses that aim to solve company-specific problems and the support for the physical infrastructure of Techno-parks.

*** Includes programs in which the projects of other institutions are supported.

Source: (WorldBank, 2009) and DPT

Yet another set of indicators which is a focus of interest for this study is related to public incentives for private R&D and innovation. As elaborated in Chapter 2, they can be examined in two groups, namely policy instruments for direct support, and fiscal incentives. Table 14, which provides a summary of the main allocation of funds within Turkey's national innovation system in the years 2005-2008, shows that annual public expenditure in USD for R&D and support programs in Turkey rose by more than 34% in four years. Figure 14 illustrates the similarity in the evolution of private R&D support and the share of R&D subsidies in Turkey between 1996 and 2008.

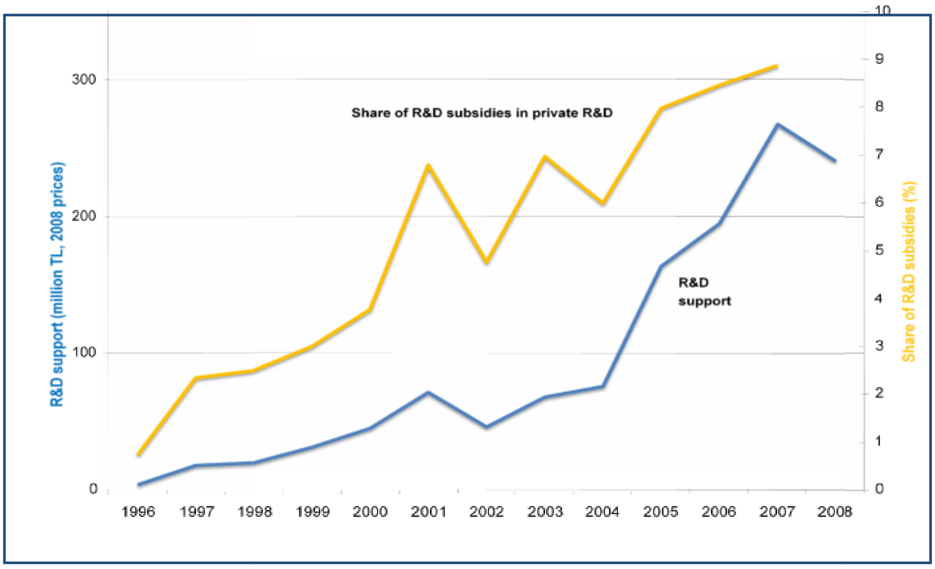

Figure 14 Evolution of private R&D support and share of R&D subsidies in Turkey: 1996-2008

Source: Taymaz, 2009

Besides the stable evolution of direct support programs in recent years, indirect support mechanisms for business R&D and innovation have also recently been strengthened in Turkey. The new fiscal incentives enforced by Law 5746, have provided an almost two million TL tax lift to 1200 R&D performer tax payers in the last two years (Table 15). During the same period, 67 research centers[58] have been accredited by the Ministry of Industry and Trade to benefit from those incentives. The total number of R&D personnel employed in research centers and promoted with income tax exemption had reached 8581 at the end of 2009.

Table 15 Beneficiaries of new Tax Incentive Law No 5746

	Number of tax payers		Amount (Million TL)	
Years	2008	2009	2008	2009
Income tax	63	73	6.6	8
Corporate tax	432	630	593.4	1309
Total	**495**	**703**	**600**	**1317**

Source: BTYK, 2010

As a summary, since 2004, significant changes and improvements that have taken place in Turkey concerning science and technology policy schemes have actually influenced the national innovation system (NIS) in a number of ways:

- Important increase in the public support provided to private R&D (share of subsidies in enterprise R&D expenditure increased from 1% to 9% over 1996-2008)

[58] A research center is defined by the Law 5746 as a separate organization located in Turkey with at least 50 FTE researchers employed to perform scheduled R&D activities on a regular basis.

- Diversification of direct support programmes for private R&D and innovation tailored to the needs of potential innovators (SMEs vs. large firms, start ups vs. incumbents, grants vs. loans, etc.)
- Widening of the scope of existing fiscal incentives for private R&D activities and implementation of new ones
- Impressive developments in support for higher education and basic research largely provided by TUBITAK
- Increased public efforts for researcher mobility, integration into the international research community and participation in collaborative research activities

Considering the large resource allocation for the aforementioned government involvements, it could be argued that there is a growing and urgent need for systematic monitoring and evaluation of NIS institutions, linkages, programs and policies in Turkey

CHAPTER V

IMPACT OF PUBLIC SUBSIDY ON INDUSTRIAL R&D IN TURKEY: EMPIRICAL ANALYSES

This chapter presents the empirical findings of three studies conducted in TUIK Data Analysis Centre between September 2009 and April 2010. In the first section, the construction of data will be explained and a corresponding descriptive analysis will be done. Section 2 in this chapter depicts the results of the study examining the position of the R&D subsidies among the other determinants of the firm's R&D investment. Section 3 and 4 illustrate the findings from matching estimations using two different data sources. The first dataset with its longitudinal feature allows us to employ both propensity score matching and difference-in-differences methods in the same analysis. The second dataset is with the PSM method only since it is originated from the Community Innovation Survey conducted in 2006 and therefore has only cross-sectional characteristic. The chapter concludes with a discussion section.

5.1. CONSTRUCTION OF DATA AND DESCRIPTIVE ANALYSIS

In the empirical analyses, two different datasets are used for estimating the determinants of industrial R&D and the effect of public subsidies on business R&D

investments in Turkey. The first dataset, DS1 is constructed using six data sources collected in the four years from 2003 to 2006:

1. Structural Business Statistics (SBS, source: TUIK); around 80,000 enterprises per year
2. Research and Development Activities Survey (RDS, source: TUIK); around 2,000 enterprises per year
3. Foreign Trade Statistics (FTS, source: TUIK)
4. General Census of Industry and Establishments (GCIE, source: TUIK); around 3,500,000 entries in 2002
5. Price Index in three-digit sector codes (PI, TUIK)
6. Administrative Data of TEYDEB (ADT, source: TUBITAK); around 2,500 business enterprises which apply to the industrial support programs of TUBITAK

The SBS, which is the primary contributor to the first dataset DS1, covers annual performance figures as well as basic firm level data of all the public and private establishments with twenty and more employees located in Turkey[59]. This survey was reconstructed[60] by TUIK in 2002 in compliance with European Council decision No 58/97, accepted in 20/12/1996. The number of responding firms[61] varies between 70,000 to 85,000 firms per year; of these firms, 18,278 have participated in all the surveys from 2003 to 2006. The sectoral coverage of the SBS includes

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[59] The SBS also includes data for a sample of enterprises with less than 20 employees.

[60] The statistical unit of SBS was also changed in 2002 from *establishment* to *enterprise*. Enterprise is defined by TUIK (2010) as "an organizational form that produces goods and services using decision autonomy at first degree. An enterprise carries out one or more activities at one or more locations. The relation between enterprise and legal unit is directly stated by this definition: An enterprise corresponds to a legal unit or combination of legal units." This major modification in the survey's organization represents an important obstacle for the researchers in Turkey when merging data collected before and after 2002.

[61] In the sequel, the terms, firm and enterprise will be used interchangeably for statistical units.

divisions from C to K and M to O in NACE Rev. 1.1. According to economic activity branches:

(C) Mining and Quarrying
(D) Manufacturing Industry
(E) Electricity, Gas and Water
(F) Construction and Public Works
(G) Wholesale and Retail Trade; Motor Vehicle, Motorcycle, Personal and Household Goods Repair
(H) Hotel, Restaurant and Café
(I) Railway Transportation, Pipeline Transportation, Airway Transportation
(K) Renting Real Estates and Business Activities
(M) Education
(N) Sanitary Affairs and Social Services
(O) Other Social and Personal Service Activities

The Research and Development Survey (RDS), conducted annually, provide data concerning R&D expenditure and R&D personnel broken down into business enterprise, government and higher education sectors. The R&D expenditure is further broken down according to source of fund (government, business and higher education), type of cost (labor and other current costs, capital, equipment, land and buildings) type of activity, type of R&D (basic, applied and experimental development), fields of science and socio-economic objectives. R&D personnel data is available in full-time equivalent and also in head count. The personnel data is further broken down according to occupation, qualification, gender and field of science. Unfortunately, when SBS and RDS records are merged using the tax-id of enterprises, significant discrepancies are observed in certain fields where the same units appear in both databases. After performing certain consistency checks and consulting experts at TUIK, it was found that SBS data for general characteristics of enterprises, such as number of employees, annual sales, R&D expenditure and sector code[62] are more reliable than TDS data, and were therefore selected to be used in the analysis.

The import and export activities of the enterprises are consolidated in DS1 using the data from the Foreign Trade Statistics, which are based on customs declarations. The FTS data is used to compute import penetration indicator (see Table 20).

Firm age is extracted from the General Census of Industry and Establishments Year 2002 database using the establishment year of business units.

All continuous monetary variables are expressed in 2003 constant prices and deflated with three-digit sectoral price indices published by TUIK. For R&D expenditure, a fixed composite index is calculated as the deflator, considering weighted contributions of labor and capital costs[63].

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[62] Experts in TUIK reported that representative-industry of the firm was reported by the firm itself both in RDS and SBS using NACE revision 1.1 but was later updated by TUIK only in SBS data by checking the firm's annual balance-sheet. They stated that the discrepancy rate between industry codes reported by the firm and extracted from the balance-sheet was found to be almost 50% and therefore sector codes from SBS should be used in analyses.

[63] In their study which uses cross-sectional data, Jaumotte and Pain (2005, p.8) argue that "R&D expenditures are a measure of inputs rather than of outputs. Hence their 'true' deflator may not reflect the full impact of productivity increases recorded in an output measure such as the GDP deflator. One possible solution to this would be to try to construct a R&D deflator using a weighted average of (pre-tax) capital and labour costs. In practice, the problems that can result from the use of the GDP deflator depend on the extent to which the shares of labour and non-labour expenditures in total R&D expenditure have varied over time and the rate of productivity growth. If they are relatively constant, the difference is likely to be reflected in the country-specific fixed effects".

The R&D subsidy data are extracted from two sources. The RDS database provides information to create both continuous variables for sectoral and regional shares in the total sum of public RD subsidies received from different sources, and dummy variables presenting the source of R&D financing (i.e. public, university, non-profit organizations, foreign countries, international organizations and self-financed). The second source, the TUBITAK administration database, is based on the TUBITAK industrial R&D projects grant program and provides project level data for industrial R&D performers. The original records, which consist of information on every R&D project proposal submitted to the program, are reconstructed to present, annual firm-level on direct support for industrial R&D provided by TUBITAK. Two variables from annual data are created from the reconstructed database: one for the support status of the firm (at least one project must be either; (i) accepted to the program, (ii) rejected by TUBITAK or retrieved by the firm itself or (iii) funded), and a second variable for the amount of support received by the firm. Computer related research activities such as software development have special characteristics in the applied research area (OECD, 2002b). As also observed in TUBITAK's administrative data, subsidy beneficiaries in the software development industry have, in general, higher R&D intensity and R&D employee shares then funded firms in most of the manufacturing industries (Table 17). In order to investigate the effect of subsidies on manufacturing industries only, and to establish the contribution of computer-related services industry separately; DS1 is built in two versions:

1) DS1-MANUF consists of the manufacturing industries branch D, i.e. in NACE Revision 1.1, two-digit sector codes (SECTOR2) from 15 to 37;

2) DS1-TOTAL consists of computer related activities and research and development services, i.e. SECTOR2 72-73 in addition to DS1-MANUF[64].

Table 16 R&D Performers according to firm size: 2003-2006

	2003		**2004**		**2005**		**2006**		**4 years average**	
Firm size (SME<250 emp	SME	Large	SME	Large	SME	Large	SME	Large	SME	Large
Share of R&D performers (%)	6.78	27.10	9.14	32.29	9.56	29.84	6.13	27.78	7.90	29.25
	8.4		11.2		11.4		8.2		9.8	
R&D intensity (%)	0.17	0.23	0.22	0.27	0.32	0.31	0.17	0.33	0.22	0.29
R&D performer units	638	226	861	290	889	282	568	272		
Total number of units	9409	834	9345	898	9298	945	9264	979		
	10243		10243		10243		10243			

SME: Firms with number of employees<250, Source: TUIK

Table 16 shows the evolution of small and large scale R&D performers throughout the years of the study. The R&D performance of the large firms presents a stable improvement (for example, their R&D intensity rose from 0.23% in 2003 to 0.33% in 2006), whereas the number of R&D performer SMEs and their R&D intensity similarly increased until 2006, but both figures sharply declined by around 30% in 2006 compared to the previous year. This variable pattern of R&D performance of SMEs can also be observed in TUIK’s R&D survey data.

[64] In the dataset DS1, the industries with codes 51 (Business) and 74 (Sale) are excluded.

Table 17 R&D Expenditure and distribution of subsidies among industries: 2004

Industry (NACE Rev1.1)	Observation (Share %)	Mean R&D Exp. per Employee (TL)	Mean Subsidy per Employee (TL)	Subsidy / Expenditure (%)
Food (15)	1038 (15.56)	1,745	741	42.46
Textile (17)	1411 (21.15)	1,809	127	7.02
Paper (21)	192 (2.88)	213	148	69.48
Chemicals (24)	346 (5.19)	5,270	1,479	28.06
Metal (27-28)	928 (13.91)	828	107	12.92
Machinery (29)	750 (11.24)	2,367	1,406	59.40
Elect-Opt (30-33)	391 (5.86)	9,269	1,789	19.30
Transport (34-35)	388 (5.82)	8,592	437	5.07
Manuf n.e.c. (36)	469 (7.03)	2,389	442	18.50
Sale (51)	77 (1.15)	8,162	2,546	31.19
Computer (72)	60 (0.90)	7,961	3,500	43.96
Business (74)	622 (9.32)	13,091	3,223	24.62
TOTAL	**6672 (100.00)**	**5,141**	**1,329**	**25.46**

Source: TUIK and TUBITAK

Table 18 shows the distribution among the beneficiary firms with respect to the year of subsidy[65]. During 2003-2006, only 5% of the 237 beneficiary firms received TUBITAK grants in all four consecutive years. In Table 18, the firms of interest used in the matching analyses are marked with a rectangular box representing the firms that received TUBITAK grants in 2004, which is selected as the reference year. These firms are used as the treatment group in propensity scores matching analysis and the non-beneficiary firms are used as the control group.

[65] The number of firms that received grants from TUBITAK is actually 3-4 times greater than these figures. Only the beneficiary firms found in TUIK's SBS and RDS surveys were taken into account here.

Table 18 Number of subsidy beneficiary firms: 2003-2006

2003	2004	2005	2006	# firms	percentage
0	**0**	**0**	**1**	42	18
0	**0**	**1**	**0**	18	8
0	**0**	**1**	**1**	40	17
0	**1**	**0**	**0**	**25**	11
0	**1**	**0**	**1**	**3**	1
0	**1**	**1**	**0**	**19**	8
0	**1**	**1**	**1**	**44**	19
1	**0**	**0**	**0**	12	5
1	**0**	**0**	**1**	3	1
1	**0**	**1**	**0**	2	1
1	**0**	**1**	**1**	3	1
1	**1**	**0**	**0**	**9**	4
1	**1**	**0**	**1**	**1**	0
1	**1**	**1**	**0**	**3**	1
1	**1**	**1**	**1**	**13**	5
Total subsidized firms				**237**	100

1 (0): Firm did (not) receive subsidy from TUBITAK during that year

Source: TUIK and TUBITAK

The second dataset used in this study (called DS2) is based on the firm-level data from the Turkish Community Innovation Survey conducted by TUIK for the period 2004-2006. Following the 3rd edition of the Oslo Manual (2005), a harmonized questionnaire was used to collect data. Questions in sections 5, 6 and 7 of the questionnaire are directed only to innovating firms[66]. Types and amount of innovation expenditure, sources of knowledge, institutional and spatial characteristics of cooperation, and the impact of innovative activities on products, processes and environmental or health issues are reported in these sections

[66] Firms that have introduced a product or process innovation, or which have an abandoned or ongoing innovation project, are defined as “innovative” in the survey.

respectively. Section 8 collects data about halted and abandoned innovation projects in addition to an assessment of barriers to innovation, whereas section 9 in the CIS gathers data about the types of intellectual property rights protection methods employed by firms. The survey provides information about 2,173 firms; of which 780 are considered to be innovative (i.e. 36% of the survey participants are innovative firms). The industrial affiliations of the innovative firms according to NACE Rev. 1.1 classification are presented in Table 19.

Table 19 Distribution of innovative firms among industries in Turkey: 2004-2006

NACE (Rev1.1)	Industry	All Firms		Innovative Firms	
		N	%	N	%
10-14	Mining and quarrying	147	6.76	37	4.74
15-16	Food, beverages, and tobacco	114	5.25	51	6.54
17-19	Textiles, wearing, apparel, and leather	286	13.16	88	11.28
20-22	Wood, pulp, paper, printing, publishing	42	1.93	20	2.56
23-25	Petroleum, chemicals, rubber, and plastic products	94	4.33	43	5.51
26-28	Metals, metallic and non-metallic mineral products	149	6.86	66	8.46
29,34,35	Machinery and equipment n.e.c. Transport equipment	126	5.80	67	8.59
30-33	Electrical and optical equipment	41	1.89	21	2.69
36-37	Manufacturing n.e.c.	40	1.84	20	2.56
40-41	Electricity, gas, and water supply	132	6.07	38	4.87
51	Wholesale trade and commission trade	350	16.11	108	13.85
60-63	Land, water, and air transport	218	10.03	48	6.15
64-67	Telecommunications, financial intermediation	163	7.50	75	9.62
72-74	Computer and related activities, architectural and engineering activities, and related consultancy	271	12.47	98	12.56
	Total	**2173**	**100**	**780**	**100**

Source: TUIK

5.2. DETERMINANTS OF INDUSTRIAL R&D: ECONOMETRIC APPROACH

According to data used in this study, only 12% of the Turkish manufacturing firms engaged in R&D activities (i.e. they have positive R&D expenditure) in 2004. In the same way, more than 64% of the firms in Turkey participating in the national community innovation survey (CIS) do not report any innovative activity in the period of 2004-2006. In this section, the determinants of industrial R&D will be examined. The role of R&D subsidy, among other factors impacting on firms' R&D decisions, will be the center of interest of this analysis, in order to understand and isolate its relative importance.

5.2.1. Methodology, empirical model and variables

In the econometric analysis, first determinants of R&D were estimated for manufacturing industry firms using DS1-MANUF, and then the same analysis was repeated using DS1-TOTAL since it includes firms involving information technologies which are supported as a separate technology group by TUBITAK. The results from both datasets showed significant similarities; therefore, only the results obtained with DS1-TOTAL will be presented and discussed here.

The estimation method used here was selected by considering the characteristics of the data: Since almost 90% of the firms did not report any R&D expenditure in four years average for all observations, a Tobit-type modeling[67] with a left-censoring value of zero was adopted for estimating the parameters of the control variables.

[67] For details, see Tobin (1958, s. 25), who suggests a new model for data with large numbers of zeros in dependent variables by arguing that "…it is inefficient to throw away information on the value of the dependent variable when it is available".

The dependent variable of the model is the logarithm of the firm's R&D intensity. It is computed as R&D spending as a percentage of sales[68]. In econometric studies, using the logarithm of a variable is a common data manipulation for variables with highly skewed distribution such as R&D intensity in DS1 (Figure 15). In order to generate the natural logarithm of the R&D intensity for all observations, zero values are replaced with the minimum observed value in the dataset (see Aerts and Schmidt, 2006).

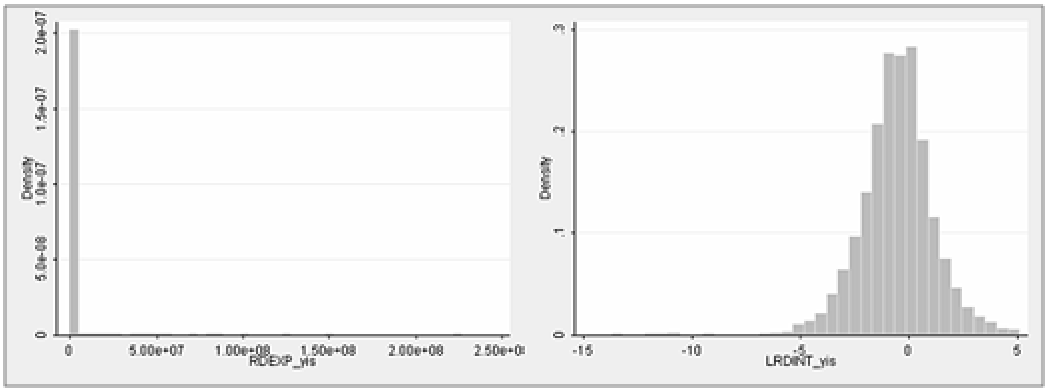

Figure 15 Histograms of the dependent variable, RDINT and LRDINT obtained from dataset DS1

[68] Although R&D intensity is used extensively to measure the degree to which selected firm or industry invests in R&D, Geisler (2000) issues two warnings about its representative power. First, there might be a gap between investment and the performance of R&D indicating that the more R&D spending does not necessarily mean "higher possibility for meaningful outcomes" (Geisler, 2000, p.100). Second, it represents only a part of innovation cost. The post-R&D expenditure is not included in it. Nevertheless R&D intensity is widely used because it is easily and reliably defined in monetary term and can be justified as a proxy for more complex and less measurable R&D and innovation activities.

Although public R&D subsidy is the center of interest as an explanatory variable in the analysis, other control variables are expected to impact on industrial R&D. These variables which are all included in the model are foreign and state ownerships, capital intensity, sectoral and the firm's own R&D intensities, technology transfer and export status, market share, import penetration and wage rate. The focus here is to determine the impact of R&D subsidies on a firm's R&D decision compared to the other determinants listed above.

Two variables are defined for R&D subsides: a firm-specific dummy variable, IFTUBITAK, to indicate whether the firm receives any subsidy from TUBITAK for its previously realized R&D activities, and a sector-specific continuous variable, SUBPUBINT_SEC indicating sector's share in total public R&D support in Turkey. SUBPUBINT_SEC is calculated as total public subsidy received by firms in an industry (identified by two-digit NACE codes) divided by the total amount of subsidies received by all industries. Being in an industry that receives a higher share from public R&D support might motivate the firm to invest more in R&D.

Since Schumpeter's (1942) rather controversial arguments on the source of innovation in the context of small and large enterprises, firm size has been one of the popular variables whose causal relationship with firm's R&D decision scholars examine. While the large firms are found to have higher potential of internal finance and easier credit access for conducting costly R&D projects and long-term programs, SMEs can involve informal R&D (Kleinknecht, 1989) without having a regular R&D department or dedicated R&D budget. In this study, as the literature suggests, both number of employees (dummy variable) and the logarithm of the firm's annual sales (i.e. income from production output) are used in separate models to represent firm size. The impact of the number of employees is also tested with the help of four dummy variables for groups of firms having less than 20, 20-249, 250-499 or more than 500 employees, respectively (the omitted category is less than 20 employees).

Technology transfer is introduced into the model as a proxy of dummy variable, TECHXFER, indicating whether the firm reports any purchase of technology licenses or knowhow agreements from abroad[69]. The dataset DS1 shows that R&D performers report almost 5 times more expenditure on technology transfer than non-performers, which increases the expectation of a positive effect on industrial R&D.

The foreign ownership[70] of the firm is another important variable where conflicted results for its effect on private R&D investment are observed in the literature. In developing countries, foreign ownership may lead to lower R&D expenditure, due to appropriability concerns and skill constraints; therefore, the foreign partner generally chooses to conduct R&D in its home base. For example, the share of R&D undertaken in foreign subsidiaries was only 11% of the total business R&D of 12 major OECD countries (OECD, 1998b). However, generous public incentives such as R&D tax reliefs or public grants may positively influence the firm’s decision to make R&D investments in the host country.

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[69] Suggested by Özçelik and Taymaz (2008).

[70] A dummy variable, IFFOR is created in DS1 equal to 1 if the firm’s foreign ownership is greater than 10%, 0 otherwise.

Public ownership is also introduced into the model with a dummy variable, IFPUB for examining the existence of any differences in the R&D decision of state-owned enterprises.

As a dummy variable, export status of the firm is included in the model since exporting is expected to increase the future return of R&D investments due to the characteristic of market expanding potential. Moreover, it also measures competitive pressures arising from world market which might be more influential than competitive pressures existing on the domestic market for leading firms to innovate.

Import penetration is also introduced by creating a continuous variable, IMPPEN2, calculated as imports divided by summation of sales plus imports of the firm. The import of capital goods with embodied foreign R&D may help the firm to increase its knowledge stock and absorptive capacity through learning by using and imitating.

The firm's capital intensity, one-year lagged sectoral R&D intensity as the proxy of technology spillovers[71], wage rate as the proxy for the skill level and degree of concentration of the sales (i.e. Herfindahl index) as the proxy for market structure are other candidate variables that are expected to contribute to the firm's R&D incentives. Table 20 includes a brief description of all the variables used in different models estimated in this part of the thesis.

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[71] Sectoral R&D intensity measures the average R&D intensity of the other firms in that industry which might be used for inter-industry spillover (Taymaz, 2001)

Table 20 Description of variables: Analysis on determinants of R&D

LRDINT <dependent variable>	Natural logarithm of firm's R&D intensity calculated by firm's annual R&D expenditure divided by total sales
IFEMP_1TO19	A dummy variable indicating if the firm size is less than 20 (omitted variable)
IFEMP_20TO249	A dummy variable indicating if the firm size is between 20 and 249
IFEMP_250TO499	A dummy variable indicating if the firm size is between 250 and 499
IFEMP_500MORE	A dummy variable indicating if the firm size is more than 499
LREVPROD <alternate firm size >	Natural logarithm of total production sales
IFTUBITAK	A dummy variable indicating if the firm receives grant from TUBITAK in that year
IFFOR	A dummy variable to indicate if the firm's foreign share is more than 10 %
IFPUB	A dummy variable to indicate if the firm has any public share
IFEXPO	A dummy variable to indicate if the firm reports any export
IFTECHXFER	A dummy variable to indicate if the firm purchase any technology license or knowhow agreement from abroad
LCAPINT	Natural logarithm of firm's capital intensity calculated by firm's capital depreciation divided by total number of employees
LWAGE_PP	Natural logarithm of firm's average wage per person
SUBPUBINT_SEC	Total public subsidy received by firms in the same industry (identified by 2 digits NACE codes) divided by total amount of subsidies received by all industries
RDINT_SEC	Sectoral R&D intensity calculated by total R&D expenditure of all the firms in an industry divided by total sales of those firms
HERFINDAHL	Herfindahl index of sales concentration at the (four-digit) sector level, calculated as the sum of squares of market shares of firms
IMPPEN2	Imports divided by sales plus imports minus exports of the firm

5.2.2. Estimation results and analysis

Two sets of TOBIT models are used for the analysis. The first set consists of three models designed to estimate the effects of the abovementioned control variables on the R&D intensity (i.e. annual share of R&D expenditure in total sales of the firm) realized in 2006. The values of the control variables are obtained from 2004 (i.e. lagged two years)[72] for the first model, 2005 for the second model and from 2006 for the third. The similar models exist in the second set as well, with the exception of firm size, which is advocated by the logarithm of production sales in the first set of models and by number of employees in the second set. The results are presented in Table 21 and 22 and illustrated by Figures 16 and 17.

In both sets of models (Table 21 and 22), R&D subsidies are found to be an important determinant of the business R&D intensity in 2006. In model set 1 (when firm size is measured by the logarithm of sales), the marginal effect for IFTUBITAK show that, for all the other control variables given, the existence of a TUBITAK grant increases the logarithm of the R&D intensity of firms by more than 100%. The difference due to the year of receiving the grant is minimal: In 2006 the increase in logarithms of firm's R&D intensity is 102.1, 107.5 and 108.1 percent, when it received TUBITAK grant in 2004, 2005 and 2006 respectively. This is an meaningful observation since firms; in general, tend to increase their R&D spending even when they have merely been informed about the positive decision of funding by the agency.

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[72] Lagged values are used to mitigate a possible endogeneity problem for some explanatory variables and to examine lagged effect of explanatory variables on R&D investment

There are two variables in the model related to sectoral variations in provided R&D support and R&D intensity. The effect of a 1 percentage point change in *industry share in total R&D support* on the R&D intensity in 2006 is significant and around 0.2%. The marginal effect of this variable did not change in 2005 and 2006. However, the effect of a 1% change in sectoral R&D intensity in 2004 on the log of R&D intensity in 2006 is observed as 0.128%. The impact drops to 0.074 and 0.077% respectively for 2005 and 2006. That is, there seems to be almost no causal relation between the firm's R&D investment and the recent or lagged share of the R&D subsidy of the firm's industry. On the other hand, firms in the industries with higher average R&D intensity are observed to have higher levels of R&D expenditure, probably to keep up competition.

It can be seen in Figure 16 that import penetration and firm size (the logarithm of total sales) are also important determinants respectively where same as the effect of R&D support; their effects on R&D intensity are maximum for the values extracted in 2006. That is, their immediate influences are more effective than their lagged impacts. For the year 2006, a 1 percentage point increase in import penetration increases the firm's logarithm of R&D intensity by 0.18%. In the same way, a 1 percentage point rise in the logarithm of total sales (i.e. firm size) raises the logarithm of the firm's R&D intensity by 0.158%. The observation of the effect of firm size on R&D investment (considering large firms' ability to offer higher salaries to qualified employees and greater access capacity to external finance sources compared to SMEs) is in line with previous findings of empirical studies on large firms' R&D and innovation performance[73].

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[73] Acs and Audretsch, 1987; Santarelli and Sterlacchini, 1990

Other variables included in the models show characteristics of stronger lagged effect, with the exception of IFPUB, state ownership, which has no significant effect and HERFINDAHL, sales concentration, which has a statistically significant marginal effect pointing to an impact of 0.002%.

