EFFECTIVENESS OF R&D TAX INCENTIVES IN TURKEY

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

BY

EKİN TAŞ

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
THE DEPARTMENT OF ECONOMICS

JULY 2021

Approval of the thesis:

EFFECTIVENESS OF R&D TAX INCENTIVES IN TURKEY

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ABSTRACT

EFFECTIVENESS OF R&D TAX INCENTIVES IN TURKEY

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July 2021, 134 pages

The aim of this study is to investigate the effectiveness of research and development (R&D) tax incentives in generating additional business R&D expenditures in Turkey by applying propensity score matching (PSM) to correct any selection bias and to estimate the average treatment effect on the treated (ATT). For this purpose, the hypothesis that "R&D tax incentives increase business sector R&D intensity (the ratio of firm's net R&D expenditures to total turnover)" is tested and the effectiveness of R&D tax incentives is examined in the context of input additionality. The questions of whether R&D tax incentives are effective in increasing business sector R&D intensity and to what extent R&D tax incentives produce additional R&D intensity are answered. According to the results, R&D tax incentives have a positive effect on business sector R&D intensity. However, the effect is limited since the R&D tax incentive multiplier is between 0 and 1.

Keywords: Impact analysis, additionality, propensity score matching, R&D tax incentives, R&D tax incentive multiplier

ÖZ

TÜRKİYE'DE AR-GE VERGİ TEŞVİKLERİNİN ETKİNLİĞİ

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Yüksek Lisans, İktisat Bölümü

Tez Yöneticisi: Prof. Dr. Erkan ERDİL

Temmuz 2021, 134 sayfa

Bu çalışmanın amacı, Türkiye'de araştırma ve geliştirme (Ar-Ge) vergi teşviklerinin etkinliğini seçim yanlılığını düzelten ve teşvikten yararlananlar üzerindeki ortalama etkiyi (ATT) tahmin etmeyi sağlayan eğilim skoru eşleştirmesi (PSM) yöntemiyle araştırmaktır. Bu amaçla, Ar-Ge vergi teşviklerinin özel sektörün Ar-Ge yoğunluğunu (firmanın net Ar-Ge harcamalarının toplam ciroya oranı) artırdığı hipotezi test edilmiş ve Ar-Ge vergi teşviklerinin etkinliği girdi katkısallığı çerçevesinde incelenmiştir. Ar-Ge vergi teşviklerinin özel sektörün Ar-Ge yoğunluğunu artırmada etkili olup olmadığı ve ne ölçüde ek Ar-Ge yoğunluğu yarattığı soruları yanıtlanmıştır. Çalışma sonuçlarına göre Ar-Ge vergi teşvikleri özel sektör Ar-Ge yoğunluğu üzerinde pozitif bir etkiye sahiptir. Ancak Ar-Ge vergi teşvik çarpanı 0 ile 1 arasında olduğundan söz konusu etki sınırlıdır.

Anahtar Kelimeler: Etki analizi, katkısallık, eğilim skoru eşleştirme, Ar-Ge vergi teşvikleri, Ar-Ge vergi teşvik çarpanı

To My Son

ACKNOWLEDGMENTS

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LIST OF ABBREVIATIONS

ATT	Average Treatment Effect on the Treated
AUS	Australia
AUT	Austria
BEL	Belgium
BERD	Business Sector R&D Expenditures
BRA	Brazil
CAN	Canada
CHN	China
CZE	Czech Republic
ESP	Spain
EU	European Union
FRA	France
FTE	Full Time Equivalent
GBR	United Kingdom
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditures on R&D
GTARD	Government Tax Relief Data
IRL	Ireland
ITA	Italy
JPN	Japan
KOR	Korea
NLD	Netherlands
NOR	Norway
NPV	Net Present Value
OECD	The Organisation for Economic Co-operation and Development
PRT	Portugal
PSM	Propensity Score Matching
R&D	Research and Development

SWE	Sweden
TUR	Turkey
USA	United States
VAT	Value-Added Tax

CHAPTER I

INTRODUCTION

Research and development (R&D) is an activity that is based on knowledge and can be described as a step in the evolution of knowledge into technology (Erdil et al., 2016).

The OECD's Frascati Manual (2015)[1] defines R&D as *"comprise creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge"*.

R&D activities grew in importance after the Second World War. The Japanese economy's high growth rates up to the 1990s after the war and its R&D commitment and technological base behind these growth rates, and the Asian tiger economies' performance, especially South Korea's high-tech strategy, increased the interest in R&D activities in the second half of the twentieth century (Bloom et al., 2002).

The evolution in growth theories that accept technological changes as an engine of economic growth accompanied countries' rising interest in R&D. Their R&D expenditures to GDP ratio (R&D intensity) has increased rapidly over time.

Since business sector R&D activities are highly correlated with the R&D intensity and growth performance of a country (OECD, 2001a), R&D expenditures by this sector have gained prominence.

As a result of several factors, such as market failures in the R&D field (Arrow, 1962; Nelson, 1959), which cause private investment to be lower than the socially desirable

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[1] It is an essential tool that includes basic concepts, data collection guidelines, and classifications for internationally recognized methodology, collecting and using R&D statistics (OECD, 2021).

level; the financial constraints of small or newly established firms; and high costs of some technological development, business R&D investments need government support.

For this purpose, governments offer generous R&D incentives through direct funding mechanisms such as procurement of R&D, grants, and subsidies, and as an indirect funding mechanism, R&D tax incentives.

In the last decade, tax incentives have been widely used for promoting business sector R&D investment. In 2020, 33 of the 37 OECD countries implemented R&D tax incentives as a policy tool, while the number of countries was just 20 in 2000 (OECD, 2020).

This rising popularity of R&D tax incentives has raised questions about the effectiveness of this instrument.

Despite the widespread use of R&D tax incentives, the effectiveness of this policy is unclear in most cases. There have been several attempts to demonstrate the impact of R&D tax incentives for different countries/country groups and different R&D tax incentive programs but there is no consensus about the impact of these incentives. The results differ widely (Thomson, 2017).

In Turkey, R&D activities have gained prominence in the 2000s. Science, technology, and innovation policies have become an important component of economic policy, especially after 2005 (Erdil et al., 2016).

In line with other countries, R&D intensity in Turkey has increased over time. It doubled to 1.06% as of 2019 in comparison to 2001. The number of full-time equivalent (FTE) R&D personnel also increased sevenfold in the same period.

To promote R&D activities in the last 20 years, the government has introduced several R&D incentives and these have become an important part of the incentive system. Both direct and indirect incentives for supporting business sector R&D expenditures (BERD) have increased significantly during this period. The share of direct funding by the government in BERD more than doubled and reached 9.97% as of 2018, compared with 4.25% in 2000.

Although the implementation of R&D tax incentives as an indirect funding mechanism was based on the announcement of the Technology Development Zone Law No 4691 in 2001, it was enhanced and made more supportive with the announcement of the R&D Activities Support Law No 5746 in 2008. This law is still the basis of R&D tax incentives in Turkey. It was later revised in 2016 and expanded to include design activities.

Due to the legal regulations governing R&D tax incentives, the share of R&D tax incentives in BERD rose and reached 14.8% in 2018 from 6.94% in 2008. According to the 2018 statistics, Turkey is sixth highest among the OECD countries in terms of its share in BERD. The EU 27-total and OECD-total R&D tax incentives to BERD ratio is 7.19% and 5.97%, respectively, as of 2018.

When R&D tax incentives are compared with direct funding, the increase in these incentives in the last decade has been more significant. The direct funding share in BERD for the period 2008-2018 remained almost flat (9.54% in 2008 and 9.97 in 2018), while there was a remarkable increase in R&D tax incentives in the same period.

R&D tax incentives have also increased as a percentage of GDP. They have risen more than fourfold since 2008 to 0.1% in 2018. The increase was not only as a percentage of GDP and BERD, but also in the number of R&D tax incentive beneficiaries in the period 2010-2018.

The aim of the study is to evaluate the effectiveness of R&D tax incentives in Turkey in order to contribute to the empirical literature in the following ways. Firstly, despite the increasing weight of R&D tax incentives in Turkey, the literature lacks measurement of the effectiveness of these incentives. The study aims to fill the gap in the literature by testing the following hypothesis: "R&D tax incentives are effective in increasing business sector R&D intensity". Secondly, extent of the impact of R&D tax incentives on business sector R&D intensity is calculated for assessing the input additionality of this instrument with the help of the R&D tax incentive multiplier. Thirdly, in the study propensity score matching (PSM) is applied to eliminate the problem of selection bias and compare R&D expenditures of R&D tax beneficiaries

and nonbeneficiaries through estimating the average treatment effect on the treated (ATT).

The study is organized as follows. The next chapter explains the theoretical background of public support for private R&D activities by asking "Why should the government support private R&D activities?" After the reasons behind government support for R&D activities are clarified in the context of market failures in particular, the support mechanisms are explained in two groups: direct funding (grants subsidies and procurement of R&D) and indirect funding (R&D tax incentives). Measurement of the effectiveness of R&D policies is also explained in this chapter in the context of additionality, which shows that the additional effects on the beneficiaries that accompany the government intervention are explained through grouping additionality into input additionality, output additionality, and behavioral additionality.

Chapter 3 presents empirical literature that investigates the effectiveness of R&D tax incentives by surveying both cross-country and firm-level studies for different countries.

Chapter 4 explains the implications of R&D tax incentives in Turkey in the light of the evaluation of the policy over time.

Chapter 5 explains the methodology, data and discusses the empirical results. The methods used in the literature for investigating the effectiveness of tax incentives can be summarized in four groups: (1) survey analyses, (2) quasi-natural experiments that rely on time and policy design change, (3) dummy variable regressions and matching techniques, and finally (4) structural econometric modeling (Ientile & Mairesse, 2009).

However, the use of methods for investigating the effect of a treatment depends on the data structure. In view of the data used in the study, PSM is considered the most suitable method for examining the effectiveness of R&D tax incentives. In 5.1, the methodology of PSM for estimating the additionality of R&D tax incentives is elucidated.

In 5.2, the data are explained and the main features of the data are shown. For investigating the effectiveness of R&D tax incentives, a combined firm-level micro-dataset constructed from TURKSTAT surveys and statistics is used. While the Innovation Survey (2018) (which is compiled about benefiting from R&D tax incentives, the innovation activities of firms, and the sources, costs, and strategies of these activities for the period 2016-2018) is the main source used in the study, the information from the survey is enriched by that from the Financial and Nonfinancial Corporations Research and Development Activities Survey (2018). For defining the firms' characteristics such as their age, turnover, foreign trade structure and financial conditions, Foreign Trade Statistics (2018), Company Accounts Statistics (2017-2018) and Annual Business Registers Framework (2018) Micro Datasets of TURKSTAT are also used in the study.

As a result of updating the Guidelines of the Oslo Manual, which is the main source for compiling innovation statistics, there have been changes in the methodology. Due to the change in the definition and types of innovation, a time series comparison for research is not possible. Therefore, an important factor limiting the study is that the dataset is only a cross-section and this hinders long-term evaluations and makes examination of causalities difficult.

In 5.3, the empirical results are given. According to the findings, ATT is 0.07 and R&D tax incentive multiplier is 0.4. These results show that firms benefitting from R&D tax incentives exhibit higher R&D intensity than they would have had without R&D tax incentives. However, the effect of R&D tax incentives on producing additional R&D intensity is limited since the multiplier is between 0 and 1. It means that R&D tax incentives partially crowd out business sector R&D expenditures in Turkey.

The final chapter, 6, reveals the conclusions about the effectiveness of R&D tax incentives in Turkey, and provides policy recommendations and advice for further studies.

CHAPTER II

THEORETICAL BACKGROUND OF PUBLIC SUPPORT OF PRIVATE R&D ACTIVITIES

R&D activities gained importance after the Second World War. R&D started to be seen as a factor that triggers growth, thus leading to enhanced welfare (David, Hall, & Toole, 2000).

The evolution of growth theory increased the prominence of technological change and innovation. Technological differences were considered the sources of productivity differences among nations, sectors, and industries (Acemoglu, 2012).

Since technological change was seen as the source of productivity, it was regarded as the main driver of economic growth and over time technological change gained importance via endogenous growth models.

Most countries aim to increase R&D activities in order to achieve higher and sustainable growth rates. Since R&D expenditures are generally used as a measure of innovation inputs, the relationship between R&D expenditures and growth or productivity is analyzed empirically. Most of the empirical studies show that R&D activities lead to increases in productivity. The impact of R&D activities on output can increase either the innovation rate or technology transfer from abroad. According to the empirical studies, a 1% increase in R&D stock raises output 0.05-0.15% on average (OECD, 2001a; OECD, 2001b; OECD, 2011).

Since the importance of R&D expenditures for higher growth rates is indicated both theoretically and empirically, many countries set targets for their R&D expenditures as a percentage of their GDP (R&D intensity) and increased it over time (OECD, 2011). As an important actor in the world economy, the European Union (EU) targeted

an increase in the R&D expenditures to GDP ratio to 3% by 2010 through its Lisbon Strategy and then extended it to 2020 (Veugelers et al., 2015).

As business sector R&D activities are highly correlated with the R&D intensity and growth performance of a country (OECD, 2001a), R&D expenditures by this sector assume greater importance.

Although investment in R&D by the private sector is highly significant, it is unwise for several reasons to allow the business sector to act alone in the R&D field and leave R&D decisions to the market. Therefore, government support for business sector R&D activities has increased and more resources are allocated from the budget for these activities. Total government allocation for R&D (at constant prices, PPP $) increased more than one and a half-fold in the last 20 years in the OECD. While it was $258,449.10 in 2000, it reached $398,300.41 in 2020. As of 2018, in most countries, direct funding and tax support for business sector R&D increased as a percentage of GDP compared to 2006. Figure 1 shows direct government funding and government tax support for business R&D (as a percentage of GDP) in 2018 and 2006.

Legend: ■ Direct Funding of BERD ■ Tax Support for BERD △ Total 2006
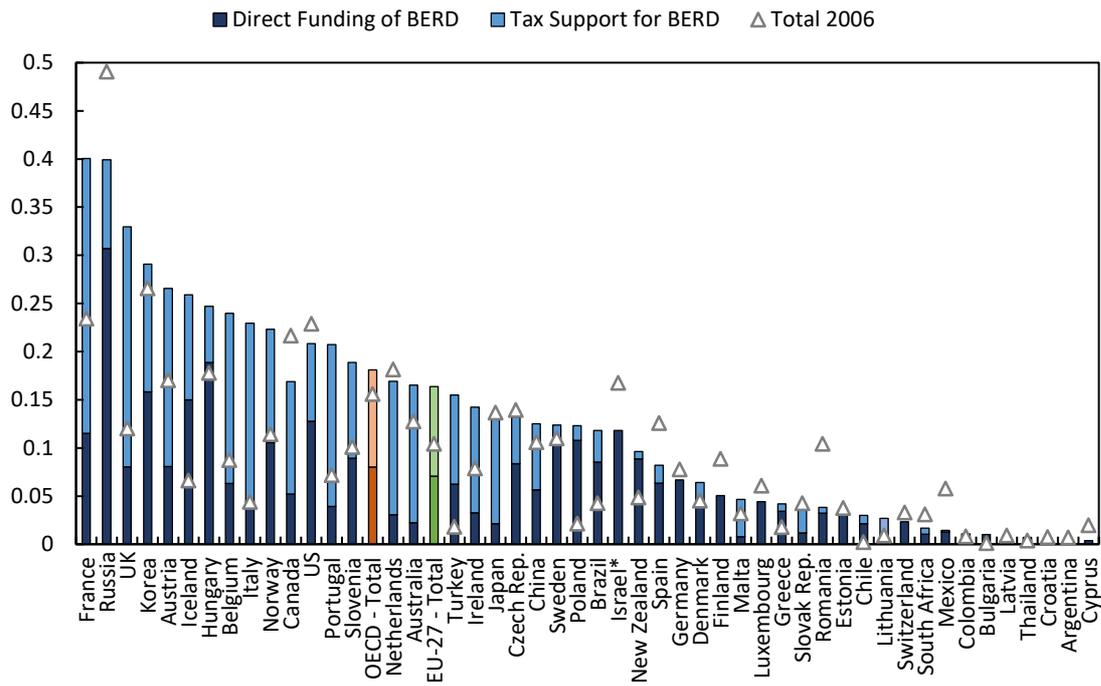
(*) Tax support data is not available.

Figure 1. Direct Funding and Tax Support for Business R&D (as a percentage of GDP, 2006 and 2018) (Source: OECD R&D Tax Incentive Database, http://oe.cd/rdtax, March 2021)

As a result of these developments, the effectiveness of government support tools has become an important issue over the years.

In 2.1, the reasons that make government actions necessary for increasing the R&D expenditures of the business sector will be explained.

After the rationale behind the government interventions regarding business sector R&D activities is investigated, the funding will be explained in terms of direct and indirect mechanisms and trends regarding their use over the years in the world economy will be examined in 2.2.

Since the increasing use of R&D tax incentives as an indirect funding mechanism has raised questions about their effectiveness, the measurement of effectiveness will be explained in the context of additionality in 2.3.

2.1. Why Do Governments Support Private R&D Activities?

Increasing business sector R&D expenditures are the one of the main focuses of countries for innovation and technological change and thereby higher growth rates.

Schumpeter (1961) explained technological progress in the light of the Theory of Economic Development (1934) as a result of entrance by innovative firms, and the commercialization of new processes or products. According to this model, innovation depends on easy entrance to the market and SMEs are the engine of technological progress (Martin & Scott, 2000).

Later, Schumpeter (1975) considered technological progress as a result of the research laboratories of large firms and he discussed whether these large firms would be willing to spend their profits on risky R&D facilities. He reached the conclusion that technological progress would be better if a few large firms dominated the market. They would benefit from commercialization advantages and scale economies and would finance R&D investments more easily than others. He also suggested that market power would act as insurance against risks during the R&D process (Martin & Scott, 2000).

Since the business sector is an important actor in technological progress, increases in their R&D expenditures are crucial for technological development. Then two important questions arise: i) Do business sector R&D expenditures reach socially desirable levels? ii) If they do not, are government interventions necessary for increasing R&D expenditures of the business sector to socially desirable levels?

Before investigating the efficiency of government R&D incentives, the necessity of government interventions in the R&D field should be examined.

The justifications behind government interventions in the R&D field mainly depend on two theories in economics. While the first approach explains the government interventions from a neoclassical perspective and clarifies them mainly in the context of market failures, the second approach explains them from an evolutionary perspective since innovation is seen as a complex evolutionary nonlinear process and emerges as a result of the interaction between economic actors. The evolutionary

approach bases its arguments for government interventions on "systemic failures" (Akçomak, 2016; Bleda & Río, 2013).

In the neoclassical approach, the business sector may invest in the R&D field less than socially desirable levels mainly due to uncertainty and market failures in the innovation process. According to this view, there is no difference in knowledge between actors and information is spread equally among all actors. In the evolutionary approach, systemic failures include both failures in the flow of information between actors and differences in the knowledge levels of the actors (Akçomak, 2016).

Therefore, market failures are not sufficient for explaining government interventions in the R&D field since innovation is a complex evolutionary process governed by both market forces and nonmarket institutions. The government has a role not only in correcting market failures but also in improving institutional frameworks and connections among the innovation setup (Bleda & Río, 2013).

Since the justification for government intervention and policy tools depend on the above-mentioned theories, policy tools can be classified according to the theories they serve.

Metcalfe (1997) groups government intervention policies in the R&D field in two categories. According to him, the first group of policies concern resources and incentives while taking the technological capabilities and possibilities of firms as given, such as R&D tax allowances, subsidies, and patent protections. The second group of policies consider changing and increasing the innovation potential of firms by enhancing access to knowledge and managerial capabilities. In this classification, while the first group of policy tools are mainly related to the neoclassical approach, the second group are based on the evolutionary approach.

Lipsey and Carlaw (1998) also grouped policies due to the object of the policy and the breadth of the policy's focus. Policy objects are categorized as policies with the objective of altering the cost and/or returns of innovative activities and altering the structure of technology that altered over time. They also claim that many policies have both objectives. They group the breadth of the policy's focus into three categories: i) framework policies, which offer general support without discrimination between

firms, industries, or technologies such as R&D subsidies and tax credits; ii) focused policies, which encourage the development of specific industries such as software or technologies such as nuclear power; iii) blanket policies, which include both framework and focused policies.

Akçomak (2016) claims that the main determinants of policy designs are the assumptions of the theoretical background used and he groups the features of government R&D policy tools based on neoclassical and evolutionary approaches as shown in Table 1.

Table 1

Government R&D Policy Tools of Neoclassical and Evolutionary Approaches

Neoclassic Approach	Evolutionary Approach
Science and research policy	Innovation (and technology) policy
Policy designs can be applied to all firms (e.g. tax exemption on R&D expenditure)	Policy designs are more selective (e.g. specific sectors and firms)
Policy designs are bound by certain rules	Policy designs may change depending on environmental conditions.
R&D tax incentives, project supports and loans for R&D expenditures	Any kind of policy design that facilitates the flow of information in the innovation system

Source: Akçomak, 2016

Since R&D tax incentives are based on the neoclassical approach, considering the purpose of the study, government interventions will be explained in the context of the neoclassic approach and market failures in the following section, 2.1.1.

2.1.1. Government Interventions in the Context of Market Failures

Ensuring optimality in resource allocation is the goal of economics. The neoclassical approach depends on rational firm behavior that aims to achieve optimal levels of investment, production, and profit in a full-information environment (Akçomak, 2016).

Nelson (1959) describes the conditions that make the allocation of resources through private sector profit maximizing behavior socially optimal as follows:

> *"If all sectors of the economy are perfectly competitive, if every business firm can collect from society through the market mechanism the full value of benefits it produces, and if social costs of each business are exclusively attached to the inputs which it purchases, then the allocation of resources among alternative uses generated by private-profit maximizing will be a socially optimal allocation of resources."* (Nelson, 1959, p. 298).

One of the main arguments behind government intervention for increasing business sector R&D expenditures is market failures in the R&D field as Arrow (1962) and Nelson (1959) pointed out.

Market failures are the situations that hinder the optimality in allocation of resources. Both Nelson (1959) and Arrow (1962) explain the reasons for nonoptimality in resource allocation by diversification in private and social gains. According to them, the decisions in the market are taken by individuals or firms due to profits and gains and these private gains can differ from socially desirable ones (Joseph & Johnston, 1985).

If the marginal value of a "good" to society surpasses the marginal value of the same "good" to the individual who pays for it, private profit opportunities do not represent social benefits sufficiently and without nonprofit organization support private expenditures for this good tend to be lower than socially desirable (Nelson, 1959).

Arrow (1962) explains the aim of R&D activities or the invention process as producing knowledge and he states the reasons for market failures in these activities as indivisibilities, uncertainty, and inappropriability.

Over time, the economic literature about R&D has reached a consensus that R&D investment is below the socially desirable level because of market failures such as indivisibilities, externalities in knowledge production, and the risk feature of R&D activities, and government support for business sector R&D activities aims to compensate for the gap between the private and social returns of R&D investments (Arrow, 1962; Carvalho, 2011; Czarnitzki et al., 2011; Martin and Scott, 2000).

Despite the above-mentioned market failures, which are mainly based on the neoclassical approach, Bebczuk (2002) approaches market failures from the evolutionary perspective and refers to the lack of rule of law, low financial depth

(which causes asymmetric information between borrowers and lenders due to legal and institutional deficiencies), volatility in output growth, and financial constraints as other market failures that cause nonoptimality in the R&D field.

Another argument for government intervention in the R&D field is the high costs of some technological developments for firms (Link & Siegel, 2007). These high costs can limit the innovation performance of the business sector, especially for small and young firms. Hall (2002) states that small and young innovative firms are exposed to higher capital costs compared to large firms. The government can reduce the relative cost of R&D investment for the business sector by providing tax incentives and subsidies or implementing other policies (OECD, 2003).

According to Romer (1990), technological change occurs with people's intentional actions as a response to market incentives.

Arrow (1962) proposes research activities be conducted by large corporations as an imperfect solution for reducing the risks of the invention process since they are carrying out many projects and the scale of each project will be small relative to the net revenue of the corporation.

Although the patent system offers a solution to the diffusion of knowledge, it could be hard to put the patent into practice immediately. Moreover, the imitation of patented inventions by competitors can limit their effectiveness (Cohen & Kleppe, 1996).

Since market incentives are insufficient on their own to close the gap between socially desirable levels and private desirable levels of R&D investment for providing the optimal allocation of resources, ease financial conditions, especially for small and start-up firms, and reduce the high costs for some technologies, government or nonprofit organization support is necessary (Arrow, 1962; Dietzenbacher & Los, 2002; Martin & Scott, 2000; Nelson 1959).

Although market failures are a strong argument for government intervention in R&D, the description of market failures in the real world could be difficult. Market failure criteria are not clear cut and determining the timing of government interventions and assuming that they would correct the nonoptimality could be questionable (Demsetz, 1969; Joseph & Johnston, 1985).

Furthermore, determining the projects that are the source of market failures and targeting them would not be easy and the government could support the projects that would be invested in by the private sector even without government intervention due to asymmetric information about the projects (Choi & Lee, 2017).

In addition, the answer to the question "Should the government give support?" is not clear since it is costly. The cost of government interventions and the administrative cost of interventions can be higher than the gains (Demsetz, 1969; Joseph & Johnston, 1985; Wang, 2018).

Support of specific projects or firms by the government, in other words picking "winners", can also create resource allocation problems in the economy since it leaves other industries or firms in a disadvantageous position (Joseph & Johnston, 1985).

While economic theory suggests the government intervene until the point where social and private costs or benefits are equal, in practice identifying this point could be difficult (Joseph & Johnston, 1985).

In summary, while all the points that are explained above indicate the necessity of government intervention in the R&D field, the methods of intervention and their efficiency are of great importance for the intervention to achieve its purpose.

In the following section, 2.2, the methods of government support for increasing business sector R&D will be explained.

2.2. How Do Governments Support Private R&D Activities?

As with any other investment decisions, R&D investments require profit opportunities for private firms.

The government attempts to solve the underinvestment problem of the business sector in R&D by implementing a policy mix that generally includes direct subsidies and tax incentives as complementary measures (Guceri, 2016).

With the help of these support mechanisms, the government aims to reduce the relative cost and uncertainty of R&D investments. While the government has several support mechanisms for the R&D field such as public–private R&D partnership, direct

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subsidies, and fiscal incentives, the decision on which one to use depends on national conditions such as firm and industrial structure, innovation performance, observed market failures in R&D, and the structure of the corporate tax system (Appelt et al., 2020; Carvalho, 2011; OECD, 2003).

The structures of the research and innovation system and sectors determine the design of the optimal policy mix (European Commission, Investing in Research: an Action Plan for Europe, 2003).

While country-specific features are important for deciding on the optimal government support policy mix for boosting business R&D investments, analyzing these support mechanisms and understanding the strength and weaknesses of each of them are also vital.

Government support mechanisms can be grouped in two main categories as direct funding, such as purchases of R&D services, grants, or subsidies, and indirect funding implemented through tax policies (Appelt et al., 2020).

In sections 2.2.1 and 2.2.2, these direct funding mechanisms and tax incentives for business sector R&D activities will be explained, including their strengths and weaknesses for providing a comparative perspective.

2.2.1. Direct Funding Mechanism

A direct funding mechanism is one of the main public R&D supporting policies that make it possible to transfer government funds directly to the selected R&D projects based on specific targets. It can be implemented through procurement of R&D where the results of R&D belong to the recipient, may not belong to the performer, or through grants and subsidies where the results of R&D belong to the performer. In both of them, sources are targeted to specific goals chosen by the government (Guellec & Van Pottelsberghe De La Potterie, 2003).

A direct funding mechanism has several advantages and disadvantages. On one hand, it allows the government to select R&D projects that have socially higher returns, thus increasing the control the government has over conducted R&D (OECD, 2003); on the other hand, selecting the most useful R&D project may have a high administrative cost

and could be difficult in practice since there is asymmetric information between projects' owners and the government. Moreover, the government could tend to reward lobbyists and bureaucrats instead of taking optimal decisions (Hall & Reenen , 2000).

In addition, providing transparency in the support mechanism can also cause higher administrative costs. Another criticism regarding direct funding through selection of R&D projects by the government concerns picking winners and losers, thus reducing market competition. The financing of R&D projects by the government can also crowd out business sector R&D expenditures instead of increasing them (OECD, 2003).

Despite all these disadvantages, direct funding provides a huge level of certainty to firms. It allows firms to know the amount financed by the government or the reduced cost before starting the project (Ravšelj & Aristovnik, 2020). Moreover, it can be more useful especially for small or newly established firms' financial constraints through providing initial money for their R&D projects.

On the other hand, the application process for direct support imposes a cost on firms and the opportunity cost may not be low, especially for SMEs (Busom et al., 2011).

Despite the above-mentioned positive sides of direct subsidies, the challenges regarding this policy have gradually directed many governments to place more emphasis on tax incentives in the R&D field over the years (Czarnitzki et al., 2011).

2.2.2. As an Indirect Funding Mechanism: Tax Incentives

Tax incentives for R&D are widely used as public policy instruments for increasing private R&D investments. Since they reduce the relative cost of R&D investment, they increase the net present value of future R&D projects (OECD, 2003).

R&D activities are affected by tax incentives in three ways. Firstly, firms are induced by a lower average effective tax rate to relocate their R&D activities. Secondly, a specified location condition for tax incentives encourages firms to undertake more R&D activity in this area due to decreasing user cost of R&D. Thirdly, tax incentives help to increase cash flow and ease financial constraints and so increase the R&D activities of firms that have financial constraints (Guceri, 2016).

Although there are many forms of tax incentives, their policy designs differ across countries and over time (Guceri, 2016).

These incentives can be classified according to their targeted groups, tax base, sources of tax relief, geographic implementation areas, and targeted R&D activities.

Tax incentives according to:

i) **Targeted Group:** They can be designed for specific targeted groups for specific policy goal groups such as providing more generous R&D tax incentives for small or medium-sized firms or startups.

ii) **Tax Base:** The base of tax incentives can vary as an increment of R&D expenditures or level of R&D expenditures. In some countries a hybrid system is offered and both of them are used as the tax base.

iii)**Sources of Tax Relief:** They can be deducted from corporate income or social security contributions.

iv)**Geographic Implementation Areas:** R&D tax incentives may differ between regions of a country, or in federal countries federal R&D tax incentives may be different from national ones.

v) **Targeted R&D Activities:** Tax incentives can be related to R&D inputs (R&D expenditures) or R&D outputs (incomes from licensing or patent) (Appelt et al., 2020; OECD, 2020; OECD, 2003).

In addition to the policy design implementations mentioned above, tax incentives can take many forms, such as tax credits, tax deductions, and cash refunds (Guceri, 2016).

Forms of tax incentives can be mainly grouped as:

i) **Tax allowances:** It is a deduction from taxable income.

ii) **Tax credits:** It is a deduction from final tax liability (OECD, 2003).

While the value of tax allowances depends on the corporate tax rate and unused allowances can be carried over to the future for offsetting future taxations, tax credit does not depend on the corporate tax rate and carrying over to the future and offsetting future taxation requires a pool of tax liability (OECD, 2003).

Table 2 shows expenditure-based R&D tax incentives in some selected countries in 2020 according to sources of tax relief and forms of R&D tax incentives (tax allowance and tax credits). The design of R&D tax incentives depends on the country's science ecosystem, tax structure, policy goals, and preferences regarding R&D. Therefore, the

policy design of R&D tax incentives differs from country to country. In some cases, countries implement both forms, like Belgium and the UK.

Table 2

Main Features of Expenditure-Based R&D Tax Incentives (Selected OECD, EU, and Partner Economies, 2020)

Against Corporate Income Tax (CIT)			Against payroll withholding tax or social security contributions
R&D tax credit		**R&D tax allowance**	
Volume	Incremental/hybrid		
Taxable: Australia, Canada, Chile, UK (large firms) **Non-taxable:** Austria, Belgium (incompatible with allowance), Colombia (general and SME only tax credits), Denmark (deficit only), France, Germany, Hungary, Iceland, Ireland, Italy, Japan (volume and special R&D), Korea (investment), Malta, New Zealand (general and deficit only tax credit), Norway	**Taxable:** United States (credit on fixed, indexed base and incremental for simplified credit) **Non-taxable:** Japan (high R&D intensity), Korea, Mexico, Portugal, Spain	**Non-taxable:** Belgium, Brazil, China, Croatia, Czech Republic (hybrid), Denmark, Greece, Hungary, Latvia, Lithuania, Poland (R&D tax allowance, deduction for R&D Centers), Romania, Russian Federation, Slovak Republic (hybrid and volume-based), Slovenia, South Africa, Switzerland (cantonal level-optional), Turkey (incremental), UK (SMEs)	**Taxable:** Belgium, France, Hungary (exemption and credit, incompatible in use), Netherlands, Spain, Sweden, Turkey

Source: OECD, R&D Tax Incentives in OECD and Partner Economies (2020), http://oe.cd/rdtax

R&D tax incentives were implemented in Japan in 1966, in Canada in the 1960s, and in the USA (1981), France (1983), and Australia (1985) in the early 1980s (Hall & Reenen, 2000). Over the years, they have become a popular public policy for supporting business sector R&D activities due to their several advantages.

They allow governments to help domestic firms to enhance their competitiveness since they are exempt from international agreements. Moreover, they are market based and they can be seen as more neutral compared to direct funding. If the policy design of tax incentives matches the policy goals, they can have lower administrative costs compared to direct funding despite their costs in budget expenditures (OECD, 2003; OECD, 2013).

On the other hand, tax incentives allow markets to determine the allocation of R&D investments. Therefore, they reduce the power wielded by the government for allocating R&D resources among sectors, firms, and projects. Firms can also focus on lowering the tax burden instead of investing in R&D projects that have higher social returns. In addition, spillover effects can be lower in tax incentive cases compared to direct subsidies. Moreover, the benefits of tax incentives can be limited in some cases, such as firms with insufficient tax profits, and, contrary to direct funding, the benefits of tax incentives can be calculated at the end of the fiscal year after the project starts, thus reducing the certainty of the R&D investment compared to direct funding. In addition, it can be considered windfall money by firms and may not change their R&D strategies (Guellec & Van Pottelsberghe De La Potterie, 2003; OECD, 2003; OECD, 2020; Ravšelj & Aristovnik, 2020).

While the policy design of R&D tax incentives is a function of the tax scheme of a country and depends on countries' specific features and countries' innovation ecosystem in terms of other public support, the impact of R&D tax incentives is affected by the magnitude of other nations' R&D tax incentives since there is competition between nations for attracting more R&D-related foreign direct investment (OECD, 2008; Tassey, 2007).

Since the above-mentioned advantages of R&D tax incentives have increased their popularity over time, today generous tax incentives for R&D are implemented in many countries.

When the trend in public policies for supporting business R&D activities is examined for the last 20 years, the rise in the use of expenditure-based R&D tax incentives for supporting business R&D activity is noteworthy in OECD and partner economies. Figure 2 shows the increase in the number of countries that offer R&D tax support in the OECD and EU-27. As of 2020, 32[2] out of the 37 OECD countries and with Germany, which introduced R&D tax incentive for the first time in 2020, 21 EU-27 countries offer R&D tax support. These numbers indicate a 65% increase in OECD countries and an almost 100% increase in EU countries compared to 2000.
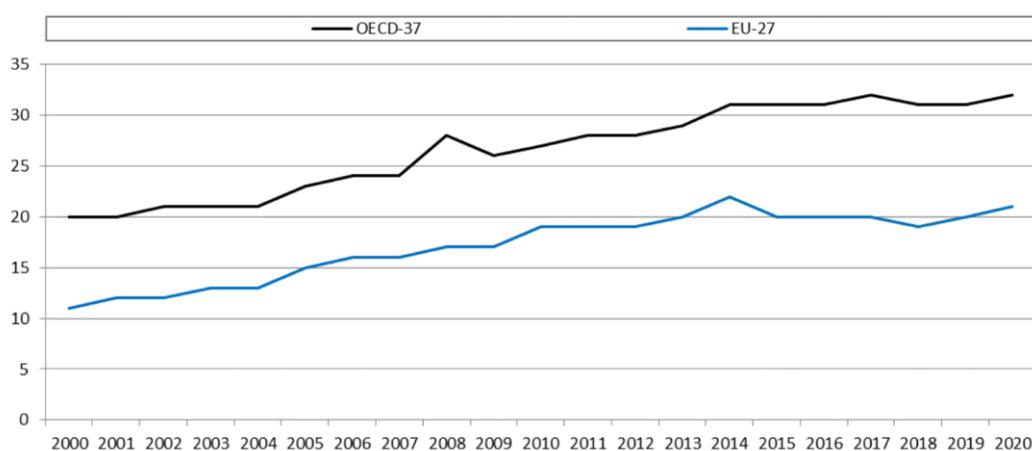
Figure 2. Number of Countries Offering R&D Tax Incentives (Central Government Level, 2000-2020) (Source: OECD, The OECD Report on the R&D Tax Incentives Database (2020), http://oe.cd/rdtax)

Over the years, expenditure-based R&D tax incentives have risen not only in terms of the number of implementing countries but also as a share of total government R&D support. In 2018, the share of R&D tax incentives in total government support for business R&D in the OECD area was 56%, while it was 30% in 2000 (Appelt et al., 2020; OECD, 2020). The ratio of R&D tax incentives as a share of GDP has also increased over the years. While it was 0.04% in 2000 in the OECD area, it increased to 0.1% of GDP in 2018. In these years, the direct funding of business R&D expenditures was 0.1% of GDP and 0.08% of GDP, respectively.

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[2] Luxembourg, Estonia, Latvia, and Finland are excluded. Since Figure 1 shows the countries that offer R&D tax incentives at central government level, Switzerland is also excluded. At subnational level, the number of countries increased to 33 in 2020.

All these figures show that the use of tax incentives has increased compared to direct subsidies over the years and they expose the shift in the funding policy of governments clearly.

Figure 3 shows the amounts of different funding mechanisms of business sector R&D activities as a percentage of GDP for the period 2000-2018 in the OECD. While there is an increasing trend in R&D tax incentives over the years, there is a decline in direct funding, especially after 2009. Figure 3 also shows clearly the shift in funding mechanism preferences in recent years. After 2015, the share of R&D tax incentives in GDP is higher than the share of direct funding.
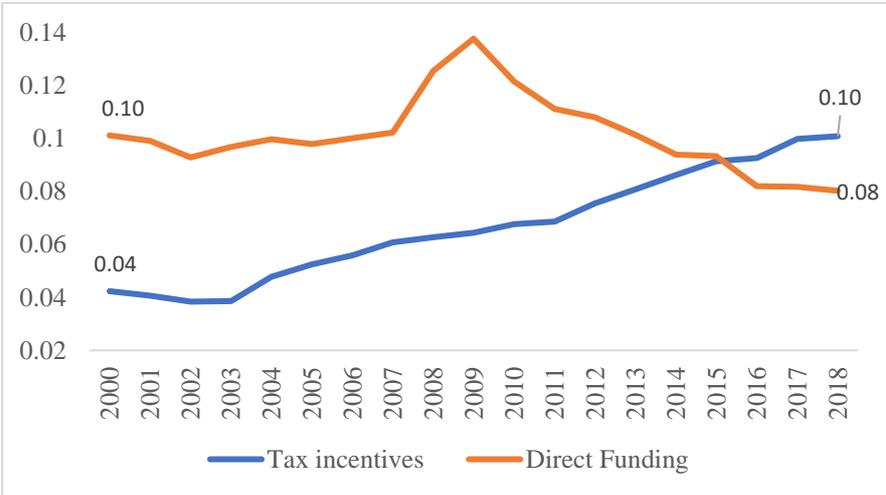
Figure 3. Tax Incentives vs. Direct Funding for Business Sector R&D Activities (OECD, 2000-2018, % of GDP) (Source: OECD R&D Tax Incentives Database, March 2021)

Greater use of R&D tax incentives among countries and the countries' efforts for increasing the attractiveness of R&D tax incentives by providing more generous R&D tax incentives over the years indicate tax competition for attracting more R&D-related foreign direct investments (OECD, 2008).

All these developments in the international environment make the measurement of R&D tax incentives' generosity more important for cross-country comparisons.

The B-index, which was designed by Warda (1996), shows the generosity of R&D fiscal incentives and provides a measure for comparing different tax incentive systems. It is calculated as one dollar R&D expenditure's after-tax cost (one minus the net

present discounted value of fiscal incentives on R&D assets) value divided by one minus the corporate income tax rate. Therefore, a smaller B-index means a more generous tax incentive system (Appelt et al., 2019; Guellec & Pottelsberghe, 2003).

The R&D tax generosity is also shown by using implied marginal R&D tax subsidy rates, which depend on the B-index and are calculated as "1 - B-index" (Appelt et al., 2019).

It shows "*the magnitude of marginal R&D tax credit rates applicable to an extra unit of R&D spend across a segment of the business population (e.g., SMEs or large enterprises).*" (OECD, 2020, p. 14).

Figure 4 shows the implied marginal R&D tax subsidy rates in the period 2000-2020 in the OECD. When the implied marginal R&D tax subsidy rate is examined for the last 20 years, an increasing trend is easily recognized. After the stabilization period between 2013 and 2019, there was a rapid increase in 2020 with its first implementation in Germany in that year and greater R&D tax relief in a number of OECD countries due to the COVID-19 crisis (OECD, 2020).[3]
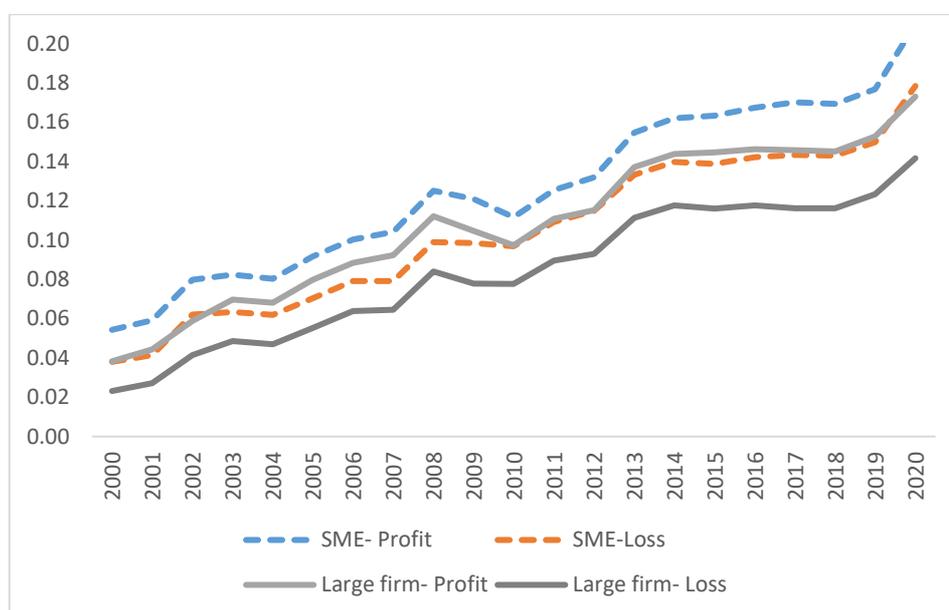
Figure 4. Implied Marginal R&D Tax Subsidy Rates (OECD (unweighted average, 2000-2020) (Source: OECD R&D Tax Incentives Database, May 2021, http://oe.cd/rdtax)

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[3] The table of countries' R&D tax incentive reactions during the COVID-19 crisis is given in the Appendix A.

Increasing use of R&D tax incentives over the years has raised questions about their effectiveness.

In addition, financial consolidation measures in the aftermath of financial crises increased the necessity for balancing public expenditures. Therefore, the efficacy of R&D tax incentives gained importance. An effective R&D tax incentive policy might reduce the budget deficit through stimulating innovation and so economic growth. For this reason, the effectiveness of R&D tax incentives has started to be questioned more. Another factor that has intensified interest in the effectiveness of R&D tax incentives has been the rising importance of innovation as a source of economic growth due to the decline in economic activity in the aftermath of the financial crises (European Commission, 2014).

All these factors have led to questions about the effectiveness of R&D tax incentives and evaluation of this public policy and measurement methods have grown in importance over the years.

In 2.3, the measurement and evaluation of R&D tax incentives will be explained in the context of additionality.

2.3. Effectiveness of R&D Tax Policies in the Context of Additionality

The evaluation of public policies and programs is crucial for analyzing the past experiences and improving future policies in the light of these experiences. Evaluation enables the monitoring of past or recent implications, determining their impacts, grading the results, and re-ordering policies for more effective future implications (Vedung, 2017).

Public policies or programs aim to reach specific targets and beneficiaries (Khandker et al., 2010). Government R&D funding mechanisms (both direct and indirect) for business sector R&D activities aim to increase business sector R&D activities. For this purpose, the funding mechanism may focus on special groups such as SMEs, start-ups, and large firms. The goal (increasing business sector R&D activities) is expected to be achieved using incentives or subsidies.

Evaluation of these incentives or subsidies shows whether the goal is achieved or not and answers the question "is the R&D subsidy or incentive effective?"

Besides the challenges concerning the methods for measuring the impacts of R&D incentives and subsidies such as using quasi-experimental methods, macro-modeling, and surveys, evaluating the effects of the R&D incentives for deciding on the effectiveness of a program is also difficult in practice.

Additionality enables assessment of the effects of R&D incentives or subsidies. It reveals the additional effects on the beneficiaries that accompany government intervention.

Additionality measures the difference that government funding programs have made to firms. The argument behind it is based on the market failure rationale. Firms tend to underinvest in R&D activities on their own because of their inability to take advantage of all the benefits arising from these activities (Georghiou L., 1999; Luukkonen, 1998).

The additionality concept was developed in the UK in the early 1980s for assessment of public support given to technology development companies. Later it was used and developed in the evaluation of many programs in Europe. Today, additionality is a major concept for the evaluation of R&D programs (Georghiou L., 1999; Luukkonen, 2000).

Additionality is the value added and it has two features:

i) Government funding must create "additional activity" to the activity that would have occurred in any situation.

ii) Government funding should have a "multiplier effect". It is expected to create more R&D activity units than funding units. If the multiplier is higher than 1, it means that one unit of government funding produces activity more than one unit. If it is between 0 and 1, government funding is partly used to reduces firm's own funds and finally if it is negative, it means that government funding is used to reduce firm's own funds more than received government funds (Guy & Arnold , 1993; Sterlacchini & Venturini, 2019).

Measurement of the additionality of a specific policy/program involves some challenges. Firstly, it depends on the assumption that the benefits that are produced by the policy/program can be identified and can be attributed to the policy/program. Secondly, measurement time is an important factor. It should be appropriate according to the appearance of the program effects. Especially in R&D activities, there is a delay factor. The results can occur in a lag. On the other hand, as time goes on, the effects of other economic conditions could increase and careful isolation of them is required. Therefore, the time of the additionality measurement should be appropriate (Davenport et al., 1998).

Additionality can be grouped into three categories:

2.3.1. Input Additionality: To What Extent the Incentives are Reflected in the Increase in Firm Expenditures (Investment in R&D and Innovation)

It is the measure of the additional R&D investment spending of a firm for every money unit of government funding. It can be also called the additionality ratio or "bang for the buck" (BFTB) and computes the benefit (the change in R&D investment) - cost (per money unit of foregone tax revenue) ratio of the R&D tax policy (Appelt et al., 2019; Sterlacchini & Venturini, 2019).

Governments expect incentive programs to create additional R&D performance (Appelt et al., 2019). Otherwise, the crowd-out effect of public R&D policy comes into question. It means that government R&D funding displaces business sector R&D investments. Therefore, government funds for R&D should be channeled towards the R&D projects that would not have been performed without government R&D funding.

2.3.2. Output Additionality: To What Extent the Incentives are Reflected in the End Results and Outputs

It shows the proportion of outputs that would not be achieved without government funding. This raises questions about what is the output. The determination or selection of an output indicator requires a major assumption. It is the connection between the intervention and what is measured. Generally, patents, sales of new product, and applications of processes and services are used as output indicators of R&D activities.

However, the output of a project is rarely ever a product, process, or service alone. Even when a project fails and does not produce an output, it could still create some outputs such as increase in knowledge stock and experiences.

Therefore, in practice, the measurement of output additionality could be more difficult compared to input additionality because of the complexity of relationships between inputs and outputs. It requires a deeper understanding about the operations of organizations.

2.3.3. Behavioral Additionality: To What Extent the Incentives are Reflected in Firms' Behaviors or Decisions (Implementation Behavior)

It means the difference in firm behavior resulting from the government intervention. It is assumed that the change in firm behavior is in a desirable direction such as encouraging firms to take more risks that they cannot afford without government intervention (Georghiou, 1994; Georghiou et al., 2004; OECD, 2006).

Concluding Remarks:

Considering technological change as a driver of economic growth with developments in growth theories increased the importance of R&D activities for countries.