If the firm purchased any knowhow or licenses from abroad in 2004, the maximum effect of this technology transfer is observed on the logarithm of the firm's R&D intensity in 2006 (i.e. 11%). The contribution of technology transfer goes down to 9 and 7% respectively if the purchase was in 2005 and 2006. It should be considered an expected result, since it takes time for an R&D performer to absorb new technologies for adoption into its innovative activities.

Among all the control variables, foreign ownership is the only determinant which turns out to have a statistically significant negative effect at the 5% level. Compared to a domestic firm, foreign firms seem to invest 5 to 7% less in R&D, which may not be a surprising result since, as discussed before; conducting R&D in the home country of the foreign partner may be a preference for these firms.

The export status of the firm is the only determinant in the model which seems to affect the firm's R&D investment, by around 8 to 10% regardless of the measurement year.

Finally, the capital intensity and the industry share in total public support have significant but almost nil effect on the firm's R&D investment[74]. This is rather a surprising result since both variables are expected to contribute to R&D investment.

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[74] The result for the capital intensity is in line with Czarnitzki and Toole (2008).

In the second set of models, the number of employees is used as the proxy for firm size. As can be observed in Table 22 and Figure 17, the results are quite in line with the observation from the models in which total sales is used for firm size. With respect to a firm with less than 20 employees being a firm with a number of employees greater than 499 in 2004, 2005 and 2006, increases log of R&D intensity in 2006 was 81.5%, 51% and 61% respectively. This observation conforms to the previous empirical evidence concerning the R&D behavior of large firms. The effect of firm size diminishes gradually as the size gets smaller, and drops to 13.2% when the number of the firm's employees is between 20 and 249 in 2004.

Table 21 TOBIT estimation: Determinants of R&D intensity, firm size = total sales: 2006

	Dependent variable: Ln(R&D intensity) in year 2006					
Variables	**2004**	SE	**2005**	SE	**2006**	SE
R&D support	**1.021*****	(0.0407)	**1.075*****	(0.0374)	**1.081*****	(0.0375)
Ln (Sales)	0.151***	(0.0176)	0.1390***	(0.0177)	0.158***	(0.017)
Ln (capital intensity)	0.006***	(0.002)	0.0142***	(0.0027)	0.008***	(0.0028)
Sector share in total support	0.002*	(0.0010)	0.002**	(0.0012)	0.003***	(0.0009)
Sectoral R&D intensity	0.128***	(0.008)	0.074***	(0.0050)	0.077***	(0.0055)
Technology Transfer	0.109***	(0.0253)	0.090***	(0.0256)	0.057***	(0.0189)
Foreign ownership	-0.077**	(0.0317)	-0.0538*	(0.0317)	-0.0662**	(0.0317)
State ownership	0.021	(0.0716)	-.0.031	(0.0676)	-0.006	(0.0669)
Export status	0.087***	(0.0177)	0.089***	(0.0176)	0.078***	(0.0177)
Ln (wage rate)	0.139***	(0.0150)	0.115***	(0.0146)	0.128***	(0.0147)
HHI concentration	0.002***	(0.0006)	0.002***	(0.0005)	0.002***	(0.0005)
Import penetration	0.147***	(0.0433)	0.144***	(0.0444)	0.177***	(0.0415)
Observations	10,162		10,169		10,156	
Log likelihood	-4258.95		-4258.77		-4269.03	
LR chi2(12)	1156.61		1158.05		1135.52	
Prob > chi2	0.0000		0.0000		0.0000	
Pseudo R2	0.1196		0.1197		0.1174	

Standard errors in parentheses, unconditional marginal effects are calculated at unit values for dummy variables and at the means of the continuous variables.
*** p<0.01, ** p<0.05, * p<0.1

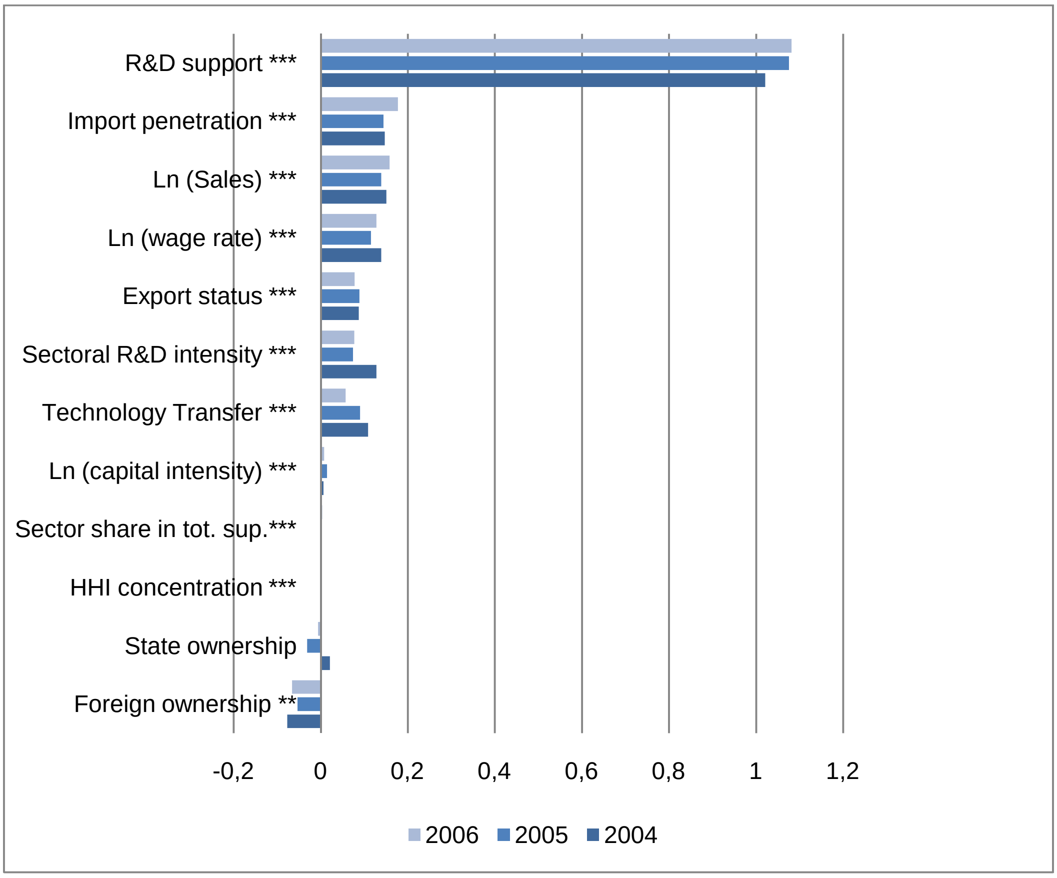

Figure 16 Determinants of business R&D intensity, firm size = total sales

Source: Author’s elaboration

Table 22 TOBIT estimation: Determinants of R&D intensity, firm size = number of employees: 2006

	Dependent variable: Ln (R&D intensity) in year 2006					
Variables	**2004**	SE	**2005**	SE	**2006**	SE
R&D support	**1.047*** **	(0.0386)	**1.095*** **	(0.0365)	**1.089*** **	(0.0365)
Size_20to249	0.132***	(0.0465)	0.0880**	(0.0444)	0.0896**	(0.0386)
Size_250to499	0.731***	(0.0528)	0.396***	(0.0514)	0.402***	(0.0465)
Size_>499	0.815***	(0.0538)	0.509***	(0.0521)	0.609***	(0.0471)
Ln (capital intensity)	0.00671***	(0.0022)	0.0147***	(0.00267)	0.00874***	(0.0028)
Sector share in total support	0.00144	(0.0009)	0.00252**	(0.00115)	0.00265***	(0.0009)
Sectoral R&D intensity	0.118***	(0.0078)	0.0719***	(0.00486)	0.0737***	(0.0054)
Technology transfer	0.113***	(0.0241)	0.0992***	(0.0249)	0.0641***	(0.0184)
Foreign ownership	-0.0731**	(0.0302)	-0.0520*	(0.0311)	-0.0624**	(0.0309)
State ownership	0.0574	(0.0673)	0.000548	(0.0650)	0.0230	(0.0645)
Export status	0.0927***	(0.0166)	0.0984***	(0.0170)	0.0879***	(0.0171)
Ln (wage rate)	0.141***	(0.0142)	0.122***	(0.0141)	0.131***	(0.0142)
HHI concentration	0.00233***	(0.0005)	0.00217***	(0.00052)	0.00192***	(0.0005)
Import penetration	0.126***	(0.0410)	0.123***	(0.0431)	0.159***	(0.0402)
Observations	10,223		10,223		10,223	
Log likelihood	-4262.16		-4266.97		-4279.29	
LR chi2(14)	1159.55		1149.93		1125.29	
Prob > chi2	0.0000		0.0000		0.0000	
Pseudo R2	0.1197		0.1187		0.1162	

Standard errors in parentheses, unconditional marginal effects are calculated at unit values for dummy variables and at the means of the continuous variables.
*** p<0.01, ** p<0.05, * p<0.1

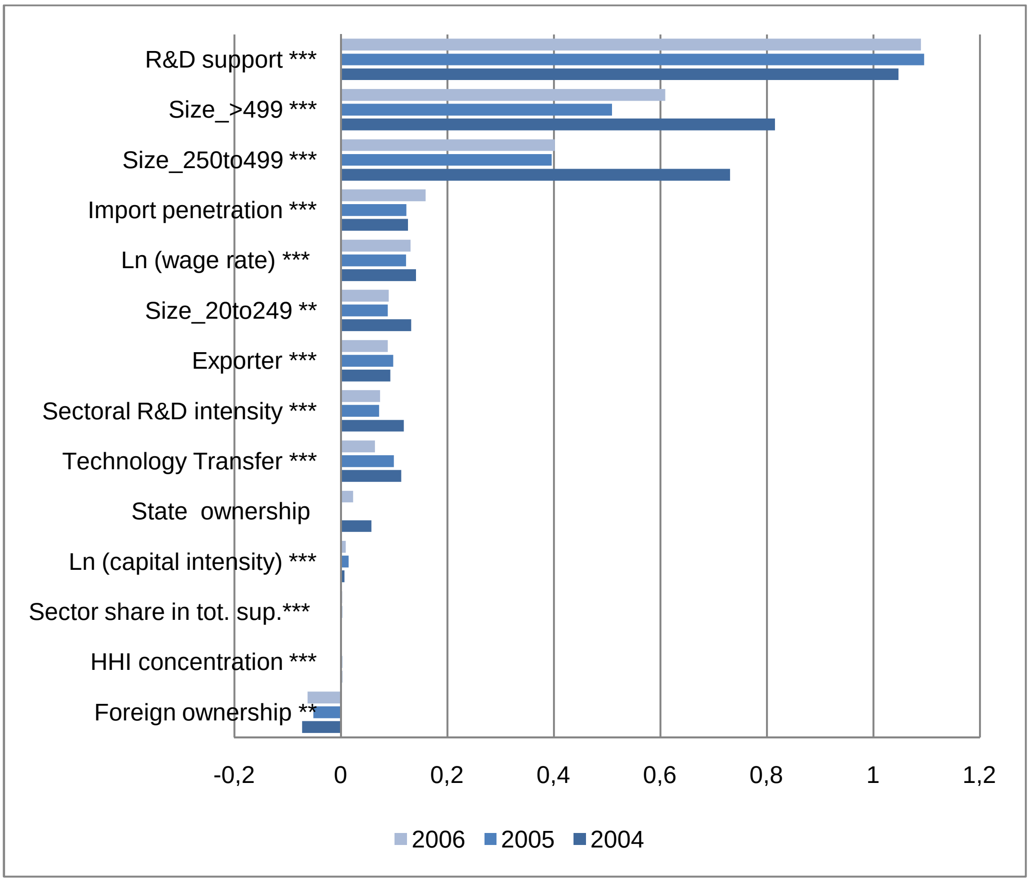

Figure 17 Determinants of business R&D intensity, firm size = number of employees

Source: Author's elaboration

5.3. IMPACT OF R&D SUBSIDIES ON PRIVATE R&D: MATCHING METHOD APPLIED TO STRUCTURAL BUSINESS SURVEY AND R&D SURVEY DATA

In the previous section, employing an R&D demand equation, R&D subsidies were found to be an important determinant of firm's R&D investment. In this section, the effects of subsidizing R&D through public resources will be examined via three variables related to the funded firm's R&D input and two variables that may be considered as R&D output. As explained in detail before, matching methods using comparison techniques between treated and untreated groups provide a reliable way to measure the effects of a public intervention by taking care of the counterfactual effect, and also reducing the selection bias problem. Therefore, for an empirical evaluation of the effects of TUBITAK's industrial R&D grants on the beneficiary firms, propensity score matching, which has frequently been employed in recent evaluation studies was adopted in this study. The method was then further improved by combining it with the conditional difference-in-differences (CDiD) estimation technique for controlling: (i) macroeconomic trends which are common for all individuals and (ii) unobserved heterogeneity that may be observed between the treated and untreated groups[75].

[75] Heckman et al. (1998) point to the advantages of using CDiD with non parametric matching methods to control selection problems. Blundell and Costa Dias (2002) mention the possibility of using repeated cross-section data in the method of repeated matching with differences-in-difference.

5.3.1. Methodology, empirical model and variables

The empirical model is based on Equation 12 derived in Chapter 2:

$$\tau_{PS}^{ATT} = E(Y_i^T | S_i = 1, P(X_i)) - E(Y_i^C | S_i = 0, P(X_i)) \qquad (13)$$

where τ_{PS}^{ATT} is the estimated average treatment effect on treated, S_i is the treatment status for firm *i*, Y_i^T and Y_i^C are the output of the treated and non-treated firm *i* respectively. Box 1 presents the details of the matching protocol developed by Aerts and Schmidt (2008).

Specify and estimate a probit model to obtain propensity scores $\boldsymbol{P(X)}$.

Restrict the sample to common support: Delete all observations on treated firms with probabilities larger than the maximum and smaller than the minimum in the potential control group (This step is also performed for other covariates that are possibly used in addition to the propensity score as matching arguments).

Choose one observation among the treated firms and delete it from the sample

Calculate the Mahalanobis distance (MD) between this firm and all non treated firms to find the most similar observation:

$$\boldsymbol{MD_{ih}} = (\boldsymbol{Z_h} - \boldsymbol{Z_i})'\boldsymbol{\Omega^{-1}}(\boldsymbol{Z_h} - \boldsymbol{Z_i})$$

Where for the current analysis, $\boldsymbol{Z}$ contains the estimated propensity score $P(\boldsymbol{X})$ and the firm size (logarithm of production sales, LREVPROD) as additional arguments in the matching function. $\boldsymbol{\Omega}$ is the empirical covariance matrix of these arguments, based on the sample of potential controls.

Select the observation with the minimum distance from the remaining sample. (Do not remove the selected control from the pool of potential controls, so that it can be used again.)

Replace the selected control into the sample and repeat steps 2 to 5 for all treated firms

Using the matched control group, the average treatment effect on the treated ($\boldsymbol{\hat{\tau}_{PS}^{ATT}}$) thus can be calculated as the mean difference of the matched samples:

$$\boldsymbol{\hat{\tau}_{PS}^{ATT}} = \frac{\boldsymbol{1}}{\boldsymbol{n^T}}\left(\sum_{i} \boldsymbol{Y_i^T} - \sum_{i} \boldsymbol{\hat{Y}_i^C} \right)$$

Where $\boldsymbol{\hat{Y}_i^C}$ being the counterfactual output for firm *i* and $\boldsymbol{n^T}$ is the sample size (of treated firms). Note that the same observation may appear more than once in that group (matching with replication).

Source: Aerts and Schmidt (2008)

Box 1 Matching protocol algorithm

If a two-period time domain is introduced into the model by adopting difference-in-differences methodology as it is depicted with links B and C in Figure 18, the equation given at Step 7 in Box 1 can be rewritten as

$$\hat{\tau}_{PS}^{DiD} = \frac{1}{n^T}\sum_i\left[(Y_{it_1}^T - Y_{it_0}^C) - \sum_h(Y_{ht_1}^C - Y_{ht_0}^C)\right] \qquad (14)$$

Where the indices $\boldsymbol{i}$ and $\boldsymbol{h}$ are used for treated and non-treated firms respectively, $\boldsymbol{T}$ and $\boldsymbol{C}$ denote treatment status, $\boldsymbol{t_0}$ and $\boldsymbol{t_1}$ are pre-treatment and post-treatment periods respectively.

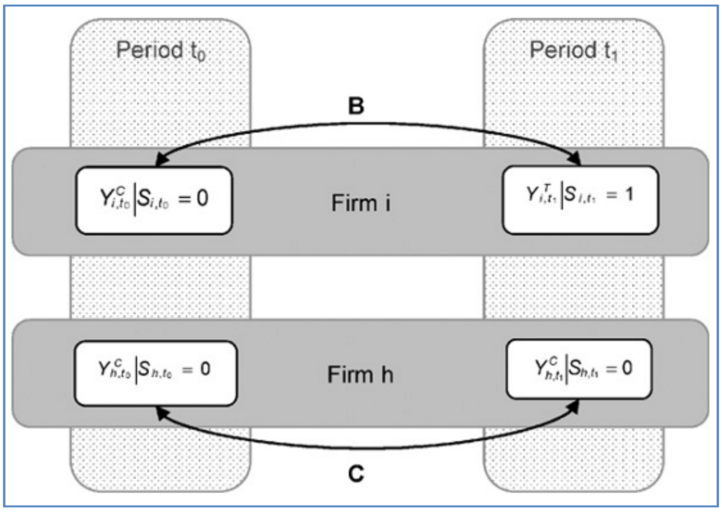

Figure 18 Illustration of difference-in-differences methodology (DiD)

Source: Aerts and Schmidt (2008)

The model can be further developed as illustrated with link A in Figure 19 to bring in conditional DiD methodology as suggested by Blundell and Costa Dias (2002) for use with repeated cross section data (RCS) instead of panel data. They warn however, that RCS can only be used if the composition of the treated and control groups do not change over time due to, for example, a change in the intervention rules. Fortunately, there were no significant changes in TUBITAK's subsidy program in the years under focus of analysis and therefore, conditional DiD with repeated cross section data was adopted in this empirical study. The matching estimator with this approach is

$$\hat{\boldsymbol{\tau}}_{PS}^{cDiD} = \frac{1}{n^T} \sum_{i \in T_1} \left\{ \left[Y_{it_1}^T - \sum_{h \in T_0} Y_{iht_0}^C \right] - \left[\sum_{h \in C_1} Y_{iht_1}^C - \sum_{h \in C_1} Y_{iht_0}^C \right] \right\} \quad (15)$$

Where T_0, T_1, C_0 and C_1 are treatment and control groups before and after the treatment respectively (for a more detailed discussion see Blundell and CostaDias, 2002). $\hat{\boldsymbol{\tau}}_{PS}^{cDiD}$ is used in the analysis as the matching estimator with t_0=2003 and t_1= 2006.

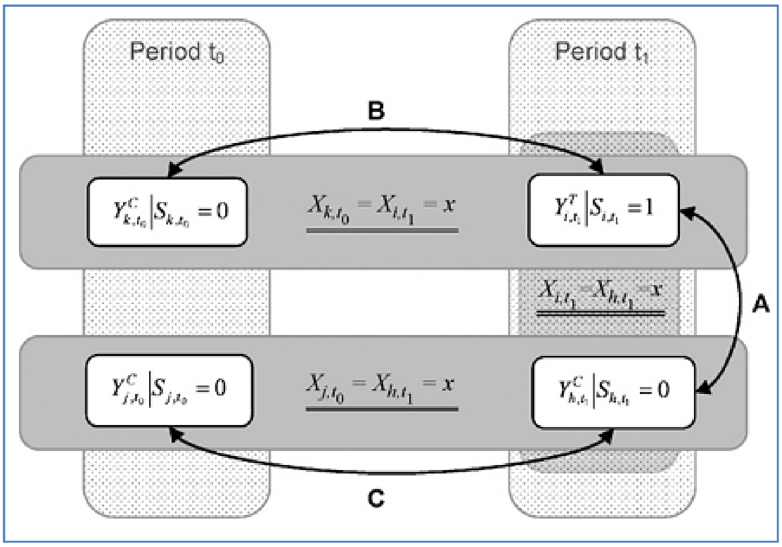

Figure 19 Illustration of conditional difference-in-differences methodology (CDiD)

Source: Aerts and Schmidt (2008)

Three essential criteria, described by Blundell and Costa Dias (2002) for the creation of adequate control groups are satisfied in this study. First, the comparisons are drawn from the same compilation of firms. Second, the data used for selecting units for treated and control groups is extracted from the same set of surveys. Third, the constructed dataset with 10,243 observations[76] in each year is rich enough to clearly make a distinction between individuals. The dependent and control variables used in this part of the study are presented in Table 23.

[76] The number of observations per year reduces from 10,243 to 6,608 after the data manipulations for industry filtering and outlier cleaning.

Table 23 Description of variables: Matching in SBS data

LRDINT	Natural logarithm of firm's R&D intensity calculated by firm's annual R&D expenditure divided by total sales
SRDEMP	Share of R&D personnel in total number of employees in percentage
LRDEXP_PP	Firm's annual R&D expenditure per person in TL
EXPOINT	Export intensity in percentage (exports divided by sales)
IMPOINT	Import intensity in percentage (imports divided by sales)
LREVPROD	Natural logarithm of total production sales
IFTUBITAK	A dummy variable indicating if the firm is funded by TUBITAK
FIRMAGE	Firm age in 2004 (in years)
IFTECHXFER	A dummy variable to indicate if the firm purchased any technology license or knowhow agreement from abroad
LCAPINT	Natural logarithm of firm's capital intensity calculated by firm's capital depreciation divided by total number of employees
LWAGE_PP	Natural logarithm of firm's average wage per person
SUBPUBINT_SEC	Total public subsidy received by firms in the same industry (identified by two-digit NACE codes) divided by total amount of subsidies received by all industries
PSMODEL0	Propensity scores calculated through the probit model in percentage
LOWTECH	A dummy variable to indicate if the firm belongs to a low technology industry (NACE 1.1 codes 15-22 or 36-37) in 2004
MEDLOTECH	A dummy variable to indicate if the firm belongs to a low-medium technology industry (NACE 1.1 codes 23, 25-28 or 351) in 2004
MEDHITECH	A dummy variable to indicate if the firm belongs to a medium-high technology industry (NACE 1.1 codes 241-246, 29, 31, 34, 352, 354 or 355) in 2004
OTHER	A dummy variable to indicate if the firm belongs to any other industry than abovementioned industries in 2004 (omitted variable)

Our thesis aims at examining possible input and output additionalities caused by TUBITAK's R&D grants program for private R&D projects. For the input additionality, R&D intensity, annual R&D expenditure per employee and share of R&D personnel in total number of employees are selected as the dependent variables. The question of whether subsidies have a crowding out effect on R&D investment will be tested with the first two variables. Export intensity and import intensity of the firm are selected as the dependent variables for examining the output additionality[77].

To represent the grant status of the firm, IFTUBITAK is employed. This is a dummy variable that takes a value of 1 for a specific year if the firm's R&D project is funded by TUBITAK in that year. Table 24 depicts the number of program beneficiaries extracted from TUBITAK's administrative data and TUIK's SBS data. Unfortunately, only around 30% of the total number of firms funded by TUBITAK could be found (i.e. matched) in TUIK's survey data. Based on the data from TUIK, the share of the program beneficiaries in R&D performer firms seems to increase from 5.3% in 2003 to 17.7% in 2006[78].

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[77] Several other firm characteristics such as total sales, productivity, wage rate and total number of employees of the firm were also used in the model and found to produce no significant additionality. The impact of subsidies on these variables should be tested with a longer time series of data when it becomes available in the future.

[78] It should be noted that in 2006, the number of R&D performers showed a decrease of 28% compared to previous year. In fact, while the number of R&D performer large firms were similar with previous years; lower number of SMEs seemingly to be involved in R&D activities, as can be observed in Table 16.

Table 24 Number of funded firms in TUBITAK and TUIK data (first dataset, DS1): 2003-2006

	2003	2004	2005	2006
Actual number of funded firms by TUBITAK	297	326	452	458
Funded firms by TUBITAK Matched in TUIK's data	46	117	142	149
Total R&D performer firms in TUIK data	864	1151	1171	840
Share of funded firms in R&D performers (%)	5.33	10.2	12.1	17.7
Share of funded firms in all firms (%)	0.45	1.14	1.39	1.46

Source: TÜBİTAK and TÜİK

Table 25 shows the mean values of the key variables for beneficiary and non-beneficiary firms, before and after the matching process in 2003 which is assumed to be the pre-treatment year. After the matching, the mean values and associated t-test results indicate that treated and control groups are successfully balanced according to all control variables in the model. The descriptive statistics also show the existence of the selection bias since there are significant differences in the mean values between beneficiary firms and total population before matching.

Table 25 Descriptive statistics for unmatched and matched samples in 2003

	Before matching			After matching		
	Treated	Control	p>|t|[a]	Treated	Control	p>|t|[a]
Number of observations	**97[b]**	**6608**		**96[b]**	**96**	
Foreign ownership	0.224	0.054	0	0.227	0.213	0.845
RD intensity	5.418	0.149	0	3.35	2.375	0.458
Ln (wage rate)	9.481	8.578	0	9.465	9.482	0.894
Ln (capital intensity)	8.558	7.395	0	8.548	8.49	0.835
Ln (sales)	17.215	15.238	0	17.244	17.241	0.992
Export intensity	24.184	17.106	0.028	23.354	25.626	0.61
Age (years)[c]	21	14.389	0	21.2	22.52	0.572
Technology transfer	0.224	0.062	0	0.227	0.293	0.355
Sectoral share in total support	0.068	0.047	0.002	0.068	0.069	0.778
Propensity score	0.145	0.098	0	0.133	0.131	0.929

[a] p-value of two sided t-test on mean equality

[b] Only one firm is dropped due to common support limitation.

[c] in 2004

5.3.2. Estimation results and analysis

The results acquired from the probit estimation to calculate the probability of receiving a TUBITAK R&D project grant is depicted in Table 26. R&D intensity, wage rate, total sales and industry share in total public support affect positively the probability of receiving public R&D subsidies at a 1% significance level. Moreover, capital intensity and technology transfer are also determining factors concerning the firm’s propensity to receive R&D grants at 5 or 10% significance levels. The results indicate marginal effects associated with firm age, export intensity and belonging to a medium-high industry are statistically insignificant. However, foreign ownership and belonging to any industry other than medium-high technology industries cause a significant negative effect. The entry policies of the funding agency for giving higher priority to high-tech domestic companies might play a significant role in these results.

Table 26 Probit estimation for receiving R&D subsidy in 2004

Variables (in 2003)	Coefficients	Std Err.	Marginal effects	Std Err.
RD intensity	0.081***	0.0247	0.001***	0.0003
Foreign ownership	-0.259*	0.1599	-0.001**	0.0007
Ln (wage rate)	0.240***	0.0862	0.002**	0.0008
Ln (capital intensity)	0.061**	0.0304	0.0005*	0.0003
Ln (sales)	0.221***	0.0366	0.002***	0.0004
Export intensity	0.0006	0.0019	$4.48x10^{-6}$	0.00001
Age (2004)	-0.001	0.0036	$-7.02x10^{-6}$	0.00003
Technology transfer	0.322**	0.1330	0.004	0.0024
MedHiTech (2004)	0.051	0.2050	0.0004	0.0018
MedLowTech (2004)	-0.523**	0.2050	-0.003**	0.0012
LowTech (2004)	-1.047***	0.2468	-0.011***	0.0038
Sector share in total support	2.915***	1.0488	0.023***	0.0081
Number of observations	6,608			
Log Likelihood	-339.7			
Pseudo R2	0.3284			

*** p<0.01, ** p<0.05, * p<0.1

In the next step, a nearest neighbor matching method with Mahalanobis distance calculation (see Box 1 for the flow of the analysis) was used to find counterpart firms to treated firms from the control group[79]. Propensity score estimates together with firm size, which is the logarithm of the number of employees, were used in the matching process. Kernel density estimates for propensity scores and the logarithm of the number of employees before and after the matching procedure are shown in

[79] *psmatch2* command, written by Leuven and Sinaesi (2003), is employed in STATA 10 for the calculation of propensity score matching.

Figure 20, which indicates that initially different distributions reach a sufficient overlap after the matching.

The estimations of the average treatment effect on treated firms are performed employing both a simple (propensity score) matching protocol and matching with conditional DiD for the post-treatment years of 2005 and 2006. Three R&D input variables, namely R&D intensity, R&D expenditure per person and share of R&D personnel in total number of employees, and two R&D output variables, namely export and import intensities are the selected estimands to examine the average treatment effects of TUBITAK's industrial R&D subsidy program on its beneficiary firms.

Our both datasets, DS1 and DS2 provide sampling weights. The use of weights in matching estimations is discussed in Reynolds and DesJardins (2009). They concluded that the use of the sampling weight of the control units is irrelevant in nearest neighbor matching algorithm because in this method, for each treated unit, only one unit is selected from the control group and the number of other untreated units is unrelated. Therefore, the sampling weight is not considered in our matching method analyses.