Since both empirical and theoretical studies emphasize the importance of business sector R&D expenditures for sustainable higher growth rates, countries' efforts to stimulate business sector R&D have increased over the years.

Many countries have put increasing R&D expenditures on their economic policy agenda and increased their R&D expenditures as a percentage of their GDP over time. As a result of this, government support for business sector R&D rose and increasing resource allocation to business sector R&D activities from the budget raised questions about the effectiveness of this support.

Before investigating the effectiveness of R&D policy instruments, the necessity of government intervention in the R&D field should be understood.

Market failures, based on the neoclassical approach, and systemic failures, depending on the evolutionary approach, are the main justifications behind government intervention in R&D.

According to the market failures view of the neoclassical approach, R&D activities or the invention process suffer from indivisibilities, externalities in knowledge production, and uncertainties. As a result, the business sector tends to invest in R&D less than socially desirable levels and government support aims to boost firms and compensate for the gap between the private and social returns of R&D investments.

The systemic failures view of the evolutionary approach considers innovation as a system governed by both market forces and nonmarket institutions and failures result mainly from diffusion of knowledge and differences in knowledge levels among the actors in the innovation system.

Therefore, government intervention is considered from a broader perspective beyond market failures and includes improvement of the innovation system through institutional frameworks and diffusion of knowledge.

Intervention tools or policy instruments are based on these approaches. Therefore, it is important to understand the theoretical approach behind the policy tool before investigating its efficiency.

Direct and indirect government funding mechanisms that try to find a solution to market failures are policy tools of the neoclassical approach. Both of them have advantages and disadvantages. Countries take into consideration these features of policy tools in their policy design of business sector R&D funding.

While direct funding mechanisms such as grants, subsidies, and public procurements allow governments to control R&D policies through targeting specific R&D projects, they could have higher administrative costs. Moreover, since governments pick "winners", there is a risk of deterioration in market competition. The financing of projects by the government can also crowd out business sector R&D expenditures instead of increasing them. On the other hand, they give huge certainty to firms and provide the initial money, especially for small and newly established firms.

Over the years because of all these features of direct support mechanisms, countries have tended to place more emphasis on R&D tax incentives since they are exempt from international agreements and more market based and neutral compared to direct funding. They also have lower administrative costs.

Nevertheless, they reduce government influence in R&D projects since the market decides on allocation of R&D investments. Firms can prefer to focus on lowering their tax burden instead of investing in R&D projects with higher social returns, and the benefits of R&D tax incentives can be limited since some firms have insufficient tax profits.

The advantages of R&D tax incentives have increased their popularity over time and today they are implemented in many countries. Wide use of R&D tax incentives and the rising importance of public expenditures, especially in the aftermath of financial crises, due to budget concerns raised questions about the effectiveness of R&D tax incentives, because if they are effective, they can reduce budget deficits through innovation and thus economic growth.

However, measurement of a policy's effectiveness is not an easy matter. Additionality is a major concept for the evolution of R&D policies. It enables measurement of the difference that public policies have made to firms. R&D policy is expected to create "additional activity" to the activity that would occur in any situation. It is grouped as input, output, and behavioral additionality, depending on where the impact of the policy is observed.

While in input additionality the impact is expected to be observed in firm expenditures, in output additionality it is expected to be observed in output indicators such as patent facilities, sales of new products, and applications of processes and services. In behavioral additionality, the impact is expected to be seen in the firm's R&D behaviors or decisions.

In summary, government intervention tools for increasing business sector R&D activities are crucial for the economic agenda and innovation policies of countries. As an R&D public policy tool, the rising popularity of R&D tax incentives has increased questions about the effectiveness of this policy. While the additionality concept

facilitates measurement of the effectiveness of this instrument, there are several attempts in the empirical literature to assess the effectiveness of the instrument. In Chapter 3, efforts for measuring the effectiveness of R&D tax incentives in the empirical literature will be summarized.

CHAPTER III

EMPIRICAL LITERATURE REVIEW

The growing popularity of R&D tax incentives as a policy tool for supporting business R&D has led to questions about the effectiveness of this policy over time. Although there are several attempts in the literature to examine the effectiveness of R&D tax incentives for different countries and different R&D tax incentive programs, there is no consensus about the impact of R&D tax incentives. The results differ widely (Thomson, 2017).

The studies in the literature differ not only in data level (such as firm-level or cross-country) or in results but also in the objective, which is affected by the R&D tax incentives, methodologies, and measures (Ientile & Mairesse, 2009).

Although the impact of tax incentives on R&D expenditures is generally investigated, some studies focus on the output side of R&D performance and examine the impact of R&D tax incentives on innovation indicators.

The impact of R&D tax incentives is mainly estimated by elasticities and/or additionality in the literature by applying a structural R&D investment model or quasi-experimental methods such as matching methods and/or the DiD method. Elasticity shows the response of the R&D expenditure to the measurement of tax credit (Ientile & Mairesse, 2009), which is generally the tax component of user cost of R&D or the B-index. Additionality is another widely applied measure for evaluation of the impact of R&D incentives since it shows the additional impact is induced by one currency unit of R&D incentives.

In this study, empirical literature for mainly the last 20 years is focused on for shedding light on the recent efforts regarding the effectiveness of R&D tax incentives. The

literature is examined in mainly two categories, cross-country studies and firm-level studies.

For literature from more than 20 years ago, Hall and Van Reenen (2000) provide a good summary of empirical evidence for the USA and other countries[4] and conclude that a dollar tax credit induces a dollar additional R&D investment.

In their important cross-country empirical study, Bloom et al. (2002) investigated the impact of R&D tax incentives on the level of business-funded R&D investment for nine OECD countries[5] for the period 1979-1997 from the user cost of R&D perspective by using a structural model. They apply ordinary least squares (OLS) to the investment demand equation for R&D, and therefore the coefficient of the user cost of R&D gives the sensitivity of business R&D investment to the change in its price (user cost of R&D). They apply a dynamic model and estimate both short- and long-run elasticities, and the endogeneity problem between the R&D expenditures and user cost of R&D in the model is solved by applying the instrumental variable (IV) method and the tax component of the user cost of R&D is applied as the IV. They conclude that tax incentives are effective after examining country-specific fixed effects such as language, culture, supply of scientists, demand conditions, and macroeconomic conditions that affect the R&D investment independently of tax incentives such as common technology shocks. According to their study, a 10% decrease in the user cost of R&D increases the level of R&D investment by just over 1% in the short run and this elasticity increases and approaches 10% in the long run.

Guellec and Pottelsberghe (2003) tackle the effectiveness issue from a broader perspective and investigate the effects of all public R&D policy tools (grants and procurements as direct funding, tax incentives and public research activities as public intramural expenditures, and higher education R&D activities) on business-funded R&D for nearly the same period as Bloom et al. (2002) (1981-1996) for 17 OECD countries. They aim not only to establish the effectiveness of tax incentives but also to measure the effectiveness of other instruments simultaneously. Thus, they provide a comparable picture of different policy instruments' effects. They apply the same

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[4] Australia, France, Sweden, Canada, and Japan
[5] Australia, Canada, Spain, USA, Italy, Germany, UK, France, and Japan

approach as Bloom et al. (2002) and use a structural model for R&D investment and try to estimate the elasticity of business-funded R&D to its prices (user cost of R&D) in both the short and long run. For estimating the generosity of the tax system, they use the B-index as the price of tax. In line with Bloom et al. (2002), they include country fixed effects and time dummies in the model. The endogeneity problem is solved by applying the three-stage least squares (3SLS) method. They find tax incentives effective in increasing business-funded R&D and their effects occur immediately, while direct funding takes effect after lags. The elasticity of business-funded R&D to the B-index is calculated as -0.28 for the short run and contrary to Bloom et al. (2002) it does not increase in the long run and is measured as -0.31. They find that the effectiveness of both direct funding and tax incentives increases if they are stable over time. Direct funding and tax incentives are also found to be substitutes, which means that an increase in the use of one instrument decreases the effectiveness of other. They explain the substitution effect by the lack of coordination in their design and implementation. Finally, the effectiveness of government funding of R&D has an inverted U shape according to the results. It raises private sector R&D up to a 10% subsidization rate and decreases beyond. After 20%, it crowds out private sector funding.

Another attempt to estimate the impact of R&D tax incentives at cross-country level is Falk's (2006) study. He tries to determine the factors that affect R&D intensity (ratio of business sector R&D expenditures to GDP) in OECD countries for the period 1975-2002 (data are used with 5-year averages) by using a structural model for R&D investment. He expands the sample compared to Guellec and Pottelsberghe (2003) and includes 21 OECD countries. He also uses data more recent than theirs. He applies the system GMM estimator for the endogeneity problem. He uses the share of business sector R&D expenditures in GDP as the dependent variable, which shows the R&D intensity. As the tax incentive indicator, the B-index is used in his study, parallel to Guellec and Pottelsberghe (2003). He measures the elasticities of R&D intensity with respect to tax prices for both the short and long term. He finds R&D tax incentives effective in increasing business sector R&D intensity. He calculates the short-term tax price elasticity as -0.22 and finds it -0.84 in the long term. These results imply that a 1% decrease in the B-index (increase generosity of tax incentives) leads to a 0.22%

(0.84%) increase in business sector R&D intensity in the short run (in the long run). This result is consistent with Bloom et al. (2002).

Nam (2012) investigates the impact of tax incentives for 19 OECD countries in 2006 from a different perspective. He uses the net present value (NPV) approach. He states the importance of after-tax NPV for R&D investment decisions of profit maximizing firms. Therefore, he investigates the impact of R&D tax incentives on after-tax NPV for 19 OECD countries. He examines the impact of corporate tax incentives on after-tax NPV from the internal equity and debt finance perspective and claims that after-tax NPV is larger in the debt finance case by a given tax depreciation plan. Therefore, the corporate tax system gives debt finance prominence. Then he states that when tax allowance and tax credits are implemented, ceteris paribus, after-tax NPV increases with corporate tax rate. Since an increase in after-tax NPV suggests stronger R&D investment, he proposes a policy of increasing corporate tax rates instead of decreasing the corporate tax rates as the majority of developed countries have applied.

Thomson (2017) also investigates the impact of R&D tax credits on business-funded R&D investment for both the short and long run. He emphasizes the difficulty in finding an exogenous measure of tax policy in the literature. He states that while the previous studies focus on either firm-level or cross-country data and he suggests a new approach based on the use of cross-country industry-level data. The panel data of the study cover 29 industries in 26 OECD countries for the period 1987-2006. He measures the generosity of R&D tax credits in line with the previous literature (Bloom et al., 2000; Guellec & Pottelsberghe, 2003) from the user cost of R&D perspective but he estimates it as country-industry specific. Since tax treatment differs for different types of R&D expenditures (tax incentives are not applied to all R&D expenditures and different tax incentives rates are applied to different types of R&D expenditures), firstly he calculates the tax price for each R&D expenditure category (capital component of R&D and current component of R&D, which includes labor costs and other current). Then he obtains the industry-specific tax price, which is the weighted average of these two R&D expenditure categories. Weighting is done by using the lagged expenditure share. The structural model, which uses an R&D investment demand function, is applied in line with the previous literature. Aggregate industry R&D investment is used as the dependent variable. As explanatory variables industry-

specific tax price is used as measure of the tax policy, industry value added is used for the demand side, and time dummies and country-industry fixed effects are also included in the model. The simultaneity problem is solved by applying the lagged expenditures weights and the systems GMM estimator. According to the results, the tax price elasticity is -0.5, which means that a 10% decrease in the tax price creates 5% additional business-funded R&D investment in the short run and in the long run the elasticity is estimated around -4. Both estimates are higher than the previous cross-country findings. While the previous cross-country literature mainly focuses on elasticities, he also calculates the input additionality by using the elasticities. He measures the input additionality as 60 cents additional R&D investment for every dollar foregone tax revenue under the 35% corporate tax assumption in the short run.

Later, Appelt et al. (2019) estimates the additionality of R&D tax support for 21 OECD countries for the period 2000-2016. Nineteen OECD countries that implement five years or more R&D tax incentives during the period are selected for calculating both the short- and long-term effects. Two OECD countries (Germany and Luxembourg) that used no R&D tax incentives during the period are also included in the sample. They estimate the additionality by using two complementary statistics. Firstly, they use the B-index in line with the previous literature and, secondly, they use government tax relief data (GTARD) that have been published recently by the OECD and provide the amount of the actual cost of R&D for government support. Although the amount of government R&D tax support data was used at firm level before for Belgium (Dumont, 2017), GTARD are used for the first time in a study for estimating the elasticity of R&D investment in a cross-country study since they provide a comparable measure for government tax relief among countries. They give a direct estimation of change in R&D investment induced by government tax support or as commonly referred to BFTB (benefit- change in R&D investment against – cost- per money unit of foregone tax revenue). Direct support by the government to R&D is checked in the estimation. The endogeneity problem between GTARD and business-funded R&D investment is solved by applying the IV and the B-index is used as the IV in the equation that uses GTARD. According to the B-index results, the elasticity of business-funded R&D is -0.11 in the short run and -0.84 in the long run. Each estimation is in line with the previous literature. On the other hand, the elasticity of business-funded R&D to GTARD is lower, i.e., 0.04. After estimates of elasticity by

using both set of data, BFTB is measured. According to the B-index estimation, the input additionality is 0.87 units for one unit of foregone tax revenue. When the input additionality is measured by the value of the tax support cost, it increases to 1.6. When it is lower than 1, it implies that tax incentives are not effective for inducing additional R&D expenditures. However, they emphasize that even if the additionality implies the partial crowd-out effect for private R&D, which means a ratio lower than 1, public funding is still valuable since its private and social returns are sufficiently high for R&D.

Cross-country analyses are important since they provide an overall evaluation of R&D tax incentive schemes, which differ between countries. Since these incentives differ between countries in their design, implementation, and generosity, they could also provide more exogenous variation compared to micro-level studies (Appelt et al., 2019; Hall & Reenen, 2000; Thomson, 2017). On the other hand, firm-level studies, which usually focus on a single country, give more specific effectiveness measures for a country-specific tax incentive scheme. Therefore, for evaluating the efficiency of an R&D tax incentive program, firm-level studies could provide more detailed and reliable results (Ientile & Mairesse, 2009). They also mostly allow for sectoral analysis or specific analysis of firms' characteristics, which could be important for policy design.

In this study, firm-level studies for the last 20 years were surveyed. While the cross-country analysis is generally done for OECD countries, the countries or country groups in firm-level studies vary. While some studies focus on a specific R&D tax incentive program in a country, some studies at firm level focus on a few countries for comparing the R&D tax incentives of these countries in the same period.

An important study at firm level by Koga (2003) investigates the effectiveness of R&D tax credits for Japanese firms in the manufacturing sector for the period 1989-1998 by calculating elasticities. He examines whether the effectiveness of R&D tax credits differs based on firm size. He uses a structural model and applies the OLS method in line with most of the cross-country literature. As the dependent variable he uses the firm R&D investment and as explanatory variables he uses the user cost of R&D, sales for representing the demand side, year dummies for macroeconomic shocks, and a

firm-specific fixed effect. For solving the simultaneity problem between the explanatory variables (user cost of R&D and sales) and firm R&D investment, the explanatory variables are used with their first lag. For avoiding errors in the calculation of the user cost of R&D, he also applies the IV method and uses the tax component of user cost of R&D as the IV. After the elasticity is calculated for all firms, it is also estimated separately for different firm sizes. For categorizing the firms, their capital is used. The median capital of firms is estimated in 1989 and the firms that have less capital than the median are categorized as medium and the others as large. He estimates the tax price elasticity as -0.68 for all firms and when it is estimated by taking into consideration firm size it is calculated as -1.03 for large firms and it is not significant for medium firms. He explains the findings for medium firms by the higher sensitivity in R&D investment to demand side factors as sales. Firms are also grouped according to their sales and the estimation according to this classification does not change from the previous one. This means that R&D tax credits are more effective in inducing R&D investments for large firms. He explains the higher effectiveness of R&D tax credits in large firms by their permanent base for R&D, related to having their own research centers and workforce for R&D. This means that they are not flexible to changes in market conditions. They also have huge R&D spending, which provides huge tax reductions.

Klassen et al. (2004) compare the effectiveness of R&D tax incentives in the USA and Canada, which have similar economies but different R&D tax incentive policies during the period 1991-1997, by taking into consideration the financial constraints of the firms. They use a structural model and apply weighted OLS. They find the US R&D tax incentive system more effective in terms of inducing additional R&D expenditure (additional R&D expenditure is $2.96 in the USA and $1.30 in Canada per dollar foregone tax revenue).

Hægeland and Møen (2007) calculate the input additionality in the short and long term for the Norwegian R&D tax credit scheme, which was announced in 2002 and called SkatteFUNN. They apply DiD regression and compare the growth of R&D investments of firms. They find the tax credit scheme effective for increasing firms' R&D investments and the magnitude of the additionality is calculated as 2.68 Krone additional spending per krone tax credit.

Corchuelo and Martínez-Ros (2009) analyze the effects of R&D tax incentives on R&D technological effort (R&D spending over sales) of firms in Spain by applying both parametric (Heckman's two-step selection model with instrumental variables) and nonparametric methods (matching method, PSM) for the period 1998-2002. They apply nearest neighbor and kernel matching for PSM. According to their results, firms that have higher capacity for innovation, are in a stable financial position, and receive R&D subsidies have a higher possibility to use R&D tax incentives, while SMEs face some challenges to use them. Moreover, they find the average effect positive but it is significant just for large firms. They conclude that R&D tax incentives increase R&D technological effort in large and high-tech firms.

Czarnitzki et al. (2011) investigate the impact of tax credits on innovation outputs such as number of new products and sales with new products in the Canadian manufacturing sector for the period 1997-1999 by using nonparametric matching methods and Canada Survey of Innovation (1999) data. Unlike the previous literature, they also focus on the effects of R&D tax incentives on firms' economic performance. They use nonparametric matching for solving the selection bias problem in the policy evaluation. Based on the results, they conclude that tax credits have a positive effect on innovation indicators (innovative product numbers and sales). However, the impact of R&D tax incentives on firms' economic performance is not significant in the context of profitability, keeping up with competitors, or share of the domestic market. The policy is only found to affect the international market share. While 17% of beneficiary firms introduce a world-first innovation and 40% a Canada-first innovation, for the other firms the percentages are 5% and 22%, respectively.

Lokshin and Mohnen (2012) investigate the impact of an R&D tax incentive program on Dutch firms' R&D expenditures for the period 1996-2004 by estimating elasticities. Then they apply cost– benefit analysis (BFTB) in a dynamic framework for examining the additionality of the program. For calculating the elasticity, they construct firm-specific user cost of R&D as a function of R&D tax incentives and calculate the user cost 26% higher in the absence of the R&D tax incentive program for the period investigated. As the dependent variable they use firm R&D expenditure as a share of the previous period's R&D stock. For solving the endogeneity problem between the user cost of R&D and the R&D expenditure amount, they apply the generalized IV

method. They determine the user cost of R&D by using the sub-component of the R&D tax incentive program. They measure the elasticities by applying a dynamic model, ECM, and a partial adjustment model. They find the R&D tax incentive program effective in inducing R&D investments by Dutch firms. According to the results for the three models, they estimate the price elasticity of R&D investment between -0.2 and -0.5 in the short run and between –0.54 and -0.8 in the long run. For revealing the effectiveness of the R&D tax incentive program, they estimate the BFTB and they find it to be 1.05 for all firms. Since it is greater than 1, it implies that one monetary unit of foregone tax revenue creates more than 1 monetary unit of R&D expenditure. This means that the R&D tax incentive program is effective in increasing R&D expenditures. They extend the investigation and compute the BFTB according to firm size and find it to be 3.24 for small firms and 0.78 for large firms. Therefore, the results indicate that the R&D tax incentive program in the Netherlands is effective for small firms and crowding out cannot be disregarded for large firms.

Kobayashi (2014) investigates the effect of R&D tax credits on firms' R&D expenditures for SMEs in Japan by applying PSM for 2009. He examines whether the effect of R&D tax credit differs according to firms' industries, size, and liquidity constraints. He applies kernel, K-nearest-neighbor, and caliper matching methods for matching propensity scores. According to the results, R&D tax credits increase SMEs' R&D expenditures and they are more effective when it comes to firms with liquidity constraints compared to unconstrained firms.

Thomson and Skali (2016) examine the effectiveness of R&D tax subsidies (tax concessions and tax incentives) in inducing additional R&D investment by Australian firms for the period 2005-2012 using ordinary least squares (OLS), PSM, difference-in-difference (DiD), and regression discontinuity design. The introduction in 2012 of an R&D tax incentive policy that is more generous than the other incentives for R&D enables the application of the DiD method. They find that after the introduction of the R&D tax policy in 2012 firms' R&D expenditures increased by 14% and the additionality of the tax program is calculated as $1.9 for each dollar of foregone tax revenue. Since it is higher than 1, it shows that the R&D tax program is effective. BAsed on all the results from the different methods, they estimated the additionality

in Australia for the period 2005-2012 to be between $0.7 and $1.9 for every dollar of foregone tax revenue.

Dechezleprêtre et al. (2016) focus on the innovation impact of R&D tax credits for UK firms for the period 2006-2011 by applying a regression discontinuity design. They state the importance of the effects on innovation of R&D tax incentives. Therefore, they suggest focusing not only on the R&D expenditure side but also on the innovation side. They claim that the innovation effects of R&D tax incentives show the use of induced R&D expenditures in high quality projects. Then they discuss the effectiveness of R&D tax incentives on not only R&D expenditures but also on patent facilities and patent values, which indicate the quality of additional innovation. According to the results, they estimate the R&D elasticity to tax adjusted user cost as -2.6, which is higher than the values reported previously. They explain this higher elasticity by the dominance of small firms, which generally have financial constraints and show a greater response to tax credits. They also compute the input additionality as £1.7 for every pound of foregone tax revenue. Therefore, the R&D tax incentives are found cost effective. Regarding the effects on innovation, they find that patenting rises about 60% due to the policy without a significant decrease in new patents' values.

Freitas et al. (2017) investigate the input and output additionality of R&D tax credits for Norway, Italy, and France for 2004, 2006, and 2008 by applying micro econometric analysis. Their study differs from the previous literature in two aspects. Firstly, they examine whether the additionality effect differs due to sector features. R&D orientation and concentration as competition indicators are used as sector features in the study. Secondly, they take into consideration both input and output additionality for these countries. Additionality is calculated by applying a three-step procedure. They calculate the probability of receiving tax credit based on R&D orientation and concentration level. Tax credit here is used as a dependent dummy variable (takes 1 if firm benefits from tax credits in the period, 0 otherwise). Then they estimate the input additionality by applying PSM and using R&D intensity (R&D expenditures as a share of total turnover) as the dependent variable and obtain ATT. Finally, they estimate the output additionality by using the share of the new or improved products' turnover as the dependent variable. They use the ATT for each firm from the second step as additional R&D intensity that is induced by tax credit. Therefore, they obtain the

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counterfactual for R&D intensity (the difference between the R&D intensity in the absence of tax credits and additional R&D intensity induced by tax credits). According to the results, the probability of receiving tax credits is high when R&D orientation is high, but for the concentration features, the high probability of receiving tax credits for sectors that have stronger concentration is valid only for France. Input additionality is positive for all countries and years (except Italy. In Italy it is positive for 2004 and 2006). It is greater in higher R&D-oriented sectors and input additionality is stronger in Norway and Italy than in France. The difference in input additionality across countries is explained by the difference in tax credit policies between countries. While Norway and Italy apply volume-based tax credits during the investigated period, France applies incremental-based tax credits. For output additionality, it is positive for all sectors and countries. In Norway and Italy, it is greater in high R&D-oriented sectors. In France, output additionality does not differ significantly between sectors.

Dumont (2017) investigates the impact of public support for R&D on business-funded R&D expenditures for the period 2003-2011 in Belgium, which provides both federal and regional R&D tax incentives, by using fixed effects regression with panel data from the input additionality perspective. He evaluates both direct subsidies and tax incentives. He claims that investigating only one type of public support for R&D can lead to bias in the results. Therefore, he examines the effects of subsidies and tax incentives for R&D individually and also investigates their effects when they are applied together. He uses the amount of the public support in his study, unlike most of the previous studies. He emphasizes that fixed effects can be useful for solving the endogeneity problem since it allows for time-invariant firm heterogeneity. The impact of each support is estimated in the case of benefiting or not benefiting from other types of support. He calculates the BFTB estimates using average R&D expenditures and average public support amount. According to the BFTB results, the effectiveness of public support decreases when firms also benefit from other support policies. Therefore, the combination of public policies decreases their effectiveness compared to their use individually. He explains the results by the lack of coordination between regional and federal authorities, similar to Guellec and Pottelsberghe (2013). He also agrees with Guellec and Pottelsberghe (2013) about the optimum subsidy rate and claims that the decrease in the efficiency in the case of the use of both subsidy and tax incentives may be related to the optimum support point being exceeded.

Carboni (2017) also focuses on the effect of public support (investment incentives, direct R&D support, and fiscal R&D incentives) on investment and R&D expenditure instead of tax incentives for seven European countries (Germany, France, Italy, Spain, UK, Austria, and Hungary) by applying nonparametric matching for manufacturing firms' combined dataset for the period 2007-2009. R&D expenditure is used as a portion of total sales. The control variables are indebtedness, GDP growth, measure of capital, number of employees as firm size, being an exporter, firm age, internal financing, origin of innovations, and financial constraints. Firms are evaluated in terms of receiving R&D grants or tax reductions or both for R&D and investment incentives are also taken into consideration in the study. He studies both the combined dataset and data for the countries separately. According to the results, public policies for R&D affect R&D spending positively and the results refute the crowding-out hypothesis. It is also mainly confirmed at single country level (holds for every country except Hungary).

Sterlacchini and Venturini (2019) investigate the impact of R&D tax incentives on the intensity of R&D expenses over sales for manufacturing firms with 10 or more employees in the UK, France, Italy, and Spain for the period 2007-2009 by using PSM. They examine whether the tax incentives' effect changes according to firm size. They include turnover for defining the size of the firms. They also identify the dummy variable for controlling the decrease in turnover during the 2008-2009 crisis. They estimate the impact for four groups, namely the total group, SMEs, small firms, and medium and large firms. According to the results, the propensity for benefiting from tax incentives is low for firms that have lower turnover except in the UK because of preferential fiscal policies towards SMEs. They show that tax incentives significantly induce R&D intensity in all countries except Spain despite its generous tax system and this effect is driven by small firms. Since it is insufficient to exhibit that the firms benefitting from fiscal incentives conduct more R&D, the study also focuses on the additionality effect, which measures whether the firm increases R&D expenses more than the fiscal benefit. Therefore, they also investigate the additionality effect of R&D tax policies by computing the R&D tax credit multiplier between 2008 and 2009. They assess the multiplier as the ratio between ATT/R&D intensity and the value of fiscal provisions as a proportion of R&D expenses. According to the results, one euro foregone in tax revenues leads to an increase of 0.7 euros in R&D in France. This is

1.5 in Italy and 1.6 in the UK (Spain is not included because of lack of data). The additionality effect is less than 1 in France. It is explained by the crowding-out effect of small firms in that country. Finally, they state that their findings must be considered a short-term effect, which is generally smaller than a long-run effect.

While the literature on the effectiveness of R&D tax incentives is highly dominated by the developed countries, it is sparse for newly industrialized and/or developing countries although these instruments have been used widely in these countries. Yang et al. (2012) investigate the effect of R&D tax incentives on R&D for Taiwan, which is newly industrialized and has shown a rapid increase in innovation and R&D. They examine the effectiveness of R&D tax incentives for manufacturing firms for the period 2000-2005 by applying PSM, IV, and GMM estimator methods. They analyze the effect of R&D tax incentives on the level of R&D expenditures and the growth of R&D expenditures. They also investigate the effectiveness in the sectoral dimension and examine the effectiveness of R&D tax incentives for electronics firms and nonelectronics firms. They firstly apply PSM to avoid the selection bias problem. They find that firms that benefit from tax incentives have a 53.8% higher R&D expenditure level. This effect rises to 71.8% for electronics firms when the analysis is done according to sector. On the other hand, they find no significant result for R&D growth. Then for solving the firm heterogeneity and R&D tax credits endogeneity problems and also calculating the marginal effects instead of average effects, which are obtained from PSM methods, they apply IV and GMM estimator methods. In the IV model, they use R&D spending as the dependent variable and instrumented R&D tax incentives with one year lagged unused tax incentives. They also add firm characteristics (age, size, and capital intensity) and performance characteristics (profit and export) explanatory variables to the model. While the elasticity of R&D expenditures with respect to tax incentives is calculated as 0.30 for all firms and 0.37 for electronics firms, it is statistically insignificant for nonelectronic firms. These results indicate that tax credits are more effective for electronic firms in line with the PSM results. GMM estimates show that tax credits have a significant positive effect on R&D growth especially for electronic firms, like the other methods' results. Since budget deficits have become an important issue, a careful evaluation of tax credits is advised as well as differentiating tax incentives between sectors because of different effects of R&D tax incentives between sectors.

Aralica and Botrić (2013) investigate the impact of R&D tax incentives on R&D expenditures and product and process innovation for Croatia as a small open country that is a moderate innovator[6] for the period 2008-2009 by applying PSM. For matching, they apply frequently used matching methods such as kernel matching, nearest-neighbor matching, and caliper matching in the study. They find that while R&D tax incentives have a positive effect on R&D expenditures and product innovation, they have no significant effect on process innovation.

Ravselj and Aristovnik (2020) take into consideration the effectiveness of both grants and tax incentives as public R&D policies at the same time and they investigate the impact of both public R&D policies on business R&D expenditures for Slovenian companies, representing a small open economy for the period 2012-2016, by using panel data regression. Therefore, the study provides a comparable picture for R&D public policies in Slovenia. They use business R&D expenditures without R&D subsidies as a portion of total assets as the dependent variable for comparing companies of different sizes. They also apply the amount of R&D subsidy and tax incentives as a portion of amount of net sales. For investigating the effects of the simultaneous use of both instruments, they use interaction terms between R&D subsidy intensity and R&D tax incentive intensity. They also use two more interaction terms for examining the interaction between these policies and net sales growth, which is an indicator of company growth, in the study. They also employ as control variables financial leverage, net sales growth, company size (natural logarithm of employees), and year dummy variables (take 1 if a company-year observation is from year studied, otherwise zero). They find that tax incentives have a positive effect on R&D expenditures for Slovenian companies, while R&D subsidies have a negative effect. They estimate that a 1% increase in R&D subsidy intensity decreases the net R&D intensity by 0.35%, while a 1% increase in tax incentives increases the net R&D intensity by 0.25%. They emphasize the importance of the tax base for the effectiveness of tax incentives. They also analyze the interaction between R&D subsidies and tax incentives and find it significant and positive. Therefore, they suggest the simultaneous use of these instruments. They also emphasize that R&D subsidies are still important for small firms that do not have a sufficient tax base and

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[6] According to the European Innovation Scoreboard metrics

R&D subsidies are effective in inducing business R&D expenditures when they are combined with R&D tax incentives. They also evaluate the policies based on company growth rates and find that both policies are effective regarding R&D expenditures for growing companies.

For Turkey, although the literature has investigated the effectiveness of R&D grants (Gök, 2006; Gürbüz, 2018; Özçelik and Taymaz, 2008; Tandoğan, 2011; World Bank, 2019) widely, there is still a lack of knowledge about the effectiveness of R&D tax incentives.

The study fills this gap in the literature and it is expected to provide guidance for public policies in this field.

Table 3 provides a summary of the empirical literature about the effectiveness of R&D tax incentives. The above-mentioned studies are grouped by:

- Authors
- Year Published
- Country/Countries Investigated
- Period Investigated
- Investigating Level (Cross-country or Firm Level)
- Research Question(s)
- Dependent Variable
- Methodology
- Results of the Study

As can be seen from Table 3, studies vary according to their focus country/countries, methodologies, and research questions.

Table 3

Summary of Empirical Literature

Authors	Year	Country	Period	Investigating Level	Research Question	Dependent Variable	Methodology	Results
Hall and Van Reenen	2000	OECD countries	-		Survey the empirical evidence on the effectiveness of tax incentives for R&D	-	Survey	A dollar tax incentive for R&D induces R&D expenditures a dollar
Bloom et al.	2002	9 OECD Countries	1979-1997	Cross-country	Impact of R&D tax incentives on the level of business funded R&D investment	The business funded R&D investment	OLS and IV	10% decrease in the user cost of R&D increases the level of R&D investment 1.4% in the short run and 10% in the long run
Guellec and Pottelsberghe	2003	17 OECD Countries	1981-1996	Cross-country	Impact of R&D public funding (grants,procurements, tax incentives, public research activities) on business funded R&D investment	The business funded R&D investment	OLS and 3SLS	1. The elasticity of tax price is calculated as -0.28 for short run and -0.31 in the long run. 2. Direct funding and tax incentives are found substitutes. 3. The effectiveness of government funding of R&D has inverted-U shape. It raises private sector R&D till 10% subsidization rate and decrease beyond
Falk	2006	21 OECD Countries	1975-2002	Cross-country	Determinants of R&D intensity	Business sector R&D expenditures as a percentage of GDP	OLS and GMM	Elasticity of tax price is -0.22 in the short run and -0.84 in the long run
Nam	2012	19 OECD Countries	2006	Cross-country	Impact of R&D tax incentives on after-tax NPV which is determinant of R&D investments	After-tax Net Present Value (NPV)	NPV method	When tax allowance and tax credits are implemented, ceteris paribus, after-tax NPV increases with corporate tax rate. Since higher value of after-tax NPV means stronger R&D investment, corporate tax rates should be increased.
Thomson	2017	29 industries in 26 OECD countries	1987-2006	Cross-country industry level	Impact of R&D tax credits on business funded R&D investment	Business funded R&D investment	OLS and GMM	Elasticity of tax price is -0.5 in the short run and 4 in the long-run
Appelt et al.	2019	21 OECD countries	2000-2016	Cross-country	The input additionality of R&D tax support	Business funded R&D investment	OLS and IV	Elasticity of business-funded R&D to B-index is -0.11 in the short run and -0.84 in the long run Elasticity of business-funded R&D to GTARD is 0.04. According to the B-index estimation, the input additionality is 0.87. Input additionality is measured by the value of the tax support cost, it increases to 1.6

Table 3 (cont'd)

Authors	Year	Country	Period	Investigating Level	Research Question	Dependent Variable	Methodology	Results
Koga	2003	Japan	1989-1998	Firm-level	Whether the effectiveness of R&D tax credits differ based on firm size	Firm R&D investment	OLS and IV	The tax price elasticity is -0.68 for all firms. It is calculated as -1.03 for large firms and it is not significant for medium firms.
Klassen et al.	2004	US and Canada	1991-1997	Firm-level	Effectiveness of tax incentives for US and Canada by taking into consideration the financial constraints of the firms	Firm R&D expenditure	Weighted OLS	Additional R&D expenditure is $2.96 in US and $1.30 in Canada per dollar foregone tax revenue
Hægeland and Møen	2007	Norway	2002	Firm Level	The input additionality of Norwegian R&D tax credit scheme	Growth of firm R&D investment	DiD	Additionality is calculated as 2.68 kroner additional R&D spending per krone tax credit.
Corchuelo and Martinez-Ros	2009	Spain	1998-2002	Firm Level	The impact of R&D tax incentives on firms' R&D technological effort (R&D spending over sales)	R&D spending over sales	Heckman's two-step selection model with instrumental variables and PSM	R&D tax incentives increases firms' R&D technological effort (R&D spending over sales) in large and high-tech firms.
Czarnitzki et al.	2011	Canada	1997-1999	Firm Level	Impact of tax credits on innovation outputs and firms' economic performance (such as number of new products, sales with new product)	Innovation outputs (number and sales of new products) and firms' economic performance (profitability, catch up competitors, share of the domestic market, international market share)	Non parametric matching methods	Tax credits have positive effect on innovation indicators innovative product numbers and sales. 17% of beneficiary firms introduce the innovation firstly in the world and 40% of them are first in Canada. The counterfactual case is estimated as 5% and 22% respectively. The R&D tax incentives impact on firms' economic performance could not be found significant.

Table 3 (cont'd)

Authors	Year	Country	Period	Investigating Level	Research Question	Dependent Variable	Methodology	Results
Lokshin and Mohnen	2012	Netherlands	1996-2004	Firm Level	The impact of R&D tax incentive on firm R&D	R&D investment of firms	OLS and Generalized IV method	The price elasticity of R&D investment is between -0.2 and -0.5 in the short run and between −0.54 and -0.8 in the long run. The BFTB is 1.05 for all firms, 3.24 for small firms and 0.78 for large firms.
Yang et al.	2012	Taiwan	2000-2005	Firm Level	Effect of R&D tax incentives on R&D	R&D expenditures (Level and growth)	PSM, IV and GMM	Firms which benefit from tax incentives have 53.8% higher R&D expenditure level. This effect rises to 71.8% for electronics firms. Not find any statistically significant result for R&D growth. The elasticity of R&D tax incentives to its price is calculated as 0.30 for all firms and 0.37 for electronics firms. The induced R&D expenditures related to tax incentives is calculated as 9.4% of R&D for all firms and 12% of R&D for electronics firms.
Aralica and Botrić	2013	Croatia	2008-2009	Firm Level	Effect of R&D tax incentives on R&D expenditures, product and process innovation	R&D Expenditures (Level and dummy variable) Product Innovation (introduction of new or significantly improved goods on the market (as dummy variable) Process Innovation (introduction of a new or significantly improved method of production on the market (as dummy variable)	PSM	R&D tax incentives have positive effect on R&D expenditures and product innovation, they have no significant effect on process innovation.
Kobayashi	2014	Japan	2009	Firm Level	The effect of R&D tax credits on firms' R&D tax expenditures	R&D expenditures	PSM	R&D tax credits increase SMEs R&D expenditures and they are more effective for firms with liquidity constraints compare to unconstrained firms.
Thomson and Skali	2016	Australia	2005-2012	Firm Level	Input additionality of R&D tax subsidies (tax concession and tax incentive)	R&D investment of firms	OLS, PSM, DiD and Regression Discontinuity Design	The introduction of R&D tax policy in 2012, firms' R&D expenditures increase by 14%. The additionality of the tax program is calculated as $1.9 for each foregone tax revenue. According to the all results of different methods, additionality is estimated between $ 0.7 and $ 1.9 range for every dollar of foregone tax revenue

Table 3 (cont'd)

Authors	Year	Country	Period	Investigating Level	Research Question	Dependent Variable	Methodology	Results
Dechezleprêtre et al.	2016	UK	2006-2011	Firm Level	The impact of tax credits on innovation	R&D expenditure of firm, patent facilities and patent values	Regression Discontinuity Method	The R&D elasticity to tax adjusted user cost is 2.6 The input additionality is £1.7 for every pound foregone tax revenue. Patenting rises about 60% due to the policy without a significant decrease in new patents' value.
Carboni	2017	Germany, France, Italy, Spain, UK, Austria, Hungary	2007-2009	Firm Level	Effect of public support (investment incentives, direct R&D support and fiscal R&D incentives) on investment and R&D expenditure	R&D expenditure as a portion of total sales	Non-parametric matching method	Public policies for R&D affect positively to R&D spending and the results reject the crowding out hypothesis It is also mainly confirmed in single country level. (Holds for every country except Hungary)
Dumont	2017	Belgium	2003-2011	Firm Level	Input additionality of public supports	Business funded R&D expenditures	Fixed effects regression	The effectiveness of public support decreases when firms benefit also from different support policies The probability for benefiting from direct subsidies is found low for SMEs although SMEs specific subsidy policies. The probability of applying and receiving subsidy is high for credit-constraint firms The probability of benefiting from tax incentives is high for high cash flow firms. Young firms' probability of benefiting from tax incentives is high with the help of the specific plan for Young Innovative Companies
Castellacci et al.	2017	Norway, Italy, France	2004, 2006 and 2008	Firm Level	Input and output additionality of R&D tax	R&D expenditures as a share of total turnover and share of the new or improved products' turnover	PSM	Input additionality is positive for all countries and years (except Italy. In Italy it is positive for 2004 and 2006). It is greater in higher R&D oriented sectors and input additionality is stronger in Norway and Italy than in France. output additionality, it is positive for all sectors and countries. In Norway and Italy it is greater in high R&D oriented sectors. In France, output additionality does not differ significantly among sectors.
Sterlacchini and Venturini	2019	UK, France, Italy and Spain	2007-2009	Firm Level	Impact of R&D tax incentives on intensity of R&D and input additionality of R&D tax incentives	R&D intensity: (R&D expenditures/sales)	PSM	Tax incentives are significantly induce the R&D intensity in all countries except Spain. One euro foregone in tax revenues increase 0.7 euro in R&D in France. This is 1.5 in Italy and 1.6 in UK
Ravselj and Aristovnik	2020	Slovenia	2012-2016	Firm Level	Effectiveness of public support for R&D (grants and tax incentives)	Business R&D expenditures without R&D subsidies as a portion of total assets	Panel data regression	1- Tax incentives' effect is positive on R&D expenditures for Slovenian companies while R&D subsidies' effect is negative. They estimate that 1% increase in R&D subsidy intensity decreases the net R&D intensity 0.35% while 1% increase in tax incentives increases the net R&D intensity 0.25%. 2- Tax incentives and grants are complement 3- Both public policies are effective on R&D expenditures for growing companies.

Since the effectiveness of R&D tax incentives in Turkey will examined by applying PSM, the empirical studies which apply matching methods for R&D tax incentives treatment are detailed in Table 4 regarding;

- Outcome variables
- Control variables
- Matching methods

As outcome variables R&D expenditures over sales or turnover stand out.

Most frequently used control variables are:

- Firm size
- Sector
- Age
- Foreign trade situations of firms
- Ownership of firms such as being multinational, domestic or foreign company
- Belonging to a group
- Cooperation for innovative activities
- Indicators for financial situations of firms such as financial constraints, financial stability, debt indicators
- Qualified personnel

While nearest neighbour and kernel matching come to the fore as matching procedure, empirical studies generally prefer to include more than one matching method.

Table 4

Summary of Empirical Literature that Apply Matching Methods

	Authors	Year	Country	Period	Outcome Variables	Control Variables - Purpose and/or Calculation	Matching Methods
1	Corchuelo and Martínez-Ros	2009	Spain	1998-2002	**The average R&D technological effort:** R&D spending/sales	**Firm size -** Account management abilities **Sector -** Technological opportunities **Financial Stability -** Finance of R&D investment activities. If firm's own equity/Total Debt >0.5, it takes "1", otherwise "0" **Receive Subsidies in 2002 -** Firms' awareness about other kinds of public support **Stable R&D firm -** The R&D experience of firms. If firm has performed R&D activities in 1998-2000 period, it takes value "1", otherwise "0" **B-index -** Minimum profit that firm expects to obtain from R&D investment, allowing for tax incentives **Lack of R&D personnel -** Human capital adequacy **Lack of importance of quality improvements in production**	Nearest neighbour matching, kernel matching
2	Czarnitzki et al.	2011	Canada	1997-1999	**WFIRST:** whether firm introduced a new product or process to world market **CAFIRST:** whether firm introduced a new product or process to Canadian market **NEWPROD:** Number of new or significanlty improved product **NEWSALES:** Proportion of new or significantly improved products **Firms' economic performance:** Profitability, Catch up Competitors, Share of the Domestic Market, International Market Share	**LNEMP1997 -** Firm size. Natural logarithm of the total employment of the firm **PCM (Price-Cost Margin) -** Internal funding capacity **INDRD1997 -** Industry specific technological opportunities. Lagged intensity of R&D expenditures per dollar of sales at the industry level **Rddep -** Firm has its own R&D department **Rdcontr -** Firm contracts out (some of) its R&D activities **PFVC -** Firm receives venture capital from the government **NEWMT -** Firm either seeking new markets or developing a specialized markets is an important aim of the firm **2 Industry dummies** and **5 provincial dummies -** Tax credits differs from province to province	The nearest neighbour based on the smallest mahalanobis distance
3	Yang et al.	2012	Taiwan	2000-2005	**R&D expenditures:** Level and growth	**ln RD2 -** Lagged two-year R&D expenditure **ln Size -** Number of employees **Age -** Firm age **ln KL -** Capital intensity. Ratio of fixed capital to employee **Profit -** Profit to sales ratio (%) **Time dummy and Industry dummy**	Caliper matching

Table 4 (cont'd)

	Authors	Year	Country	Period	Outcome Variables	Control Variables - Purpose and/or Calculation	Matching Methods
4	Aralica and Botrić	2013	Croatia	2008-2009	**R&D Expenditures:** Level and dummy variable **Product Innovation:** Introduction of new or significantly improved goods on the market (as dummy variable) **Process Innovation:** Introduction of a new or significantly improved method of production on the market (as dummy variable)	**Size -** Small (less than 50 employees), medium (50-250 employees) and large firms (250+ employees) **Employment change -** Job creation of firms **Participation international markets -** Firms that have no participation in international markets could seek more for government supports **Belong to an enterprise group -** The prior experiences with R&D tax credits within the group **Innovation cooperation -** Spreading information about R&D tax credits	Nearest neighbour matching, kernel matching, caliper matching
5	Kobayashi	2014	Japan	2009	**R&D expenditures**	**ln total workers -** Firm size. Since larger firms are thought to afford conducting R&D **Patent -** Innovation activities of firms **Recurring profit margin -** Firm's profitability. Since profit situation is important for applying tax credits **Dependence on debt -** Sufficiency of firm's internal funding for R&D investments **ln (capital fund), main financing bank, industry dummy and region dummy**	Kernel matching, K-nearest-neighbour matching, caliper matching
6	Carboni	2017	Germany, France, Italy, Spain, UK, Austria, Hungary	2007-2009	**R&D expenditures/total sales**	**Debt -** Firm's ability to find sources for investment costs. Total debt to banks over the previous period **GDP -** For determining changes in firms' behavior, in particular because of the financial and economic crises **K -** Measure of capital **Emp -** Firm size **Export -** Firm export status. Since firms that operating in foreign markets tend to be more innovative **INV_internal- finan and its squared term (INV _internal-finan)^2** Amount of internal financing **Age -** Firm age. For determining learning by doing effect **Large -** Large firms. Firms that have 250+ employees **Innorg -** Innovations that have been introduced inside firm **Group -** Belonging to a group. Since it can reduce financial constraints **Ration -** Financial constraints	The nearest neighbour based on the smallest mahalanobis distance

Table 4 (cont'd)

	Authors	Year	Country	Period	Outcome Variables	Control Variables - Purpose and/or Calculation	Matching Methods
7	Castellacci et al.	2017	Norway, Italy, France	2004, 2006 and 2008	**R&D intensity:** R&D expenditures/total turnover **TURN_NEW:** Share of the new or improved products' turnover (0-100 sale)	**Size -** Logarithm of number of employees **H Finance Int -** Internal funding adequacy **H Finance Ext -** External funding adequacy **H Personnel -** Qualified personnel adequacy **Coop -** Innovation cooperation **Export -** Export status of firm **Group -** Group affiliation of firm **Industry-level dummies**	Nearest neighbour matching
8	Sterlacchini and Venturini	2019	UK, France, Italy and Spain	2007-2009	**R&D intensity:** R&D	**Turnover dummies -** Firm size **Individual holder -** Having individual holder **National group -** Belonging to a national group **Foreign group -** Belonging to a foreign group **Quality certification -** Demanding quality certification as an innovation indicator **Patent -** Applying for patent protection as an innovation indicator **Exporter -** Export status of firms **Graduated employees -** Qualified employees. University graduates/total employees **Sales reduction -** Effects of 2009 crisis. It takes "1" if the firm had a turnover reduction in 2009. **Regional R&D intensity and Industry dummies**	Kernel matching

Concluding Remarks:

The rising popularity of R&D tax incentives over the years and their potential positive budget effects through innovation and economic growth have increased interest about their effectiveness.

Although there have been several empirical efforts to measure the impact of R&D tax incentive policies in recent years, most of the studies mainly suffer from inadequacy in data. Since an R&D tax incentive policy generally targets special group(s) for achieving policy targets as a natural consequence of public innovation policy and high heterogeneity among firms since R&D tax incentive beneficiary groups differ from nonbeneficiary groups widely in many aspects in R&D activities such as R&D awareness, know-how, and having their own R&D department, empirical studies suffer from selection bias and heterogeneity problems widely. Although researchers try to overcome these challenges with the help of econometric methods such as IV, matching methods, and GMM, in most cases it is difficult to find appropriate data for applying these methods.

The OECD B-index as a comparable indicator among countries is used in the majority of cross-country studies. GTARD data, recently published by the OECD, also provide a comparable picture across countries since they show the government tax relief for R&D in the same currency base.