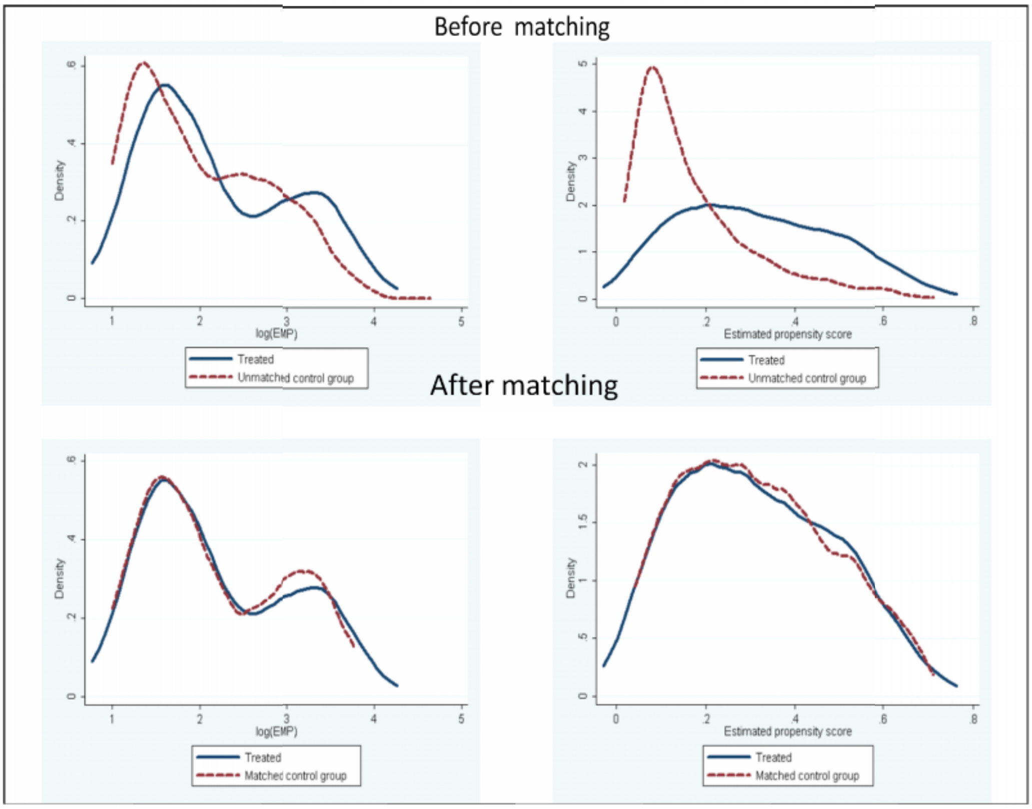

Figure 20 Kernel density estimates of firm size and propensity score distributions

5.3.2.1. Input Additionality

Table 27 Average Treatment Effect on the Treated Companies and DiD: R&D intensity in percentage

Variable	Status	Subsidized Firms	Control Group (all firms)	ATT	ATT (bootstrap)
R&D intensity (2006)	unmatched	5.07 (97 firms)	0.22 (6.511 firms)		
	matched	4.43 (96 firms)	1,05 (96 firms)	3.38***	3.38***
R&D intensity (2005)	unmatched	5.11 (97 firms)	0.21 (6.511 firms)		
	matched	4.13 (96 firms)	1.39 (96 firms)	2.74***	2.74***
Change in R&D intensity (2003-2006) : DiD	unmatched	-0.14 (97 firms)	0.01 (6.511 firms)		
	matched	0.91 (96 firms)	-1.02 (96 firms)	1.93	1.93
Change in R&D intensity (2003-2005) : DiD	unmatched	1.67 (97 firms)	0.14 (6.511 firms)		
	matched	2.24 (96 firms)	-1.15 (96 firms)	3.39**	3.39**

As can be seen in Table 27, which presents the results of the first set of matching procedures, receiving public R&D subsidies in 2004 significantly increased the firm's post-treatment R&D intensity. After the matching procedure, funded firms are observed to have average R&D intensities of 4.13 and 4.43% in 2005 and 2006 respectively, whereas the average R&D intensity of non–treated counterparts in the same years is 1.39 and 1.05%. The difference of 2.74 and 3.38% in 2005 and 2006 respectively can be interpreted as the average treatment effect, and it is statistically significant at the 1% level. When conditional DiD methodology is adopted in the matching process as explained in the previous section, a 3.39% contribution of the program can be observed between the years 2003 (i.e. pre-treatment year) and

2005 at 5% significance. However, the DiD estimation between 2003 and 2006 reveals no significant treatment effect even after the bootstrap[80] post-manipulation in STATA[81]. The probable reason for observing significant result for the effect of subsidies on R&D intensity over the period of 2003-2005 but not in 2003-2006 can be that, the longer term effect can not be observed. in the available dataset we used.

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[80]Bootstrapping is a common *resampling method* (Wooldridge, 2001)which can be used alternative to asymptotic approximation for producing standard errors, t-statistics and-p-values. As Reynolds and DesJardins (2009) argued, it is one of the most common methods for obtaining standard errors in matching methods. Bootstrapping is a technique to construct confidence intervals by randomly resampling data as many times as requested to create a distribution of treatment effects. The method is assumed to be "computationally intensive" since the whole matching procedure is estimated for each treated unit (Reynolds & DesJardins, 2009).

[81] STATA 10 includes built in routines for bootstrapping.

Table 28 Average Treatment Effect on the Treated Companies and DiD: R&D expenditure per employee (in Turkish liras)

Variable	Status	Subsidized Firms	Control Group (all firms)	ATT	ATT (bootstrap)
R&D expenditure per employee (2006)	unmatched	6,159 (97 firms)	225 (6.504 firms)		
	matched	5,558 (96 firms)	1,768 (96 firms)	3,790***	3,790***
R&D expenditure per employee (2005)	unmatched	5,830 (97 firms)	337 (6.504 firms)		
	matched	5,210 (96 firms)	1,862 (96 firms)	3,348***	3,348***
Change in R&D expenditure per employee (2003-2006) : DiD	unmatched	1,062 (97 firms)	-139 (6.504 firms)		
	matched	1,123 (96 firms)	-262 (96 firms)	1,385	1,385
Change in R&D expenditure per employee (2003-2005) : DiD	unmatched	2,422 (97 firms)	-76 (6.504 firms)		
	matched	2,209 (96 firms)	-524 (96 firms)	2,733***	2,733***

The results of the second set of matching estimations for R&D expenditure per employee are presented in Table 28. After the matching procedure, beneficiary firms are observed to have average R&D expenditure per employee of 5,210 TL and 5,558 TL in 2005 and 2006 respectively, whereas the average R&D intensities of non–treated counterparts in the same years are 1,862 TL and 1,768 TL. The difference of 3,348 TL and 3,790 TL in 2005 and 2006 respectively, which are found to be statistically significant below 1% and can be interpreted as the average treatment effect. When conditional DiD methodology was adopted in the matching process as explained in the previous section, a 3.39% contribution of the program can be observed between the years 2003 (i.e. pre-treatment year) and 2005 at 5% significance. As in the previous case, the DiD estimation between 2003 and 2006 reveals no significant treatment effect, which might indicate that the longer-term effect cannot be observed with the available sample data.

As explained before, one of the principle questions in ex-post impact assessment of R&D subsidies is whether a full or partial crowding out effect is observed on the beneficiary firm's R&D investment behavior[82]. Evidence obtained in the first two parts of the analysis validate a significant treatment effect on firm's R&D investment and, therefore, full crowding out effect can be rejected. To test partial crowding out, firm's net R&D investment without the subsidy should be used in the model, which does not exist in the dataset. However, a rough calculation from TUBITAK's administrative data for the years under investigation reveals that the average annual subsidy per employee varied between 1,500 TL and 2,800 TL. Since these values are still below the ATT differences given in Table 29 for the years 2005 and 2006, the hypothesis of a partial crowding out effect of the program can confidently be rejected.

Table 29 Average Treatment Effect on the Treated Companies and DiD: Share of R&D personnel in total employment in percentage

Variable	**Status**	**Subsidized Firms**	**Control Group (all firms)**	**ATT**	**ATT (bootstrap)**
Share of R&D personnel (2006)	unmatched	9.8 (97 firms)	0.6 (6.504 firms)		
	matched	9.3 (96 firms)	2.3 (96 firms)	7.0***	7.0***
Share of R&D personnel (2005)	unmatched	8.3 (97 firms)	0.6 (6.504 firms)		
	matched	8.0 (96 firms)	2.5 (96 firms)	5.5***	5.5***
Change in the share of R&D personnel (2003-2006) : DiD	unmatched	4.5 (97 firms)	-0.8 (6.504 firms)		
	matched	3.8 (96 firms)	-0.6 (96 firms)	4.4***	4.4***
Change in the share of R&D personnel (2003-2005) : DiD	unmatched	5.1 (97 firms)	-1.4 (6.504 firms)		
	matched	4.4 (96 firms)	-0.5 (96 firms)	4.9***	4.9***

[82] See Czarnitzki and Hussinger (2004) for an exemplified definition of partial and full crowding out.

The last estimand examined for input additionality is the share of R&D personnel in the total number of employees of the beneficiary firm.

Table 29 presents strong evidence for the contribution of the grants to the R&D personnel both in 2005 and 2006. The ATT differences between the firms belonging to funded and control groups after the matching is found to be 4.9 and 4.4% during 2003-2005 and 2003-2006 respectively at a 1% significance level. This uninterrupted and significant positive effect may be related to the nature of R&D investment in which the largest portion is generally used for financing the relatively high wages of R&D personnel. Subsidized R&D performers may employ more high qualified R&D personnel and are able to keep them longer than their counterparts which conduct R&D using resources with higher costs.

5.3.2.2. Output Additionality

Table 30 Average Treatment Effect on the Treated Companies and DiD: export intensity in percentage

Variable	Status	Subsidized Firms	Control Group (all firms)	ATT	ATT (bootstrap)
Export intensity (2006)	unmatched	23.07 (97 firms)	16.15 (6.511 firms)		
	matched	22.90 (96 firms)	19.72 (96 firms)	3.18	3.18
Export intensity (2005)	unmatched	22.66 (97 firms)	16.79 (6.511 firms)		
	matched	22.18 (96 firms)	20.46 (96 firms)	1.72	1.72
Change in export intensity (2003-2006) : DiD	unmatched	1.24 (97 firms)	-1.93 (6.511 firms)		
	matched	2.16 (96 firms)	-2.22 (96 firms)	4.38	4.38

The estimations for output additionality on export and import intensity which are depicted in Table 30 and 31 respectively reveal no statistically significant impact of the subsidies on these two variables. This might have been expected result since the dataset used in the analysis did not cover a long enough period to yield the output additionality of the program. Although it is industry-dependent, the funding agency's experience with the long-term beneficiaries, as well as previous evaluation studies shows that, two to three years are not generally sufficient to observe the effect of R&D output on a firm's business performance including sales, employment, export quota, and the like.

Table 31 Average Treatment Effect on the Treated Companies and DiD: Import intensity in percentage

Variable	Status	Subsidized Firms	Control Group (all firms)	ATT	ATT (bootstrap)
Import intensity (2006)	unmatched	20.13 (97 firms)	7.27 (6.511 firms)		
	matched	20.34 (96 firms)	18.74 (96 firms)	1.60	1.60
Import intensity (2005)	unmatched	20.79 (97 firms)	7.92 (6.511 firms)		
	matched	21.00 (96 firms)	20.59 (96 firms)	0.41	0.41
Change in import intensity (2003-2006) : DiD	unmatched	-1.97 (97 firms)	-1.96 (6.511 firms)		
	matched	-1.99 (96 firms)	-5.56 (96 firms)	3.57	3.57

5.4. IMPACT OF R&D SUBSIDIES ON PRIVATE R&D: MATCHING METHOD APPLIED TO COMMUNITY INNOVATION SURVEY DATA

This part of the study replicates the empirical analysis presented in Section 5.3 with a different dataset (DS2) extracted from Community Innovation Survey (CIS), conducted for the period 2004-2006 by TUIK. In this study, a consolidated set of results were expected to reveal the effects of public R&D subsidies provided in three years on the firm's R&D expenditure during the same period of time. In CIS data, public R&D subsidies consisted of the KOSGEB and TTGV supports explained in Section 4.2, in addition to TUBITAK grants. Since the details of the matching method were given before, only the variables used in the model and the results will be explained in this section.

5.4.1. Empirical model and variables

Following the 3rd edition of the Oslo Manual (2005), a harmonized questionnaire was used to collect data. The first section of the questionnaire is designed to gather general firm characteristics such as the legal title, foreign share, annual turnover, average number of employees, and the markets in which the firm is active. Sections 2 and 3 are devoted to questions regarding product and process innovations. Questions in sections 5, 6, and 7 are directed only at innovating firms[83]. The variety and amount of innovation expenditure, sources of knowledge, institutional and spatial characteristics of cooperation, and the impact of innovative activities respectively are reported in these sections. Section 8 collects data about halted and abandoned innovation projects in addition to an assessment of barriers to innovation, whereas section 9 gathers data about the variety of intellectual property rights protection methods pursued by firms. The last section, which has been integrated into the survey according to the recommendations in the 3rd edition of the Oslo Manual, is related to organizational and marketing innovations. The survey provides information about 2,173 firms, of which 780 are considered to be

[83] Firms that have introduced a product or process innovation, or which have an abandoned or ongoing innovation project are defined as "innovative" in the survey.

innovative. The industrial affiliations of firms according to NACE Rev. 1.1 classification are presented in Table 19.

As explained in Section 5.3, probit models are estimated to obtain propensity scores. Receipt of subsidy in the period 2004 to 2006 is denoted by a dummy variable, and it covers supports provided by TÜBİTAK, TTGV and KOSGEB. As these schemes mainly target R&D projects, a dummy variable for in–house R&D performance, RDIN, is added to the model. Moreover, firms may apply to subsidy programs in order to finance their innovation-related machinery and equipment investments; thus, a dummy variable for such expenditure, INMACH, is also included.

Exporting firms are expected to be more productive than non–exporting firms (Özçelik & Taymaz, 2008). In order to sustain their level of productivity and compete in foreign markets, firms may choose to build technological skills through performing R&D; hence a dummy variable for exporting firms, EXPO, is added to the model.

Firms cooperating with universities and government R&D institutes are expected to be more inclined to perform R&D. Consequently a dummy variable indicating cooperation with other parties for innovative activities, COOP, is introduced into the model.

In this analysis which employs CIS data, the natural logarithm of total sales in 2006 is used as the firm size (SIZE).

Average ratio of novel products and services to total sales, INNOSPILLSEC, calculated at the two-digit NACE code level is used in the probit models as an indicator for intra-industry innovation spillover.

The main outcome variables used in the treatment analyses is in–house R&D expenditure intensity. Moreover, intensities for external R&D, machinery and equipment purchases and licensing fees (IPR) are also used in the analyses.

In empirical analyses, extreme values may affect the distribution of variables, thus a few observations may determine the estimation results. Hadi's outlier elimination method[84] (Hadi, 1992) was used to tag observations with extreme sales per employee values. 38 such observations were deleted from the data set.

Description of variables and the descriptive statistics pertaining to the explanatory variables are shown in Table 32 and 33 respectively.

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[84] For outlier elimination, the command *hadimvo* is employed in STATA 10.

Table 32 Description of variables, matching analysis with CIS data

RDIN	Dummy variable indicating if the firm perform any R&D activity
INMACH	Dummy variable indicating if the firm bought any machinery, equipment or software for product or process innovation
EXPO	Dummy variable indicating if the firm had any export
COOP	Dummy variable indicating if the firm cooperated with other parties
SIZE	Natural logarithm of total sales in 2006 used as a proxy for firm size
INNOSPILLSEC	Average ratio of novel products and services to total sales calculated at the two - digit NACE code level
Sales	Total sales in 2006
In-house R&D	Total internal R&D spending in 2006
External R&D	Total external R&D spending in 2006
Machinery	Total expenditure for machinery in 2006
IPR	Total expenditure for license and knowhow purchase in 2006
Total-invest	In-house R&D + External R&D + Machinery + IPR

Table 33 Average values of independent variables

	Full Sample (N=2.135)		Innovative firms (N=756)	
	Treated (149)	Control (1.986)	Treated (149)	Control (706)
RDIN	0.6443	0.0931	0.6443	0.3048
INMACH	0.5571	0.1229	0.5571	0.402
EXPO	0.6242	0.3117	0.6242	0.4053
COOP	0.4631	0.0781	0.4631	0.2554
SIZE	7.3783	6.8901	7.3783	7.168
INNOSPILLSEC	10.017	6.3991	10.017	7.121

5.4.2. Estimation results and analysis

The results of the probit estimates are presented in Table 34. In–house R&D performance, machinery and equipment acquisition, export performance and cooperation positively affect the probability of receiving public R&D subsidies at a 1% significance level for both the whole sample and innovating firms only. Moreover, sectoral spillover effects also exert an impact on firm's propensity to receive R&D grants. The results indicate that firm size, as depicted by the logarithm of annual sales, is insignificant with respect to subsidy receipt. Negative sign of the control variable, SIZE may indicate that larger firms are more inclined to finance their R&D activities with internal sources and they do not seek public funding. However, the effect of firm size on receipt of subsidies requires further investigation.

In the next step, the nearest neighbor matching method was used to find counterpart firms to treated firms from the control group. Propensity score estimates together with firm size were used in the matching process. Kernel density estimates for propensity scores before and after the matching procedure are shown in Figure 21 which depicts that initially different distributions reach a sufficient overlap after the matching.

As can be seen in Table 35, which presents the results of the matching procedure carried out on the full sample, receiving public R&D subsidies significantly increased the firm's R&D intensity. After the matching procedure, treated firms have an average intensity of 3.94%, whereas the average R&D intensity of non–treated counterparts is 1.42%. The difference of 2.52% can be interpreted as the average treatment effect, and it is statistically significant below 1%. The results are in line with the matching estimations acquired from the DS1 dataset in the previous analysis.

Table 34 Probit estimations for full sample and innovating firms only

	Full Sample		Innovating firms only	
Variables	**Coeff.**	**Mar. Eff.**	**Coeff.**	**Mar. Eff.**
RDIN	0.832***	0.105***	0.524***	0.140***
	(0.130)	(0.0251)	(0.121)	(0.0334)
INMACH	0.574***	0.0599***	0.224*	0.0569*
	(0.128)	(0.0187)	(0.116)	(0.0299)
EXPO	0.361***	0.0293***	0.359***	0.0917***
	(0.107)	(0.00948)	(0.116)	(0.0299)
COOP	0.731***	0.0887***	0.452***	0.123***
	(0.128)	(0.0234)	(0.118)	(0.0343)
SIZE	-0.00150	-0.000108	-0.0104	-0.00262
	(0.0524)	(0.00377)	(0.0545)	(0.0137)
INNOSPILLSEC	0.0381**	0.00274**	0.0334**	0.00839**
	(0.0157)	(0.00111)	(0.0165)	(0.00415)
Constant	-2.489***		-1.730***	
	(0.392)		(0.428)	
Observations	2135	756		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

However, differences in the intensities of external R&D, machinery and equipment, and licensing expenditure are not statistically different between treated and non–

treated firms. When total innovation-related investments are considered, there is a 3.51% average treatment effect, which is statistically significant below 1%.

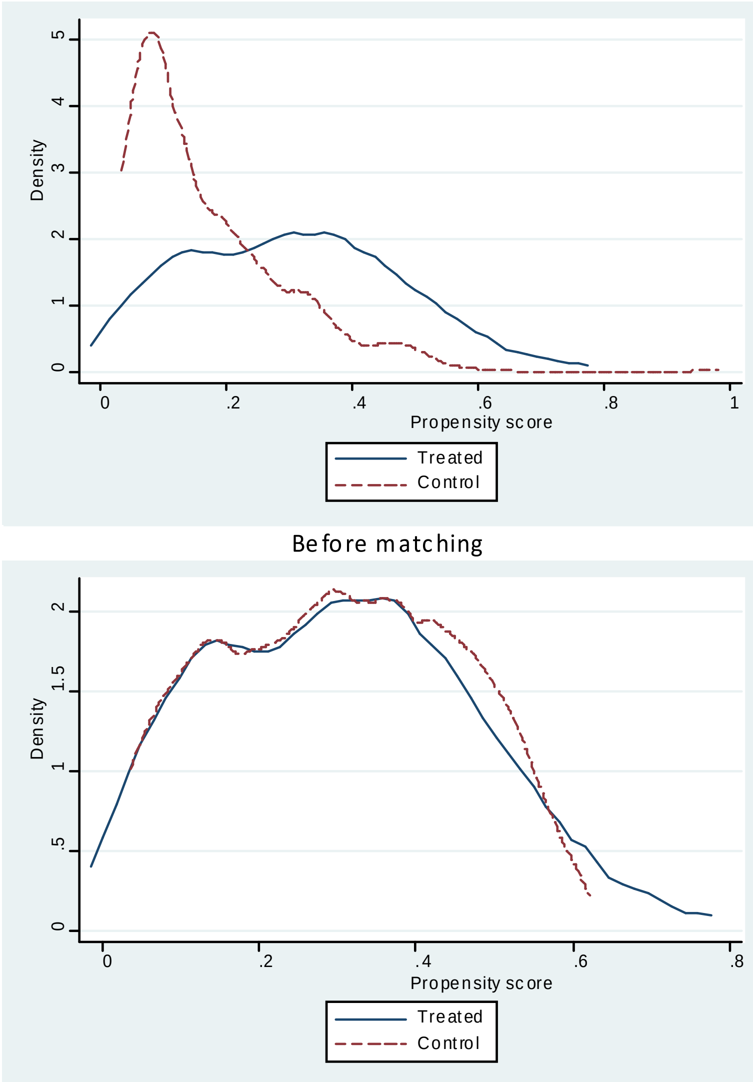
Table 35 Matching results based on full sample

Number of firms	Unmatched Matched	Treated (149) (149)	Control (1986) (149)	Difference	p>|t|
In–house R&D/Sales	Unmatched	3.94	0.28	3.66	0.0000
	Matched	3.94	1.42	2.52	0.0075
External R&D/Sales	Unmatched	0.27	0.07	0.20	0.0128
	Matched	0.27	0.16	0.11	0.5167
Machinery/Sales	Unmatched	2.45	0.47	1.98	0.0000
	Matched	2.45	1.67	0.78	0.3749
IPR / Sales	Unmatched	0.19	0.05	0.14	0.0186
	Matched	0.19	0.09	0.10	0.2603
Total invest./ Sales	Unmatched	6.85	0.87	5.98	0.0000
	Matched	6.85	3.34	3.51	0.0108

Performing the matching procedure on the full sample may create a bias towards treated firms due to the high number of non–innovators in the data set. Consequently the matching procedure is performed on the sub–sample of innovating firms only, and the obtained results are shown in Table 36.

Table 36 Matching results based on the sub–sample of innovating firms

Number of firms	Unmatched Matched	Treated (149) (149)	Control (607) (149)	Difference	p>|t|
In-house R&D / Sales	Unmatched	3.94	0.93	3.01	0.0000
	Matched	3.94	1.75	2.19	0.0286
External R&D / Sales	Unmatched	0.27	0.23	0.04	0.7875
	Matched	0.27	0.14	0.13	0.3643
Machinery/Sales	Unmatched	2.45	1.54	0.91	0.0692
	Matched	2.45	1.88	0.57	0.5232
IPR / Sales	Unmatched	0.19	0.14	0.05	0.6897
	Matched	0.19	0.41	-0.22	0.5362
Total invest. / Sales	Unmatched	6.85	2.84	4.01	0.0000
	Matched	6.85	4.19	2.66	0.0788



After matching

Figure 21 Kernel density estimates of the propensity scores

Results obtained from the sub–sample of innovating firms comply with previous results (Table 36). When only innovating firms are considered, is the average treatment effect of R&D subsidy on in house R&D intensity estimated to be 2.19%. Subsidy recipient firms significantly increase their in–house R&D intensity, as well as their total innovation investments. As a result, it can be concluded that full crowding out effects of public R&D subsidies can be rejected. However, such a general conclusion may not be sufficient to explain the complete picture because firms may show different innovation characteristics. Firm level heterogeneity has been addressed in a number of studies. Leiponen and Drejer (2007) compare the innovation patterns of Finnish and Danish firms and identify similar groups, of which categories exceed specific industries. Srholec and Verspagen (2008) use firm level data from 13 countries to assess the heterogeneity of innovation process. They identify four innovation patterns and claim that sectors and countries matter to a certain extent in explaining the heterogeneity of innovation process, but far most of the variance is given by the heterogeneity of firms within either sectors or countries (Srholec and Verspagen, 2008). Not all these studies explicitly aim to test the relevance of sectoral patterns by a quantitative analysis. However their findings indicate that innovation patterns, which are not confined to specific industries, exist[85]. In order to assess the efficiency of public R&D subsidies, varying innovation strategies of firms should be taken into account which may be a potential topic for further study.

[85] Following this strand of research, Yurtseven and Tandoğan (2010) identified four patterns of innovation in Turkey after performing a double–stage factor analysis: networked R&D, production intensive, market driven, and external oriented patterns. These patterns may be interpreted as ingredients of distinct innovation strategies.

5.5. DISCUSSION

In this chapter, three empirical studies for examining the causal relations between the direct public support and the R&D activities and performance figures of beneficiary firms were presented. The first study demonstrated that receiving an R&D subsidy is the most influential determinant for the private R&D intensity compared to other factors such as technology transfer, capital intensity, firm size, etc. The positive impact of the subsidy remains at the top of the list when the estimation includes its one or two years lagged values. In the second study, employing a two-step matching method, a control group is constructed among the R&D performer firms, having a similar probability of receiving a grant from TUBITAK industrial R&D support program comparing with the beneficiary firms in 2004. The results indicate that the program induced input additionality in (i) R&D personnel, (ii) R&D intensity and (iii) R&D expenditure per employee of the beneficiary firms during 2004-2006. However, no statistically-significant output additionality (e.g. sales, export intensity, import intensity, productivity, employment, etc.) is observed in the same period possibly because a longer time series dataset is needed to analyze out additionality.

In order to check the robustness of the methodology for testing crowding out behaviour of the beneficiaries, PSM estimation is used with another data set (called previously DS2) collected through community innovation survey (CIS) in the same period of 2004-2006 (DiD method could not be applied since DS2 includes only cross-sectional data). Although the CIS does not provide firm level data as rich as structural business statistics and annual R&D survey of TUIK, The empirical evidence, indicating statistically significant increase both in–house R&D intensity and total innovation investments of the subsidy beneficiaries, causes to reject hypothesis of total crowding out which in line with the previous analysis conducted with DS1. The similarity of the results from two different analyses reflects that public R&D subsidies in Turkey have had complementary rather than substitution effects on private R&D investments in the period of 2003-2006.

CHAPTER VI

CONCLUSION

6.1. AN OVERVIEW OF MAIN ISSUES

The causal relationship between government intervention in private R&D and the targeted firms, individuals or organizations needs to be studied using a variety of perspectives, methods and elaborations. Diverse motivations as well as diverse viewpoints might end up with competing evaluations of, and conclusions from, the data depicting the abovementioned relationships. In this thesis, the research framework was confined to seeking and implementing a quantitative evaluation methodology with which to measure the effectiveness of R&D subsidy programs in Turkey.

Market failure stemming from uncertainty and public good characteristics of R&D output constitutes the principal rationale behind the government's efforts to encourage private R&D investment. Public intervention in private R&D and innovation occurs through incentives and regulations. Government attempts to promote or control technology-related activities by means of policies such as R&D subsidies, tax incentives, corrective or distortionary taxation, or regulations of property rights, and the like. Public support for higher education may act on the supply side of R&D whereas selective grants and soft loans for private R&D projects can promote the demand side of R&D and innovation. Authorities often try to achieve an optimal mixture of policies. Almost every economic activity is somehow regulated by government. The scope and scale of intervention in technology might depend on how well the public interest should be protected against private benefits, avoiding free-rider problems. Given the importance of R&D and innovation policy, it becomes rather urgent to evaluate the actual and potential influence of such government involvements for accomplishing evidence-based justification and public body transparency.

Measuring the effect of a policy instrument, or a *treatment* in general, carries a number of challenging attributes and obstacles, such as identifying the objectives and stakeholders of the process, satisfying rich data requirements for *before and after* treatment evaluation, constructing an appropriate control group for *counterfactual* estimation in *with and without* treatment analysis or dealing with selection bias problems due to *non-experimental* settings. It was one of the tasks of this thesis to discuss such issues with the objective of conducting an impact assessment exercise of a major R&D grant program in Turkey.

The growing popularity and the generous practices of public incentives in industrial R&D and innovation in Turkey, in addition to the controversial results in the recent literature on evaluation of public R&D intervention (see Table 5), were the basic motivations of this dissertation. Since 2004, significant changes and improvements that have taken place in Turkey concerning science and technology policy schemes have actually influenced the national innovation system (NIS) in a number of ways:

- Important increase in the public support provided to private R&D (share of subsidies in enterprise R&D expenditure increased from 1% to 9% over 1996-2008)

- Diversification of direct support programmes for private R&D and innovation tailored to the needs of potential innovators (SMEs vs. large firms, start ups vs. incumbents, grants vs. loans, etc.)
- Widening of the scope of existing fiscal incentives for private R&D activities and implementation of new ones
- Impressive developments in support for higher education and basic research largely provided by TUBITAK
- Increased public efforts for researcher mobility, integration into the international research community and participation in collaborative research activities

Considering the large resource allocation for the aforementioned government involvements, it could be argued that there is a growing and urgent need for systematic monitoring and evaluation of NIS institutions, linkages, programs and policies in Turkey.

This dissertation is built mainly upon four chapters, namely, the theoretical framework, the review of the relevant literature, the overview of science and technology policies in Turkey and a quantitative evaluation analyses.

In the first chapter, the theoretical background of government intervention in technological change and evaluation methodologies are presented under three headings. First, a historical account and an economic rationale of government intervention in technological change are elaborated. Then, a range of public-involvement measures, from science-driven policies provoked by national security concerns to industrial subsidies and fiscal incentives aimed at diminishing the gap between social and private returns, are examined. Based on a feature set of domain, objective, strategy and specificity; intervention policies are classified and their rationales and goals were illustrated.

In the second chapter, the measurement and evaluation methodologies of the effects of public policies are elaborated with different classification approaches, which are built on additionality (input, output, behavioral, etc.), evaluation time (ex-ante or ex-post) and qualitative vs. quantitative methods. The strengths and weaknesses of each approach are illustrated through examples. It should be noted that each method may illuminate a different part of the picture, and hence adopting several evaluation methods, when it is possible, can provide a better understanding of the actual treatment effect.