Since firm-level studies require micro data, which are relatively scarce, these studies also suffer from lack of data mostly. Although firm-level studies are crucial since they could provide more detailed information about R&D tax incentive policies at firm structure level thereby enabling countries to improve their R&D public policies, in most cases it is a challenge to find appropriate firm-level data for countries. This also makes it difficult to compare countries' R&D tax incentive policies from a micro perspective.

Empirical efforts in the literature for tackling these challenges over the years have led to variation between studies. Although both cross-country and firm-level studies in general find R&D tax incentives effective, they differ in many aspects:

1. **Objective of the Study:** While some studies focus on cross-country data from a macro perspective and aim to measure an overall R&D tax incentive impact for a country group, others focus on the effectiveness of R&D tax incentives in a specific country or for a specific R&D tax incentive program from a micro perspective by using firm-level data.

2. **Methodology:** The impact of R&D tax incentives is examined mainly by using structural models and estimating the elasticities of business sector R&D expenditures to R&D tax relief or applying quasi-experimental methods such as matching and DiD and comparing situations among beneficiaries and nonbeneficiaries.

3. **Impact Indicator:** For evaluating the effectiveness of R&D tax incentives, it is important to determine where the impact of R&D tax incentives should be observed. While most studies investigate the impact of R&D tax incentives on R&D expenditures of firms, there are limited studies that focus on the impact on the innovation performance of firms.

Cross-country studies generally apply structural models and focus on business sector R&D expenditures. For investigating the effectiveness of R&D tax incentives, they estimate the elasticity of business sector R&D expenditures to R&D tax relief generally for both the short run and the long run. In general, the elasticity of business sector R&D expenditures to R&D tax relief increases in the long run. While the elasticity is between 0.1 and 0.5 in the short run, it approaches 1 in the long run.

The heterogeneity between the results of firm-level studies is higher compared to that of cross-country studies. One reason behind this variation in results might be that firm-level studies concentrate on country-specific R&D tax programs and they differ widely in many aspects such as their targeted groups (like SMEs or large firms), geographic implementation area, and structural forms (tax credit/tax allowance).

Firm-level studies generally apply matching techniques and DiD methods, which are based on the comparison of treatment (being a beneficiary) and nontreatment (not being a beneficiary) cases. While studies generally focus on the impact of R&D tax incentives on R&D expenditures of firms, very few studies focus on innovation outputs

such as patent facilities and new product/services. Firm-level studies also find R&D tax incentives in general effective especially for raising business sector R&D expenditures. In most studies, R&D tax incentives have a positive effect on R&D expenditures of firms. On the other hand, the effect of R&D tax incentives on innovation outputs is mostly limited or statistically insignificant. This means that while the impact of this policy is seen on the input side of innovation activity, it is difficult to observe the positive effects of the policy in most cases on the output side of the innovation process.

While firm level studies determine the effect of R&D tax incentives, the studies that calculate the extent of this effect are limited. It may be related to data restrictions or inadequacies. When the studies that can calculate the extent of the effect are evaluated, despite the results differ from country to country, they find multiplier generally around 1 or between 0 and 1.

In addition, the empirical literature about the effectiveness of R&D tax incentives generally focuses on developed countries although it is a widely used instrument in developing countries as well.

In the following section, the evolution of R&D tax incentives and recent policy in Turkey will be explained.

CHAPTER IV

EVOLUTION OF R&D TAX INCENTIVES IN TURKEY

Although several attempts have been made over the last 50 years in Turkey to promote R&D activities parallel to developments in the world economy and growth theories, major steps were taken in the 2000s towards promotion, especially for the business sector.

As a result of efforts to increase R&D activities, gross domestic expenditures on R&D (GERD) as a percentage of GDP doubled in 2019 compared to 2001 and reached 1.06% (Figure 5), and the number of FTE R&D personnel increased sevenfold to 182,847 (Figure 6) in the same period.
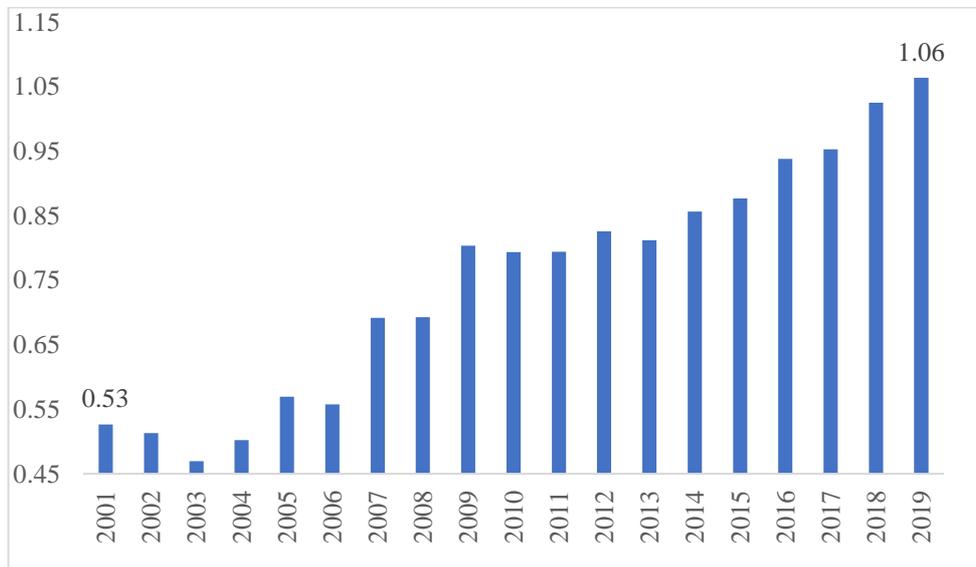
Figure 5. R&D Intensity in Turkey, 2001-2019 (Source: TURSKTAT)
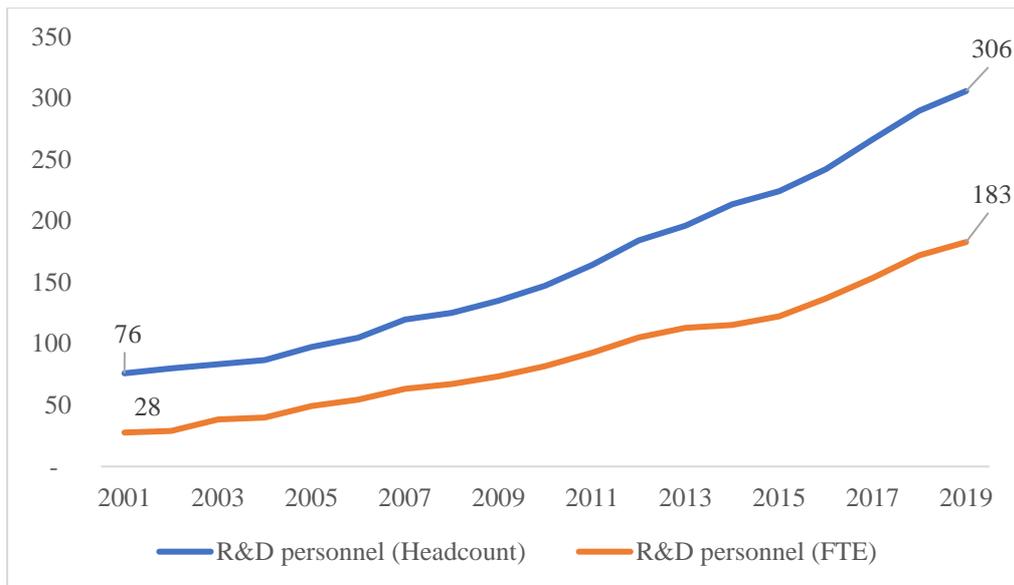
Figure 6. R&D Personnel in Turkey (thousand people, 2001-2019) (Source: TURSKTAT)

Figure 7 shows the shares of the business sector, higher education, and government sector in total R&D expenditures. As a consequence of policies aiming to increase business sector R&D expenditures, financial and nonfinancial corporations' share in total R&D expenditures increased during the period 2001-2019 and, as of 2019, more than 50% of total R&D expenditures come from the business sector.
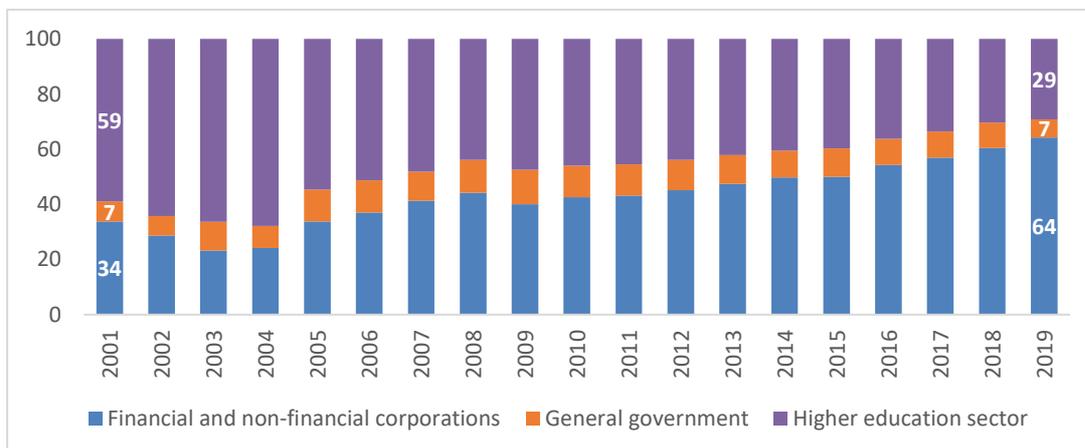
Figure 7. Shares of Sectors in Total R&D Expenditures (%, 2001-2019) (Source: TURSKTAT)

On the budget side, budget appropriations and outlays on R&D[7] (at 2015 constant prices and PPP $) more than doubled from 2008 to 2019 (Figure 8) and, as of 2019, Turkey ranks tenth among the OECD and non-OECD countries with 8.1 billion (at 2015 constant prices and PPP $) budget appropriations and outlays on R&D (Figure 9).
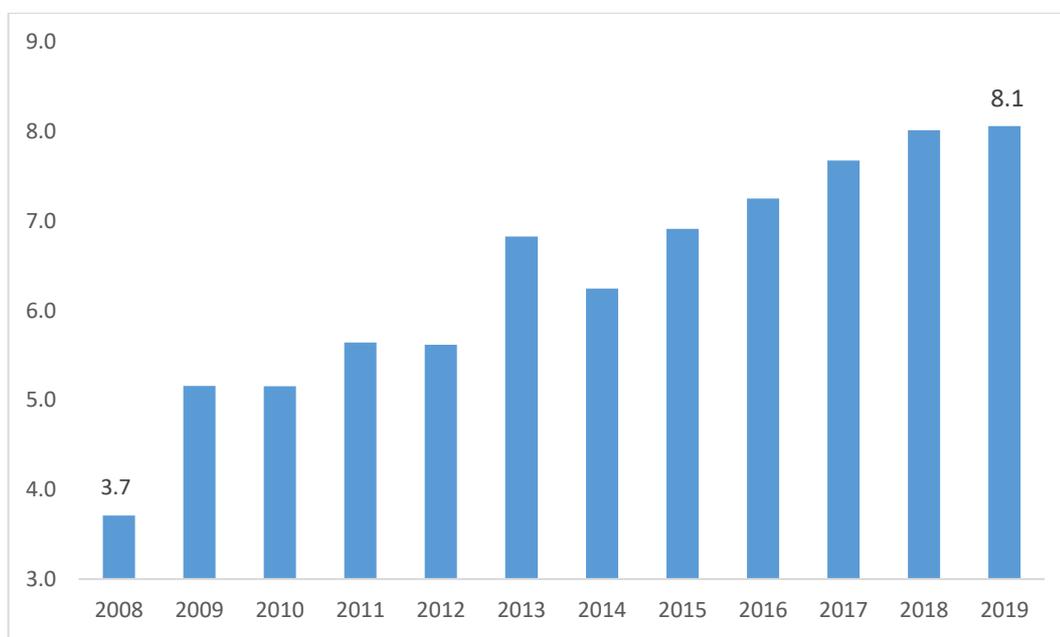
Figure 8. Central Government Budget Appropriations and Outlays on R&D (at 2015 constant prices and PPP $, billions, 2008-2019) (Source: OECD Database, May 2021)
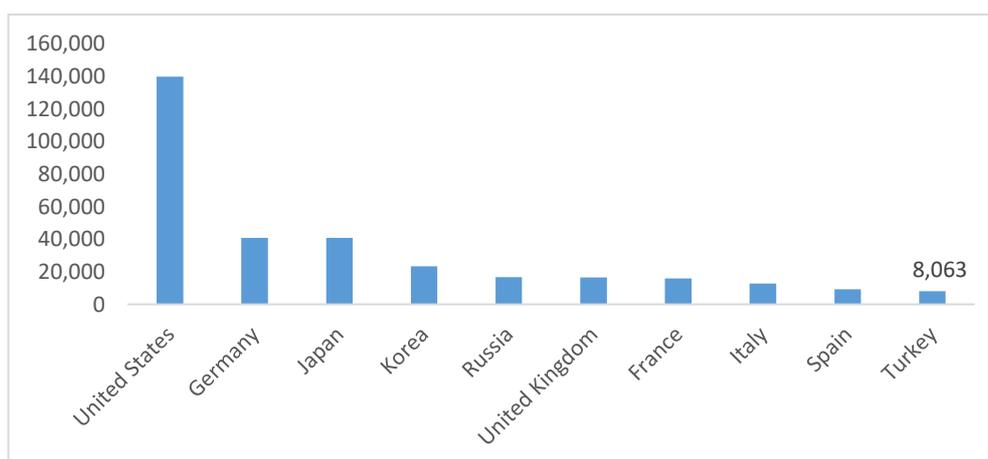
Figure 9. Top 10 Countries for Central Government Budget Appropriations and Outlays on R&D (at 2015 constant prices and PPP $, millions, as of 2019) (Source: OECD Database, May 2021)

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[7] Central Government

As in many countries, grants and subsidies are the traditional government R&D funding mechanism in Turkey for promoting business sector R&D expenditures, but implementation of R&D tax incentives started with the Technology Development Zone Law No 4691, which came into force in 2001 for supporting R&D activities in techno-parks and organized industrial zones.

In 2004, a 40% tax allowance was provided to business sector R&D expenditures through updating the existing Corporate Tax Law 5520 and Income Tax Law 193.

In 2006, Turkey set ambitious R&D targets within the ninth development plan for the period 2007-2013 such as increasing R&D expenditures to 2% of GDP, increasing private R&D expenditures to 60% of GDP, and raising the number of researchers to 80,000 (revised to 150,000 in 2008 since the target had been achieved) in 2013 (Tandoğan, 2011).

Policies were also updated in line with the targets set for R&D indicators and in 2008 the R&D Activities Support Law No 5746, which is the basis of R&D tax incentives, came into force. In 2016 Law 5746 was revised and design activities were also included and the name of the law was changed to "R&D and Design Activities". Moreover, R&D tax incentives in Corporate Tax Law 5520 and Income Tax Law 193 were regulated in Law No 5746.

Figure 10 shows the trends of government funding mechanisms in Turkey in the last decade. While direct funding of business sector R&D expenditures (as a percentage of BERD) remained almost flat during 2008-2018 period, government tax relief for business sector R&D expenditures (as a percentage of BERD) increased significantly in the same period.
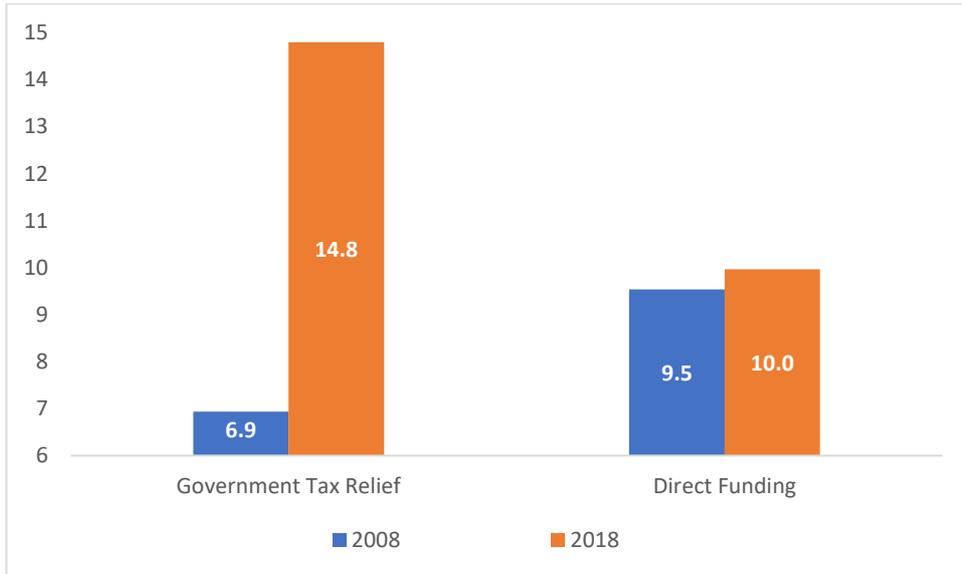
Figure 10. Direct Funding of Business Sector R&D Expenditures vs. R&D Tax Incentives (% of BERD, 2008-2018) (Source: OECD Database, May 2021)

R&D tax incentives have become widely used as a policy tool and R&D tax incentives as a percentage of GDP increased more than fourfold from 2008 to 2018 (Figure 11).
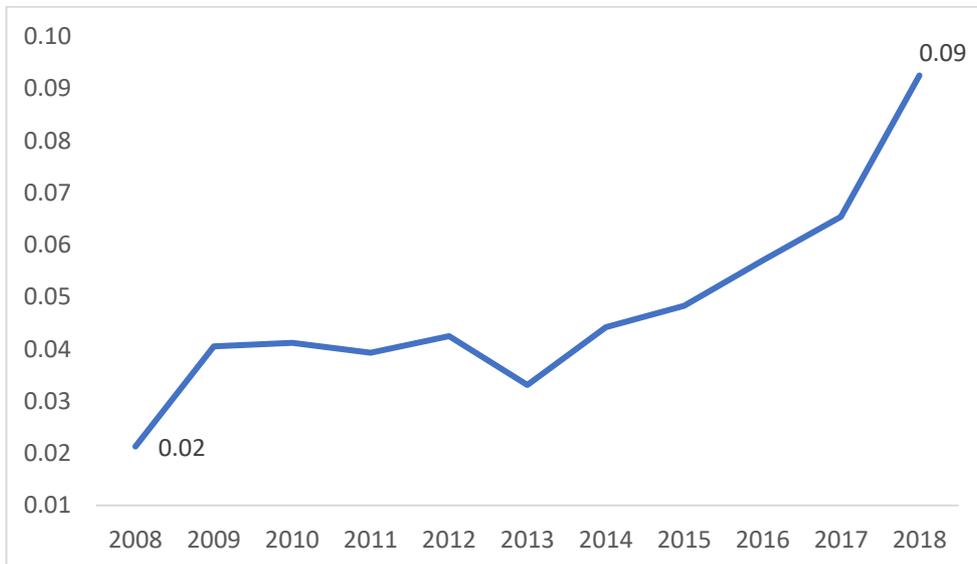
Figure 11. R&D Tax incentives in Turkey (% of GDP, 2008-2018) (Source: OECD Database, May 2021)

Not only the amount but also the number of beneficiaries increased over time. The beneficiaries numbered between 1,000 and 8,000 per year on average during the period

2010-2018 and the trend in the number of beneficiaries was significantly positive compared to other countries in the same range (Figure 12).
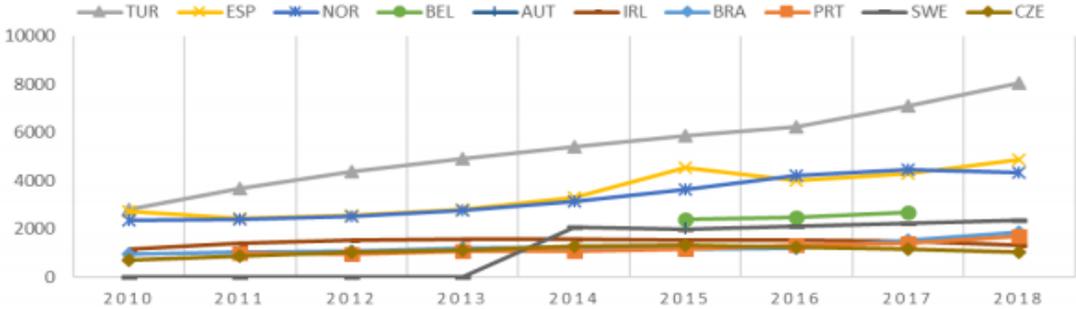
Figure 12. Number of R&D Tax Relief Beneficiaries (2010-2018) (Countries with less than 8,000 and more than 1,000 beneficiaries per year on average) (Source: OECD, The OECD Report on the R&D Tax Incentives Database (2020), http://oe.cd/rdtax)

As of 2018, the number of R&D tax incentives beneficiaries is more than 5,000. Regarding the other countries that have more than 5,000 R&D tax relief beneficiaries in 2018, most of them are pioneers in R&D activities with high R&D expenditures as a percentage of GDP (Figure 13).
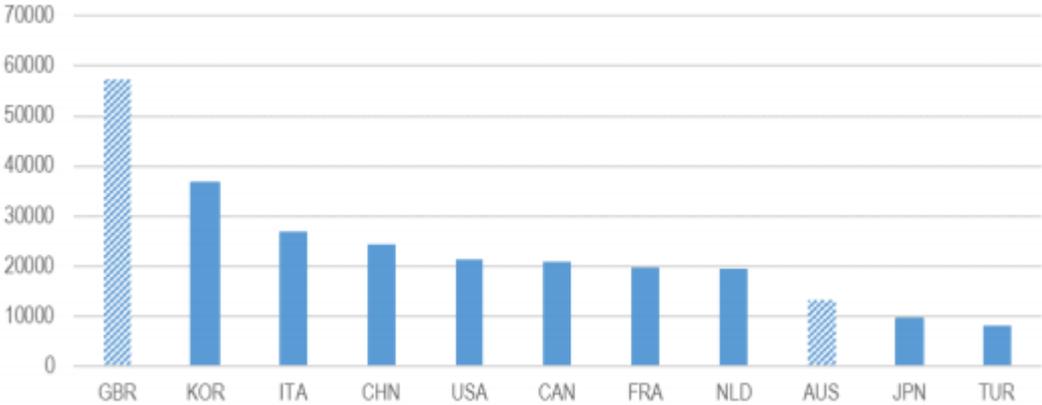
Figure 13. Number of R&D Tax Relief Beneficiaries, 2018 (Countries with more than 5,000 beneficiaries) (Source: OECD, The OECD Report on the R&D Tax Incentives Database (2020), http://oe.cd/rdtax)

Today, business sector R&D activities are mainly supported by R&D and Design Activities Support Law No 5746. The Technology Development Zone Law No 4691, which accompanies Law No 5746 for supporting business sector R&D activities, is also still in force.

R&D and Design Activities Support Law No 5746, which is the backbone of R&D tax incentives, aims to:

- Produce technological knowledge
- Innovate in products and production processes
- Increase product quality and standards
- Increase productivity
- Decrease production costs
- Commercialize technological information
- Develop pre-competitive cooperation

through R&D, innovation, and design. It also aims to accelerate the inflow of direct capital investments towards R&D, innovation and design with technology-intensive production, entrepreneurship and investments in these fields, and support and encourage the employment of R&D and design personnel and labor force (The Official Gazette Republic of Turkey, 2016).

Law No 5746 includes supports and incentives for:

- R&D and design centers
- R&D and design projects
- Pre-competitive cooperation projects
- Techno venture capital (The Official Gazette Republic of Turkey, 2016).

Law No 5746 provides special R&D tax incentives to R&D and design centers[8] for R&D activities with special conditions. According to Law No 5746 the following are provided:

- 100% corporate tax base deduction
- Income withholding tax exemptions for the salaries of R&D, design, and support personnel (between 80% and 95% of their salaries)[9]

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[8] R&D centers are the separate units of capital companies that have legal or business centers in Turkey, including permanent establishment of nonresident companies. They must employ a minimum of 50 full-time equivalent R&D personnel (for design centers 10 FTE R&D personnel)

[9] Income withholding tax exemption rates are 95%, 90%, and 80%, respectively, for personnel with a PhD or master's degree in basic sciences, a master's degree or undergraduate degree in basic sciences, and others.

- 50% of the employer's share of social security premium exemption for R&D, design and support personnel 5 years period.
- VAT exemption for deliveries of machinery and equipment
- Stamp duty exemption for documents that are provided for R&D, design, and innovation projects (Deloitte, 2021; The Official Gazette Republic of Turkey, 2016; PwC, 2021).