The third chapter is devoted to the analysis of theoretical frameworks of the available empirical evaluation approaches. In this part, identifying the distinction between correlation and causality, quasi-experimental (or nonrandom) techniques for identifying causal relationships are explained by investigating the Rubin Causal Method. The essential elements of matching methods such as counterfactual outcome, treatment and control groups, conditional probability of receiving the treatment (i.e. cause) are clarified. Then, within the context of Rosenbaum and Rubin's framework, the theoretical aspects of PSM, which eliminates the dimensionality problem of covariates (control variables used for matching), are explained. The presentation of the theoretical framework ends with the clarification of the different matching algorithms employed in PSM applications.

In the literature review, after a brief presentation of the available econometric studies pertaining to the measurement of incentive-generated *additionalities* which have been published since the late 1970s, the empirical evaluation studies which use firm-level data and have been published in the last fifteen years are reviewed in detail. Based on representative samples from the body of literature, a summary table of empirical findings is created. Depicting previous evidence that has been obtained from various recent evaluation approaches, including structural models, semi-parametric matching, differences-in-difference (DiD), instrumental-variable methods and two- or three-stage selection models.

In chapter 4, the chronological development of science, technology and innovation (STI) policies and incentives in Turkey since the 1960s is presented in order to provide an historical perspective. Then, the significant public R&D support programs during the period of analysis (i.e. 2003-2006) are elaborated. In the last section, the evolution of key STI indicators in Turkey is presented, with reference to national and international publications.

Chapter 5 contains the findings of the research obtained from three empirical studies. The major aim of the dissertation is to identify a set of key issues related to the implementation of an impact assessment of the rapid growth observed in industrial R&D funding in Turkey, especially since 2004. This entails examining existing evaluation literature, specifying qualitative and quantitative evaluation methodologies in terms of their strengths and weaknesses, and selecting an appropriate set of methods to assess the impact of the designated subsidy program operated by TUBITAK. To this end, an enterprise-level dataset was constructed by merging various data sources and an evaluation method based on the semi-parametric method of propensity score matching (PSM) is adopted. By the help of the PSM, a control group from the nonparticipant of the program is created to estimate the effect of R&D subsidies on beneficiary firms. The same method is employed to perform the same analysis with another dataset from community innovation survey conducted for the period of 2004-2006. The main findings with corresponding implications will be given in the next section.

6.2. RESEARCH FINDINGS AND POLICY IMPLICATIONS

The descriptive analysis of private R&D schemes in Turkey using our first dataset shows that the four-year average of the number of R&D performers is 9.8% of all the firms in the dataset during the period 2003-2006. This share is 7.9% for SMEs and 29.3% for large firms. The average R&D intensity of all firms is 0.19% for manufacturing firms and 0.23% when the business and service sectors are included. The average R&D intensity in this period seems to be similar to the average value 0.2% for manufacturing firms observed in the period of 1991-1997 (Taymaz, 2001). According to the consolidated data, the share of the firms funded by TUBITAK in the total number of R&D performer firms seems to increase from 5.3% in 2003 to 17.2% in 2006. The share of the beneficiary firms in all firms in our dataset increased from 0.45% in 2003 to 1.46% in 2006. The grant-receiver firms have, on average, higher R&D intensity and wage rates, and undertake more technology transfer from abroad than the non-beneficiary firms which indicates the existence of selection bias in the grant delivery process.

In this dissertation, findings of three quantitative studies examining the causal relations between direct public support and R&D activities and performance figures of beneficiary firms are presented. The first study which adopts an econometric approach with several Tobit models using our first dataset demonstrates that receiving an R&D subsidy is a highly important determinant for private R&D intensity besides other influential factors such as firm size (number of employees and sales are both used as proxy of firm size in separate analyses), import penetration, wage rate, technology transfer and sectoral R&D intensity. Also being in a medium-high tech industry has a positive effect on the firm’s R&D investment.

In the second study, employing a two-step semiparametric matching method, a control group is constructed among the R&D performer firms, having a similar probability of receiving a grant from the TUBITAK industrial R&D support program compared with the beneficiary firms in 2004. The results indicate the program-induced input additionality in (i) R&D personnel, (ii) R&D intensity and (iii) R&D expenditure per employee of the beneficiary firms during 2004-2006. However, no statistically significant output additionality (e.g. sales, export intensity, import intensity, productivity, employment, etc.) is observed in the same period, possibly because a longer time series dataset is needed to analyze output additionality.

In order to check the robustness of the methodology for testing the crowding out behaviour of the beneficiaries, PSM estimation is used with another data set (previously called as DS2) collected through innovation survey in the period of 2004-2006 (The DiD method could not be applied since DS2 includes only cross-sectional data). Although the CIS does not provide firm level data as rich as the structural business statistics and annual R&D survey of TUIK, the empirical evidence, indicating a statistically significant increase in both in–house R&D intensity and total innovation investments of the subsidy beneficiaries, points to the rejection of the hypothesis of total crowding out, which is in line with the previous analysis conducted with DS1. The similarity of the results from two different analyses points out that public R&D subsidies in Turkey have had a complementary rather than substitution effect on private R&D investments in the period of 2003-2006.

The results from three steps of analyses validate that engagement in public R&D programmes in Turkey is beneficial for private R&D performance. Sufficient evidence was obtained to conclude that TUBITAK's industrial R&D project support program has encouraged most private firms to increase their R&D spending and

R&D personnel. These findings are similar to those obtained by Özçelik and Taymaz (2008) over the period 1993-2001. Based on the findings of this study, a number of policy recommendations can be formulated for Turkey.

First, data covering a longer time span should be accessed and used to replicate the quantitative analysis implemented in our thesis in order to check whether the input-additionality effect identified for the period 2003-2006 is confirmed. Such a finding would show that TUBITAK-TEYDEB's industrial R&D support program is fulfilling its mission. Use of longer time series is crucial for detecting a possible output additionality effect. Further cooperation between TUIK and TUBITAK is needed in order more easily to access and merge data used in this kind of exercise.

Second, evaluation analyses should not be limited to TUBITAK industrial support programs but should be carried out for other major R&D support schemes, including TUBITAK grants for basic research, Law No 5746 for R&D tax incentives, Law No 4691 for technology development zones, TTGV support programs and KOSGEB incentives for SMEs and entrepreneurs. A considerable amount of funds involving significant social opportunity costs are at stake here. International institutions, such as the World Bank and the OECD, recommended made several recommendations for such an impact analysis exercise for accountability reasons[86].

Third, qualitative as well as quantitative methods should be exploited to investigate other dimensions of the additionality issue such as *behavioral additionality*, which is difficult to analyze through quantitative methods but might be particularly relevant for a developing country like Turkey. Such an effort would require most probably

[86] For example, see World Bank (2009).

designing and conducting surveys for R&D performers as well as face-to-face interviews with firm directors.

Fourth, considering efficiency measurement possibilities for systemic program monitoring, TUBITAK may develop an extension for its administrative database to include new firm and industry level performance indicators. This may help in the design and initiation of a self evaluation mechanism for support programs, which may build a complementary knowledge base to possible external assessments. The outcome of such a mechanism can also provide valuable feedback for improving existing programs and designing new ones in TUBITAK.

Fifth, an institutional framework should be established by the public authority for the coordination of evaluation activities concerning technology policy instruments, dissemination of their findings and exploitation of the assessment outcomes by the policy makers in Turkey.

6.3. DIRECTIONS FOR FURTHER RESEARCH

The propensity score matching (PSM) which is the primary methodology adopted in this study should not be considered as a golden key that will measure treatment effect in every case. Although it addresses issues such as self-selection bias and the counterfactual problem in nonrandom cases, the PSM depends strongly on the quality and richness of available data and carefully selected covariates to achieve meaningful results. Furthermore, its adaptability in multi-treatment cases (e.g. firms that receive both R&D subsidy and tax incentive in the same year) as well as measuring indirect causal effects[87] needs further investigations including a search for alternative methodologies. Another approach for estimating the treatment effect

[87] For an excellent explanation of direct and indirect causal effects, see Rubin (2004).

would be regression discontinuity design (Imbens and Lemieux, 2007), which can be used when the intervention is assigned based on a rank (e.g. anti-poverty or regional R&D programs).

Moreover, it can be stated that two crucial data-related shortcomings of this study should be addressed in future research concerning TUBITAK's program evaluation. The absence of any significant output additionality points to a need to repeat the analysis over a longer period of time. Further studies should be planned to carry out the same analysis using a longer dataset, including the latest available TUIK data since 2007. Since only one-third of the firms actually funded by the TUBITAK industrial grant program in 2004 were matched with TUIK's data from structural business and R&D surveys, a closer collaboration between TUIK and TUBITAK is required to assure that all the beneficiary firms of TUBITAK's industrial R&D support programs be included in TUIK's R&D, SBS and innovation surveys.

BIBLIOGRAPHY

ABGS. (2007). *History of Turkey-EU Relations.* Secretariat General for EU Affairs: http://www.abgs.gov.tr/index.php?p=111&l=2, last accessed at August 2010

Acs, Z. S. and Audretsch, D. B. (1987). Innovation, market structure and firm size. *The Review of Economics and Statistics,* 567-574.

Aerts, K. and Czarnitzki, D. (2004). *Using Innovation Survey Data to Evaluate R&D Policy: The Case of Belgium.* Mannheim: ZEW 04-55.

Aerts, K. and Schmidt, T. (2008). Two for the price of one? Additionality effects of R&D subsidies: A comparison between Flanders and Germany. *Research Policy,* 806-822.

Aerts, K. and Thorwarth, s. (2008). *Additionality effects of public R&D funding: "R" versus "D".* Leuven: Katholieke Universiteit Leuven.

Akerlof, G. A. (1970). The market for "Lemons": Quality uncertainty and the market mechanism. *The Quarterly Journal of Economics*, 488-500.

Ali-Yrrkö, J. (2004). *Impact of public R&D financing on private R&D – Does financial constraint matter?* Helsinki: The Research Institute of the Finnish Economy, Discussion Paper No 943.

Altuğ, S., Filiztekin, A. and Pamuk, Ş. (2008). Sources of long-term economic growth for Turkey, 1880–2005. *European Review of Economic History*, 393-430.

Arrow, K. (1962). *Economic welfare and the allocation of resources for innovation:.The rate and direction of inventive activity.* Princeton: Princeton University Press.

Autio, E., Kanninen, S. and Gustafsson, S. (2008). First- and second-order additionality and learning outcomes in collaborative R&D programs. *Research Policy*, 59-76.

Bach, L. and Matt, M. (2002). Rationale for science and technology policy. L. Georghiou, & J. Rigby in *Assessing the socio-economic impacts of the Framework Programme.* Brussels: DG Research.

Bernstein, T. I. and Nadiri, I. (1988). Interindustry R&D spillovers, rates of return, and production in high-tech industries. *The American Economic Review*, 429-434.

Bloom, H. S., Michalopoulos, C., Hill, C. and Lei, Y. (2002). *Can Nonexperimental Comparison Group Methods Match the Findings from a Random Assignment*

Evaluation of Mandatory Welfare-to-Work Programs? MDRC Working Papers on Research Methodology .

Blundell, R. and Costa Dias, M. (2002). Alternative approaches to evaluation in empirical microeconomics. *Portuguese Economic Journal*, 91-115.

Blundell, R. and Macurdy, T. (1999). *Labors supply: A review of alternative approaches.* W98/18: The Institute of Fiscal Studies.

Branstetter, L. G. and Sakakibara, M. (2002). When do research consortia work well and why? Evidence from Japanese panel data. *American Economic Review*, 143-159.

Brouwe, E. and Kleinknecht, A. (1999). Keynes Plus? Effective demand and changes in firm-level R&D: an empirical note. *Cambridge Journal of Economics,* 385-391.

BTYK. (2004). *TÜBİTAK BTY Politikaları BTYK 10. Toplantısı, 8 Eylül 2004*.
TÜBİTAK: http://www.tubitak.gov.tr/sid/1079/cid/1365/index.htm, last accessed at December 2010

Buisseret, T. J., Cameron, H. and Georghiou, L. (1995). “What difference does It make? Additionality in the public support of R&D in large firms”. *International Journal of Technology Management* , 587-600.

Bush, V. (1945). Science: The Endless Frontier. *Transactions of the Kansas Academy of Science* , s. 231-264.

Busom, I. (2000). An empirical evaluation of the effects of R&D subsidies. *Economics of Innovation and New Technology,* 111-148.

Caliendo, M. and Kopeinig, S. (2008). Some practical guidance for the implementation of prepensity score matching. *Journal of Economic Surveys,* 31-72.

Cansiz, M. (2008). *Türkiye’de kobiler ve KOSGEB.* Ankara: Devlet Planlama Teşkilatı, Yayın no:2782.

Capron, H. (1992). *Economic quantitative methods for the evaluation of the impact of R&D programmes.* Brussels: EU, EUR 14864 EN.

Capron, H. (1992). Proceedings of the workshop on quantitative evaluation of the impact of R&D programmes. *Monitor/Spear.* Brussels: EC.

Capron, H. and Cincera, M. (2002). *"Econometric models: Macroeconomic modelling and simulation approaches" in RTD Eevaluation toolbox.* Sevilla, Vienna: IPTS, Joanneum Research.

CEA, C. o. (1963). *Economic Report of the President.* Washington: Council of Economic Advisers.

Cerulli, G. (2010). Modelling and Measuring the Effect of Public Subsidies on Business R&D: A Critica lReview of the Econometric Literature. *The Economic Record-The Economic Society of Australia*, 1-28.

Cerulli, G. and Poti, B. (2008). *Evaluating the Effect of Public Subsidies on firm R&D activity: an Application to Italy Using the Community Innovation Survey.* Rome: Ceris-Cnr, W.P. N° 9 .

Chudnovsky, D., Lopez, A., Rossi, M. and Diego, U. (2006). *Evaluating a Program of Public Funding of Private Innovation Activities. An Econometric Study of FONTAR in Argentina.* Washington: Office of Evaluation and Oversight, OVE.

Cincera, M., Czarnitzki, D. and Thorwarth, S. (2007). Efficiency of public spending in support of R&D activities. *Technology And Economic Development 2nd International Conference on the Dynamics of Science and Technology Policies.* Izmir.

Clarysse, B., Wright, M. and Mustar, P. (2009). Behavioural additionality of R&D subsidies: A learning perspective. *Research Policy*, 1517-1533.

Clausen, T. H. (2009). Do subsidies have positive impacts on R&D and innovation activities at the firm level? *Structural Change and Economic Dynamics,* 239-253.

Cochran, W. G. (1968). The effectiveness of adjustment by subclassification in removing bias in observational studies. *Biometrics*, 295-313.

Cohen, L. R. and Noll, R. G. (1991). *The technology pork barrel.* The Brooking Institution Press: Washington, DC.

Cohen, W. M. and Levinthal, D. A. (1989). Innovation and Learning: Two Faces of R&D. *The Economic Journal* , 569-596.

Czarnitzki, D. (2001). Die Auswirkungen der Forschungs und Technologie politik auf die Innovations aktivitaten ostdeutscher Unternehmen. *Journal of Applied Social Science Studies,* 1-22.

Czarnitzki, D. and Hussinger, K. (2004). *The link between R&D subsidies, R&D spending and technological performance.* ftp.zew.de: ZEW Discussion Paper 04-56.

Czarnitzki, D. and Toole, A. A. (2008). Business R&D and the interplay of R&D subsidies and product market uncertainty. *Springer Science+Business Media*, 169-181.

Czarnitzki, D., Hanel, P. and Rosa, J. M. (2004). *Evaluating the impact of R&D tax credits in innovation: A microeconometric study on Canadian firms.* Mannheim: ZEW Discussion Paper, No 04-77.

David, P. A. and Hall, B. (2000). Heart of darkness: modeling public–private funding interactions inside the R&D black box. *Research Policy*, 1165-1183.

David, P. A., Hall, B. and Toole, A. A. (2000). Is public R&D a complement or substitute for private R&D? A review of the econometric evidence. *Research Policy,* 497-529.

De Negri, J. A., Lemos, M. B. and De Negri, F. (2006). *Impact of R&D incentive program on the performance and technological efforts of Brazilian industrial firms.* Washington, D.C.: Office of Evaluation and Oversight, Inter-American Development Bank.

Dehejia, R. H. and Wahba, S. (2002). Propensity score-matching methods for nonexperimental causal studies. *The Review of Economics and Statistics,* 151-161.

Diamond, A. (1999). Does federal funding “crowd in” private funding of science? *Contemporary Economic Policy,* 423-431.

DPT. (2004). *Devlet yardımlarını değerlendirme özel ihtisas komisyonu raporu.* Ankara: DPT Yayınları, No 2681.

DPT. (1963). *Kalkınma planı (Birinci beş yıl) 1963-1967.* Ankara: Devlet Planlama Teşkilatı.

Duguet, E. (2004). Are R&D subsidies a substitute or a complement to privately dunded R&D? *Les enjeux économiques de l'innovation* , 245-274.

Ebersberger, B. and Lehtoranta, O. (2005). *Pattern of innovative activities among Finnish firms.* Helsinki: VTT Publications 558.

EC. (2006). *Screening report Turkey, Chapter 25, science and research.* Brussels: EC.

Ergas, H. (1986). *Does Technology Policy Matter?* Centre for European Policy Studies.

Erichsen, R. (2003, 12 5). *Scientific research and science policy in Turkey.* Cemoti, n° 25 - Les Ouïgours au vingtième siècle: http://cemoti.revues.org/document61.html, last accessed at March 2010

EU. (2009). *Ex-post evaluation of the Sixth Framework Programmes for research and technological development 2002-2006.* Brussels: EC.

EUROSTAT. (2009). *Science, technology and innovation in Europe.* Luxembourg: Office for Official Publications of the European Communities.

Falk, R. (2004). *Behavioural additionality effects of R&D-subsidies.* Wien: Austrian Institute of Economic Research.

Falk, R. (2007). Measuring the effects of public support schemes on firms' innovation activities Survey evidence from Austria. *Research Policy,* 665-679.

Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society,* 253-290.

Fisher, R. A. (1935). The Logic of inductive inference. *Journal of the Royal Statistical Society,* 39-82.

Folster, S. (1991). *The art of encouraging innovation, a new approach to government innovation policy.* Stockholm: The Industrial Institute for Economic and Social Research.

Freeman, C. and Soete, L. (2003). *Yenilik iktisadı.* Ankara: TÜBİTAK Yayınları.

Garcia-Quavedo, J. (2004). Do public subsidies complement business R&D? A meta-analysis of the econometric evidence. *Kyklos,* 87-102.

Geisler, E. (2000). *The metrics of science and technology.* London: Quorum Books.

Georghiou, L. and Roessner, D. (2000). Evaluating technology programs: Tools and methods. *Research Policy,* 657-678.

Georgiou, L. (2002). Impact and Additionality of Innovation Policy. P. Boekholt in, *Innovation Policy and Sustainable Development: Can Innovation Incentives Make a Difference?* Brussels: IWT-Observatory.

GIB. (2009). *Law 5746 related to the support of research and development activities.* Ankara: Gelir Idaresi Başkanlığı.

Golsbee, A. (1998). Does government R&D policy mainly benefit scientists and engineers? *Tax and Human Capital Policy,* 298-302.

Gonzales, X. and Pazo, C. (2008). Do public subsidies stimulate private R&D spending? *Research Policy,* 371–389.

Goren, H. (2008). *Testing additionality effects of TUBITAK's industrial R&D projects funding programme: Pilot study on software development sector in Ankara.* Ankara: METU, Unpublished Master Thesis.

Gossling, F. (1999). *The Manhattan Project: Making the atomic bomb.* The United States Department of Energy.

Görg, H. and Strobl, E. (2007). The effect of R&D subsidies on private R&D. *Economica* , 215-234.

Griliches, Z. (1979). Issues in assessing the contribution of research and development to productivity growth. *The Bell Journal of Economics,* 92-116.

Griliches, Z. (1992). *The search for R&D spillovers.* Cambridge: NBER Working Papers, No 3768.

Grupp, H. and Linstone, H. A. (1999). National technology foresight activities around the globe: Resurrection and new paradigms. *Technological Forecasting and Social Change* , 85-94.

Guellec, D. and Pottelsberghe de la Potterie, B. (2003). The Impact of Public R&D Expenditure on Business R&D. *Econ. Innov. New Techn.* , 225-243.

Hadi, A. S. (1992). A modification of a method for the detection of outliers in multivariate samples. *Journal of the Royal Statistical Society,* 393-396.

Hahn, Y. and Yo, P. (1999). Towards a new technology policy: the integration of generation and diffusion. *Technovation* , 177-186.

Hall, B. H. (2002). The financing of innovation. *Oxford Review of Economic Policy,* 35-51.

Hall, B. H. and Maffioli, A. (2008). *Evaluating the impact of technology development funds in emerging economies: Evidence from Latin-America.* Cambridge: National Bureau of Economic Research.

Hall, B. and Reenen, J. V. (2000). How effective are fiscal incentives for R&D? A review of the evidence. *Research Policy,* 449-469.

Harris, R., Li, Q. and Trainor, M. (2009). Is a higher rate of R&D tax credit a panacea for low levels of R&D in disadvantaged regions? *Research Policy,* 192-205.

Heckman, J. J. and Robb, R. (1985). Alternative methods for evaluatiıng the impact of intervention. *Journal of Econometrics,* 239-267.

Heckman, J. J., Ichimura, H. and Todd, P. (1998). Matching As An Econometric Evaluation Estimator. *Review of Economic Studies,* 261-294.

Hippel, E. (1994). "Sticky Information" and the Locus of Problem Solving: Implications for Innovation. *Management Science* , 429-439.

Holland, P. W. (1986). Statistics and Causal Inference. *Journal of the American Statistical Association* , 945-960.

House, E. (1980). *Evaluating with validity.* London: Sage Publications Inc.

Howe, J. D. and Fertidge, D. G. (1976). The determinants of R&D expenditures. *The Canadian Journal of Economics,* 57-71.

Huitt, B., Hummel, J. and Kaeck, D. (2001). *Assessment, Measurement, Evaluation & Research*. Educational Phychology Interactive: http://www.edpsycinteractive.org/topics/intro/sciknow.html, last accessed at April 2010

Hulten, C. R. (2000). *Total factor productivity: A short biography.* Cambridge: NBER Working Paper No: 7471.

Hussinger, K. (2008). R&D and subsidies at the firm level:an application of parametric and semiparametric two-step selection models. *Journal of Applied Econometrics,* 729-747.

Hyvärinen, J. and Rautiainen, A. (2007). Measuring additionality and systemic impacts of public research and development funding -the case of TEKES, Finland. *Research Evaluation* , 205-215.

Imbens, G. W. (2004). Nonparametric estimation of average treatment effects under exogeneity: A review. *The Review of Economics and Statistics,* 4-29.

Imbens, G. W. and Wooldridge, J. M. (2009). Recent Developments in the Econometrics of Program Evaluation. *Journal of Economic Literature* , 5-86.

Imbens, G. and Lemieux, T. (2007). *Regression Discontinuity Designs: A Guide to Practice.* Cambridge: NBER Working Paper 13039.

Ingham, R. (2010, January 31). *Ancient and modern: First science academy is 350 years old*. PHYSORG.com: http://www.physorg.com/news184127779.html, last accessed at March 2010

Irwin, D. A. and Klenow, P. J. (2004). *High Tech R&D Subsidies: Estimating the Effect of SEMATECH.* Cambridge: NBER Working Paper Series No 4974.

Janz, N., Lööf, H. and Peters, B. (2003). *Firm Level Innovation and Productivity – Is there a Common Story across Countries?* Mannheim: ZEW Discussion Paper No. 03-26.

Jaumotte, F. and Pain, N. (2005). *From Ideas to Development: The Determinants of R&D and Patenting.* Paris: OECD, No 457.

Jones, C. I. and Williams, J. C. (2000). Too much of a good thing? The economics of investment in R&D. *Journal of Economic Growth* , 65-85.

Kleinknecht, A. (1989). Firm size and innovation, observation in Dauch manufacturing industries. *Small Business Economics,* 212-222.

Klette, T. J. and Moen, J. (1999). From Growth Theory to Technology Policy-Coordination Problems in Theory and Practice. *Nordic Journal of Political Economy,* 53-74.

Klette, T. J., Moen, J. and Griliches, Z. (2000). Do subsidies to commercial R&D reduce market failures? Microeconometric evaluation studies. *Research Policy,* 471-495.

Krauch, H. (1966). Resistance against Analysis and Planning in Research and Development. *Management Science , 13* (4), s. C47-C58.

Kuznets, S. (1966). *Modern Economic Growth.* New Haven: Yale University Press.

Lach, S. (2002). Do R&D Subsidies stimulate ot displace private R&D? Evidence from Israel. *The Journal of Industrial Economics,* 369-390.

Lahiri, S. and Ono, Y. (1999). R&D Subsidies Under Asymmetric Duopoly: A Note. *The Japanese Economic Review* , 109-111.

Lamoreaux, N. and Sokoloff, K. L. (2007). *Financing Innovation in the United States,1870 to the Presents.* MIT Press Books.

Lang, G. (2009). Measuring the returns of R&D—An empirical study of the German manufacturing sector over 45 years. *Research Policy,* 1438-1445.

Lechner, M. (1998). *Training the East German labour force. microeconometric evaluations of continuous vocational training after unification.* Heidelberg: Springer/Physica.

Lechner, M. (1999). *Identification and estimation of causal effects of multiple treatments under the conditional independence assumption.* Bonn: IZA Discussion Paper No 91.

Leiponen, A. and Drejer, I. (2007). What exactly are technological regimes? Intra-industry heterogeneity in the organization of innovation activities. *Research Policy,* 1221-1238.

Leland, H. E. and Pyle, D. H. (1977). Informational asymmetries, financial structure, and financial intermediation. *The Journal of Finance* , 371-387.

Lerner, J. (1999). The government as venture capitalist: The long-run impact of SBIR Program. *Journal of Business,* 285-318.

Lerner, J. (2002). 150 Years of Patent Protection. *The American Economic Review* , 221-225.

Leuven, E. and Sianesi, B. (2003). *PSMATCH2: Stata module to perform full Mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing.* Boston College Department of Economics, S432001.

Levin, R. C., Klevorick, A. K., Nelson, R. R. and Winter, S. G. (1987). Appropriating the returns from industrial research and development. *Microeconomics,* 783-831.

Levy, D. M. and Terleckyj, N. E. (1983). Effects of government R&D on private R&D investment and productivity: A macroeconomics analysis. *The Bell Journal of Economics,* 551-561.

Leydesdorff, L., Cozzens, S. and Besselaar, P. (1994). Tracking areas of strategic importance using scientometric journal mappings. *Reserach Policy,* 217-229.

Lhuillery, S. (2005). *The Research and Development Tax Incentives: A Compparative Analysis of Various National Mechanisms.* Strasbourg: Technology Policy and Practice.

Lichtenberg, F. R. (1984). The Relationship Between Federal Contract R&D and Company R&D. *The American Economic Review* , 73-78.

Lichtenberg, F. R. (1987). The Effect of Government Funding on Private Industrial Research and Development: Re-assessment. *The Journal of Industrial Economics,* 97-104.

Locke, J. (1995, 1 1). *An Essay Concerning Human Understanding:Book 2: Chapter 26*. (I. f. Technologies, Prodüktör) Publications: http://www.ilt.columbia.edu/publicATIONS/Projects/digitexts/locke/understanding/chapter0226.html, last accessed at May 2010

Lööf, H. and Hesmati, A. (2005). *The impact of public funding on private R&D investment. New evidence from a firm level innovation study.* Stockholm: Centre of Excellence for studies in Science and Innovation, CESIS, The Royal Institute of technology, INFRA.

Luo, H. (2010). The Role for an Evaluator: A Fundamental Issue for Evaluation of Education and Social Programs . *International Education Studies,* 42-50.

Machlup, F. (1958). *An Economic Review of the Patent System.* Study No. 15: Subcomm. Patents, Trademarks and Copyrights of the U.S. Senate Judiciary Comm.

Mackie, A. (1974). *The Cement of the Universe: A Study of Causation.* London: Oxford University Press.

Madore, O. (2006). *Scientific Research and Experimental Development: Tax Policy(89-9E).* Parliament of Canada, Virtual Library: http://www2.parl.gc.ca/Content/LOP/ResearchPublications/899-e.htm, last accessed at March 2010

Mamuneas, T. P. and Nadiri, I. N. (1996). Public R&D policies and cost behavior of the US manufacturing industries. *Journal of Public Economics,* 57-81.

Mansfiled, E. (1980). Basic research and productivity increase in manufacturing. *The American Economic Review* , 863-873.

Metcalfe, J. S. (1994). Evolutionary economics and technology policy. *The Economic Journal* , 931-944.

Mohnen, P. and Lokshin, B. (2009). *What Does it Take for an R&D Tax Incentive Policy to be Effective?* Available at SSRN: http://ssrn.com/abstract=1499876: SSRN CIRANO Scientific Publications 2009s-11.

Mohnen, P. and Therrien, P. (2002). *Comparing the innovation performance of Canadian firms and thode of selected European Countries: An econometric analysis.* Montreal: CIRANO.

Nadiri, M. I. and Mamuneas, T. P. (1994). The effects of public infrastructure and R&D capital on the cost structure and performance of U.S. manufacturing Industries. *The Review of Economics and Statistics,* 22-37.

Nelson, R. R. (1959). The simple economics of basic scientific research. *The Journal of Political Economy,* 297-306.

Nelson, R. R. (1983). Government Support of Technical Progress: Lessons from History. *Journal of Policy Analysis and Management , 2* (4), s. 499-514.

Niinnien, P. (2000). Effect of publicly and privately financed R&D on total factor productivity growth. *Finnish Economic Papers,* 56-68.