Law No 5746 also provides incremental tax incentives for R&D and design centers in addition to the above-mentioned incentives. These centers are able to deduct extra 50% of their R&D, innovation, and design expenditures from their corporate income tax base if they increase any of the indicators that are explained below at least 20% compared to the previous year. These indicators are:

- The number of registered patents (national or international)
- The number of internationally funded projects
- R&D or design expenditures as a share of total turnover
- Share of researchers with graduate degrees in total R&D personnel
- Share of total researchers in total R&D personnel
- Share of new products' turnover in total turnover (PwC, 2021).

Table 5 summarizes the structure of incremental R&D tax allowances in Turkey.

Table 5

Structure of Incremental R&D Tax Allowances in Turkey

Expense Base	C, ME, B, Intangibles
Deducted from	Taxable income
Incremental Rate	50 (qualifying R&D centre)
Base Amount (if incremental)	R&D expenditures in previous year
Taxability of R&D Tax Relief	The R&D tax allowance is not taxable
Conditions for Benefiting from Incremental R&D Tax Incentives	The 50% incremental super deduction will be available if the R&D or design center has at least a 20% increase over the previous year with respect to any of the following: • Portion of R&D and design expenditure within total turnover • Number of registered national or international patents • Number of internationally supported projects • Ratio of post-graduate degree researchers to total R&D personnel • Ratio of all researchers to total R&D personnel • Ratio of the turnover obtained from new products emerging from an R&D project to total turnover.

C=Current; ME=Machinery and equipment; B=Buildings

Source: OECD, Compendium of Information on R&D Tax Incentives, 2020, http://oe.cd/rdtax

Furthermore, through the regulations of Law No 5746 about Law No 5520 and 193, 100% of R&D expenditures of income and corporate taxpayers are deducted from their tax bases (The Official Gazette Republic of Turkey, 2016).

Law No 4691 also offers special R&D tax incentives to firms operating in technology development zones[10]. The tax incentives for these zones are:

- Corporate tax exemption of the profits of software development and R&D activities
- VAT exemption for deliveries of machinery and equipment
- Income withholding tax exemptions for employees in R&D activities (100%)
- Social security premium exemption for employer's share of social security premium for 5 years (Deloitte, 2021; PwC, 2021).

In February 2021, some revisions were made to Law No 5746 and Law No 4691. Some critical points of these revisions are as follows:

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[10] Technology Development Zones are the areas that are designed for attracting investment for high-tech sectors.

- Tax incentive period is extended from 2023 to 2028

- Corporate taxpayers whose annual earnings exempted in Technology Development Zones and discounted R&D expenditures amount in R&D or design centers is 1 million TL or more will transfer 2% of the said amount to fund accounts, which will be used as venture capital investment funds. If the amounts are not transferred to the funds, 20% of annual earnings or R&D expenditures will not be subject to the tax incentive.

- The liability for the amount to be transferred will be limited to 20 million TL on an annual basis.

- Before regulation, social security premium and income withholding tax exemptions were implemented for working hours that were spent in R&D/Design Centers or Technology Development Zones. Since remote work has increased due to Covid-19 measures, social security premium and income tax exemptions have been made available for periods spent outside, provided that they do not exceed 20%[11] of the total working time (The Official Gazette Republic of Turkey, 2021).

The aforementioned new regulation, which concerns benefiting from R&D tax incentives, may have a decreasing effect on R&D tax incentives. The effects of the regulation will become apparent in the upcoming period.

Concluding Remarks:

R&D policies gained importance in the 2000s in Turkey in line with other countries.

As a result of ambitious R&D targets, R&D indicators such as R&D intensity and personnel improved in the last decade.

The share of business sector R&D expenditures in total R&D expenditures has increased over time and central government budget appropriations and outlays on R&D have risen in line with the policy targets in the last decade.

For promoting R&D activities in the business sector, both direct and indirect funding mechanisms have been applied.

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[11] This rate can be increased up to 50% by the President.

As an indirect funding mechanism, R&D tax incentives, which provide deduction of 100% of R&D expenditures from corporate tax bases, income withholding tax exemptions, VAT exemptions, social security premium exemptions have been regulated with laws and updated over time.

R&D tax incentives have grown in importance compared to direct funding, similar to the trend in other countries.

The increasing share of R&D tax incentives as a percentage of GDP and as a percentage of business sector R&D expenditures and the rising trend in number of R&D tax beneficiaries have reinforced the importance of these policy instruments recently.

Despite R&D tax incentive amounts being foregone revenue for the budget, when they are effective, they could stimulate innovation and thus growth and could be positive in budgetary terms. Therefore, it is important to assess the effectiveness of this policy instrument.

Over the years, it has been an important government support mechanism in Turkey, but there is a lack of literature about the effectiveness of this policy instrument. The study aims to fill this gap.

In the next chapter, the PSM methodology that is applied for investigating the effectiveness of R&D tax incentives in Turkey will be explained. Furthermore, the data used in impact analysis will be specified. Finally, the empirical results will be discussed in Chapter 5.

CHAPTER V

METHODOLOGY, DATA AND EMPRICAL RESULTS

5.1. Methodology

Efforts for measuring the impact of a treatment or policy implication require the comparison of treatment outcomes and counterfactual outcomes.

When the binary treatment is T_i and it is equal to 1 for beneficiaries and 0 otherwise. $i = 1, ..., N$ and N indicates the number of total samples. Then the potential outcomes for each member i of the sample (firm or participant) are Y_i (T_i) and the impact of the treatment for i can measured by using the Roy-Rubin model as equation (1) (Caliendo & Kopeinig, 2008):

$$\tau_i = Y_i(1) - Y_i(0) \tag{1}$$

where τ_i denotes the treatment effect

and potential outcome Y_i (T_i) for i is the function of observable X and unobservable U(1) and U(0) as in the equations (2) and (3) (Heckman et al., 1997):

$$Y_i(1) = g_i(1)(X) + U_i(1) \tag{2}$$

$$Y_i(0) = g_i(0)(X) + U_i(0) \tag{3}$$

Therefore, measuring the impact of a treatment requires the counterfactual outcome $Y_i(0)$ that shows what if the beneficiary does not benefit from the treatment (program) but it is impossible to get this answer. Once a firm or an individual benefits from a treatment or a policy program, it is impossible to observe the outcome(s) without treatment for same person or firm.

Measurement efforts for impact of a treatment mostly focus on treated sample and calculate the average treatment effect on the treated (ATT) by using mean outcomes as in the equation (4):

$$\tau_{ATT} = E(\tau|D = 1) = E[Y(1)|D = 1] - E[Y(0)|D = 1] \qquad (4)$$

Counterfactual mean $E[Y(0)|D = 1]$, which is the answer of the question of what if the treated group does not benefit from the treatment, is not observable. If $E[Y(0)|D = 1$ is replaced with the mean outcome of non-beneficiaries $E[Y(0)|D = 0]$ then equation (4) will be revised as equation (5) and (6):

$$\tau_{ATT} = E[Y(1)|D = 1] - E[Y(0)|D = 0] - E[Y(0)|D = 1] + E[Y(0)|D = 0]$$
$$(5)$$

$$\tau_{ATT} + E[Y(0)|D = 1] - E[Y(0)|D = 0] = E[Y(1)|D = 1] -$$
$$E[Y(0)|D = 0] \qquad (6)$$

However, in this method, unless $E[Y(0)|D = 1] - E[Y(0)|D = 0] = 0$, ATT cannot give the impact of the treatment because beneficiaries and non- beneficiaries could differ even without treatment and this problem is called as selection bias ($E[Y(0)|D = 1] - E[Y(0)|D = 0] \neq 0$ case).

One possible solution of selection bias is randomization of treatment. When the randomizing the treatment is not possible, matching approach could solve the selection bias problem.

The idea behind the matching approach depends on creation a control group, which consist of non-beneficiaries with most similar observable characteristics X that, are not affected by treatment to beneficiaries and matching each beneficiary with a most similar non-beneficiary. Then the differences of average outcomes can give the impact of the treatment (Khandker et al., 2010).

Identifying a control group with most similar characteristics to treatment group could be difficult in a long vector X which is called as "curse of dimensionality". It could be difficult to find a similar firm or participant in terms of many characteristics (Khandker et al., 2010).

To deal with this problem, Rosenbaum and Rubin (1983) propose to apply balancing scores b(X) which are the function of the relevant observed characteristics X and in given b(X), conditional distribution of X is independent of benefiting treatment.

Propensity Score Matching (PSM) method which eliminates the selection bias and bases on balancing scores is applied widely in the literature for investigating the impact of a treatment.

PSM depends on the calculation of probability of benefiting (participating) from a treatment for all sample (both beneficiaries and non-beneficiaries) by using observed characteristics of participants.

The validness of PSM is depends on two assumptions:

1. Conditional Independence: Potential outcomes Y are independent of treatment T in a given set of observed covariates X that are independent from treatment (Caliendo & Kopeinig, 2008).

$$(Y_i(1), Y_i(0)) \perp T_i \mid X_i.$$

This condition assumes that benefiting from a treatment and outcomes of a treatment base on solely observed characteristics. In other words, unobserved characteristics are not effective in both treatment participation decide and outcomes.

The validity of this assumption is reinforced by using a rich covariates X variable set in the application of propensity scores and the selection of covariates X depends on prior empirical studies and theory (Morris et al., 2013).

2. Overlap (Sizable common support): Overlap area between beneficiary and non-beneficiary samples with same characteristics X should be sizable (Khandker et al., 2010).

In other words, control group should be sufficient for comparison with treatment group. If the overlap area between two groups is too small, then matching estimator is not valid (Aerts & Czarnitzki, 2004).

Examples of common support region and poor common support case are in the Figure 14 and Figure 15 respectively:
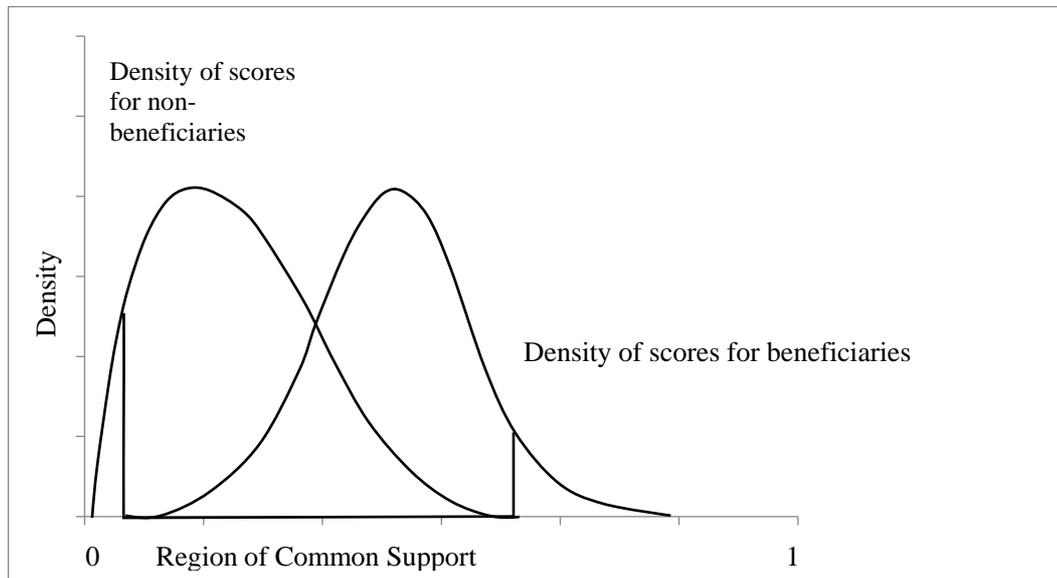
Figure 14. Example of Common Support Region (Source: Khandker et al., 2010, "Handbook on Impact Evaluation**:** Quantitative Methods and Practices", p.57)
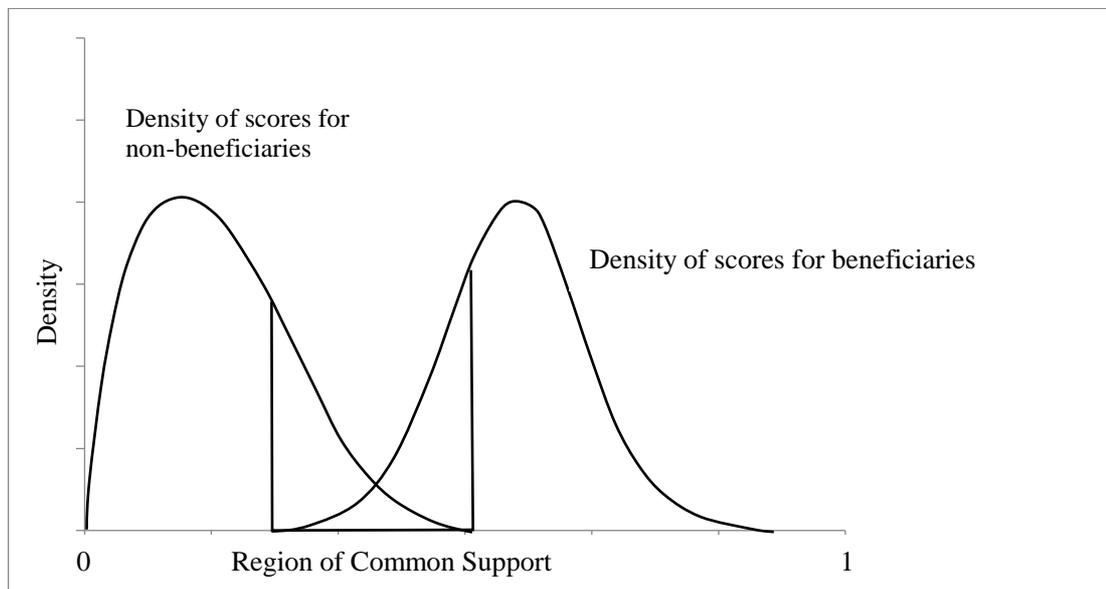
Figure 15. Example of The Poor Common Support Case *(*Source: *Khandker et al., 2010, "Handbook on Impact Evaluation: Quantitative Methods and Practices", p.57)*

Deciding which covariates should be taken into consideration while applying PSM is a critical step for validness of PSM. X are the covariates that determine the benefiting from the treatment and X are determined by applying logit or probit models. Since

these models are not determinants of model, statistics such as t-statistics and the adjusted R^2 can be misleading. Therefore, in determining X covariates by applying these models, correlation of X with T should be taking into consideration. If all related X does not include in the model, the PSM results will be biased. However, using too many X in the model can cause over specification and higher standard errors for the estimated propensity scores (Khandker et al., 2010).

For validity of PSM, the selection of matching method is another important step. The matching approaches are:

1. **Nearest neighbor matching:** Each treatment unit is matched to the control unit that has the closest propensity score. It is one of the mostly used matching methods. Same non-beneficiary can be used for matching with different beneficiaries in matching process and this method is called as replacement. Allowance of replacement increases the average matching quality and decreases the bias. If the matching is applied without replacement, then the estimation results will depend on the order of matching observations. For this reason, when nearest neighbor matching is done without replacement; order of matching observations should be random.

2. **Caliper and Radius matching:** In nearest neighbor matching method, nearest neighbor could have a very high propensity score and, in this case, the matching quality could be poorer. Therefore, defining a threshold could help to overcome this challenge. Caliper is the maximum propensity score distance, which drops the non-beneficiaries that have a propensity score outside the specified limits. Although this method helps to increase matching quality, it could also increase the sampling bias. Radius matching is a variant of caliper matching. In this method, all control group members within the caliper are used instead of using just nearest neighbor within each caliper. Therefore, it allows the usage of more members from comparison group if they are available without bad matching risk.

3. **Stratification and interval matching:** In this matching method, common support area is divided to different strata and impact is calculated with in each stratum. The weighted averages of each calculation give the overall impact of the treatment. Weighting is done by taking into consideration the share of beneficiaries in each stratum.

4. **Kernel matching and local linear matching (LLM):** In abovementioned matching methods, the sample of non-beneficiaries that satisfy the criteria and are in the common support area could be small. In kernel and local linear matching, the weighted averages of all members in the control group are used for setting up counterfactual outcome. Therefore, this matching method decreases the variance since it uses more information. On the other hand, it could use the bad matches. For avoiding use of bad matching, imposing common support condition is highly important in this method (Caliendo & Kopeinig, 2008; Khandker et al., 2010).

PSM method has several advantages. Since unobserved characteristics are negligible and observed characteristics for benefiting from treatment are well defined, PSM method is a good method for comparison. Moreover, a baseline or panel survey does not require for application of the method. Since it is semiparametric, it requires fewer constraints for the functional form of treatment model and assumptions for distribution of error term (Khandker et al., 2010).

Furthermore, regression-based methods, which use the propensity scores as weight for beneficiary and non-beneficiary groups, produce efficient estimates. In this method, a linear model is used for outcome and weights are applied to the matched comparison group due to propensity scores. Under the assumption that unobservable characteristics do not change over time, this method gives chance to control unobservable characteristics (Khandker et al., 2010).

Other methods such as difference in difference, instrumental variables and regression discontinuity can also be used in the impact analysis of the treatment. However, selection of the method for investigating the effect of a treatment depends on the data structure.

For applying instrumental variables method, it is required to find a good instrument for treatment. Since the impact of R&D tax incentives is investigated in the study, it is hard to find a valid instrument for R&D tax incentives.

Similarly, regression discontinuity and difference in difference methods cannot be applied in the study due to the limitations in the data. While regression discontinuity method requires a cutoff point, difference in difference method requires the before and

after treatment situations. Since the data contains neither before and after treatment status of the members nor cutoff point, it could not be possible to apply also these methods in the study.

Considering the data structure, PSM and regression-based models are used in the study.

5.2. Data

5.2.1. Dataset

In this study, the effectiveness of tax incentives is investigated by using two combined datasets which are constructed the from Innovation Survey (2018), Financial and Nonfinancial Corporations Research and Development Activities Survey (2018), Foreign Trade Statistics (2018), Company Accounts Statistics (2017-2018) and Annual Business Registers Framework (2018) Micro Datasets of TURKSTAT[12].

The Innovation Survey (2018), which is compiled about the innovation activities of firms and sources and the costs and strategies of these activities for the period 2016-2018, is the main source used in the study since it includes a question about whether firms are R&D tax incentive beneficiaries during the period 2016-2018. The survey (2018) covers 12,593 firms.

The firms' characteristics and R&D activity data are supported by using the Financial and Nonfinancial Corporations Research and Development Activities Survey (2018), which is compiled with annual surveys and administrative registration information. The survey covers 7251 firms for 2018. It aims to provide detailed information about the firms' R&D activities in the context of R&D personnel structure, R&D expenditures, and the finance sources of R&D activities.

For defining the firms' characteristics such as firm age, turnover, foreign trade status and financial conditions the Foreign Trade Statistics (2018), Company Accounts Statistics (2017-2018) and Annual Business Registers Framework (2018) Micro Datasets are also used in the study.

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[12] Detailed information about the surveys and statistics are available on the TURKSTAT web page https://www.tuik.gov.tr/Kurumsal/Mikro_Veri.

After the combination of the above-mentioned surveys and statistics, the first dataset (d_total) covers 917 firms and all firms engaging in R&D activity in 2018.

According to the d_total, 70% of firms are manufacturing firms and 17.1% of firms are in the information and communication sector. Of the manufacturing firms, 65.3% are R&D tax beneficiaries as seen in Table 6.

Table 6

R&D Active Firms by Sectors*

Sectors	Number of firms	R&D tax incentive beneficiaries	Proportion of R&D tax incentive beneficiary firms
Mining and quarrying	7	5	71.4
Manufacturing	**639**	**417**	**65.3**
Electricity, gas steam and air conditioning supply	8	3	37.5
Water supply; sewerage, waste management and remediation activities	3	0	-
Wholesale trade, except of motor vehicles and motorcycles	34	26	76.5
Transportation and storage	14	10	71.4
Information and communication	**157**	**135**	**86.0**
Architectural and engineering activities, technical testing and analysis	12	7	58.3
Scientific research and development & Advertising and market research	43	34	79.1
Total	**917**	**637**	**69.5**

(*) Data has been aggregated for sectors that have 2 or less firms at the request of TURKSTAT.

Source: TURKSTAT

Table 7 shows the structure of the dataset according to the size of the firms. Of the total firms in the dataset (917 firms), 62.2% are large firms and almost 70% of them are tax beneficiaries during the investigation period.

Table 7

R&D Active Firms by Size

Firm Size	Number of firms	R&D tax incentive beneficiaries	Proportion of R&D tax incentive beneficiary firms
Small	174	117	67.2
Medium	173	129	74.6
Large	570	391	68.6
Total	917	637	69.5

Source: TURKSTAT

Most of the firms are between 11 and 30 years old in the data for 2018 and in all age groups more than 50% are R&D tax beneficiaries as seen in Table 8. Although the number of young firms is relatively small, the proportion of beneficiaries is high among all the age groups.

Table 8

R&D Active Firms by Age

Firm age	Number of firms	R&D tax incentive beneficiaries	Proportion of R&D tax incentive beneficiary firms
0-5	87	69	79.3
6-10	98	65	66.3
11-20	265	192	72.5
21-30	339	224	66.1
31-40	86	56	65.1
41-50	29	23	79.3
50+	13	8	61.5
Total	917	637	69.5

Source: TURKSTAT

Another important feature of firms is their integration into the international markets for R&D activities. While 85% of the total firms included in the study are integrated to international markets, 68% of these firms are R&D tax incentive beneficiaries as seen in Table 9.

Table 9

R&D Active Firms by Foreign Trade Status

Exporter/Importer	Number of firms	R&D tax incentive beneficiaries	Proportion of R&D tax incentive beneficiary firms
Yes	776	527	67.9
No	141	110	78.0
Total	917	637	69.5

Source: TURKSTAT

Later, the Company Accounts Statistics (2017), which provide information about the financial statements of firms, are also added to the dataset to enrich the study.

Since Company Account Statistics (2017) are not available for 917 firms, the second dataset (d_bs) covers 617 firms and it is a sub-sample of the first dataset. The details

of the second dataset such as sectors, age, and foreign trade status are given in Appendix B.

As a result of the updating of the Guidelines of the Oslo Manual, which is the main source for compiling innovation statistics, there have been changes in the methodology. As a result of the change in the definition and types of innovation, a time series comparison for research is not possible. Therefore, an important factor limiting the study is that the dataset is only a cross section and this hinders long-term evaluations and makes examination of the causalities difficult.

5.2.2. Treatment Variable

The treatment variable of the study is firms' situation regarding their benefiting from R&D tax incentives. It is investigated for the first time in the Innovation Survey (2018) and announced in December 2019.

Since R&D tax incentives received by firms are a binary variable in the survey, they are used only as a dummy variable in the study. If firms benefit from R&D tax incentives during the period 2016-2018, it takes a value of "1", otherwise "0".

Among the 917 firms in the first combined dataset, 637 are R&D tax incentive beneficiaries during the period 2016-2018.

On the one hand, the fact that firms' R&D tax incentives are included in the survey for the first time makes this study more important, but, on the other hand, it hampers investigation of the effectiveness of R&D tax incentives over a longer time period.

5.2.3. Control Variables

Defining variables as control variables that affect a firm's decision about benefiting from R&D tax incentives is a critical step for ensuring the validity of the results. Correct determination of control variables is important since it enables the conditional independence assumption to be held, which ensures that the outcome variable is independent of the treatment conditional on the propensity score (Sterlacchini & Venturini, 2019).

In this regard, control variables include variables that simultaneously affect the participation decision and the outcome variable (Caliendo & Kopeinig, 2008).

In empirical studies, selection of control variables mostly depends on previous empirical literature, economic theory, and the statistical significance of the probit/logit model.

In the study, a probit model is applied for determining the control variables. In this model, only variables that are not influenced by R&D tax incentives (treatment) and affect firms' decision about benefiting from R&D tax incentives and the outcome variable are included in the light of the empirical literature and economic theory.

For this purpose, control variables that are fixed variables over time or have not been affected by the expectation about participation are chosen (Caliendo & Kopeinig, 2008). The control variables are used to the extent permitted by the data source. It is aimed to include a large set of control variables for determining counterfactuals with the most similar features since omitting important variables can increase the bias in the estimation (Aralica & Botrić, 2013; Caliendo & Kopeinig, 2008; Heckman et al., 1997). The selected control variables and the reasons behind their selection are as follows.