NSB (2008). *Digest of Key Science and Engineering Indicators.* National Science Foundation.

OECD. (1998a). *Spotlight on public support to industry.* OECD Publications.

OECD. (1998b). *Technology, productivity and job creation; Best policy practices.* OECD Publication

OECD. (2002a). *Tax incentives for research and developments: Trends and issues.* Paris: OECD Publications.

OECD. (2002b). *Frascati Manual.* Paris: OECD Publications.

OECD and EUROSTAT. (2005). *Oslo Manual.* Paris: OECD Publications.

OECD. (2006). *Government R&D Funding and Company Behaviour: Measuring Behavioural Additionality.* Paris: Source OECD Science & Information Technology.

Özçelik, E. and Taymaz, E. (2008). R&D support programs in developing countries:The Turkish experience. *Research Policy,* 258-275.

Penrose, E. (1951). *The economics of the international Patent System.* Baltimore: John Hopkins University Press.

Piric, A. and Reeve, N. (1997). *Evaluation of public investment in R&D–towards a contingency analysis, OECD Conference on Policy Evaluation in Innovation and Technology Report.* Paris: OECD.

Polt, W. and Rojo, J. (2002). *Policy Insturments in RTD evaluation toolbox, "Socio-economic evaluation of public RTD policies (EPUB)".* Sevilla, Vienna: IPTS, Johenneum Research.

Polt, W. and Woitech, B. (2002). *Cost benefit analysis in RTD Evaluation toolbox, "Socio-Economic Evaluation of Public RTD policies (EPUB)".* Sevilla, Vienna: IPTS, Johenneum Research.

Prescott, E. C. (1997). *Needed: A theory of total factor productivity.* Minnesota: Federal Reserve Bank of Minneapolis.

Reynolds, C. L. and DesJardins, S. L. (2009). The use o fmatching methods in higher education research: Answering whether attendance at a 2-year institution results in differences in educational attainment. J. C. Smart in, *Higher education: Handbook of theory and research* (s. 47-104). Dordrecht, The Netherlands: Springer.

Romer, P. M. (1990). Endogenous technological change. *The Journal of Political Economy,* 71-102.

Rosenbaum, P. R. and Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika* , 41-55.

Rosenberg, N. (1976). Science, invention and economic growth. *The Economic Journal* , 90-108.

Rossi, P. H., Freeman, H. E. and Lipsey, M. W. (1999). *Evaluation A systemic approach* (6 b.). London, New Delhi: SAGE Publications.

Rubin, A. A. (2004). Direct and indirect causal effects via potential outcomes. *Scandinavian Journal of Statistics,* 161-170.

Rubin, D. B. (1977). Assignment to Treatment Group on the Basis of a Covariate. *Journal of Educational Statistics,* 1-26.

Rubin, D. B. (1974). Estimating causal effects of treatments in rondomized and nonrondomized studies. *Journal of Educational Psychology,* 688-701.

Ruegg, R. (2003). *A Toolkit for evaluatıng public R&D investment.* Gaithersburg: US Department of Commerce, NIST.

Santarelli, E. and Sterlacchini, A. (1990). Innovation, formal vs. informal R&D, and firm size: Some evidence from Italian manufacturing firms. *Small Business Economics,* 223-228.

Sarıtaş, Ö., Taymaz, E. and Tümer, S. T. (2007). Vision 2023: Turkey's national Technology Foresight Program: A contextualist analysis and discussion. *Technological Forecasting & Social Change* , 1374-1393.

Schmookler, J. (1965). Technological Change and Economic Theory. *The American Economic Review* , 333-341.

Schneider, C. and Vaugelers, R. (2008). *On Young Innovative Companies: why they matter and how (not) to policy support them.* SSRN.

Schumpeter, J. (1942). *Capitalism, Socialism, and Democracy .* New York: Harper and Row.

Shadish, W. R., Cook, T. and Champbell, D. (2002). *Experimental and quasi-experimental designs for generalized causal inference.* Boston, Newyork: Houghton Mifflin Company.

Simar, L. (2007). How to Improve the Performances of DEA/FDH Estimators in the Presence of Noise? *Journal of Productivity Analysis*, 183-201.

Smith, J. (2000). A Critical Survey of Empirical Methods for Evaluating Active Labor Market Policies. *Schweizerische Zeitschrift fr Volkswirtschaft und Statistik* , 1-22.

Splawa-Neyman, J. (1990). “On the Application of Probability Theory to Agricultural Experiments. Essays on Principles. Section 9.”. *Statistical Science* , 465-72 (Orig.pub. 1923).

Srholec, M. and Verspagen, B. (2008). *The voyage of the Beagle in innovation systems land: Explorations on sectors, innovation, heterogeneity and selection.* UNU-MERIT Working Paper Series.

Suetens, S. (2002) *R&D subsidies and production effects of R&D personnel Evidence from the Flemish Region* CESIT Working Papers.

Takalo, T., Tanayama, T. and Toivanen, O. (2008). *Evaluating innovation policy: a structural treatment effect model of R&D subsidies.* Helsinki: Bank Of Finland, Discussion Paper 7/2008.

Taymaz, E. (2001). *Ulusal Yenilik Sistemi, Turkiye imalat sanayiinde teknolojik değişim ve yenilik süreçleri.* Ankara: Tübitak/TTGV/DIE.

Taymaz, E. (2009). "Does innovation and technology policy pay-off?". *Knowledge Economy Forum VIII INSEAD.* Fontainebleau, France.

Taymaz, E. and Üçdoğruk, Y. (2007). *The demand for researchers: Does public R&D support make a difference?* Ankara.

Telçeken, Y. (2010, 5 26). *Ar-Ge Teşvikleri Semineri.* Türk İşadamları ve Sanayiciler Derneği: http://www.tusiad.org.tr/FileArchive/Yucel_Telceken.pdf, last accessed at November 2010

Teubal, M. (1996). R&D and Technology Policy in NICs as Learning Processes. *World Development , 24* (3), 449-460.

Tobin, J. (1958). Estimation of Relationships for Limited Dependent Variables. *Econometrica* , 24-36.

TUIK. (2010). *Annual Business Statistics Metadata.* Turkish Statistical Institute: http://www.turkstat.gov.tr/MetaVeri.do?tb_id=30&ust_id=9, last accessed at March 2010

TÜBİTAK. (2004). *TÜBİTAK BTY politikaları, Vizyon 2023*. TÜBİTAK: http://www.tubitak.gov.tr/sid/472/pid/468/index.htm, last accessed at December 2010

TÜBİTAK. (2005). *Bilim ve Teknoloji Politikaları Uygulama Planı (2005-2010)*. TÜBİTAK BTY Politikaları: http://www.tubitak.gov.tr/sid/1045/pid/468/index.htm, last accessed at December 2010

TÜBİTAK. (2010). *Ulusal Bilim, Teknoloji ve Yenilik Stratejisi 2011-2016*. TÜBİTAK BTY Politikaları: http://www.tubitak.gov.tr/tubitak_content_files//BTYPD/strateji _belgeleri/UBTYS_2011-2016.pdf, last accessed at January 2011

Türkcan, E. (1974). The limits of science policy in a developing country: The Turkish case a study based on the experience of the scientific and technical research council of Turkey. *Research Policy,* 336-363.

Türkcan, E. (2009). *Dünya'da ve Türkiye'de Bilim Teknoloji ve Politika.* İstanbul: Bilgi Üniversitesi Yayınları.

UN. (1980). *Manual for evaluation of Iidustrial projects.* New York: United Nations.

UNESCO. (2010). *UNESCO Science Report 2010: The Current Status of Science around the World.* Paris: Unesco Publishing.

Usher, D. (1964). The Welfare Economics of Invention. *Economica, New Series,* 179-287.

Wallsten, S. (2000). The effects of government-industry R&D programs on private R&D: the case of the Small Business Innovation Research program. *RAND Journal of Economics,* 82-100.

Wang, J. and Tsai, K. (1998). The impact of research and development promotion schemes in Taiwanese electronic component industry. *R&D Management* , 119-124.

Wooldridge, J. M. (2001). *Econometric Analysis of Cross Section and Panel Data.* London, England: The MIT Press, Cambridge, Massachusetts.

WorldBank. (2009). *Turkey National Innovation and Technology System, Recent Progess and Ongoing Challenges.* Europe and Central Asia Region: World Bank, 48755-TR.

Yegorov, I. (2009). Post-Soviet science: Difficulties in the transformation of the R&D systems. *Research Policy,* 600-609.

Yoo, S. J. (2007). *National Evaluation System of Public R&D Program in Korea.* Madrid, Spain: Seminar on Evaluating Innovative Approaches to Public Service Delivery.

Yurtseven, A. E. and Tandoğan, V. S. (2010). *Patterns of innovation and intra-industry heterogeneity in Turkey.* Ankara: METU STPS Working Paper No 1001.

APPENDICES

APPENDIX A: R&D TAX INCENTIVES IN EU AND SELECTED COUNTRIES

Table 37 Summary of R&D Tax incentives in EU and selective other countries (2008)

Country	Corporate income tax rate large/small firm	Rate on level	Rate on increment	Base for increment[1]	Expense base	Deducted from
European Union and EEC Countries						
Austria	25%					
– special allowance		125%	(+)[2] 135%	3 yrs	Current expenses	Income
– capital allowance		115%			Machinery, buildings	Income
– alternative refundable tax credit		8%			Current expenses	Tax
Belgium	33.99%/24.97%					
– investment deduction		13.5%			Machinery, buildings	Income
– withholding tax credit		75%			Research wages	Withholding tax
Czech Republic	21%	200%			Current expenses	Income
Denmark	25%					
– collaborative R&D with universities		150%			Current expenses	Income
France (refundable)	34.43%				Current expenses and depreciation	Income
– R&D 100 M euro		30%				
– over 100 M euro		5%				
Greece	25%		50%	2 yrs	Current expenses	Income
Hungary	16%					
– tax credit		10%			Research wages	Tax
– with/at universities		400%			Current expenses	Income
– other R&D		200%			Current expenses	Income
Ireland	12.5%					
– R&D expenditure			25%	2003 level	Current expenses and machinery	Tax
– R&D buildings		20%			Buildings	Tax
Italy	31.4%					
– tax credit		10%			Current expenses and machinery	Tax
– collaborative R&D		40%			Contracts	Tax
Malta	35%	150%			Current expenses	Income
Netherlands	25.5%/20%	14% large firm; 42 % small			Research wages	Income
Poland	19%					
– credit for technology purchases		30% large firm; 50% small			Machinery	Tax
Portugal	26.5%	20%	50%	2 yrs	Current expenses	Tax
Spain	30%/25%					
– Tax credit		25%	(+) 42%	2 yrs	Current expenses	Tax
– Capital R&D		10%			Machinery	
United Kingdom	28%/21%					
– Small company (refundable)		175%			Current expenses	Income
– Large company		130%			Current expenses	Income

Table A1(Continued)

Country	Corporate income tax rate large/small firm	Rate on level	Rate on increment	Base for increment[1]	Expense base	Deducted from
		Other Countries				
Australia	30%					
- R&D allowance		125%	(+) 175%	3 yrs	Current expenses and machinery	Income
Brazil	34%					
- R&D allowance		160%			Current expenses	Income
Canada (federal)	19%/11%					
– Small company (refundable)		20%			Current expenses and machinery	Tax
– Large company		35%				
China	25%					
- R&D allowance		150%			Current expenses	Income
India	33.9%					
- R&D allowance		150%			Current expenses and machinery	Income
Japan	39.5% 29.3%					
– large (small) firm <10% research intensity		8% (12%)			Current expenses and machinery depreciation	Tax
– large (small) firm >10% research intensity		10% (12%)			Current expenses and machinery depreciation	Tax
– collaboration with universities and other R&D institutes		12% (15% small firms)			Current expenses and machinery depreciation	Tax
Norway (refundable)	28%	18%(20% small firms)			Current expenses	Tax
Turkey	20%					
- R&D allowance		200%			Current expenses	Income
United States (federal)	35%/15%		20%	Maximum 50% of current expenses	Current expenses	Tax

NOTES:
1. Average over specified number of years 2. (+) In conjunction with volume tax incentive

Source: Expert Group on Impacts of R&D Tax Incentives Directorate General – Research European Commission Annex 4 and 5

APPENDIX B: EVALUATION METHODOLOGIES

Table B1 Qualitative and quantitative evaluation methodologies

Methodology	Data application level	Areas of application	Output	Outcome	Impact
Innovation Surveys	Firm Industry Economy-wide	Innovation IPRs Technology transfer Research collaboration	New products and processes Increase in sales Increase in value added Patent counts, IPRs	Creation of new jobs Innovation capacity building	Enhanced Competitiveness Institutional and organisational efficiency, Faster diffusion of Innovation Employment
Micro Methods	Plant Firm Industry Economy-wide	Sectoral Returns to R&D	Output and value added (collect baseline info for before-after comparisons)	Sectoral productivity industry sectoral spillovers Additionality, Leverage effects	Firms competitiveness
Macro Methods	Firm Industry Economy-wide	Sectoral Regional Economy-wide	Output and value added	Change in R&D Capital, Human capital, Social capital International R&D Spillovers	Regional, country productivity Employment, Good governance Economic and social cohesion
Productivity Studies	Plant Firm Industry Regional Economy-wide	Sectoral Regional Economy-wide	Output and value added	knowledge, geographical and International R&D Spillovers	Regional, country productivity Employment Economic and social cohesion
Control Group Approaches	Firm Industry	Technology implementation Innovation	Output and value added (on supported and non supported firma)	Additionality Rate of return to R&D	Firm, industrial competitiveness
Cost Benefit Analysis	Firm Industry	Health Environment Energy Transport	Value added benefit-cost ratio IRR Consumer surplus	Health improvements Consumer protection Environmental sustainability	Quality of life Standard of living
Expert Panels/ Peer Review	Firm Industry Economy-wide	Scientific merit Technological capacity	Publication counts Technological output	Scientific and Technological capabilities	R&D performance
Field/ Case Studies	Firm Industry	Science-industry relationships	Detailed inputs and outputs	firms RTD capabilities on the job-training educational schemes	Industrial competitiveness Quality of life Organisational efficiency
Network Analysis	Firm Industry Regional	RJVs, cooperation science industry Clusters	Cooperation linkages	Cooperation in clusters Social embededness	Efficiency of institutional relationships
Foresight/ Technology Assessment	Institution Regional Economy-wide	Technology Trends	Identification of generic technologies Date of implementation	Technological capacities	Technological paradigms shifts
Benchmarking	Firm Industry Economy-wide	Efficiency of technology policy	S&T indicators	Technology capabilities	Industry competitiveness Good governance

Table B1(Continued)

Methodology	Data application level	Areas of application	Output	Outcome	Impact
Innovation Surveys	Firm Industry Economy-wide	Innovation IPRs Technology transfer Research collaboration	New products and processes Increase in sales Increase in value added Patent counts, IPRs	Creation of new jobs Innnovation capacity building	Enhanced Competitiveness Institutional and organisational efficiency, Faster diffusion of Innovation Employment
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Macro Methods	Firm Industry Economy-wide	Sectoral Regional Economy-wide	Output and value added	Change in R&D Capital, Human capital, Social capital International R&D Spillovers	Regional, country productivity Employment, Good governance Economic and social cohesion
Productivity Studies	Plant Firm Industry Regional Economy-wide	Sectoral Regional Economy-wide	Output and value added	knowledge, geographical and International R&D Spillovers	Regional, country productivity Employment Economic and social cohesion
Control Group Approaches	Firm Industry	Technology implementation Innovation	Output and value added (on supported and non supported firma)	Additionality Rate of return to R&D	Firm, industrial competitiveness
Cost Benefit Analysis	Firm Industry	Health Environment Energy Transport	Value added benefit-cost ratio IRR Consumer surplus	Health improvements Consumer protection Environmental sustainability	Quality of life Standard of living
Expert Panels/ Peer Review	Firm Industry Economy-wide	Scientific merit Technological capacity	Publication counts Technological output	Scientific and Technological capabilities	R&D performance
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Foresight/ Technology Assessment	Institution Regional Economy-wide	Technology Trends	Identification of generic technologies Date of implementation	Technological capacities	Technological paradigms shifts
Benchmarking	Firm Industry Economy-wide	Efficiency of technology policy	S&T indicators	Technology capabilities	Industry competitiveness Good governance

Source : Polt and Rojo (EBUP, 2002, pp.74-75)

APPENDIX C: HIGHLIGHTS FROM CAPRON'S STUDY ON EVALUATION OF THE IMPACTS OF R&D PROGRAMS

Table C1 Synthesis of evaluation methods –Relevance and drawbacks

Method	Relevance	Drawbacks	Field of application
a. Assessment by peers, questionnaires and interviews.	- Screens of projects and research orientations.	- Subjectivity of experts. - Partial forecasts. - Lack of independence of experts. - Does not allow to measure the global economic impact.	- Selection and technical evaluation. - Technological forecasting.
b. Matrix approaches : - Analysis matrices.	- Rich information.	- Difficult, even impossible to collect the required information.	- Evaluation of the industrial impact of R & D expenditure.
- Decision-making matrices	- Decision-making process. - Rationalise and simplify choices.	- Subjectivity. - Lack of flexibility. - The number of statistics required is substantial.	- Multicriteria interpretation.
- Multicriteria analysis	- Profiles projects and R & D planning.	- Requires constituting a specialized group. - Subjective choice of criteria and weightings.	- Project selection.
- Relevance trees	- Provide lots of information.	- Strongly empirical. - Arborescence. - Subjectivity in the allocation of quantitative values.	- Emphasizing the links between the different research projects, technology and the economy.
c. Systemic approaches : - Systemic analysis.	- Can be used to implement an evaluation. - R & D strategies. - Appropriate to select projects.	- Not really suitable for evaluating as such.	- Selection and control.
- Dynamic modelling.	- Takes the evolutionary character of the economy into account. - Includes social, historical and ecological structures. - Takes feedback phenomena into account.	- Very difficult to implement.	- Analysis of the evolution of a system and of its adaptability.

Table C1 (Continued)

d. Financial methods :			
- Cost-benefit / cost-effectiveness analyses.	- Measure marketable outputs and commercial resources.	- Difficult to collect the information. - Some factors cannot be measured or financially assessed. - The actualisation rate is difficult to choose. - Do not allow to take R & D externalities into account.	- *Financial* evaluation of a project.
- Ratios methods.	- Simple instruments.	- Difficult to estimate time-lag between research and development. - Number of periods to take into account.	- Measurement of the ex-post return. *Financial* evaluation. - Project selection. - Determining the financial lump sum to invest in R & D.
- Risk profiles.		- Highly variable results.	
- Programming models.		- Subjectivity in the choice of the success probability and of criteria.	
- Portfolio models.		- Purely financial aspects.	
e. Technological forecasting methods			
- Scenario method.	- Allows to reverse the causality chain. - Takes social transformations into account.	- See a.	- Selection and technical evaluation. - Technological forecasting.
- Cross-impact matrices.	- Overcome the problem of interdependences between questions.	- Subjectivity always present.	- Selection and technical evaluation. - Technological forecasting.
- Morphological analysis.	- Discontinuous character.	- See a.	- Forecasting.
f. Quantitative indicators			
- Science and technology indicators.	- Easy measurement. - Measure technical resources.	- Purely descriptive. - Does not take the indirect effects into account. - Micro-macro cross-cutting.	- Measuring how efficient the R & D input is at the macro level.
- Bibliometrics	- Builds up fundamental research indicators.	- Not well suited for evaluating development. - Partial indicators.	- Analysis of the evolution of a system and of its adaptability.
g. Econometrics.	- The only general quantitative method available for evaluating the economic impact of R & D expenditure.	- Theoretical and methodological background. - Availability of statistical material. - Aggregation bias. - Not well-suited for forecasting.	- Evaluation of the impact of R & D expenditure upon the economy.

Source: Capron, 1992b, pp. 27-28

Table C2 Impact of publicly funded R&D on productivity

Study	Sample	Specification [1]	Additional variables	Results
Leonard (1971)	16 industry groups United States (1957-63)	- correlation analysis between research intensity and measures of industrial growth	- sales, assets, net income, net worth, net plant, production and equipment, value added, real output, productivity	- significant only for commercially oriented industries (14 industry groups) - economically inefficient, excessive allocation of R & D resources to defense and space uses
Terleckyj (1974, 1980a, 1980b)	20 manufacturing industries United States (1948-66)	- Cobb-Douglas TFPG [2] - alternative measures of productivity growth due to extensive adjustments of capital stocks - government R & D intensity and R & D embodied in purchases from other industries	- non-government sales, relative unionization rate, cyclical component and human capital - private R & D intensity and R & D embodied in purchases from other industries	non-significant impact
Mansfield (1980)	20 manufacturing industries United States (1948-66)	- Cobb-Douglas TFPG - government-financed applied R & D intensity	- distinction between basic and applied research, relative number of union members and R & D pay-off expectations	non-significant impact except for R & D pay-off expectations
Griliches (1980b)	883 companies United States (1957-65)	- Cobb-Douglas PFPG - growth rates of total R & D expenditures and company R & D expenditures	- approximated physical capital, "quality of data" variables	- no direct evidence of the superiority of company-financed R & D as against federally financed R & D - additional evidence that federally financed R & D is biased towards large companies and is concentrated in industries with the lowest rate of return

[1] TFPG = total factor productivity growth.
PFPG = partial factor productivity growth.
TFP = total factor productivity.
PFP = partial factor productivity.

[2] Some measures have also been derived from a translog production function including intermediate inputs.

Table C2 (Continued)

Link (1981)	51 manufacturing firms United States (1973-78)	- Cobb-Douglas TFPG - government-financed basic and applied R & D intensities	- company-financed basic and applied R & D intensity and relative number of union members	only government-financed basic R & D has a significant impact
Levy-Terleckyj (1983)	private business sector United States (1949-81)	- Cobb-Douglas PFP - ratio of government R & D capital to fixed capital - distinction between government contract R & D and other government R & D	- unemployment, fixed capital and company R & D	only government-contract R & D significant but much smaller effect than that of the private R & D
Cunéo (1984)	84 enterprises of the heavy sector and 98 enterprises of the scientific sector France (1972-77)	- Cobb-Douglas PFP - ratio of R & D capital to labor with a distinction between enterprises receiving more than 1 % of their R & D investment from government and others. An additional constant variable is also introduced for these enterprises	- fixed capital, basic R & D investment and basic R & D investment dummy	significant impact with level effect
Griliches-Lichtenberg (1984)	27 manufacturing industries United States 3 subperiods (1959-68), (1964-73), (1969-76)	- Cobb-Douglas TFPG - government R & D intensity	- private R & D intensity	non-significant impact
Reiss (1990)	27 manufacturing industries United States (1969-76)	- Cobb-Douglas TFPG - distinction between outlying and nonoutlying industries - governement R & D intensity	- private R & D intensity	significant impact except for outliers (missiles, engines, computers and farm machinery)
Griliches (1986)	500-1000 enterprises United States (1966-77)	- Cobb-Douglas PFPG - R & D growth rate and ratio of company-financed R & D stock to total	- basic research and capital services - alternative results presented for the production function and the gross profit rate	significant implicit impact

Table C2 (Continued)

Levy-Terleckyj (1989)	telecommunications industy United States (1958-85)	- Cobb-Douglas and CES production functions - government R & D stock	- labor, capital and private R & D stock	significant impact for the Cobb-Douglas
Klette (1991)	1268 establishments Norway (1976-85)	- generalized TFPG - publicly-financed R & D	- manhours, ownership	non-significant impact reported
Lichtenberg-Siegel (1991)	over 2000 companies United States 3 subperiods (1973-76), (1977-80), (1981-85)	- Cobb-Douglas TFPG - federally-funded R & D	- company-funded R & D	non-significant impact

Source: Capron, 1992a, pp. 114-116

Table C3 Impact of publicly-funded R&D on private R&D investment

Study	Sample	Specification [1]	Additional variables	Results
Leonard (1971)	16 industry groups United States (1957-63)	- correlation analysis between research intensity and measures of industrial growth	- sales, assets, net income, net worth, net plant, production and equipment, value added, real output, productivity	- significant only for commercially oriented industries (14 industry groups) - economically inefficient, excessive allocation of R & D resources to defense and space uses
Terleckyj (1974, 1980a, 1980b)	20 manufacturing industries United States (1948-66)	- Cobb-Douglas TFPG [2] - alternative measures of productivity growth due to extensive adjustments of capital stocks - government R & D intensity and R & D embodied in purchases from other industries	- non-government sales, relative unionization rate, cyclical component and human capital - private R & D intensity and R & D embodied in purchases from other industries	non-significant impact
Mansfield (1980)	20 manufacturing industries United States (1948-66)	- Cobb-Douglas TFPG - government-financed applied R & D intensity	- distinction between basic and applied research, relative number of union members and R & D pay-off expectations	non-significant impact except for R & D pay-off expectations
Griliches (1980b)	883 companies United States (1957-65)	- Cobb-Douglas PFPG - growth rates of total R & D expenditures and company R & D expenditures	- approximated physical capital, "quality of data" variables	- no direct evidence of the superiority of company-financed R & D as against federally financed R & D - additional evidence that federally financed R & D is biased towards large companies and is concentrated in industries with the lowest rate of return

[1] TFPG = total factor productivity growth.
PFPG = partial factor productivity growth.
TFP = total factor productivity.
PFP = partial factor productivity.

[2] Some measures have also been derived from a translog production function including intermediate inputs.

Table C3 (Continued)

Study	Sample	Specification	Additional variables	Results[1]
Nadiri (1980)	11 manufacturing, 5 durables and 6 non durables industries United States (1966-75)	- derived demand model for private R & D investment - government-financed R & D	ratio of wage to user cost of capital, output level, lagged employment, lagged capital, lagged utilization rate and lagged private R & D investment	- spin-off effect in manufacturing and non durables industries (.09, .02) - crowding-out effect in durable industries (-.04)
Carmichaël (1981)	46 firms in the transport industry United States (1976-77)	- capital asset pricing model for private R & D investment - government-financed R & D	- sales - distinction between small and big firms	crowding-out effect (-.08)
Levy-Terleckyj (1983)	private business sector United States (1949-81)	- private R & D investment function - government-financed R & D investment and distinction between contracting R & D, reimbursed overhead R & D and other R & D	output, taxes, unemployment, weighted average age of the R & D stock	- spin-off effect of government contract R & D (.27) - non-significant effect for reimbursed and other R & D
Levin-Reiss (1984)	20 industries United States (1967, 1972, 1977)	- behavioral model for private R & D intensity - government-financed R & D intensity	relative basic R & D expenditures, industry age, concentration index, new and improved products-oriented R & D	spin-off effect (.10)
Scott (1984)	3387 lines of business United States (1974)	- company R & D intensity - government-financed R & D industry	alternative results presented for company R & D investment with sales as explanatory variable	spin-off effect (.08)
Switzer (1984)	125 enterprises United States (1977)	- flow-of-funds model for private R & D investment - government-financed R & D	lagged R & D, concentration index, change in sales, financial variables	non-significant effect

Table C3 (Continued)

Lichtenberg (1984)	991 enterprises United States (1967, 1972, 1977)	- company R & D intensity - government-financed R & D intensity - company R & D intensity changes - federal R & D intensity changes		spin-off effects on 1967 and 1972 and crowding-out effect in 1977 (.05, .10, -.22) crowding-out effect (-.48, -.17, -.26)
	12 manufacturing industries United States (1963-79)	- company R & D changes - federal R & D changes	lagged independent variable	non-significant impact
		- company R & D employment changes - federal-funded R & D employment changes	lagged independent variable	crowding-out effect (-.30)
Link (1982)	275 manufacturing firms United States (1977)	- company R & D intensity and relative composition of R & D between basic research, applied research and development - government-financed R & D intensity	relative profits, diversification index, concentration index and ownership form	spin-off effect (.09) and reallocation from basic and applied research toward development
Mansfield-Switzer (1984)	25 firms engaged in energy R & D projects United States (1979)	estimates by R & D officials of the effects of federal funding		asymmetric dynamic spin-off effects (.12 for an increase and .69 for a cut in federal funding)
Lichtenberg (1987)	private business sector United States (1956-83)	- private R & D investment - federally funded R & D	GNP decomposed between federal expenditures and other GNP components	spin-off effect (.33) canceled by GNP decomposition
	1987 firms United States (1979-84)	- company R & D investment - federally funded R & D	sales decomposed between government and non-government sales	spin-off effect (.13) canceled by decomposition
Lichtenberg (1988)	169 firms United States (1979-84)	- company R & D investment - R & D - non R & D and competitive - non competitive government procurement	non-government sales data span a major defense buildup	- non R & D contracts at least as well as incentive as R & D contracts - large crowding-out effect for non - competitive R & D - non-significant effect for competitive R & D

Table C3 (Continued)

Holemans-Sleuwaegen (1988)	236 companies Belgium (1980-84)	- company R & D investment - government-funded R & D with a distribution between foreign-owned companies and domestic companies - dummy variable for firms not receiving public support	sales, employment, royalties and fees, concentration index, foreign-owned companies dummy, diversification index	non-supported firms dummy significantly positive, significant spin-off elasticity (0.35)
Antonelli (1989)	80 firms Italy (1983)	- company R & D investment - ratio of public subsidies to total R & D expenditures	profit, size, export, growth rate of profit, diversification dummy, average ratio of US R & D expenditures to sales	significant spin-off elasticity (0.37)
Levy (1990)	private business sector 9 OECD countries (Italy, Japan, Germany, Sweden, Netherlands, France, Switzerland, UK, USA) (1963-84)	- private R & D investment - government-financed R & D	GDP estimation based on Box-Cox transformation with pooled data	significant positive impact except for : - UK and Netherlands : negative impact - Italy and Switzerland : no impact

1. Note : values between parentheses are the estimated impacts.

Source: Capron, 1992a, pp. 117-119

APPENDIX D: INDUSTRY AND GOVERNMENT FINANCED GERD

Table D1 Gross Domestic Expenditures of R&D (GERD) as a percentage of Gross Domestic Product (GDP)

Percentage | *Pourcentage*

	1995	2004	2005	2006	2007	2008	2009
Australia / Australie	..	1.78	..	2.06	..	..	..
Austria / Autriche	1.55[b]	2.26	2.45[b]	2.47	2.54	2.67[c]	2.78[p]
Belgium / Belgique	1.67	1.86	1.83	1.86	1.90	1.92[p]	..
Canada	1.70	2.08	2.05	1.97	1.90	1.84[p]	1.99[b,p]
Czech Republic / République tchèque	0.95[a]	1.25	1.41	1.55	1.54	1.47	..
Denmark / Danemark	1.82	2.49	2.46	2.48	2.55[a]	2.72[c]	..
Finland / Finlande	2.27	3.45	3.49	3.45	3.48	3.49[c]	..
France	2.29	2.15[a]	2.10	2.10	2.04[p]	2.02[p]	..
Germany / Allemagne	2.19[b]	2.49	2.49	2.53	2.53	..	..
Greece / Grèce	0.43[a]	0.55[c]	0.59	0.58[c]	0.58[p]	..	..
Hungary / Hongrie	0.72[d]	0.87[a]	0.95	1.00	0.97	..	..
Iceland / Islande	1.53	..	2.77	2.99	2.70	2.65[p]	..
Ireland / Irlande	1.26[b]	1.23	1.25	1.25	1.28[p]	1.40[p]	..
Italy / Italie	0.97	1.10	1.09	1.13	1.18	1.18[p]	..
Japan / Japon	2.92[i]	3.17	3.32	3.41	3.44	..	..
Korea / Corée	2.27[g]	2.68[g]	2.79[g]	3.01[g]	3.21[a]	..	..
Luxembourg	..	1.63	1.56	1.65	1.57[p]	1.62[p]	..
Mexico / Mexique	0.28	0.40[a]	0.41	0.39	0.38	..	..
Netherlands / Pays-Bas	1.97	1.81[a,f]	1.79[p]	1.78[f]	1.71[p]	..	..
New Zealand / Nouvelle-Zélande	0.95	..	1.16	..	1.21	..	..
Norway / Norvège	1.69[a]	1.59	1.52	1.52	1.64	1.62[p]	..
Poland / Pologne	0.63[a]	0.56	0.57	0.56	0.57	0.61	..
Portugal	0.54	0.77[c]	0.81	1.02[c]	1.21	1.51[a,p]	..
Slovak Republic / République slovaque	0.92[d]	0.51	0.51	0.49	0.46	0.47	..
Spain / Espagne	0.79	1.06	1.12	1.20	1.27	1.35	..
Sweden / Suède	3.26[a,m]	3.62[m]	3.60[a]	3.74	3.61	3.75[c]	..
Switzerland / Suisse	..	2.90	..	..	..	..	..
Turkey / Turquie	0.28	0.52	0.59	0.58	0.72	..	..
United Kingdom / Royaume-Uni	1.91	1.69	1.73	1.76	1.82	1.88[p]	..
United States / États-Unis	2.50[i]	2.54[i]	2.57[i]	2.61[i]	2.66[i]	2.77[i,p]	..
EU27 / UE27	1.66[b]	1.73[b]	1.74[b]	1.76[b]	1.77[b]	..	..
OECD-Total / OCDE-Total	**2.05[a,b]**	**2.17[b]**	**2.21[b]**	**2.24[b]**	**2.28[b]**	**..**	**..**
Argentina / Argentine	..	0.44	0.46	0.50	0.51	..	..
China / Chine	0.57[m]	1.23	1.34	1.42	1.44	..	..
Israel / Israël	2.57[d]	4.26[c]	4.37[d,p]	4.41[c,f]	4.76[d,p]	4.86[d,p]	..
Romania / Roumanie	0.80[a]	0.39	0.41	0.45	0.52	0.59	..
Russian Federation / Fédération de Russie	0.85	1.15	1.07	1.07	1.12	1.04	..
Singapore / Singapour	1.15	2.19	2.28	2.27	2.52	..	..
Slovenia / Slovénie	1.53[i]	1.40	1.44	1.56	1.45	1.66	..
South Africa / Afrique du Sud	..	0.86	0.92	0.95	..	..	..
Chinese Taipei / Taipei chinois	1.72[d]	2.38	2.45	2.58	2.62	..	..