Sectoral differences are important in R&D engagement since it affects the R&D facilities of firms. Manufacturing and nonmanufacturing firms can differ in terms of R&D activities in many aspects. Protection of intellectual property can be more difficult in the service sector compared to the manufacturing sector (Czarnitzki & Fier, 2002). R&D intensity is another factor that can differ between manufacturing and nonmanufacturing firms. Manufacturing firms can be more R&D intensive and their R&D tax incentive claims can be higher compared to nonmanufacturing firms (Kobayashi , 2014). Innovation strategies in the service sector can be also different from those in the manufacturing sector (Freitas et al., 2017). Technological capability is another factor that differs among sectors and affects the R&D activities of firms. Although new services such as information and communication technologies have high technological capability, the manufacturing sector still dominates R&D activities. The service and manufacturing sectors also differ in terms of production technologies (Czarnitzki & Fier, 2002).

According to the empirical literature, the R&D tax price elasticity of firms also can differ regarding their industries (Yang et al., 2012). In addition, for taking into consideration unobservable differences between firms such as fixed costs differences, sectoral differences should be included in the study (Carboni, 2017). For the reasons mentioned above, being a manufacturing firm (dum_manu) is a dummy variable in the study.

According to the literature, firm size can be an important factor for the effectiveness of R&D tax incentives and firms' R&D decisions. Koga (2003) stated that R&D tax price elasticity may differ according to the firm size. He found that it is higher for large firms. Firm size could also affect the R&D decisions according to organizational structure, specialization, and easy access to financial markets (Carboni, 2017). It could be also important for the tax incentive awareness of the firm. The probability of receiving public support for R&D could be higher for larger firms if smaller ones are not supported explicitly (Dumont, 2017). For these reasons, firms are grouped as small (small), medium (medium), and large (large) based on the number of employees. Firms that have between 10 and 49 employees are defined as small, those that have between 50 and 249 are defined as medium, and those that have 250 or more are defined as large, and small (small) and medium (medium) variables are used as dummy variables in the study[13].

While firm age is another important factor in firms' R&D activities, the effect of firm age on firms' R&D activities and thus their R&D tax incentive claims is unclear (Dumont, 2017; Yang et al., 2012). On the one hand, innovative activities could increase with firm age if "learning by doing" (Arrow, 1962) occurs. On the other hand, young firms may tend to be more innovative compared the older ones, as is the case in Turkey (The World Bank, 2019). Hence, firm age (age) is also included in the study as a control variable.

Integration into international markets can be another important factor in R&D activities since competition forces firms to be more innovative. Hence it increases the application for incentives and subsidies (Carboni, 2017). Therefore, the export and

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[13] Large firms (large) are taken as the reference (base category).

import activity of firms (international_markets) is also included as a dummy variable in the study.

Benefiting from other R&D subsidies can be an indicator about a firm's awareness about public support (Corchuelo & Martínez-Ros, 2009). It can increase the probability of benefiting from R&D tax incentives. On the other hand, it is an important factor that can affect the R&D activities of the firm. Therefore, benefiting from other R&D subsidies (other_subsidies) during the period 2016-2018 is controlled for in the study by including other_subsidy as a dummy variable.

Belonging to a group can affect the financial conditions of a firm. It can reduce the financial constraints of the firm (Carboni, 2017). It can also help the firm to benefit from prior experiences of R&D tax incentives within the group (Aralica & Botrić, 2013). Belonging to an enterprise group like a holding or group of companies (belongs_to_group) is added to the model as a dummy variable.

Moreover, engaging in R&D cooperation with other institutions or enterprises can also affect the R&D activities and R&D tax claims of firms. It can increase the diffusion of knowledge (Aralica & Botrić, 2013). Therefore, the R&D cooperation status of firms (cooperation) is also used as a dummy variable in the model.

Being a part of a multinational company or foreign ownership is another important firm characteristic for R&D activities and decisions since it allows knowledge spillovers and affects financial conditions. Therefore, being a domestic firm (domestic_firm) is also included in the study as a dummy variable.

Having qualified employees is another important factor for the innovation activities of firms. Inadequacy in human capital can hamper innovative activities (Corchuelo & Martínez-Ros, 2009; Freitas et al., 2017; Sterlacchini & Venturini, 2019). It can also affect the R&D tax incentive claims of firms since it influences innovation activities. Hence, the firm's situation in terms of having qualified employees (qualified_employees) is used in the study as a dummy variable. It takes "1" for firms that the share of higher education graduate employees on total employees is higher than 50%, "0" otherwise.

In the Innovation Survey (2018), some of the firms list inadequacy of financial resources within the enterprise and/or loans and capital inadequacy as important factors that hinder the innovation activities of firms. Since financial constraints are important for both the R&D activities and R&D tax incentive claims of firms, the question of whether financial constraints hamper the firm's innovation activities (financial_constraint) is included as a dummy variable in the study. It takes "1" for firms that indicate inadequacy of financial resources within the enterprise and/or loans and capital inadequacy as important factors which hamper innovation activities, "0" otherwise.

For the purpose of extending the study, the balance sheet information of firms is also added as control variables in the second model. The profitability of firms is an important factor for the propensity to apply for R&D tax incentives since firms that have higher profitability can spend more on R&D activities and therefore, they more likely to claim R&D tax incentives (Yang et al., 2012). Profitability (profitability) is defined as net profit over total sales in line with the literature. For the conditional assumption to hold, one-year lagged value of profitability (2017) is used in the second model since profitability is only available for a small sample of firms for the beginning of the treatment period, 2016.

Financial debt situation is another important factor for the R&D activities of firms, although the sign of the effect on a firm's R&D activities is not clear. As access to finance becomes easier, the R&D activities of firms can increase since it is an additional financial source for their R&D activities. On the other hand, increasing indebtedness can hamper the R&D activities of firms (Ravšelj & Aristovnik, 2020). The financial liability situation of firms (financial_leverage) is described as total liabilities (short and long-term) divided by total assets in line with the literature and one-year lagged value of it is used in the study for the same reason as profitability.

For robustness check, the second model is also estimated with 2018 values of profitability and financial_leverage. ATT result of the model does not differ widely from second model. The result is consistent with second model. It is provided in Appendix E.

5.2.4. Outcome Variables

Since the effectiveness of R&D tax incentives is investigated in the context of input additionality, the impact of R&D tax incentives on R&D intensity is examined in the study in line with the literature. For the calculation of R&D intensity, net R&D expenditures of firms in 2018 are divided by total turnover in same year.

All variables except for the dummy variables and firm age are used by transforming them to natural logarithms.

A summary of all variables used in the study and the descriptive statistics of datasets are presented in Table 10 and Table 11 respectively.

Table 10

Variables Used in the Study

	Variables	Type	Description	Source
Treatment	rd_tax_incentives	Dummy	Equal 1 for firms that benefit from tax incentives in the period 2016-2018, 0 otherwise	Innovation Survey (2018)
Control	d_manu	Dummy	Equal 1 for manufacturing firms, 0 otherwise	Innovation Survey (2018)
	small	Dummy	Equal 1 for firms that have between 10 and 49 employees, 0 otherwise	Innovation Survey (2018)
	medium	Dummy	Equal 1 for firms that have between 50 and 249 employees, 0 otherwise	Innovation Survey (2018)
	age	Number	Firm age in 2018	Annual Business Registers Framework (2018)
	belongs_to_group	Dummy	Equal 1 for firms belong to a group	Financial and Nonfinancial Corporations Research and Development Activities Survey (2018)
	domestic_firm	Dummy	Equal 1 for firms have domestic capital more than 50%	Financial and Nonfinancial Corporations Research and Development Activities Survey (2018)
	cooperation	Dummy	Equal 1 for firms have R&D cooperation, 0 otherwise	Innovation Survey (2018)
	other_subsidy	Dummy	Equal 1 for firms benefit from other R&D subsidies in the period 2016-2018, 0 otherwise	Innovation Survey (2018)
	international_markets	Dummy	Equal 1 for exporter/importer firms, 0 otherwise	Foreign Trade Statistics (2018)
	qualified_employees	Dummy	Equal 1 for firms that the share of higher education graduate employees on total employees is higher than 50%, 0 otherwise	Innovation Survey (2018)
	financial_constraints	Dummy	Equal 1 if firm lists inadequacy of financial resources within the enterprise and/or loans and capital inadequacy as important factors that hinder the innovation activities of firms	Innovation Survey (2018)
	financial_leverage	Ratio	Total liabilities (short and long-term) over total assets	Company Accounts Statistics (2017-2018)
	profitability	Ratio	Profit of firm over sales	Company Accounts Statistics (2017-2018)
Outcome	rd_intensity	Ratio	Net R&D expenditures of firms over total turnover	Financial and Nonfinancial Corporations Research and Development Activities Survey (2018), Annual Business Registers Framework (2018)

Table 11

Descriptive Statistics of Datasets

Variable	First Dataset (d_total)			
	rd_tax_incentive=1 N^1= 637		rd_tax_incentive=1 N^0= 280	
	Mean	Std. Dev.	Mean	Std. Dev.
rd_intensity	0.814	0.130	0.726	0.118
dum_manu	0.655	0.476	0.793	0.406
small	0.184	0.388	0.204	0.403
medium	0.203	0.402	0.157	0.365
age	19.699	11.729	20.946	12.165
belongs_to_group	0.349	0.477	0.314	0.465
domestic_firm	0.845	0.363	0.846	0.361
cooperation	0.570	0.495	0.286	0.453
other_subsidy	0.774	0.419	0.421	0.495
international_markets	0.827	0.378	0.889	0.314
qualified_employees	0.438	0.497	0.286	0.453
financial_constraints	0.590	0.492	0.579	0.495
Second Dataset with Financial Conditions (d_bs)				
Variable	rd_tax_incentive=1 N^1= 440		rd_tax_incentive=1 N^0= 177	
	Mean	Std. Dev.	Mean	Std. Dev.
rd_intensity	0.792	0.089	0.724	0.721
dum_manu	0.752	0.432	0.842	0.366
small	0.111	0.315	0.130	0.337
medium	0.173	0.378	0.153	0.361
age	21.640	10.704	21.876	10.080
belongs_to_group	0.395	0.490	0.288	0.454
domestic_firm	0.850	0.357	0.876	0.331
cooperation	0.625	0.485	0.282	0.451
other_subsidy	0.814	0.390	0.418	0.495
international_markets	0.893	0.309	0.927	0.262
qualified_employees	0.355	0.479	0.232	0.423
financial_constraints	0.570	0.496	0.576	0.496
financial_leverage	1.811	0.108	1.809	0.959
profitability	0.852	0.066	0.834	0.737

5.3. Empirical Results

In the study, the effectiveness of R&D tax incentives is investigated by applying PSM[14] for two datasets.

According to the Heckman, Ichimura, and Todd (1997, 1998), bias in PSM could be low and, thus, the estimation performance of the method could be better under the following conditions:

1. Using the same data source for the treatment and control groups

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[14] "psmatch2" STATA command is applied in line with the literature.

2. Including a broad set of control variables X

3. Using treatment and control groups that operate in the same location and market and are exposed to the same economic incentives (Cintina & Love, 2019; Khandker et al., 2010).

In the study, all three conditions above are satisfied for both of the datasets. The same surveys and statistical databases are used for both the treatment and control groups and both groups are in the same geographic area. Further, a rich dataset is used for control variables by taking into consideration the empirical literature and/or economic theory. The Innovation Survey (2018) and Financial and Nonfinancial Corporations Research and Development Activities Survey (2018) provide detailed information about firms' R&D activities. The Foreign Trade Statistics (2018), Company Accounts Statistics (2017), and Annual Business Registers Framework (2018) are also very informative about firms' characteristics such as firm age, turnover, number of employees, foreign trade status, and balance sheets. They are all used as observable characteristics that affect benefiting from R&D tax incentives and the R&D expenditures of firms.

5.3.1. Empirical Results of the First Model

In the study, the control variables X that are explained above are decided on by applying a probit model. The results of the probit model are given in Table 12.

Table 12

Probit Model Results

Dependent: rd_tax_incentives	Coef.	Std. Err.
dum_manu	-0.432*	0.141
small	-0.401**	0.159
medium	-0.062	0.142
age	-0.007	0.005
belongs_to_group	0.015	0.113
domestic_firm	-0.010	0.142
cooperation	0.603*	0.100
other_subsidy	0.851*	0.098
international_markets	-0.219	0.167
qualified_employees	0.239**	0.115
financial_constraints	-0.002	0.098
_cons	0.356	0.250
Observation		917
LR chi2 (11)		181.67
Prob>chi2		0.0000
Pseudo R2		0.1610
Log likelihood		-473.41616

* Significant at 1%
** Significant at 5%

In the probit model, the R&D cooperation status of firms and benefiting from other R&D subsidies affect positively the probability of benefiting from R&D tax incentives at the 1% significance level. Having qualified employees affects positively this probability at the 5% significance level. While being a manufacturing firm affects negatively the probability of benefiting from R&D tax incentives at the 1% significance level, being a small firm affects negatively this probability at the 5% significance level. Although other variables are not significant individually, all variables of the probit model are used as control variables in the estimation since the probit model is significant.

The propensity scores for benefiting from R&D tax incentives are calculated[15] by using the probit model with the control variables determined above. The region of common support where the distributions of propensity scores of benefiting and nonbenefiting groups overlap is defined and the balancing test is applied.

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[15] Propensity scores for benefiting from R&D tax incentives are calculated by applying the "pscore" command, developed by Becker and Ichino (2002) in STATA 16. Detailed information about the "pscore" command's algorithms is provided in Appendix C.

Then the treatment group, which consists of R&D tax incentives beneficiaries, is matched with the control group, which consists of the nonbeneficiaries with the most similar characteristics to the treatment group on the basis of their propensity scores.

In the study, kernel matching[16], which is a frequently used matching method in the empirical literature, is applied since it allows us to use more information from the control group with smaller variance in ATT by using the weighted averages of propensity scores of control group members. The risk of including bad matches from the control group is reduced by applying common support. Therefore, the treated firms that have propensity scores outside of the untreated firms' propensity score range are discarded (Caliendo & Kopeinig, 2008; Sterlacchini & Venturini, 2019).

Table 13 shows the kernel matching results, which are obtained by using the propensity scores. Under the assumptions of conditional independence and sizable common support, the mean differences in outcomes over common support give the ATT, which shows the impact of the treatment.

The difference between the treated and control groups are smaller in ATT than the unmatched result. This means that the unmatched difference result is overestimated since it ignores selection bias. PSM allows us to correct selection bias. According to the ATT result, which is obtained by applying PSM, R&D tax incentives have a positive and statistically significant effect on firms' R&D intensity. R&D tax incentive beneficiary firms have 7% higher R&D intensity than they would have had without R&D tax incentives.

Table 13

ATT of R&D Tax Incentives

Treatment Variable:	rd_tax_incentives			
Outcome Variable:	rd_intensity			
	Treated	Controls	Difference	t stat
Unmatched	0.814	0.726	0.088	9.65
ATT	0.809	0.734	0.073	6.22

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[16] For the matching procedure the "psmatch2" command, developed by Leuven and Sianesi (2003), is applied in STATA 16.

After matching the treated and control groups mean values and *t* stats show that both groups are balanced regarding the control variables as shown in Table 14 and Figure 16.

Table 14

Descriptive Statistics Before and After Matching

Variable	Before Matching			After Matching		
	Treated	Control	p>|t|	Treated	Control	p>|t|
dum_manu	0.655	0.793	0.00	0.693	0.676	0.54
small	0.184	0.204	0.48	0.194	0.206	0.63
medium	0.203	0.157	0.11	0.173	0.164	0.68
age	19.699	20.964	0.14	20.058	19.378	0.31
belongs_to_group	0.349	0.314	0.31	0.342	0.311	0.25
domestic_firm	0.845	0.846	0.94	0.847	0.839	0.68
cooperation	0.570	0.286	0.00	0.545	0.536	0.75
other_subsidy	0.774	0.421	0.00	0.761	0.758	0.91
International_markets	0.827	0.889	0.02	0.839	0.813	0.24
qualified_employees	0.438	0.286	0.00	0.405	0.393	0.68
Financial_constraint	0.590	0.579	0.74	0.593	0.640	0.10

Sample	MeanBias	MedBias
Unmatched	23.2	11.8
Matched	4.1	2.8
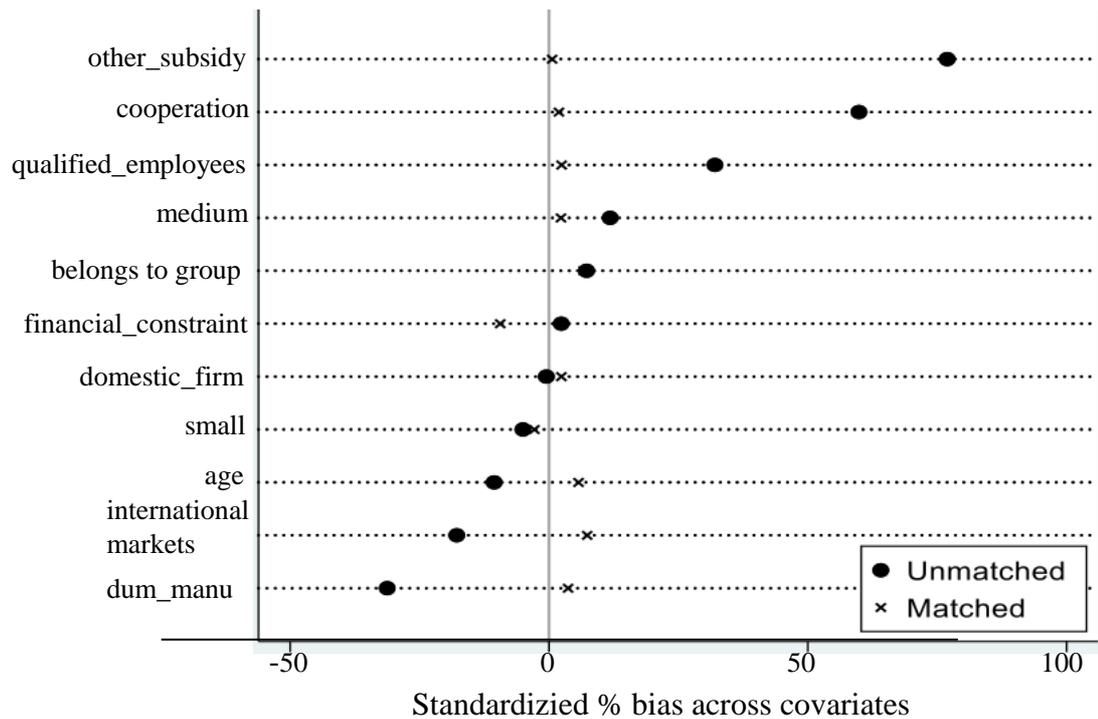
Figure 16. Matching Results

Kernel density estimates of propensity score distributions are shown in Figure 17 regarding the matching status. The figure shows that the distributions overlapped sufficiently after matching.
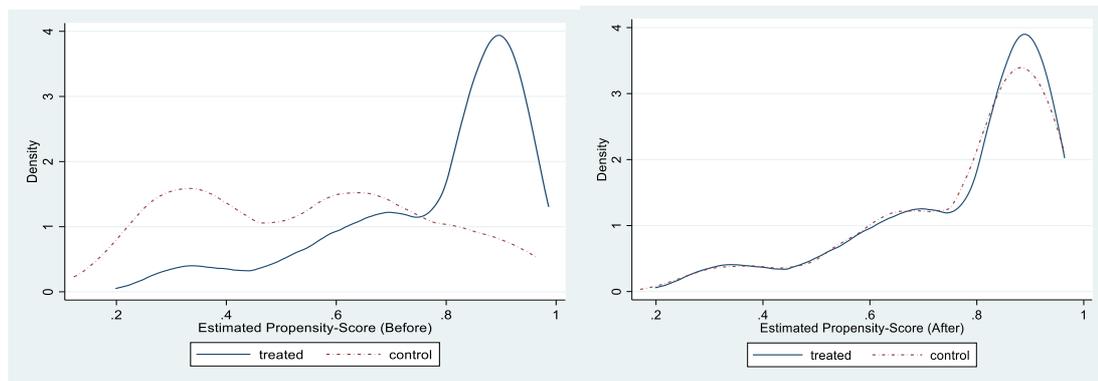
Figure 17. Kernel Density Estimates of Propensity Score Distributions

As a robustness check, in line with the literature, the kernel matching results are checked by applying nearest neighbor matching. The result of this matching method is consistent with the results of kernel matching and it is shown in Appendix D.

5.3.2. Empirical Results of the Second Model (Including Financial Conditions)

In order to enrich the study, for the financial condition variables of firms, financial_leverage and profitability control variables, which are defined in section 5.2.3, are added to the study in the second model.

These variables are defined by using balance sheets and income statements statistics obtained from Company Accounts Statistics (2017).

Since these statistics are not available for all 917 firms from the first model, the second dataset includes only 617 firms from the first dataset. Therefore, it is a sub-sample of the first dataset.

All estimation steps and methods of the first model are preserved in the second model. The control variables, which include financial_leverage and profitability this time, are decided on by applying the probit model.

The results of the probit model are given in Table 15. According to the results, the R&D cooperation status of firms and benefiting from other R&D subsidies positively affect the probability of benefiting from R&D tax incentives at the 1% significance level. Profitability affects this probability 5% significance level. Only being a manufacturing firm negatively affects the probability of benefiting from R&D tax incentives at the 10% significance level. Since the probit model is significant, all other variables are also used as control variables in the study.

Table 15

Probit Model Results (Second model with Financial Conditions)

Dependent: rd_tax_incentives	Coef.	Std. Err.
dum_manu	-0.375***	0.196
small	-0.226	0.220
medium	-0.021	0.185
age	-0.007	0.007
belongs_to_group	0.135	0.143
domestic_firm	-0.013	0.188
cooperation	0.675*	0.125
other_subsidy	0.974*	0.125
international_markets	-0.142	0.246
qualified_employees	0.151	0.150
financial_constraints	0.079	0.126
financial_leverage	0.211	0.662
profitability	1.950**	0.918
_cons	-1.925	1.621
Observation		617
LR chi2 (11)		144.46
Prob>chi2		0.0000
Pseudo R2		0.1953
Log likelihood		-297.55709

* Significant at 1%
** Significant at 5%
*** Significant at 10%

The propensity scores for benefiting from R&D tax incentives is calculated, the region of common support where the distributions of propensity scores of the benefiting and nonbenefiting groups overlap is defined, and the balancing test and kernel matching are applied as in the first model.

Table 16 shows the kernel matching results. According to the results, R&D tax incentives have a positive and statistically significant effect on firms' R&D intensity when the financial conditions of firms are also controlled for. However, the effect of R&D tax incentives on firms' R&D intensity is slightly lower when the financial conditions of firms are taken into consideration.

The R&D tax incentive beneficiary firms have 6% higher R&D intensity than they would have had without R&D tax incentives.

Table 16

ATT of R&D Tax Incentives (Second model with Financial Conditions)

Treatment Variable:	rd_tax_incentives			
Outcome Variable:	rd_intensity			
	Treated	Controls	Difference	t stat
Unmatched	0.792	0.724	0.067	8.95
ATT	0.787	0.732	0.056	5.85

Treated and control groups mean values and *t* stats show that both groups are balanced regarding to control variables after matching as shown in Table 17 and Figure 18.