Source: OECD, Main Science and Technology Indicators database, December 2009

Table D2 Industry and Government-financed Gross Expenditure on R&D (GERD), as a Percentage of GDP (1995 and 2006, or closest date)

	Industry-funded GERD			Government-funded GERD		
	2006	1995	Difference	2006	1995	Difference
Sweden	2.55	2.17	0.38	0.91	0.96	-0.05
Finland	2.30	1.35	0.95	0.87	0.79	0.08
Germany	1.68	1.31	0.37	0.70	0.83	-0.13
Denmark	1.46	0.82	0.64	0.67	0.72	-0.05
Luxembourg	1.28	na	na	0.27	na	na
Austria	1.14	0.70	0.44	0.90	0.72	0.18
France	1.12	1.10	0.02	0.82	0.96	-0.14
Belgium	1.11	1.12	-0.01	0.46	0.39	0.07
Netherlands	0.90	0.90	0.00	0.64	0.83	-0.19
Czech Republic	0.88	0.60	0.28	0.60	0.31	0.29
Slovenia	0.82	0.72	0.10	0.56	0.64	-0.08
Ireland	0.79	0.85	-0.06	0.40	0.28	0.12
United Kingdom	0.75	0.94	-0.19	0.58	0.64	-0.06
Spain	0.52	0.35	0.17	0.48	0.35	0.13
Italy	0.43	0.41	0.02	0.56	0.52	0.04
Hungary	0.43	0.27	0.16	0.45	0.38	0.07
Portugal	0.29	0.11	0.18	0.45	0.35	0.10
Poland	0.18	0.23	-0.05	0.32	0.38	-0.06
Slovak Republic	0.17	0.55	-0.38	0.27	0.35	-0.08
Greece	0.16	0.10	0.06	0.24	0.20	0.04
Romania	0.14	0.31	-0.17	0.29	0.46	-0.17
Median	0.82	0.70	0.10	0.56	0.46	0.00
EU27	0.94	0.86	0.08	0.61	0.66	-0.05
United States	1.70	1.51	0.19	0.77	0.89	-0.12
Japan	2.53	1.96	0.57	0.56	0.67	-0.11
China	0.99	na	na	0.35	na	na

Source: B. van Pottelsberghe (2008, p. 8)

APPENDIX E: 2004-2006 TURKISH INNOVATION SURVEY

Table E1 2004-2006 Turkish Innovation Survey (TÜİK)

T.C.
BAŞBAKANLIK
TÜRKİYE İSTATİSTİK
KURUMU
BAŞKANLIĞI

2006
YENİLİK ANKETİ

TÜİK

Sayın Yetkili;

Bu araştırma ile 2004-2006 yılları arasındaki üç yıllık döneme ilişkin ürün yenilikleri, süreç yenilikleri, pazarlama yenilikleri ve organizasyonel yenilikler ile ilgili bilgi toplanmaktadır. Bu çalışmadan elde edilecek sonuçlar yeniliği ve yeniliğin ekonomik büyüme ile ilişkisinin daha iyi anlaşılmasını sağlayacaktır. Ayrıca, karar alıcılar bilim politikası, sanayi politikası ve bunlara bağlı olarak genel ekonomik politikaların oluşturulmasında girişimlerin yenilik yaratma kapasitelerini etkileyen faktörler hakkında bilgi sahibi olacaklar ve benzer konularda uluslararası karşılaştırma yapma imkanına sahip olacaklardır.

Gizlilik

Vereceğiniz bilgiler, sadece istatistiksel çalışmalarda kullanılmak amacıyla toplanmakta olup, gizliliği **5429 sayılı kanun** ile teminat altına alınmıştır.Bilgiler herhangi bir mükellefiyetin doğmasında veya tahkikatın yapılmasında delil olarak kullanılamaz. Bu gizlilik **Türkiye İstatistik Kurumu'**nun yasal sorumluluğudur.

Kapsam ve Yöntem

Sanayi ve hizmet sektöründe 10 ve daha fazla çalışanı olan girişimlerden örnekleme yöntemi ile tespit edilen girişimler kapsanmıştır. Bu çalışmanın gözlem dönemi 2004-2006, referans dönemi 2006 yılıdır.

Soru kağıdı, birden fazla birimi olan girişimlerin merkezlerinde, bağlı tüm birimlerin bilgilerini kapsayacak şekilde ve yenilik faaliyetlerinden sorumlu bir yönetici tarafından doldurulmalıdır.

Soru kağıdı kati surette muhasebe biriminde veya mali müşavirlik bürosunda doldurulmayacaktır.

Yukarıdaki açıklamalar doğrultusunda gereğinin yapılmasını önemle rica eder, iyi ilişkilerimizin sürmesi dileğiyle, işlerinizde başarılar dilerim.
Saygılarımla,

Doç. Dr. Ömer DEMİR
Başkan

GEREKTİĞİNDE BİLGİ İÇİN BAŞVURULACAK BÖLGE MÜDÜRLÜKLERİ TELEFON ve FAKS NUMARALARI

İL	KOD	TELEFON	FAKS	İL	KOD	TELEFON	FAKS	İL	KOD	TELEFON	FAKS
ADANA	322	457 65 58	457 64 19	GAZİANTEP	342	336 94 00	336 16 22	MALATYA	422	323 06 64	323 07 84
ANKARA	312	310 99 08	310 91 57	HATAY	326	216 70 40	216 70 78	MANİSA	236	211 49 94	211 49 97
ANTALYA	242	243 45 61	243 45 62	İSTANBUL	212	258 66 26	258 36 78	NEVŞEHİR	384	212 82 23	212 82 24
BALIKESİR	266	244 99 45	244 53 88	İZMİR	232	483 14 54	483 70 81	SAMSUN	362	431 25 08	432 50 88
BURSA	224	361 75 25	361 84 88	KARS	474	223 28 02	223 58 41	SİİRT	484	223 49 00	223 28 77
DENİZLİ	258	266 65 22	266 66 23	KASTAMONU	366	215 50 92	215 50 89	TRABZON	462	321 57 49	322 57 44
DİYARBAKIR	412	223 80 24	228 14 93	KAYSERİ	352	221 31 22	221 31 25	VAN	432	214 25 11	216 30 06
EDİRNE	284	225 31 47	212 08 51	KOCAELİ	262	321 52 86	332 52 28	ZONGULDAK	372	253 79 70	253 71 28
ERZURUM	442	235 20 15	234 40 32	KONYA	332	353 25 60	350 16 40				

Sanayi ve İş İstatistikleri Dairesi Başkanlığı **web sayfası** : http://www.tuik.gov.tr
0 (312) 410 04 12 - 410 04 15 - 410 04 19 **e-posta** : biltek@tuik.gov.tr

Yasal Unvan :

Girişim Sıra No

1

Sayfa 2'ye geçiniz

Table E1 (Continued)

BÖLÜM 1. Girişim (*) Hakkında Genel Bilgiler

(*)GİRİŞİM: Birinci derecede karar alma özerkliğini kullanarak, mal veya hizmet üreten bir organizasyon biçimidir. Girişim bir veya birden fazla faaliyet yürütebilir. Girişim ve yasal birim arasındaki ilişki şu tanımla doğrudan ifade edilir: Bir girişim ya yasal birime ya da yasal birimlerin birleşimine karşılık gelmektedir. Bu soru kağıdı; eğer girişiminizin aynı vergi kimlik numarası altında birden fazla adreste faaliyette bulunan birimi var ise girişim merkezinde tüm birimlerin bilgilerini kapsayacak şekilde doldurulmalıdır.

YEREL BİRİM: Coğrafi olarak tanımlanan bir yerdeki mal ve hizmetlere ilişkin faaliyetleri ya da bunların bir kısmını yürüten bir birimdir. Yerel birim, girişimin büro, mağaza, büfe, fabrika, atelye, maden ocağı, şantiye, otel, lokanta, kafe, okul, hastane, depo gibi adresi coğrafi olarak tanımlanabilen bir yerde yerleşik olan bölümdür. Yerel birim bu yerde bir veya daha çok kişinin tam gün veya kısmi olarak çalışması ile kendi girişimi için ekonomik faaliyet yürüttüğü yerdir. Girişimin merkezinin bulunduğu yer ile yardımcı faaliyet yürüten birimler de yerel birimlerdir.

1.1. Yasal Unvanınız nedir?

1.2. Girişiminiz bir girişim grubuna (holding, şirketler grubu vb.) bağlı mıdır?

Evet ☐ 1 Hayır ☐ 2 → Lütfen soru 1.3'e geçiniz

Grup adını ve grup merkezinin bulunduğu ülkeyi belirtiniz.

1. Grubun Adı
2. Ülkesi

1.3. Girişiminizin sermaye dağılımı nasıldır?

1. Yerli sermaye payı (%)	
2. Yabancı sermaye payı (%)	
Toplam	100

1.4. Girişiminizin 2006 yılındaki toplam satış hasılatı (CİRO) ne kadardır?

2006 yılı satış hasılatı (KDV hariç, YTL) ______ YTL

1.5. Girişiminizin 2006 yılı çalışan sayısı kaçtır?

Aylar	Çalışan sayısı (Kişi) (Ücretli çalışanlar, iş sahibi ve ortaklar ile ücretsiz çalışan aile fertleri dahil, aktif çalışmayan ortaklar hariç)
1. Şubat	
2. Mayıs	
3. Ağustos	
4. Kasım	
5. TOPLAM (Yukarıdaki 4 ayın toplamı)	
6. ORTALAMA (= TOPLAM satırı / 4) (Tamsayı olacak şekilde yuvarlayınız.)	

ÜCRETLİ ÇALIŞANLAR: Maaşlı ve ücretli çalışanlar sayısı; maaş, ücret, komisyon, ikramiye, parça başı ödeme veya ayni karşılıklar şeklinde yapılan ödemeleri alan, iş akdine sahip ve işveren için çalışan kişiler olarak tanımlanır. Maaşlı ve ücretli çalışanlar sayısında, kısmi çalışanlar, evde çalışanlar, mevsimlik çalışanlar, grevde olanlar veya kısa dönemli ayrılışlar içerir. Ancak uzun süreli ayrılan kişiler hariç tutulur. Maaşlı ve ücretli çalışanlar sayısında gönüllü çalışanlar kapsanmaz.

İŞ SAHİBİ VE ORTAKLAR: Zamanının çoğunu işyerinde çalışarak geçiren iş sahibi ve ortakları ifade eder. Bu kişilerden kar dışında emeği karşılığı ücret alanlar varsa iş sahibi ve ortaklar sütununda değil, ücretli çalışanlar kısmında kapsanır.

ÜCRETSİZ ÇALIŞAN AİLE FERTLERİ: Birimin sahibi ile birlikte yaşayan ve düzenli olarak birim için çalışan, ancak çalışmaları için sabit bir ücret almayan ve hizmet anlaşması olmayan kişiler kapsanır. Bu kişilere, başka bir işyerinde sürekli çalışanlar dahil değildir.

1.6. 2004-2006 yıllarını kapsayan üç yıllık dönemde girişiminiz hangi pazarlarda mal veya hizmet sattı? (Lütfen uygun olan tüm seçenekleri işaretleyiniz)

Türkiye içinde yerel/bölgesel pazarlar	☐ 1
Türkiye geneli	☐ 2
Avrupa ülkeleri	☐ 3
Diğer ülkeler	☐ 4

2

Sayfa 3'ye geçiniz

Table E1 (Continued)

BÖLÜM 2. Ürün (Mal ve Hizmet) Yeniliği

Ürün yeniliği (product innovation): Mevcut özellikleri veya öngörülen kullanımlarına göre yeni ya da önemli derecede iyileştirilmiş bir mal veya hizmetin ortaya konulmasıdır. Bu; teknik özelliklerde, bileşenler ve malzemelerde, birleştirilmiş yazılımda, kullanıcıya kolaylığında ve diğer işlevsel özelliklerinde önemli derecede iyileştirmeleri içermektedir.

Ürün yeniliğinin (yeni ya da önemli ölçüde geliştirilmiş / iyileştirilmiş mal veya hizmetin) sizin girişiminiz için yeni olması önemlidir. Sektörünüz ya da piyasa için yeni olup olmadığı önemli değildir. Yeniliğin ilk olarak başka bir girişim tarafından geliştirilmiş olması da önemli değildir.

Yeni ürünler, özellikleri ve öngörülen kullanımları açısından, girişim tarafından daha önce üretilmiş ürünlerden önemli derecede farklılaşan mal ve hizmetlerdir. İlk mikroişlemciler ve dijital kameralar, yeni teknolojiler kullanılarak üretilen yeni ürünlerin örnekleri olmuştur. **Mevcut üründe yapılan önemli derecede iyileştirmeler**, malzemelerde, bileşenlerde ve performansı artıran diğer özelliklerdeki değişiklikler yoluyla ortaya çıkmaktadır. Giyim eşyalarında nefes alabilir kumaşların kullanımı, ürün performansını iyileştiren yeni malzemeler kullanımını kapsayan bir ürün yeniliğine örnektir.

Hizmetlerde ürün yenilikleri; sağlanma biçimlerinde yapılan önemli iyileştirmeleri (örneğin, verimlilik ve hız açısından), mevcut hizmetlere yeni fonksiyonlar veya özellikler ilave edilmesini veya tümüyle yeni hizmetlerin piyasaya sürülmesini içerebilir. Buna örnek olarak, İnternet üzerinde ürün bilgileri ve çeşitli destek işlevleri gibi yeni hizmetlerin ücretsiz olarak müşterilere sunulabildiği web sitelerinin oluşturulması, yüksek derecede iyileştirilmiş hız ve kullanım kolaylığı getiren internet bankacılığı hizmetleri veya müşterilerin kiralık araçlara erişimini kolaylaştıran eve teslim, evden alım hizmetlerinin ilavesi gibi önemli yenilikler verilebilir.

Ürün yenilikleri; küçük çaplı değişiklikler veya iyileştirmeleri, rutin yükseltmeleri (upgrade), düzenli mevsimsel değişiklikleri (konfeksiyon modelleri gibi), mal veya hizmetin işlevini, öngörülen kullanımını ya da teknik özelliklerini değiştirmeyen tasarım değişikliklerini, diğer girişimlerden satın alınan mal veya hizmetlerin yeniden satılmasını içermez.

2.1. Girişiminiz 2004-2006 yıllarını kapsayan üç yıllık dönemde yeni ya da önemli ölçüde geliştirilmiş / iyileştirilmiş ürün (mal veya hizmet) piyasaya sundu mu?

Evet ☐ 1 → Hayır ☐ 2 → Bölüm 3'e geçiniz.

(Lütfen uygun olan seçenekleri işaretleyiniz.)

Yeni ya da önemli ölçüde geliştirilmiş / iyileştirilmiş mal	☐ 1
Yeni ya da önemli ölçüde geliştirilmiş / iyileştirilmiş hizmet	☐ 2

2.2. Bu ürün yeniliği kim tarafından yapılmıştır? (En uygun seçenek işaretlenmelidir.)

Büyük ölçüde kendi girişiminiz veya girişim grubunuz tarafından	☐ 1
Diğer girişim veya kuruluş ile birlikte girişiminiz tarafından	☐ 2
Büyük ölçüde diğer girişim veya kuruluşlar tarafından	☐ 3

2.3. 2004-2006 yıllarını kapsayan üç yıllık dönemde gerçekleştirdiğiniz mal veya hizmet yeniliklerinin durumu nedir? (Lütfen uygun olan tüm seçenekleri işaretleyiniz.)

2.3.1. Kendi pazarınız için yeni: Rakiplerinizden önce piyasaya sürdüğünüz yeni ya da önemli ölçüde geliştirilmiş mal veya hizmetler	☐ 1
2.3.2. Sadece girişiminiz için yeni: Rakipleriniz tarafından daha önce piyasaya sürülmüş yeni ya da önemli ölçüde geliştirilmiş mal veya hizmetler	☐ 2

2.4. 2004-2006 yıllarını kapsayan üç yıllık dönemde gerçekleştirdiğiniz mal veya hizmet yenilikleri sonucu üretilen ürünlerden 2006 yılında elde ettiğiniz satış gelirlerinin, 2006 yılı toplam cironuzdaki payı ne kadardır?

	%
2004-2006 yıllarını kapsayan üç yıllık dönemde piyasaya sürdüğünüz ve **kendi pazarınız** için yeni olan mal veya hizmet yenilikleri sonucu üretilen ürünlerden 2006 yılında elde ettiğiniz satış gelirlerinin, 2006 yılı toplam cironuza oranı	☐☐☐.☐
2004-2006 yıllarını kapsayan üç yıllık dönemde piyasaya sürdüğünüz ve **sadece kendi girişiminiz** için yeni olan mal veya hizmet yenilikleri sonucu üretilen ürünlerden 2006 yılında elde ettiğiniz satış gelirlerinin, 2006 yılı toplam cironuza oranı	☐☐☐.☐
2004-2006 yıllarını kapsayan üç yıllık dönemde **değiştirilmemiş veya çok az değişikliğe uğramış** (bu dönemde geliştirilmiş veya iyileştirilmiş olmayan) mal veya hizmetlerin 2006 yılı içerisindeki satış gelirlerinin, 2006 yılı toplam cironuza oranı	☐☐☐.☐
2006 Yılı toplam cirosu	1 0 0 . 0

(Toplam 100 olmalıdır.)

3

Sayfa 4'e geçiniz

Table E1 (Continued)

BÖLÜM 3. Süreç Yeniliği

Süreç yeniliği (process innovation), yeni ya da önemli derecede iyileştirilmiş bir üretim veya dağıtım yönteminin gerçekleştirilmesidir. Bu yenilik; teknikler, teçhizat veya yazılımlarda önemli değişiklikler içerir.

Süreç yeniliğinin (yeni ya da önemli ölçüde geliştirilmiş / iyileştirilmiş) sizin girişiminiz için yeni olması önemlidir. Sektörünüz ya da piyasa için yeni olup olmadığı önemli değildir. Yeniliğin ilk olarak başka bir girişim tarafından geliştirilmiş olması da önemli değildir. Tamamen organizasyon yapısında gerçekleşen yenilikler süreç yeniliği sayılmamaktadır.

Üretim yöntemlerinde yapılan yenilik için, bir üretim hattında yeni otomasyon teçhizatının uygulanması, otomatik ambalajlama ve ürün geliştirmek için bilgisayar destekli tasarım gerçekleştirilmesi örnek olarak verilebilir.

Dağıtım yöntemlerinde yapılan yenilik için, tedarik zincirinde ürünü takip etmek üzere yapılan barkod uygulaması, ulaşım araçlarının global pozisyonlama sistemi (GPS) ile izlenmesi örnek olarak verilebilir.

Destek faaliyetlerinde yenilik için, en uygun teslim güzergahının belirlenmesi için uygulanan yazılım, satın alma, muhasebe ve bakım sistemleri için uygulanan yeni ya da iyileştirilmiş yazılımlar örnek olarak verilebilir.

3.1. Girişiminiz 2004-2006 yıllarını kapsayan üç yıllık dönemde herhangi bir süreç yeniliği uyguladı mı?

Evet ☐ 1 → Hayır ☐ 2 → Bölüm 4'e geçiniz.

Aşağıdaki süreç yeniliklerinden hangileri uygulandı? (Lütfen uygun olan tüm seçenekleri işaretleyiniz.)

Mal veya hizmet üretiminde kullanılan yeni ya da önemli ölçüde geliştirilmiş yöntemler	☐	1
Girdileriniz ile ürettiğiniz mal veya hizmetler için yeni veya önemli ölçüde geliştirilmiş lojistik, teslimat ve dağıtım yöntemleri	☐	2
Süreçleriniz için yeni veya önemli ölçüde geliştirilmiş destekleme faaliyetleri (Bakım sistemleri, satın alma, bilgi işlem, muhasebe v.b.)	☐	3

3.2. Bu süreç yeniliği kim tarafından yapıldı? (En uygun seçenek işaretlenmelidir.)

Büyük ölçüde kendi girişiminiz veya girişim grubunuz tarafından	☐	1
Diğer girişimler veya kuruluşlar ile birlikte girişiminiz tarafından	☐	2
Büyük ölçüde diğer girişimler veya kuruluşlar tarafından	☐	3

Bölüm 4. Devam Eden veya Sonuçsuz Kalan Yenilik Faaliyetleri

4.1. Girişiminizin 2006 yılı sonu itibariyle devam eden ürün veya süreç yeniliği faaliyeti oldu mu?

Evet ☐ 1 Hayır ☐ 2

4.2. Girişiminizin 2004-2006 yıllarını kapsayan üç yıllık dönemde sonuçsuz kalan (durdurulmuş veya başarısız olan) ürün ya da süreç yeniliği faaliyeti oldu mu?

Evet ☐ 1 Hayır ☐ 2

Eğer Soru 2.1, 3.1, 4.1 ve 4.2'nin <u>tamamına</u> HAYIR yanıtı verildiyse Soru 8.2'ye geçiniz.

4

Sayfa 5'e geçiniz

Table E1 (Continued)

Bölüm 5. Yenilik Faaliyetleri ve Harcamaları

5.1. Girişiminiz 2004-2006 yıllarını kapsayan üç yıllık dönemde aşağıdaki yenilik faaliyetlerinden hangilerini gerçekleştirdi? (Tamamlanmamış yenilik faaliyetleri dahil edilmelidir.)

	Evet	Hayır
5.1.1. Girişiminiz bünyesinde yürütülen Ar-Ge faaliyetleri [Bilgi birikimini artırmaya yönelik yürütülen yaratıcı çalışmalar (yazılım geliştirme dahil) ve bu çalışmaların ürün ve süreç yeniliği için kullanımı konularında girişiminizde yapılan Ar-Ge faaliyetleri]	1	2 → Bölüm 5.1.2'ye geçiniz

5.1.1.1. Bu Ar-Ge faaliyetleri hangi sıklıkla gerçekleştirilmiştir?

Sürekli olarak	1
Gerektikçe	2

	Evet	Hayır
5.1.2. Dışarıdan temin edilen Ar-Ge hizmetleri [Ürün ve süreç yeniliği yapmak amacıyla bilgi birikimini artırmaya yönelik bir başka girişim (kendi girişim grubunuzdaki diğer girişimler de dahil), kamu ya da özel araştırma kurumları tarafından yapılan ve girişiminizce satın alınan Ar-Ge faaliyetleri]	1	2
5.1.3. Ürün ya da süreç yeniliğine ilişkin makine, teçhizat, yazılım temini [Ürün ve süreç yeniliği gerçekleştirmek için makine-teçhizat, bilgisayar yazılımı ve donanımı temin edilmesi]	1	2
5.1.4. Diğer dışsal bilgilerin temini [Başka girişim veya kuruluşlardan patentli ya da patentsiz buluş, know-how ve bilginin diğer tiplerinin satın alınması veya lisanslanması (ruhsat verilmesi) (Fikri mülkiyet hakları alınması)]	1	2
5.1.5. Eğitim [Ürün ve süreç yeniliği geliştirmek ve/veya tanıtmak amacıyla personele kurum içi veya kurum dışından eğitim verilmesi]	1	2
5.1.6. Yenilikler için pazar tanıtımı [Pazar araştırması ve reklam faaliyetleri dahil olmak üzere ürün ve süreç yeniliğinin pazarda tanıtılması]	1	2
5.1.7. Diğer hazırlıklar [Ürün veya süreç yeniliğinin uygulanmasına yönelik diğer işlemler ve teknik hazırlıklar]	1	2

5.2. Aşağıdaki yenilik faaliyetleri için 2006 yılı harcamalarınız ne kadardır? (Personel giderleri ve diğer maliyetler dahil)

	2006 yılı harcaması			
	Milyon	Bin		
5.2.1. Girişiminiz bünyesinde yürütülen Ar-Ge faaliyetleri (Ar-Ge için yapılan bina ve makine-teçhizat yatırım harcamaları dahildir.)				YTL
5.2.2. Girişiminizin dışarıdan satın aldığı Ar-Ge hizmetleri				YTL
5.2.3. Makine-teçhizat ve yazılım temin edilmesi (Ar-Ge amaçlı makine-teçhizat harcamaları hariç)				YTL
5.2.4. Dışarıdan sağlanan bilgi (Patent, lisans, know-how, vs.)				YTL

5.3. Girişiminiz 2004-2006 yıllarını kapsayan üç yıllık dönemde yürüttüğü yenilik faaliyetleri için aşağıdaki kurumlardan finansal destek aldı mı? (Vergi indirimi, hibe, düşük faizli kredi ve kredi teminatı yoluyla gerçekleşen finansal destekler dahil)

5.3.1. Merkezi kamu kurum/kuruluşları ve TTGV (TÜBİTAK-TEYDEB, KOSGEB, Maliye Bakanlığı, Hazine Müst. vb.)	1	2
5.3.2. Yerel veya bölgesel kamu kuruluşları (belediye, valilik v.b.)	1	2
5.3.3. Avrupa Birliği (AB) kurumları	1	2
5.3.3.1 AB kurumları için cevabınız Evet ise girişiminiz Avrupa Birliği 6. Çerçeve Programına (2003-2006) katıldı mı?	1	2
5.3.4. Diğer uluslararası kurum/kuruluşlar	1	2

5

Sayfa 6'ya geçiniz

Table E1 (Continued)

Bölüm 6. Yenilik Faaliyetlerinde Bilgi Kaynakları ve İşbirliği

6.1. 2004-2006 yıllarını kapsayan üç yıllık dönemde gerçekleştirdiğiniz yenilik faaliyetleri için aşağıdaki bilgi kaynaklarının yenilik faaliyetleriniz açısından önem derecesi nedir?

Bilgi Kaynakları	Bilgi kaynağı olarak kullanıldıysa, yenilik faaliyetleriniz için önem derecesi			Bilgi kaynağı olarak kullanılmadı
	Çok	Orta	Az	
Kurum İçi Kaynaklar				
6.1.1. Girişiminiz veya dahil olduğunuz girişim grubu	1	2	3	4
Piyasa Kaynakları				
6.1.2. Makine, teçhizat ve yazılım sağlayıcıları	1	2	3	4
6.1.3. Müşteriler	1	2	3	4
6.1.4. Aynı sektördeki diğer girişimler (rakip girişimler)	1	2	3	4
6.1.5. Danışmanlar, ticari laboratuvarlar veya özel Ar-Ge kuruluşları	1	2	3	4
Kurumsal Kaynaklar				
6.1.6. Üniversite ve diğer yükseköğretim kurumları	1	2	3	4
6.1.7. Kamuya ait araştırma enstitüleri	1	2	3	4
Diğer Bilgi Kaynakları				
6.1.8. Konferanslar, ticari fuarlar, sergiler	1	2	3	4
6.1.9. Bilimsel dergiler, ticari/teknik yayınlar	1	2	3	4
6.1.10. Dernekler, meslek ve sanayi odaları	1	2	3	4

6.2. 2004-2006 yıllarını kapsayan üç yıllık dönemde yenilik faaliyetlerinizden herhangi birinde başka bir girişim veya kuruluş ile işbirliği yaptınız mı?

(İşbirliği; diğer girişimler ya da ticari olmayan kuruluşlarla birlikte yenilik faaliyetlerinin aktif olarak yürütülmesidir. Bu işbirliğinden her iki tarafında ticari olarak faydalanması zorunlu değildir. Aktif katılımda bulunmadığınız, ücret karşılığı başka

Evet 1 Hayır 2 ⟶ Bölüm 7'ye geçiniz.

6.3. Yenilik konusunda aşağıdakilerden hangileri ile işbirliği yaptınız?

İşbirliği yapılan kişi veya kuruluşlar	Türkiye'den	Avrupa ülkelerinden	ABD'den	Diğer ülkelerden	İşbirliği yapmadı
6.3.1. Dahil olduğunuz girişim grubundaki diğer girişimler	1	2	3	4	4
6.3.2. Makine, teçhizat, malzeme veya yazılım sağlayıcılar	1	2	3	4	4
6.3.3. Müşteriler	1	2	3	4	4
6.3.4. Rakip girişimler veya sektördeki diğer girişimler	1	2	3	4	4
6.3.5. Danışmanlar, ticari laboratuvarlar veya özel Ar-Ge kuruluşları	1	2	3	4	4
6.3.6. Üniversite ya da diğer yükseköğretim kurumları	1	2	3	4	4
6.3.7. Kamuya ait araştırma enstitüleri	1	2	3	4	4

6.4. Yenilik faaliyetinde işbirliği yaptığınız Soru 6.3'deki kişi veya kuruluşların hangisi sizin için en büyük öneme sahiptir?

En büyük öneme sahip kişi veya kuruluşun sıra numarasını yazınız. 6 . 3 .

6

Sayfa 7'e geçiniz

Table E1 (Continued)

Bölüm 7. Yenilik Faaliyetlerinin Etkileri

7.1. 2004-2006 yıllarını kapsayan üç yıllık dönemde gerçekleştirdiğiniz yenilik faaliyetleri ne ölçüde etkili olmuştur?

	Gözlemlenen etki derecesi			
	Çok	Orta	Az	Etkisi yok
Ürün Temelli Etkiler				
7.1.1. Ürün çeşidini artırdı	1	2	3	4
7.1.2. Yurtiçinde yeni pazar yarattı ya da pazar payını artırdı	1	2	3	4
7.1.3. Yurtdışında yeni pazar yarattı	1	2	3	4
7.1.4. Mal veya hizmet kalitesini artırdı	1	2	3	4
Süreç Temelli Etkiler				
7.1.5. Hizmet sunma ve üretim esnekliğini artırdı	1	2	3	4
7.1.6. Hizmet sunma ve üretim kapasitesini artırdı	1	2	3	4
7.1.7. İşgücü maliyetini azalttı	1	2	3	4
7.1.8. Enerji ve hammadde tüketimini azalttı	1	2	3	4
Diğer Etkiler				
7.1.9. Olumsuz çevresel etkileri azalttı veya sağlık ve güvenlik konusunda iyileşme sağladı	1	2	3	4
7.1.10. Standart ve mevzuatların gereklerine uyum sağladı	1	2	3	4

Bölüm 8. Yenilik Faaliyetlerini Engelleyici Faktörler

8.1. Girişiminizin 2004-2006 yıllarını kapsayan üç yıllık dönemde sonuçsuz kalan (durdurulmuş veya başarısız olan) veya yarım bırakılan yenilik faaliyeti var mıydı?

	Evet	Hayır
8.1.1. Tamamlanmadan tasarım aşamasında bırakılan	1	2
8.1.2. Faaliyet veya proje başladıktan sonra yarım bırakılan	1	2
8.1.3. Bitirilmesi önemli ölçüde geciken	1	2

7

Sayfa 8'e geçiniz

Table E1 (Continued)

8.2. 2004-2006 yıllarını kapsayan üç yıllık dönemde yenilik faaliyeti yapmamanıza veya yaptığınız yenilik faaliyetlerinin engellenmesine sebep olan aşağıdaki faktörler hangi derecede etkili olmuştur ?

Engelleyen Faktörler	Etki derecesi			
	Çok	Orta	Az	Etkisi yok
Maliyet Faktörleri				
8.2.1. Girişiminizin veya girişim grubunuzun parasal kaynak yetersizliği	1	2	3	4
8.2.2. Girişiminiz dışındaki kaynaklardan finansman sağlanamaması	1	2	3	4
8.2.3. Yenilik maliyetlerinin çok yüksek olması	1	2	3	4
Bilgi Faktörleri				
8.2.4. Nitelikli personel yetersizliği	1	2	3	4
8.2.5. Teknoloji konusunda gerekli bilginin yetersizliği	1	2	3	4
8.2.6. Piyasalar hakkında bilgi yetersizliği	1	2	3	4
8.2.7. Yenilik konusunda işbirliği yapılacak bir ortak bulmanın güç olması	1	2	3	4
Piyasa Faktörleri				
8.2.8. İstikrarlı girişimlerin piyasaya hakim olması	1	2	3	4
8.2.9. Yeni mal/hizmetlere olan talebin belirsiz olması	1	2	3	4
8.2.10. Ülke ekonomisindeki belirsizlikler	1	2	3	4
Yenilik Yapmama Sebepleri	Çok	Orta	Az	Etkisi yok
8.2.11. Daha önceki yenilik faaliyetlerinden dolayı ihtiyaç duyulmaması	1	2	3	4
8.2.12. Yeniliğe talep olmadığı için ihtiyaç duyulmaması.	1	2	3	4

Bölüm 9. Fikri Mülkiyet Hakları

9.1. Girişiminiz 2004-2006 yıllarını kapsayan üç yıllık dönemde aşağıdaki fikri mülkiyet hakları için başvuru yaptı mı ?

	Evet	Hayır
9.1.1. Patent için başvuru yapılması	1	2
9.1.2. Endüstriyel tasarımın kayıt altına alınması	1	2
9.1.3. Ticari markanın kayıt altına alınması	1	2
9.1.4. Telif hakkı istenmesi	1	2

8

Sayfa 9'a geçiniz

Table E1 (Continued)

Bölüm 10. Organizasyon ve Pazarlama Yeniliği

Organizasyon yeniliği: Girişimin bilgi kullanımını, mal ve hizmet kalitesini ya da iş akış verimliliğini artırmak amacıyla firma yapısında ya da yönetim biçiminde yenilik ya da belirgin değişiklik yapılmasıdır. Diğer girişimlerle birleşmeler, diğer girişimleri satın almalar, yeni bir organizasyonel yöntem eşlik etmediği sürece yönetim stratejisindeki değişiklikler organizasyon yeniliği sayılmaz.

Pazarlama yeniliği: Mal ve hizmetlere olan ilgiyi artırmak ya da yeni pazar yaratmak amacıyla ürün tasarımı, ambalajlaması, tanıtımı veya fiyatlandırmasında önemli değişiklikleri kapsayan yeni pazarlama yöntemlerinin uygulanmasıdır.

10.1. Girişiminiz 2004-2006 yıllarını kapsayan üç yıllık dönemde aşağıdaki yenilik çalışmalarından hangilerini gerçekleştirdi?

Organizasyon Yeniliği

	Evet	Hayır
10.1.1.Girişim bünyesinde bilgi ve becerinin daha iyi kullanılması veya aktarılması için yeni veya önemli ölçüde geliştirilmiş/iyileştirilmiş bilgi yönetim sistemi kurulması (Satış, araştırma, üretim vb. birimler için bilgiye erişimi ve paylaşımı sağlamak amacıyla çalışma grupları oluşturulması, tedarikçi ve taşeronlar için kalite kontrol standartları uygulanması, tedarik yönetim sisteminin kurulması vb.)	1	2
10.1.2. İşlerin organizasyonunda önemli değişiklik; örneğin yönetim yapısında değişiklik veya değişik bölüm veya faaliyetlerin birleştirilmesi (Yönetim kademe sayısını azaltmak, sorumluluk yüklemek gibi), yeni birim oluşturulması vb.)	1	2
10.1.3. Diğer girişimler veya kamu kuruluşları ile ilişkilerde işbirliği, ortaklık, taşeronluk vb. yollarla yeni ya da önemli ölçüde geliştirilmiş yöntemler kullanılması	1	2

Pazarlama Yeniliği

	Evet	Hayır
10.1.4. Ürün tasarımında veya ambalajında önemli değişiklik yapılması (Giyim sektöründe olduğu gibi rutin veya mevsimsel değişiklikler dahil değildir)	1	2
10.1.5. Yeni yada önemli ölçüde geliştirilmiş satış veya dağıtım yöntemlerinin uygulanması (İnternet üzerinden satış yapılması, başka girişimlere satış yetkisi verilmesi (franchising), başka girişimlere satış ya da dağıtım izni verilmesi gibi)	1	2

10.2. 2004-2006 yıllarını kapsayan üç yıllık dönemde gerçekleştirdiğiniz organizasyon yeniliği ne ölçüde etkili olmuştur?

	Çok	Orta	Az	Etkisi yok
10.2.1. Müşteri ve tedarikçilerin ihtiyaçlarının daha kısa sürede karşılanmasını sağladı	1	2	3	4
10.2.2. Ürün kalitesini arttırdı	1	2	3	4
10.2.3. Birim maliyetini azalttı	1	2	3	4
10.2.4. Çalışan memnuniyetini artırdı veya çalışanların iş yükünü azalttı	1	2	3	4

	CEVAP VEREN	ANKETÖR	VERİ GİRİŞ ELEMANI
Ad, Soyad			
Tarih			
Unvan			
Telefon			
E-Posta			
İmza			

10

Source: TUIK

APPENDIX F: TURKISH SUMMARY

TÜRKİYEDEKİ SANAYİ ARAŞTIRMA VE GELİŞTİRME DESTEK PROGRAMLARININ ETKİ ANALİZİ: NİCEL YAKLAŞIMLARIN DEĞERLENDİRİLMESİ

Bu tez, uluslararası bilim ve teknoloji topluluğunun son zamanlarda oldukça yoğun ilgisini çeken politika değerlendirmeleri çerçevesinde iki ana amaç doğrultusunda oluşturulmuştur. Bu amaçlardan ilki, Türkiye bağlamında, özel sektör araştırma ve geliştirme (Ar-Ge) çalışmalarında kamu sübvansiyonlarının etkisini ölçmek için uygun olabilecek nicel yöntemi seçmek ve uyarlamaktır. İkinci amaç ise, gelişmekte olan ülkeler bağlamında, 2004 yılından bu yana önemli ölçüde çeşitlendirilerek artan miktarda kaynak sağlanan kamu Ar-Ge ve yenilik desteklerinin özel sektörün Ar-Ge faaliyetlerine etkisini inceleyerek var olan etki analizi literatürüne katkıda bulunmaktır.

F.1 KAMU AR-GE VE YENILIK DESTEKLERININ KURAMSAL DAYANAKLARI

Yirminci yüzyıl ortalarından başlayarak teknolojik ilerlemenin düzenlenmesi ve teşvik edilmesi, gelişmiş ve gelişmekte olan ülke hükümetlerinin programlarında sürekli olarak yer almaktadır. Bunun en önemli sebebi sadece teknoloji kaynaklı yeniliklerin ekonomik büyümenin önemli bir belirleyicisi olarak kabul edilmesinden d değil, aynı zamanda ulusal, bölgesel veya sektörel yenilik sistemlerinin karmaşık yapısında hükümetlerin daha çok kolaylaştırıcı bir rol oynaması gerektiğine dair artan bir fikir birliği olmasından da kaynaklanmaktadır. Bu bağlamda, yenilik süreçlerinde önemli yer tutan Ar-Ge faaliyetlerine verilen önemin de arttığı gözlenmektedir. de artmaktadır. Örneğin Avrupa Birliği, 2003 yılında Lizbon Stratejisi uyarınca 2010 yılına kadar üye ülkelerdeki toplam araştırma ve geliştirme harcamalarının gayri safi yurt içi hasılaya (GSYİH) oranını %3'e yükseltmeyi hedeflemiştir. Ancak, bu hedeflerin her zaman tam anlamıyla gerçekleştiğini söylemek mümkün olmayabilir. Örneğin, Pottelsberghe (2008) AB, ABD ve Japonya'da endüstri ve kamu tarafından finanse edilen Ar-Ge harcamalarının GSYİH'ya oranını karşılaştırarak aralarındaki önemli farkları ve Avrupa'nın göreceli olarak geride olduğunu göstermiştir (Tablo D2, Ek D). 2007 1995 yılları arasında, GSYİH yüzdesi olarak Ar-Ge harcamaları Japonya'da % 2,92 den % 3,41'e, ABD'de % 2,50'den % 2.66'e, artarken AB-27 ülkeleri ortalaması ancak %1.66'dan % 1.77'ye ulaşabilmiştir. Bu oran Çin'de etkileyici bir şekilde % 0.57'den % 1.44'e yükselmiş, Türkiye'de ise, 1998 yılında % 0.37 iken 2009 yılında % 0.85'e ulaşabilmiştir[88]. 2008 yılında, "yanlış hedeflere ulaşamamak" adıyla yayınladığı eleştirel yazısında Pottelsberghe, Lizbon şartlarını yerine getirebilmek için AB politikalarının (i) yenilik için tümleşik bir pazar yaratmak ve (ii) daha kaliteli ve daha fazla temel araştırma yapılmasını teşvik eden mekanizmalara yönelmesi gerektiğini vurgulamıştır (Pottelsberghe, 2008:223-224).

Ar-Ge faaliyetlerinin temel çıktısı olarak kabul edilen bilginin yarı dışlanabilir ve rakip olmama özellikleriyle (Romer, 1990) özel mülkiyet altında korunamaması ve bu yüzden taşma (*spillover*) etkisiyle bilgiden edinilen toplumsal faydanın üreticisine sağlayacağı kazançtan fazla olması özel sektörün istenen ölçüde Ar-Ge harcaması yapmasını engellemektedir (Nelson 1959; Arrow, 1962). Pazar aksamasına (*market failure*) yol açan bu engelin giderilerek, ekonomik büyümeye önemli katkı sağlayan

[88] Verilen değerler TÜİK'in Mart 2008 de revize ettiği GSYİH serisi kullanılarak hesaplanmıştır.

özel sektörün Ar-Ge ve yenilik faaliyetlerini artırmasını sağlamak bu alandaki kamu destek ve düzenlemelerinin başlıca sebebi olarak sayılmaktadır. Ayrıca Ar-Ge faaliyetlerinin doğasında olan teknik ve mali riskler nedeniyle özel sektörün bu faaliyetleri gerçekleştirmek için dış finansal kaynak bulması zorlaşmaktadır (Görg ve Strobl, 2007). Türkiye'de 2004-2006 yılları arasında özel sektörün gerçekleştirdiği yenilik faaliyetlerini ölçmek için TÜİK tarafından yapılan ve bu çalışmada kullanılan iki veri setinden birini oluşturan anket sonuçlarına göre, girişimlerin % 69.2'si yenilik faaliyetlerini etkiyen en önemli faktör olarak maliyetlerin çok yüksek olmasını göstermiştir. Bunu % 65.3 ile girişim veya girişim grubunun parasal kaynak yetersizliği ve % 65.7 ile nitelikli personel yetersizliği takip etmektedir.

Bu nedenlerle kamu müdahalesinin Ar-Ge ve yenilik faaliyetlerini sosyal olarak istenilen seviyeye yükseltmesi beklenebilir. Devlet, araştırma merkezleri kurarak doğrudan Ar-Ge faaliyetleri yürütüp yaratılan bilginin özel sektör tarafından kullanılmasını hedefleyebilir ya da çeşitli mali destekler sunarak ya da kolaylaştırıcı düzenlemelerle Ar-Ge ve yenilik faaliyetlerinin sanayi tarafından gerçekleştirilmesini hızlandırabilir. Ayrıca kamu kurumları, özel sektörün Ar-Ge ve yenilik faaliyetleri sonucunda ortaya çıkardığı ürün ve hizmetlere talepte bulunarak bu çıktıların ticarileşmesine önemli ölçüde katkıda bulunabilirler. Günümüzde, yukarıda açıklanan gerekçeler ile meşruiyet kazanan teknoloji politikaları arasında doğrudan Ar-Ge destekleri ve vergi teşvikleri, artan sayıda ülkede politika yapıcılar tarafından iki iyi bilinen ve birlikte ya da ayrı ayrı en sık kullanılan mekanizmalar haline gelmektedir.

F.2 TEKNOLOJİ POLİTİKALARININ ETKİLERİNİN DEĞERLENDİRİLMESİ

Devlet yardımlarıyla teknolojik değişimin yönü ve hızı üzerinde etkili olmak için kamu kaynaklarının artarak kullanılması, doğal olarak, kamu politikalarının uygulanmasında giderek önem kazanan şeffaflık ve hesap verebilirlik konularını gündeme getirmektedir. Bilim ve teknoloji politikalı alanında uluslararası kuruluşların uygulanan politikaların sonuçlarının değerlendirilmesi gerektiği konusundaki ısrarları bu kuruluşların yayınladıkları güncel belgelerde de giderek daha sık yer bulmaya başlamıştır (OECD, 2006; Dünya Bankası, 2009; UNESCO, 2010). Buna paralel olarak son yıllarda, daha önce ilaç sanayinde ve eğitim programlarının analizinde kullanılan nitel ve nicel yaklaşımlarla, kamu tarafından özel sektöre yönelik uygulanan Ar-Ge ve yenilik destek ve teşvik programların firma üzerindeki etkilerinin değerlendirilmesi yaygınlaştı. Bu etki değerlendirmelerinin sonucunda elde edilen bulgular hem kamu kurumlarının uyguladıkları bilim ve teknoloji politikalarının gerekçelendirilerek meşruiyet kazanmasında hem de uygulayıcılara sağladığı geri bildirimlerle, destek, teşvik ve düzenlemelerde iyileştirmeler yapılmasında kullanılır oldu.

Türkiye de dahil olmak üzere pek çok ülkede teknolojik değişime yönelik politika ve programların rutin olarak değerlendirilmesi ve sonuçlarından faydalanılması henüz istenildiği kadar yaygınlaşmamıştır. Buna karşılık bazı ülkelerde değerlendirme mekanizmalarının hukuksal alt yapısının da sağlanarak kurumsallaştırıldığı ve kamu kaynağı kullanan programlarda standart olarak uygulandığı görülmektedir. Örneğin Güney Kore'de, Ar-Ge ve yenilik faaliyetlerinin geliştirilmesi için uygulamada olan 250'den fazla destek ve teşvik programının önceden belirlenen hedef ve ölçütlerine uygun yürütülüp yürütülmediği, gelişmiş bir meta-değerlendirme programı aracılığıyla periyodik olarak değerlendirilir. Değerlendirme sonuçları merkezi bir kurumda puanlanarak her bir programın sürdürülüp sürdürülmeyeceği ve bir sonraki yıl kullanacağı kamu kaynağının belirlenmesinde hükümetin karar vermesine yardımcı olur (Yoo, 2007).

Türkiye'de teknoloji politikaları ve programlarına yönelik nitel ve nicel değerlendirmelerin çok az sayıda akademik olarak yapılmış çalışmaların ötesine geçmediği (Özçelik ve Taymaz, 2008; Gök, 2006; Gören, 2008) ve kamu kurumlarında etki değerlendirmesine yönelik yöntem ve gereksinimlerin tartışmasının son birkaç yıldır daha fazla yapıldığı gözlemlenmektedir.

Etki değerlendirmesi bağlamında literatüre bakıldığında genel olarak Ar-Ge faaliyetlerine kamu tarafından sağlanan doğrudan desteklerin destek alanlar üzerindeki kısa ve uzun dönem etkileri farklılık göstermektedir (David ve Hall, 2000). Kısa dönem ele alındığında Ar-Ge harcaması ve personeli gibi girdilerde statik bir artımsallık (additionality) beklenirken, uzun dönemde, beklenmeyen dinamik etkileri olabilmektedir. Örneğin, sanayi Ar-Ge destekleri akademisyenlerin danışmanlık faaliyetlerinin artmasına yol açarak üniversitelerde yaptıkları temel araştırma ve eğitim faaliyetlerini olumsuz yönde etkileyebilir. Desteklerin etkilerini zaman boyutunda (ani ya da geciken etkiler), etkilenen kişi ya da topluluklar seviyesinde (sadece destekten faydalanan, destek alan firmanın ait olduğu sanayide ya da diğer sanayilerde, tüm ülke ya da dünyada), veya alansal boyutta (bilimsel, teknolojik, ekonomik, politik ya da örgütsel boyutta etkiler) sınıflandırmak mümkündür. Ekonomik etkiler, mevcut verilere bağlı olarak mikro, makro ya da ulusal seviyede analiz edilebilir. Değerlendirme hangi sınıflamaya göre yapılırsa yapılsın, yöntemler ne kadar teknik olursa olsun sürecin sosyal bilimler alanında bir araştırma pratiği olduğu unutulmamalıdır (Rossi, 1999)

Etki değerlendirmesi yaklaşımları üç eksende incelenebilir. Birincisi değerlendirmenin ne zaman yapılacağı ile ilgilidir. Müdahale öncesi (*ex-ante*) analiz yürütülecek uygulamanın olası etkilerini tahmin etme üzerine uzman değerlendirme, fayda maliyet analizi gibi yöntemler kullanılarak gerçekleştirilebilir. Müdahale sırasında (*interim*) değerlendirme, izleme yöntemleri ile uygulamanın başarısı ve zorlukları üzerine çıktı sağlayan, iyileştirmelere ve uygulamada yeniden ayarlamalara fırsat yaratan bir çalışma olarak görülür. Müdahale sonrası (*ex-post*) değerlendirme ise genellikle tamamlanmış bir uygulamanın sonuçlarını ortaya çıkarmakta ve planlanan başarı ölçütlerine göre karşılaştırma yapmakta kullanılır. Bu yaklaşımda sıklıkla, anket ve görüşmelerle elde edilen veriler nitel ve nicel yöntemlerle (makro ve mikro ekonometrik, fayda maliyet analizi, teknolojik, vb.) incelenmektedir. Ek B de güncel değerlendirme yöntemlerinin özellikleri özetlenmiştir.

Değerlendirme yöntemleri ikinci olarak nitel ve nicel gruplar altında incelenebilir. Müdahalenin daha detaylı, çok yönlü ve dolaylı etkilerini araştırmak için anket, görüşme ve durum analizi gibi çalışmalar içeren nitel yöntemler öne çıkmaktadır. Bu çalışmalarla elde edilen *en iyi uygulama örnekleri* ve *başarı öyküleri* politika yapıcıları ve kaynak sağlayıcı otoriteyi yönlendiren ve cesaretlendiren önemli bulgular sunabilir. Ek B de listelenen, pek çok farklı yöntem içeren nitel değerlendirme çalışmaları, (*i*) ekonometrik analizler, (*ii*) maliyet fayda analizleri, (*iii*) kontrol grubu ile karşılaştırma analizleri, (*iv*) finansal yöntemler ve (*v*) uygulamanın verimini değerlendiren yöntemler olmak üzere beş farklı grupta yer almaktadır. Nitel ve nicel yöntemler, çoğu zaman, birbirini tamamlayan sonuçlara ulaşmak amacı ile birlikte kullanılarak değişik açılardan müdahalenin etkilerinin anlaşılmasına çalışılmaktadır. Bu tezde yürütülen çalışmada kullanılan nicel yaklaşım, hem firma seviyesinde mikro ekonometrik hem de kontrol grubu yöntemlerinin birlikte kullanılmasını içermektedir.

Üçüncü ve son eksen olan ve son yıllarda daha çok sözü edilmeye başlanan *artımsallık* kavramı ile neyin değerlendirilmesi gerektiği sorusuna yanıt bulunabilir. Artımsallık kısaca müdahale sonucunda gözlenen değişiklik olarak tanımlanabilir. Bu kavram basit girdi ve çıktı artımsallığından Bach ve Matt, (2002) tarafından kullanılan bilişsel kapasite artımsallığı (*cognitive capacity additionality*) gibi ölçmesi ve değerlendirmesi oldukça karmaşık yöntemler gerektiren özelliklerle de ilişkilendirilebilir. Falk (2008) birçok farklı artımsallık yaklaşımını üç ana grup altında incelemiştir. Bunlar kaynak temelli yaklaşımlar, sonuç temelli yaklaşımlar ve kamu müdahalesinin, yani destek mekanizmasının, etkinliğini yenilik sürecinde politika yapıcılar tarafından arzu edilen değişikler ile ölçen yaklaşımlar olarak özetlenebilir. Kaynak temelli yaklaşımlardan girdi artımsallığı, kamu desteği neticesinde özel sektörün Ar-Ge harcamalarındaki artışa odaklanmaktadır. Diğer taraftan proje artımsallığı, bir Ar-Ge projesinin sadece kamu desteği ile gerçekleşebileceği durumu ifade etmektedir. Ancak fon sağlayanlar başarı şansı daha yüksek, iç ve dış kaynaklarla finanse edilmesi daha kolay olan projeleri seçme eğilimde olabilirler (Lach, 2002). Ayrıca, başarı ölçütlerine göre doğru projelerin desteklenmesinde, destek alan ve veren tarafın sahip olduğu bilgi seviyenin farklılığından kaynaklanan *asimetrik bilgi sorunu* dikkate alınması gereken bir mesele olarak tartışılmaktadır.

F.3 ÖNCEDEN YAPILMIŞ NİCEL ETKİ ANALİZİ ÇALIŞMALARI

Son yıllarda gerçekleştirilen, nicel yöntemlerle teknoloji program ve projelerinin etkilerinin değerlendirilmesi çalışmalarına örnek oluşturacak bir seçki 3. Bölümde Tablo 4 de yer almaktadır. Bu tabloda yer alan, mikro ya da makro verilerle, çeşitli ülkelerde değişik zaman dilimlerinde, farklı yöntemlerle yapılan etki analizi çalışmalarından bir kaç örnek verilecektir.

Belçika'da gerçekleştirilen ve 1998–2000 yıllarına ait yenilik anketi üzerinde çalışan Aerts ve Czarnitzki (2004), yarı parametrik eşleme yöntemleri kullanarak kamu tarafından sağlanan doğrudan Ar-Ge desteklerinin firmaların Ar-Ge harcamalarında istatistiksel olarak anlamlı artışa yol açtığını, dışlama etkisi (*crowding-out*) olmadığı sonucuna ulaşmışlardır.

Aerts ve Schmidt (2008), Belçika (Flaman bölgesi) ve Almanya için yenilik anketleri üzerinde çalışmışlar ve parametrik olmayan eşleme yöntemlerini kullanarak kamu desteklerinin her iki ülkede de girdi artımsallığına neden olduğu sonucuna varmışlardır. Benzer şekilde, 1994, 1996 ve 1998 yıllarına ait verileri içeren, *Mannheim Innovation Panel* anketlerini kullanan Almus ve Czarnitzki (2003), kamu desteklerinden faydalanan Doğu Alman firmalarının Ar-Ge yoğunluklarının desteklerden faydalanmayan firmalara göre ortalama yaklaşık %4 daha fazla olduğu sonucuna ulaşmışlardır. Kamu desteklerinin yanı sıra, işbirliği durumunu da dışsal (*exogeneous*) müdahale olarak değerlendiren Czarnitzki vd. (2007), Almanya ve Finlandiya'ya ait mikro veriler üzerinde analizler yapmışlar, Almanya'da desteklerin patent performansı ya da Ar-Ge harcamalarına pozitif etkisi gözlenmezken Finlandiya firmalarının Ar-Ge yatırımlarını dikkate değer oranda artırdığı gözlemlenmiştir.

İspanya'da imalat sanayinde faaliyet gösteren firmaları inceleyen Busom (2000), küçük firmaların kamu desteklerinden yararlanma olasılığının daha yüksek olduğunu ve genel anlamda kamu desteklerinin Ar-Ge harcamalarında artışa neden olduğunu, ancak veri setinde yer alan firmaların yaklaşık %30'u için dışlama etkisinin yadsınamayacağını bildirmiştir. Finlandiya'da yerleşik teknoloji firmalarının

1996 – 2002 yılları arasındaki verilerini analiz eden Ali-Yrrkö (2004), kamu fonlarının bir dışlama etkisi yaratmadığına ve büyük firmalarda görülen girdi artımsallığının küçük firmalara göre daha fazla olduğunu bildirmiştir. Diğer taraftan Toivanen ve Niinen (2000), Finlandiya'da büyük firmalara sağlanan desteklerin dışlama etkisine neden olduğunu bildirmişlerdir. İsrail'de imalat sanayinde faaliyet gösteren firmaları araştıran Lach (2002), kamu desteklerinin küçük firmalarda önemli ölçüde girdi artımsallığı yarattığını, ancak istatistiksel olarak anlamlı olmasa da büyük ölçekli firmalarda Ar-Ge harcamaları bakımından olumsuz bir etki gözlemlendiğini bildirmiştir. İrlanda'da 1999–2002 yıllarını arasında gerçekleştirilen ve imalat sektöründeki firmaları kapsayan yıllık iş anketlerini kullanan Görg ve Strobl (2007), özellikle yerli sermayeye ait küçük firmalara sağlanan desteklerin Ar-Ge harcamalarının artırılmasında etkili olduğunu, ancak belirli bir miktarın üzerindeki desteklerin dışlama etkisi yarattığını bildirmişlerdir.

Desteklenen yenilik faaliyetlerinin niteliği de destek programının etkinliği bakımından önemlidir. Norveç'te gerçekleştirilen 1999-2001 yılları arasındaki dönemi kapsayan yenilik anketini ülke çapında gerçekleştirilen Ar-Ge anketiyle beraber kullanan Clausen (2009), firmalara temel araştırma için sağlanan kamu desteklerinin Ar-Ge harcamasında artışa neden olduğunu, ancak deneysel geliştirme amaçlı desteklerin firma yatırımlarının yerini alarak dışlama etkisi yarattığını belirtmiştir.

Destek mekanizmasının etkinliği, programın yürütüldüğü ülkenin ekonomik düzeyine ve gelişmişlik seviyesine de bağlı olduğu öngörülmektedir. Gelişmekte olan ülkelerde yapılan çalışmalarda Hall ve Maffioli (2008), Brezilya, Şili, Arjantin, ve Panama'daki teknoloji geliştirme fonlarının firma düzeyindeki etkilerini inceleyerek programlarının etkinliğinin, kredi ya da hibe olarak kullanılan finans kaynakları, sanayi üniversite ilişkileri ve diğer firma özelliklerine bağlı olduğunu belirtmişlerdir. Araştırmaları sonucunda Hall ve Maffioli (2008), fonların verildiği ülkelerde girdi artımsallığı yarattığını ve desteklenen firmaların yenilik alanında daha etkin olduğunu, ancak destek almanın ilk beş yılın sonunda firma üretkenliği ve rekabetçiliğinde belirgin bir etkisi olmadığını bildirmişlerdir Bu sonuç bu tez kapsamında yapılan araştırma bulgularında da benzer şekilde gözlenmiştir. Türkiye'de imalat sektöründe faaliyet gösteren firmaların 1993–2001 yılları arasında TÜİK tarafından derlenen verilerini kullanan Özçelik ve Taymaz (2008), genel olarak kamu Ar-Ge desteklerinin firmaların Ar-Ge harcamalarının artırmasını sağladığını ve bu etkinin küçük firmalarda daha fazla gözlendiğini bildirmişlerdir.

Kamu desteklerinin dışlama etkisine neden olduğu çeşitli çalışmalarda bildirilmiştir. Amerika Birleşik Devletleri'nde yürütülen Small Business Innovation Research (SBIR) programından faydalanan firmaları inceleyen Wallsten (2000), sağlanan desteklerin özel sektör Ar-Ge yatırımlarını önemli ölçüde dışladığı sonucuna ulaşırken Stuetens (2002) Belçika Flaman Ar-Ge destek programının bölgedeki firmaların Ar-Ge harcamalarında ve istihdam artışına hiçbir etkisi olmadığını rapor etmiştir.

F.4 KAMU AR-GE VE YENİLİK DESTEKLERİNİN ETKİ ANALİZİ: TÜRKİYE, 2003-2006

Giderek yaygınlaşan kamu Ar-Ge desteklerinin nicel yöntemlerle değerlendirilmesi çalışmaları, Bölüm 3 Tablo 5 de görüldüğü üzere tartışmalı sonuçlar üretmiştir. Sonuçların bazen olumlu bazen de olumsuz olmasının sebebi sadece analiz edilen destek uygulamaların etkili olup olmamasından değil, kullanılan yöntem ve verinin kalitesine de bağlı olduğunu gösteren ipuçları bulunmaktadır. Bu çelişkili sonuçlar henüz nicel değerlendirme yaklaşımlarında tam bir fikir birliği olmadığını, yöntemler üzerinde daha fazla araştırmaya gereksinim olduğunu göstermektedir. Bu gereksinimle birlikte, Türkiye'de son yıllarda ivme kazanan teknolojik değişime yönelik teşvik ve düzenlemeler bu tezin konusunun seçiminde önemli yer tuttu. Türkiye bağlamında , 2004 yılından bu yana bilim ve teknoloji politikalarında ulusal yenilik sistemini etkileyen önemli değişiklikler ve düzenlemeler yapıldığı gözlemlenebilir. Bu değişikliklerin bazıları şu şekilde özetlenebilir:

- Özel sektör Ar-Ge faaliyetlerine verilen kamu desteğinde önemli bir artış oldu (kurumsal Ar-Ge harcamalarında kamu desteklerinin payı 1996 yılında % 1 iken 2008 de % 9 a, yaklaşık 10 kat arttı)
- Sanayi Ar-Ge ve yenilik faaliyetlerine dönük doğrudan destek programlarında güncel ihtiyaçları dikkate alan çeşitlendirmeler yapıldı (KOBİ - büyük firmalar, eski köklü firmalar -,yeni girişimler, hibe destekler-kredi destekleri vb.)
- Özel Ar-Ge ve yenilik harcamalarında bulunan girişimlere verilen vergi teşvikleri hem kaynak artırımı sağlayan hem de kapsamını genişleten hukuki düzenlemeler yapıldı. Bu düzenlemeler, Ar-Ge projeleri yoluyla kamu desteği almayı daha da cazip hale getirdi.
- Büyük ölçüde TÜBİTAK tarafından sağlanan yüksek öğrenim burslarında ve temel araştırma proje desteklerinde çeşitlilik da içeren etkileyici bir artış meydana geldi.
- Ortak araştırma faaliyetleri ve işbirliklerine dönük destekler ve araştırmacıların yer değiştirmesini kolaylaştırıcı düzenlemeler Türkiye Araştırma Alanının (TARAL) Avrupa Araştırma Alanı (ERA) başta olmak üzere uluslararası toplumla bütünleşmesini hızlandırdı.

Yukarıda belirtilen örneklerden de anlaşılabileceği gibi kamu politika ve programlarına aktarılan geniş kaynaklar göz önüne alındığında, ulusal yenilik sisteminde yer alan kurumların, uygulanan politika ve yürütülen programların sistematik olarak değerlendirilmesi önem kazanmaktadır. Bu değerlendirmelerin sonuçlarından faydalanarak kanıta dayalı politikalar üretilmeye başlanmasının, her ülke gibi Türkiye için de gittikçe artan bir gereksinim haline geldiği bu konunun uzmanları ve ilgili akademik çevreler tarafından belirtilmektedir.

İşte böyle bir gereksinim çerçevesinde ele alınmış olan bu tezin temelini oluşturan nicel çalışma, kamu desteklerinin destek alan firmaların Ar-Ge faaliyetlerini belirleyen kişi başı Ar-Ge harcaması, Ar-Ge personeli ve Ar-Ge yoğunluğu (Toplam Ar-Ge harcamasının firma satış toplamına oranı) olarak belirlenen *girdi artımsallığı* ve firmanın ithalat, ihracat, satış, istihdam ve üretkenlik gibi performans değerlerinden oluşan *çıktı artımsallığının* araştırılmasıyla sınırlandırılmıştır.

F.5 KULLANILAN YÖNTEMLER VE VERİ SETLERİ

Bu çalışmanın temel amacı, “Kamu Ar-Ge desteğinden faydalanmasaydı destek alan bir firmanın Ar-Ge girdileri -harcamalar, nitelikli personel sayısı vb.) ve performansı (satışlar, istihdam, üretkenlik vb.- hangi seviyede olurdu?” sorusunu yanıtlayacak ampirik bir değerlendirme yönteminin bulunması ve ülkemizdeki desteklerin sonuçlarına uygulanmasıdır. Nicel metotlarla yapılan çalışmalarda karşılaşılan iki önemli kısıt nedeniyle deneysel ekonometrik yöntemlerin Ar-Ge desteklerinin firma üzerindeki etkisinin hesaplanmasında iyi sonuç vermediğini göstermektedir. Kısıtlardan birincisi, çıktı gözleminin karşıt gerçeklik (counterfactual) özelliğinden kaynaklanmaktadır (Winship ve Morgan, 1999). Aynı firma için ve aynı zaman aralığında hem destek alma hem de almama durumun gözlemlenmesi mümkün olmadığı için karşılaştırma amacıyla uygun bir kontrol grubu oluşturulmalıdır. Kontrol grubu destek almayanlar arasından rastgele seçilmesi ise ikinci kısıt sebebiyle mümkün olmamaktadır. İkinci kısıt, desteklerden yararlanmanın rastgele olmamasından kaynaklanan seçim yanlılığıdır (selection bias). Firmalar kendi iç stratejileri, pazar konumları ve deneyimlerine uygun olarak bu desteklerden faydalanmayı tercih edebilirler. Ayrıca desteklerden faydalanan ve faydalanmayan firmaların özellikleri önemli ölçüde farklılık gösterebilmektedir. Belirtilen kısıtlamalar nedeniyle bu çalışmada deneysel olmayan, yarı parametrik eğilim skoru eşlemesi (propensity score matching) yöntemi kullanılmıştır. Rosenbaum ve Rubin'in (1983) öncü çalışmasının ardından bir çok araştırmacı eğilim skoru eşleme yöntemini geliştirmiş ve farklı amaçlarla kullanmıştır (Heckman vd., 1999; Smith, 2000, Blundel ve Costa Dias, 2000; genel bir inceleme için Cerulli; 2010). Eğilim skoru eşleme yöntemi sıklıkla kamu müdahalelerinin ya da bir dışsal müdahalenin yol açtığı nedensel etkilerin değerlendirilmesi amacıyla kullanılmaktadır.

Eğilim skoru eşleme yöntemi, belirlenen çok sayıda değişkeni dikkate alarak kontrol grubu yaratmakta ve seçim yanlılığı problemini en aza indirmede başarılı olmakla birlikte önemli bir eksikliği bulunmaktadır. Bu yöntem, sadece gözlemlenebilir değişkenlerle seçim yapabildiğinden sonuca etkisi olabilecek gözlemlenemeyen olguları göz ardı etmektedir. Bunun sonucu olarak yıllar içinde zamanla değişmeyen firmaya özel farklılıklar ve hem destek alan hem de almayan grupları birlikte etkileyen durumların (örneğin makro ekonomik şoklar) etkileri ortalama müdahale etkisi hesabına istenmeden katılmış olmaktadır. Sonucu bu etkilerden arındırmak için çalışmada farkların *farkı* (difference in differences) olarak adlandırılan ikinci bir yöntem modele dahil edilmiştir. Zaman serisi içeren panel veri setlerinde eğilim skoru eşlemesi ve farkların farkı yöntemlerinin birlikte, kullanılması Blundell ve

CostaDias'ın (2002) *şartlı farkların farkı* (*conditional difference in differences*) olarak literatüre kazandırdığı yönteme dönüşmüştür. Bu yöntemle destek programlarının etkisinin kestirilmesinde var olan seçme yanlılığı ve karşıt gerçeklik problemlerinin çözülmesi, hem de firmanın zamanla değişmeyen sabit özelliklerinin ve zaman içinde tüm örnekleme tesir eden olguların sonucu etkilemesinin önlenmesi mümkün olmaktadır.

Çalışmada, doğrudan kamu destekleri ve yararlanıcı firmaların Ar-Ge faaliyetleri arasındaki nedensellik ilişkileri iki ayrı veri seti ile üç nicel çalışma kullanılarak sunulmaktadır. Kullanılan veri setlerinden ilki aşağıdaki veri kaynakları kullanılarak 2003-2006 yılları için zaman serisi içeren bir panel olarak hazırlanmıştır:

- Yapısal iş istatistikleri (TÜİK)
- Araştırma ve geliştirme anketi (TÜİK)
- 3-hane (NACE 1.1) düzeyinde sektörler için üretici fiyat endeksi (TÜİK)
- İş kayıt veri tabanı (TÜİK)
- İhracat ve ithalat istatistikleri (TÜİK)
- TÜBİTAK TEYDEB Sanayi Ar-Ge projeleri destek programı veri tabanı

Oluşturulan veri seti, her yıl için imalat sanayi, yazılım ve bilgisayar hizmetleri sektörlerine ait 18243 işyeri kaydı içermektedir. Etki değerlendirilmesi yapılan, TÜBİTAK-TEYDEB (Teknoloji ve Yenilik Destek Programları Başkanlığı) tarafından yürütülen, 1501-sanayi Ar-Ge projeleri Destek Programı kapsamında 2003-2006 yılları arasında hibe destek alan firmalar vergi sicil kayıt numaraları kullanılarak TÜİK verileriyle eşleştirilmiş[89], destek alan firmaların sadece % 30'unun TÜİK

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[89] Eşleştirme sonunda oluşturulan veri setinde TÜİK verilerinde yer alan firma kayıtlarına yapılan ekleme ticari gizlilik kuralları gereği sadece firmanın o yıl içinde desteğe hak kazandığı, ret edildiği ya da firmaya ödeme yapıldığına dair bilgi ile sınırlı tutulmuştur.

anketlerinde yer aldığı gözlemlenmiş, diğerlerinin eşlemesi yapılamadığı için örnekleme dahil edilmemiştir. Destek alan firmaların yıllara dağılımı ve TÜİK verileriyle yapılan eşleme sonuçları Tablo F1 ve F2 de gösterilmiştir. İleride yapılacak etki analizi çalışmalarda bu eksiklikle karşılaşılmaması için TÜBİTAK ve TÜİK arasında daha yakın bir işbirliğine ihtiyaç olduğu görülmektedir.

Tablo F1 TÜBİTAK-TEYDEB Sanayi Ar-Ge Projeleri Destek Programından yararlanan firma sayılarının yıllara göre dağılımı

2003	2004	2005	2006	Firma sayısı	%
0	**0**	**0**	**1**	42	18
0	**0**	**1**	**0**	18	8
0	**0**	**1**	**1**	40	17
0	**1**	**0**	**0**	**25**	11
0	**1**	**0**	**1**	**3**	1
0	**1**	**1**	**0**	**19**	8
0	**1**	**1**	**1**	**44**	19
1	**0**	**0**	**0**	12	5
1	**0**	**0**	**1**	3	1
1	**0**	**1**	**0**	2	1
1	**0**	**1**	**1**	3	1
1	**1**	**0**	**0**	**9**	4
1	**1**	**0**	**1**	**1**	0
1	**1**	**1**	**0**	**3**	1
1	**1**	**1**	**1**	**13**	5
Toplam desteklenen firma				**237**	100

1 (0) firmanın o yıl içinde destek aldığını (almadığını) gösteririr

Kaynak: TUIK and TUBITAK

Tablo F2 TÜBİTAK tarafından destek alan firma sayıları: 2003-2006

	2003	2004	2005	2006
TÜBİTAK desteği alan firma sayısı	297	326	452	458
Desteklenen firmalardan TÜİK verisi ile eşlenenler	46	117	142	149
Toplam Ar-Ge yapan firma sayısı	864	1151	1171	840
Desteklenen firmaların Ar-Ge Yapanlara oranı (%)	5.33	10.2	12.1	17.7
Desteklenen firmaların toplam Firma sayısına oranı (%)	0.45	1.14	1.39	1.46

Kaynak: TUIK ve TUBITAK

İkinci veri seti, TÜBİTAK ve TÜİK arasında imzalanan işbirliği protokolüne istinaden TÜİK tarafından sağlanan ve firma düzeyinde veri içeren 2004 - 2006 Yenilik Anketi sonuçları kullanılarak hazırlanmıştır. Bu ankette OECD tarafından çıkarılan Oslo Kılavuzunun 3. sürümüne uyumlu bir soru kümesi kullanılarak veri toplanmıştır. Anketin ilk kısmı yasal unvan, firmadaki yabancı sermaye payı, yıllık satış hasılatı, ortalama çalışan sayısı, firmanın yerli ya da yabancı bir gruba mensubiyeti ve firmanın etkin olduğu yurtiçi ve yurtdışı pazarlar gibi genel bilgilerin derlenmesi amacıyla tasarlanmıştır. Anketin ikinci ve üçüncü kısımlarında firmalara sırasıyla gerçekleştirdikleri ürün ve süreç yenilikleri ile ilgili sorular yöneltilmektedir. Dördüncü bölümde firmanın devam eden ya da sonuçsuz kalan yenilik faaliyetleriyle ilgili bilgi alınmaktadır. Anketin beşinci, altıncı ve yedinci kısımlarındaki sorular sadece yenilikçi firmalara[90] yöneltilmektedir. Yenilik faaliyetlerinin çeşitliliği ve yenilik harcamalarının miktarları, yenilik sürecinde kullanılan bilgi kaynakları, kurumsal ve bölgesel işbirliklerinin özellikleri ve gerçekleştirilen yeniliklerin firma düzeyindeki etkileri ilgili veriler bu bölümlerden elde edilmektedir. Sekizinci kısımda durdurulan veya iptal edilen yenilik projeleri ile ilgili bilgi alınmakta ve firmalara yenilik sürecinde karşılaştıkları engellerle ilgili sorular yöneltilmektedir. Dokuzuncu kısımda fikri hakların korunmasında kullanılan yöntemlerle, onuncu kısımda ise örgütsel ve pazarlama yenilikleri ile ilgili sorular yer almaktadır[91]. Anket sonuçlarından hazırlanan veri setinde 780'sı yenilikçi olarak tanımlanan 2173 firma yer almaktadır. Firmaların 2-hane NACE 1.1 düzeyinde sektörel dağılımı Bölüm 5, Tablo 19 da verilmiştir.

F.6 ANALİZ SONUÇLARI

Ekonometrik yaklaşımla, Tobit modeli kullanılarak yapısal iş istatistikleri kaynaklı veri seti üzerinde yapılan ilk çalışmada, Ar-Ge yardımı sağlanmasının özel sektörün kendisinin gerçekleştirdiği Ar-Ge yatırımları için çok önemli bir belirleyici olduğunu göstermektedir. Firmanın yıllık Ar-Ge harcamasının satışa oranı olarak tanımlanan Ar-Ge yoğunluğu (veri setinde Ar-Ge harcaması olmayan pek çok firma olduğundan normal dağılımını elde etmek için değişkenin logaritması kullanıldı, Bölüm 5, Şekil 15) Tobit modelinde bağımlı değişken olarak yer aldı. Yıl içinde TÜBİTAK hibe Ar-Ge desteğinden yararlanmak bir kukla değişkenle tanımlandı. Tobit modeli ile elde edilen bulgular, AR-Ge desteklerinin yanında firmanın yurt dışından teknoloji

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[90] 2004 - 2006 Yenilik Anketi'nde ürün ya da süreç yeniliği gerçekleştiren firmalar ya da devam eden veya durdurulan yenilik faaliyeti olan firmalar yenilikçi olarak tanımlanmıştır.

[91] Verileri kullanılan, 2004-2006 yenilik anketine ait desen Ek E de yer almaktadır.

aktarımı yapmasının, nitelikli personel çalıştırıyor olmasının, ithalat ve ihracat faaliyetlerinde bulunmasının, büyük firma ölçeğinde olmasının[92] ve ait olduğu sektörün Ar-Ge yoğunluğunun firmanın Ar-Ge harcamasını olumlu yönde etkilediğini göstermektedir. Firmanın yabancı ortaklı olması ise Ar-Ge harcamasını istatistiksel olarak anlamlı bir biçimde negatif etkilemektedir. Bunun sebebinin yabancı ortağın bağlı olduğu grubun Ar-Ge faaliyetlerini ağırlıklı olarak kendi ülkesinde yapma eğilimi olduğu düşünülmektedir. Tobit sonuçlarına ait bulgular Bölüm 5, Tablo 21 ve 22 ile Şekil 16 ve 17 de yer almaktadır.

İkinci çalışmada, yarı-parametrik eğilim skoru eşlemesi ve farkların farkı kestirimi yöntemleri benimsenerek ve panel özelikli ilk veri seti kullanılarak, TÜBİTAK Sanayi Ar-Ge desteği programından hibe alma etkinliği incelenmiştir. Sonuçlar, programdan 2004 yılında hibe desteği alarak yararlanan firmaların 2004-2006 yıllarında (i) Ar-Ge personeli, (ii) Ar-Ge yoğunluğu ve (iii) çalışan başına Ar-Ge harcamalarında girdi artımsallığı olduğunu göstermektedir. Ancak bu firmaların aynı dönemdeki ihracat ve ithalat yoğunluklarında pozitif bir etki görülmekle birlikte istatistiksel olarak anlamlı bir çıktı artımsallığı gözlenmemiştir. Bunun olası sebebi olarak çıktı artımsallığı için daha uzun bir zaman serisi içeren veri seti gerektiği düşünülmektedir.

Araştırmanın son bölümünde, eğilim skoru eşlemesi yöntemi ile 2006 yılında gerçekleştirilen TÜİK Yenilik Anketi verileriyle hazırlanan ikinci bir veri seti kullanılarak bir analiz daha yapılmış ve aynı dönemi kapsayan farklı bir veri seti ile yapılan ilk analizdekine benzer biçimde girdi artımsallığı bulunmuştur. Zaman serisi içermeyen ikinci veri setinde firma seviyesindeki değişkenler ilkindeki kadar zengin

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[92] Firma büyüklüğü, hem çalışan sayısı hem de toplam yıllık satışla gösterilen 2 farklı değişkenle ayrı modellerde kullanılmıştır.

olmasa da aynı dönem içinde farklı bir veri kümesi ile sadece TÜBİTAK desteklerinin değil tüm kamu desteklerinin etkisine eğilim skoru eşleme yöntemi ile elde edilen benzer sonuçlar kullanılan yöntemin güvenirliliğinin sınanması açısından da önem taşımaktadır.

Gerçekleştirilen üç nicel analizin sonuçları Türkiye'de kamu tarafından sağlanan Ar-Ge desteklerinin özel sektörün Ar-Ge performansına yararlı olduğunu doğrulamaktadır. Özetle, 2003-2006 döneminde TÜBİTAK-DTM sanayi Ar-Ge projeleri destek programının özel sektörün Ar-Ge harcamalarının ve Ar-Ge personel istihdamının artmasını teşvik ettiği sonucuna ulaşmak için yeterli kanıt elde edilmiştir.

APPENDIX G: CURRICULUM VITAE

Vedat Sinan TANDOĞAN
sinantandogan@gmail.com

Summary

Local and international experience in various areas of information technologies and technology management:

Corporate management, sales and business analysis (14 years), teaching and research (9 years), Internet infrastructure and enterprise network design (10 years), telecommunication software engineering (8 years).

Strong background in software development, network security and telecommunication technologies.

Research experience in evaluation of public policies.

B.Sc. and M.Sc. degree in Electrical Engineering, Ph. D. Candidate in Science and Technology Policy Studies.

Work Experience

2006-Present Chief Expert in Scientific Programs, Technology and Innovation Funding Programs Directorate in Research Council of Turkey, TUBITAK**,** Ankara, Turkey

Responsibilities and achievements in TUBITAK:

- Initiating and coordinating an internal project on assessment and impact analysis of industrial funding policies (Project was coordinated with own Ph.D. dissertation)
- Participating in several ERANET projects including MATERA, MNT and LEADERA as working group or steering committee member.
- Designed and coordinated PRODIS, a computer assisted work flow and electronic submission system for evaluating and monitoring of R&D and innovation projects in industrial funding programs.
- Managerial responsibilities for monitoring industrial ICT research projects funded by TUBITAK.
- Participating planning, budgeting and financial management activities of the industrial funding programs of TUBITAK
- Providing assistance and consultancy to the presidency on technical and managerial issues for creation and execution of science, technology and innovation policies both at the national and international level.

2001-2006 Founder, Chief Executive Officer, K-NET Information Technologies Ankara, Turkey

K-NET provides turnkey projects, consultancy and training services on telecommunication, enterprise networking and information security areas in public and private organisations.
Executive corporate management. Responsibilities also extend to: Determining customer' s needs; emerging project requirements and technical specifications, project planning, executing amd controlling phases; developing and coordinating customer training programs; managing project follow-ups and maintaining service layer agreements.

1995-2001 Co-founder, Chief Executive Officer, KilimNet Istanbul, Turkey

KilimNet is an Internet service provider (ISP) and enterprise networking company. Carried out design and implementation of internet technologies

1989-1995 Software Development Engineer, Alcatel Telecom, Oslo, Norway.

Carried out system responsibility for products of Access Network, tender preparation for domestic and international customers, technical negotiations with the customer, developed system requirements and specifications. Had been an active member of several international work groups within ALCATEL NV. Contributed to setting the long-term strategy for the access products of ALCATEL. Composed product feature sets, realized and coordinated their top level design, performed effort estimations and planning. Customer training and documentation.
Participated in the large-scale international project for System 12 (S12) telephone exchange. Special topics are various CCITT and ETSI telecommunication standards and optimization of the SW packet replacement in the telecommunication networks. The work involved half a year of relocation to Stuttgart, Germany.

1986-1989 Software Specialist-External Consultant, Alcatel STK, Oslo, Norway.

Carried out the responsibility for SW Configuration Management, participated to test and integration of S12 digital exchange. Provided on site testing of the Norwegian national telecommunication network in exchanges all over Norway. Special topics are Software Configuration Control, Number 7 Signaling System, Operation and Maintenance in the S12 environment.

1985-1986 Software Development Consultant, ITT Telecom, Raleigh NC, USA.

Participated in the design and the execution of master integration test specifications for the Signaling Transfer Point (STP) digital switch. Special topics are non-switch services and network management layers of Common Channel Signaling (CCS) System Number 7, The HW and the SW set-up of the exchanges for the first Number 7 demonstrations in trade shows in USA.

1982-1985 Data Communication Specialist, Koç-Burroughs (UNISYS), Ankara, Turkey.

Involved in the design and the implementation of data communication software and hardware for the Burroughs mainframe and mini computers.

1980-1982 System Operator, Computer Center, Middle East Technical University, Ankara, Turkey.

Teaching experience

2002 -2005 Part-time Lecturer, Baskent University, Ankara, Turkey.

Courses on computer networks, information security and cryptology in Electrical Engineering and Computer Engineering Departments.

1994-1995 Lecturer, Bilkent University, Ankara, Turkey.

Courses on computer programming and information processing in Business and Administration Faculty.

Courses taught

Baskent University:

BIL413 Computer Networks and Security
EEM437 Computer Networks
EEM438 Information Security and Cryptology

Bilkent University:

MAN273 Computer Programming and Applications I
MAN274 Computer Programming and Applications II

Languages

English (fluent), Norwegian (basic)

Publications

Tandoğan, S., 1982. Prediction of Steady-State Temperature Distribution of Electrical Machines. Department of Electrical Engineering, Middle of Technical University, Unpublished Master Thesis.

Beyhan, B., Dayar, E., Fındık, D., Tandoğan, S., (2009). Comments and critics on the discrepancies between the Oslo Manual and the community innovation surveys in developed and developing countries. METU STPS Working Paper No: 0903.

Yurtseven, A.E., Tandoğan, S. (2010). Patterns of innovation and intra-industry heterogeneity in Turkey, METU STPS Working Paper No: 1001.

Yurtseven, A.E., Tandoğan, S., (2011). Patterns of innovation and intra-industry heterogeneity in Turkey. International Review of Applied Economics, under revision.

Conference presentations

Tandoğan, S., 2007. Public support for financing innovation. 3. Bilişim Zirvesi, CEBIT, Istanbul, Turkey, 2-5 October.

Tandoğan, S., 2007. Financing innovation and R&D subsidies. Keynote speaker in Workshop on Innovation and Entrepreneurship, Çankaya University, Ankara, Turkey, 1-2 November.

Beyhan, B., Dayar, E., Fındık, D., Tandoğan, S., 2009 Comments and critics on the discrepancies between the Oslo Manual and the community innovation surveys in developed and developing countries. Technology and Economic Development (TED) 3rd International Conference on Innovation, Technology and Knowledge Economics, Ankara, Turkey, 24-26 June.

Pamukçu, T., Tandoğan, S., 2010. Evaluating Effectiveness of Public Support to Business R&D in Turkey: Lessons from a Study for the Turkish Economy. Competition and Innovation Summer School (CISS) Turunç, Turkey, 17-21 May.

Tandoğan, S., Yurtseven, A.E., 2010. Input additionality of R&D and innovation subsidies: Empirical evidence from Community Innovation Survey in Turkey. The 8th GLOBELICS International Conference Making Innovation Work for Society: Linking, Leveraging and Learning. Kuala Lumpur, Malaysia, 1-3 November.

Pamukçu, T., Tandoğan, S., 2010. Evaluation of Innovation Policies: Current Trends in Developing Economies and Turkish Experience. Design and Evaluation of Innovation Policy (DEIP) in an Emerging Country Context, Gebze, Turkey, 6-10 December.

Tandoğan, S., Pamukçu, T., 2011. Evaluating Effectiveness of Public Support to Business R&D in Turkey through Concepts of Input and Output Additionality. ERF 17th International Annual Conference, Antalya, Turkey, 20-22 March.

Yurtseven, A.E., Tandoğan, S., 2011. Determinants of intra-industry heterogeneity: Evidence from Turkey. DIME Final Conference, Maastricht, The Netherlands, 6-8 April.

Education

2006-11 Ph. D. in Science and Technology Policy Studies at Middle East Technical University, Ankara.

1992-93 Norwegian School of Economics and Business Administration, Oslo Norway.

1982 M.Sc. in Electrical Engineering from Middle East Technical University, Ankara.
Thesis: Computer Aided Design of Electrical Machinery

1979 B.Sc. in Electrical Engineering from Middle East Technical University, Ankara.