Table 17

Descriptive Statistics Before and After Matching (Second model with Financial Conditions)

Variable	Before Matching			After Matching		
	Treated	Control	p>|t|	Treated	Control	p>|t|
dum_manu	0.752	0.842	0.02	0.781	0.742	0.19
small	0.111	0.130	0.52	0.113	0.145	0.17
medium	0.173	0.153	0.54	0.158	0.153	0.86
age	21.641	21.876	0.80	22	20.621	0.05
belongs_to_group	0.395	0.288	0.01	0.382	0.331	0.12
domestic_firm	0.850	0.876	0.41	0.853	0.834	0.42
cooperation	0.625	0.282	0.00	0.610	0.599	0.72
other_subsidy	0.814	0.418	0.00	0.807	0.783	0.41
international_markets	0.893	0.927	0.21	0.906	0.870	0.10
qualified_employees	0.355	0.232	0.00	0.335	0.356	0.52
financial_constraint	0.570	0.576	0.90	0.564	0.611	0.16
financial_leverage	1.811	1.809	0.75	1.814	1.811	0.77
profitability	0.853	0.834	0.002	0.851	0.850	0.94

Sample	MeanBias	MedBias
Unmatched	22.9	11.7
Matched	6.7	5.8
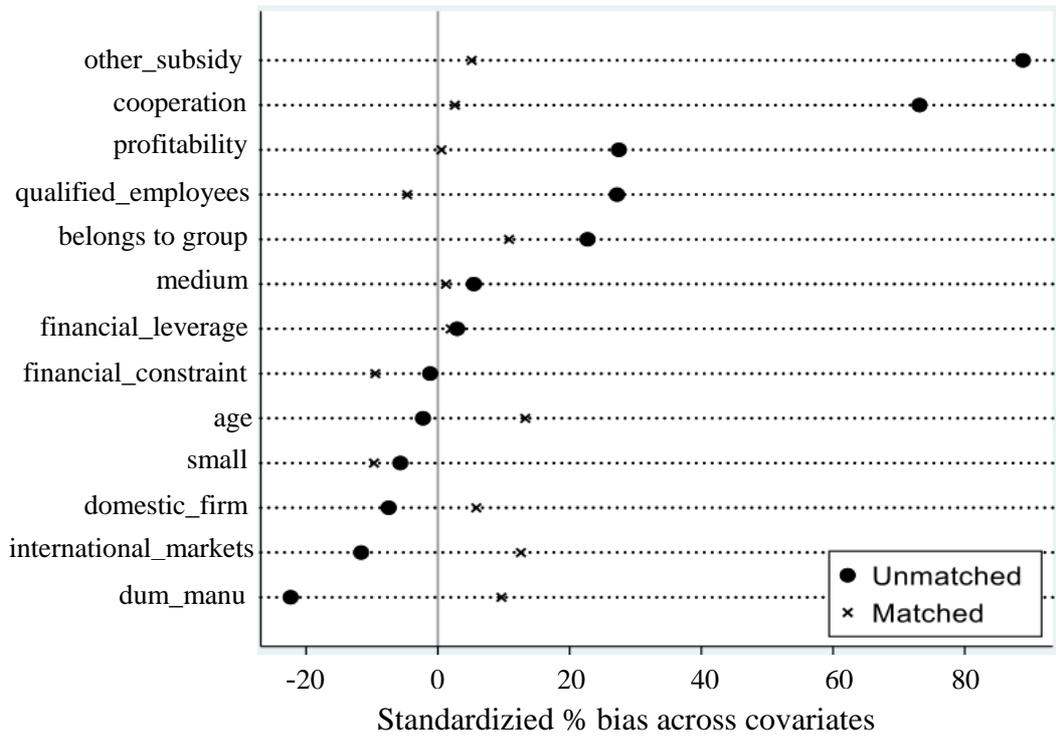
Figure 18. Matching Results (Second model with Financial Conditions)

Figure 19 shows that the kernel density estimates of propensity score distributions overlapped sufficiently after matching.
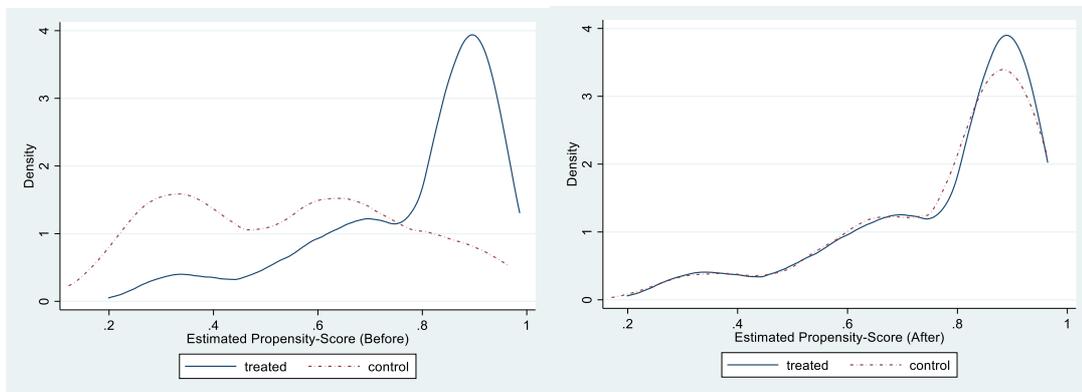
Figure 19. Kernel Density Estimates of Propensity Score Distributions (Second model with Financial Conditions)

The kernel matching results are checked by applying nearest neighbor matching, as in the first model. The result of this matching method is consistent with the results of kernel matching also for the second model and it is shown in Appendix D.

5.3.3. Input Additionality of R&D Tax Incentives

PSM enables evaluation of the effect of R&D tax incentives through calculation of ATT. With the help of ATT estimation, it is apparent that R&D tax incentive beneficiary firms have higher R&D intensity than they would have had without R&D tax incentives.

Although this result indicates a positive effect of R&D tax incentives on the R&D intensity of firms, it does not reflect directly the input additionality, which shows to what extent the R&D tax incentives are reflected in the increase in R&D intensity.

Calculation of the input additionality ratio or BFTB, which is the measure of the additional increase in R&D intensity of a firm for every money unit of foregone tax revenue, is important for assessing the input additionality of R&D tax incentives.

The input additionality ratio or BFTB can be interpreted as an R&D tax credit multiplier. A value of the multiplier greater than 1 implies that one money unit of government support produces R&D intensity more than one money unit. If the value of the multiplier is between 0 and 1, it means that government funding is partly used for reducing the firm's own funding. In other words, one unit of government support is translated to R&D intensity less than one unit by the beneficiary firm. It means that government funding partially crowds out business R&D. This case indicates that the firm uses some part of the government support in other activities. Finally, a negative multiplier indicates that government support crowds out business R&D, which means that government support is used to reduce the firm's own funding more than the received R&D tax incentives. This implies that the beneficiary firm uses all R&D government support for other activities rather than R&D (Appelt et al., 2019; Sterlacchini & Venturini, 2019).

Since BFTB or the additionality ratio is a cost–benefit analysis, the amounts of foregone tax revenue for firms are necessary as a cost of government funding. R&D tax incentives data are only available as a binary variable that shows whether the firm benefits from R&D tax incentives during the period 2016-2018. This hampers the calculation of the multiplier using firm-level data.

Sterlacchini and Venturini (2019) compute the R&D tax multiplier by using the ATT value as a percentage of the R&D intensity of treated firms and the average effective tax credit rate of the country in their study. They calculate the average effective tax credit rate by dividing the amount of tax credits by R&D expenditures claimed for tax credits at country level. Then they state that the ratio of ATT/R&D intensity (%) to average effective tax credit rate (%) gives the R&D tax credit multiplier.

Due to the data constraints, the method applied by Sterlacchini and Venturini (2019) is followed for calculation of the multiplier.

Since the ATT value and R&D intensity of treated firms is calculated by applying PSM, the average effective R&D tax incentive rate is needed for Turkey.

TURKSTAT announces the amounts of R&D tax incentives for Turkey yearly. Table 18 shows the amounts of R&D tax incentives during the period 2008-2018. As of 2018, the amount of R&D tax incentives is 4,599 million TL.

Table 18

R&D Tax Incentives (Million TL, 2008-2018)

Year	R&D Tax Incentives	Year	R&D Tax Incentives
2008	198	2014	1,282
2009	430	2015	1,653
2010	518	2016	2,126
2011	614	2017	2,871
2012	752	2018	4,599
2013	835		

Source: TURKSTAT

Although the R&D tax incentives amount is available, the amount of R&D expenditures claimed for R&D tax incentives is not announced. Therefore, it is requested from TURKSTAT.

Table 19 shows the R&D expenditures claimed for R&D tax incentives and R&D tax incentive amount for 2018.

Table 19

R&D Expenditures Claimed for R&D Tax Incentives and R&D Tax Incentives (Million TL, 2018)

	R&D Expenditures Claimed for R&D Tax Incentive (Million, TL)	Tax Rate (%)	R&D Tax Incentives (Million, TL)
Corporate Tax	13,266.50	22	2,918.63
Income Tax	172.97	35	60.54
Total (Corporate and Income Tax)	13.439,48		2,979.17
Income Tax Withholding and VAT	-	-	1,619.63
Total	-	-	4,598.80

Source: TURKSTAT

R&D expenditures claimed for R&D tax incentives could be provided only for 2,979 million TL R&D tax incentives by TURKSTAT. Due to data privacy, tax bases for 1,619 million TL R&D tax incentives (Income tax withholding and VAT) could not be provided. Therefore, the average effective R&D tax incentive rate is calculated in the light of the shared data.

Table 20 shows the calculation of the average effective R&D tax incentive rate. According to the calculations, it is computed as 22.2% for Turkey in 2018.

Table 20

Average Effective R&D Tax Incentive Rate for Turkey (2018)

R&D Expenditures Claimed for R&D Tax Incentive (Million, TL) (x)	R&D Tax Incentives (Million, TL) (y)	Average Effective R&D Tax Incentive Rate (%) (z=y/x)
13.439,48	2,979.17	22.2

Source: TURKSTAT, Author's calculation

Table 21 shows the calculation of the R&D tax incentive multiplier. ATT/R&D intensity (%) is divided by the average effective R&D tax incentive rate (%). It is calculated as 0.4 for the first model for Turkey in 2018. When the financial conditions of firms are taken into account, the multiplier decreases slightly to 0.3 for the same year.

Table 21

R&D Tax Incentive Multiplier for Turkey (2018)

	First Model	**Second Model (with financial conditions)**
ATT/ R&D intensity of beneficiary firms (%) (x)	9.1	6.5
Average effective R&D tax incentive rate (%) (y)	22.2	22.2
R&D tax incentive multiplier (x/y)	**0.4**	**0.3**

Source: Author's calculation

Both of the multipliers are between 0 and 1. These results imply that although R&D tax incentives produce additional R&D intensity, these incentives are partly used to reduce firms' own funding in Turkey in 2018 since the multiplier is positive but less than 1. In other words, although R&D tax incentives have a positive effect on business R&D, this effect is limited since R&D tax incentive beneficiary firms allocate government support partially for other activities. Despite this, R&D tax incentives contribute to increased business sector R&D performance since the multiplier is positive.

Due to the lack in emprical literature about the effectiveness of this instrument in Turkey, the results of the study can only be compared with empirical studies which is done for other countries in the literature. Although R&D tax incentive schemes differ from country to country and measurement methods of additionality of R&D tax incentives also differ widely in the empirical literature, the justification behind this policy instrument in economic theory and the advantages and disadvantages of the instrument are similar. Therefore, many studies such as Hall and Reenen (2000), Guellec and Van Pottelsberghe De La Potterie (2003), and Appelt et al. (2019) try to form a framework for a general assessment about the effectiveness of this instrument through cross-country analysis.

For this reason, when the results are compared to other studies, they are consistent with the empirical literature. Although the measurement techniques differ, the impact

of this instrument on business R&D is found mostly positive but limited in both cross-country and firm-level empirical studies such as Hall and Reenen (2000), Koga, (2003), Falk (2006), Lokshin and Mohnen (2012), Thomson (2017), Appelt el al. (2019), Sterlacchini and Venturini (2019), and Ravšelj and Aristovnik (2020). Generally, the effect of R&D tax incentives on business R&D increases in the long run.

Due to data restrictions, it is impossible to evaluate R&D tax incentives for the long run for Turkey in the study. Therefore, investigating the long-term impact can be useful for policy evaluation in further studies with improvement of the R&D tax incentive data for Turkey.

CHAPTER VI

CONCLUSION

Technological change has started to be accepted as an engine of growth through the evolution in growth theories. This approach has increased the importance of R&D activities, in particular business sector R&D activities, over time.

Most countries have set ambitious targets for R&D indicators, especially for R&D intensity. This has led to expectations of increased R&D intensity led by business sector R&D expenditures.

Several factors in the R&D field oblige governments to support business sector R&D activities. In economics, these factors that make government interventions in the R&D field necessary are explained mainly by neoclassical and evolutionary approaches. While the justification for government interventions in this field is explained through market failures in the neoclassical approach, it is explained through systemic failures in the evolutionary approach. The logic (market failures or systemic failures) behind the interventions shapes the policy tools.

While the market failures approach proposes the funding of business sector R&D activities directly with grants, subsidies, or procurements or indirectly with R&D tax incentives, the systemic failures approach suggests improvement of institutional frameworks and connections among actors in the innovation system.

Funding of business sector R&D activities based on the market failure approach increased government support in this field over time. It also raised the importance of the effectiveness of these policy instruments. Since they are budget-related instruments, their effective implication could compensate for government spending in this field through innovation and economic growth.

Therefore, the advantages and disadvantages of these funding mechanisms are investigated widely over time. Their combination in funding of the business sector has also changed as a result of these evaluations.

While direct funding has been a traditional funding mechanism for years, R&D tax incentives, as an indirect funding mechanism, have increased as both a percentage of GDP and the number of countries that implement this policy tool.

As a result of this rising popularity of R&D tax incentives, the effectiveness of this instrument is investigated widely in the empirical literature.

While interest in the R&D field in Turkey has increased in line with other countries and the trend in the world economy over time, it accelerated in the 2000s. As a result of policies formulated in the light of ambitious targets in this field, R&D indicators such as R&D intensity and personnel have risen over time. The share of BERD in total R&D expenditures has increased as required.

Government funding for business sector R&D expenditures has also risen as a result of these developments. While direct funding (as a percentage of GDP) has remained flat as a traditional policy tool in this field, R&D tax incentives (as a percentage of GDP) have increased. Tax incentives for R&D have increased not only as a percentage of GDP, but also as the number of beneficiaries over time.

Despite the wide use of R&D tax incentives, there is a lack of studies in the empirical literature about the effectiveness of this instrument.

The aim of the study is to investigate the effectiveness of R&D tax incentives in Turkey. For this purpose, firstly the hypothesis that "R&D tax incentives increase business sector R&D intensity" is tested by using two cross-sectional datasets, which are combined versions of the Innovation Survey (2018), Financial and Nonfinancial Corporations Research and Development Activities Survey (2018), Foreign Trade Statistics (2018), Company Accounts Statistics (2017-2018), and Annual Business Registers Framework (2018) Micro Datasets of TURKSTAT. Since the question of whether firms benefit from R&D tax incentives during the period 2016-2018 is included in the Innovation Survey (2018), this survey forms the backbone of the study. The data of the Innovation Survey are enriched by using the other above-mentioned

surveys and statistics that include information about R&D activities and firm characteristics and balance sheets.

The first dataset includes 917 firms and the following control variables:

- Whether a manufacturing firm
- Firm size (small, medium, large)
- Firm age
- Belonging to a group
- Whether a domestic firm
- R&D cooperation status of firm
- Benefiting from other subsidies
- Integration in international markets
- Having qualified employees
- Whether financial constraints hamper firm's innovation activities

Since balance sheet indicators such as financial leverage and profitability are also important for benefiting from R&D tax incentives and R&D investments of firms, these variables are added as control variables in the second dataset in line with the literature. This is intended to enrich the study and check the robustness of the result. In the second dataset the number of firms decreases to 617 since balance sheet variables are not available for all 917 firms.

For avoiding the problem of selection bias, PSM is applied for both of the datasets and ATT is calculated. The estimations for both datasets confirm the hypothesis that R&D tax incentives increase business sector R&D intensity in Turkey.

Then the extent of the impact for producing additional R&D intensity is calculated with the help of the R&D tax incentive multiplier. The multiplier is calculated between 0 and 1 for both of the datasets. It is slightly lower for the second dataset, which takes the financial conditions of firms into account.

These results imply that although R&D tax incentives are effective in increasing business sector R&D since they have a positive effect on the R&D intensity of firms, their effectiveness is limited as the multipliers indicate partial crowd-out.

Several factors may have contributed to these results. Firms may focus on lowering their tax burden instead of investing in R&D, benefits of R&D tax incentives may be limited due to insufficient tax profits of some firms, or firms may consider these incentives as windfall money and they may not change their R&D policies.

Since they do not provide an initial money for R&D expenditures, they may not ease financial conditions, especially for firms experiencing financial difficulties. This means that if firms have sufficient financial resources for R&D expenditures, they may benefit more from R&D tax incentives but the effect of those incentives for encouraging firms to spend more on R&D may be lower if they do not have sufficient financial resources for spending on R&D.

However, the results of the study have to be treated with caution for several reasons. Firstly, the multiplier approach takes into account private benefits. Knowledge spillovers due to increased R&D intensity of firms with the help of the R&D tax incentives are not taken into consideration in this approach. The sum of private and social benefits may be higher than estimated (Appelt et al., 2019; Sterlacchini & Venturini, 2019).

Secondly, as a treatment variable, benefiting from R&D tax incentives is available only as a binary variable. Since the amount of R&D tax incentives for firms is not available, the multiplier was calculated from the overall country R&D tax incentives amount and total R&D tax incentives claims. Calculation of the multiplier can be improved by using firm-level R&D tax incentive data in future studies through improvement in R&D tax incentive data.

Thirdly, the effect is calculated for only short-run in the study. The available data for R&D tax incentives are only cross-sectional because of changes in the definition and types of innovation in the main source of innovation statistics, the Guidelines of the Oslo Manual, and the question of whether firms benefit from R&D tax incentives is asked for the first time in the 2018 Innovation Survey. Therefore, these factors hamper

long-term investigation of the effectiveness of these incentives and they limit the econometric methods in terms of impact analyses. The effect can be higher in the long-run since most of the studies in the literature show that the effect of these incentives increases in the long-run.

Despite all the above-mentioned shortcomings, the study contributes to the empirical literature in the following ways. Firstly, the main contribution of the study is filling the gap in the empirical literature concerning the impact analysis of R&D tax incentives in Turkey. Since measurement of public policies is an up-and-coming issue in Turkey and the resources allocated for these incentives has increased over time, the efforts for investigating the effectiveness of these incentives are important.

Secondly, majority of the control variables in the literature could be included in estimations.

Another contribution of the study is that the estimations provide some insights about this public policy. It shows that the improvement of policies for R&D tax incentives can be useful for decreasing the crowd-out effect.

The studies in this field show that it is useful to evaluate R&D policies as a whole. Therefore, the coherence of policies that affect the R&D field is important. In this sense, the policy set that improves the financial conditions and predictability of firms (not only direct subsidies but also other factors such as credit conditions and certainty in economic policies) and tax policy may increase the effectiveness of R&D tax incentives.

However, the results of the study can be considered as inferences based on R&D tax incentives and the R&D intensity in the business sector for the period 2016-2018 rather than as an evaluation of R&D tax incentive policy. Evaluation of this policy may require a broader perspective instead of calculation of the impact only for the R&D intensity in the business sector. In this sense, examination of effectiveness in the context of output additionality in further studies may be useful.

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APPENDICIES

A. COVID-19 RELATED CHANGES IN R&D TAX INCENTIVES (OECD COUNTRIES, 2020)

Table A. 1: Covid-19 Related Changes in R&D Tax Incentives

(Selected OECD Countries, 2020)

Change	Country
Increased	Australia Denmark Iceland Italy Spain
Ceiling Increased	Germany Iceland
Ceiling Decreased	France Norway
Ceiling Adjusted	New Zealand
Ceiling Introduced	Denmark
Accelerated or earlier processing of R&D tax relief claims	Canada Poland
Advanced and/or expedited cash payments (refunds)	Denmark France Ireland
Extension of time limit for filing applications	Australia Canada Mexico Portugal
More favorable evaluation of claims	Mexico

Notes: The table does not include income-based tax incentives. It covers only expenditure-based R&D tax incentives for business sector.

Source: OECD R&D Tax Incentive Database, http://oe.cd/rdtax, December2020.

B. DETAILS OF SECOND DATASET

Table B. 1: R&D Active Firms by Sectors*

Sectors	Number of firms	R&D tax incentive beneficiaries	Proportion of R&D tax incentive beneficiary firms
Mining and quarrying & Electricity, gas steam and air conditioning supply	10	5	50.0
Manufacturing	**480**	**331**	**69.0**
Water supply; sewerage, waste management and remediation activities & Transportation and storage	8	5	62.5
Wholesale trade, except of motor vehicles and motorcycles	24	21	87.5
Information and communication	**68**	**60**	**88.2**
Architectural and engineering activities, technical testing and analysis	9	5	55.6
Scientific research and development	18	13	72.2
Total	**617**	**440**	**71.3**

Source: TURKSTAT

(*) Data has been aggregated for sectors that have 2 or less firms at the request of TURKSTAT.

Table B. 2: R&D Active Firms by Size

Firm Size	Number of firms	R&D tax incentive beneficiaries	Proportion of R&D tax incentive beneficiary firms
Small	72	49	68.1
Medium	103	76	73.8
Large	442	315	71.3
Total	617	440	71.3

Source: TURKSTAT

Table B. 3: R&D Active Firms by Age

Firm age	Number of firms	R&D tax incentive beneficiaries	Proportion of R&D tax incentive beneficiary firms
0-5	28	22	78.6
6-10	54	38	70.4
11-20	174	126	72.4
21-30	258	181	70.2
31-40	70	47	67.1
41-50	26	21	80.8
50+	7	5	71.4
Total	617	440	71.3

Source: TURKSTAT

Table B. 4: R&D Active Firms by Foreign Trade Status

Exporter/Importer	Number of firms	R&D tax incentive beneficiaries	Proportion of R&D tax incentive beneficiary firms
Yes	557	393	70.6
No	60	47	78.3
Total	617	440	71.3

Source: TURKSTAT

C. ALGORITM OF "PSCORE" COMMAND

The program "pscore" is developed by Becker and Ichino (2002). It estimates the propensity scores and apply balancing test according to the following algoritm:

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1. Fit the probit (or logit) model:
$$\Pr(D_i = 1 | X_i) = \Phi\{h(X_i)\}$$
   where Φ denotes the normal (logistic) c.d.f. and $h(X_i)$ is a starting specification that includes all the covariates as linear terms without interactions or higher order terms.

2. Split the sample into k equally spaced intervals of the propensity score, where k is determined by the user and the default is 5.

3. Within each interval, test that the average propensity score of treated and control units does not differ.

4. If the test fails in one interval, split the interval in half and test again.

5. Continue until, in all intervals, the average propensity score of treated and control units does not differ.

6. Within each interval, test that the means of each characteristic do not differ between treated and control units. This is a necessary condition for the Balancing Hypothesis.[4]

7. If the means of one or more characteristics differ, inform the user that the balancing property is not satisfied and that a less parsimonious specification of $h(X_i)$ is needed.

Source: (Becker and Ichino (2002), p. 360

D. OTHER MATCHING RESULTS FOR THE FIRST AND SECOND MODEL

Table D. 1 shows the results of nearest neighbor matching for the first model. It is applied without replacement. Therefore the sort order is randomized before matching.

Table D. 1: *ATT of R&D Tax Incentives*
(nearest neighbor matching)

Treatment Variable:	rd_tax_incentives			
Outcome Variable:	rd_intensity			
	Treated	Controls	Difference	t stat
Unmatched	0.814	0.726	0.088	9.65
ATT	0.809	0.745	0.064	4.02

All above-mentioned matching steps are also applied for the second model. Table D. 2 shows the results of nearest neighbor matching for the second model.

Table D. 2: ATT of R&D Tax Incentives
(Second model with financial conditions, nearest neighbor matching)

Treatment Variable:	rd_tax_incentives			
Outcome Variable:	rd_intensity			
	Treated	Controls	Difference	t stat
Unmatched	0.792	0.724	0.067	8.95
ATT	0.787	0.725	0.062	5.38

E. "ATT" RESULTS WITH COMPANY ACCOUNT STATISTICS (2018)

As a robustness check, profitability and financial_leverage variables are calculated for 2018 by using Company Account Statistics (2018) and combined with first dataset as in the second model.

It is also a sub-sample of first dataset since 2018 values of profitability and financial leverage are available only for 574 firms.

All variables and calculation steps of second model are preserved since probit model is significant and balancing property is satisfied.

ATT results of the model with kernel matching are not differ widely from the second model as shown in Table E. 1.

Table E. 1: ATT of R&D Tax Incentives

(kernel matching)

Treatment Variable:	rd_tax_incentives			
Outcome Variable:	rd_intensity			
	Treated	Controls	Difference	t stat
Unmatched	0.800	0.729	0.070	9.37
ATT	0.795	0.743	0.052	4.97

F. TURKISH SUMMARY / TÜRKÇE ÖZET

Araştırma ve geliştirme (Ar-Ge) faaliyetleri İkinci Dünya Savaşı sonrası yüksek büyüme oranlarına sahip ülkelerin büyüme oranlarının arkasındaki Ar-Ge faaliyetleri ve teknoloji stratejilerinin etkisiyle önem kazanmıştır.

Ar-Ge faaliyetleri, büyümeyi tetikleyen ve dolayısıyla refah artışı sağlayan bir faktör olarak görülmeye başlanmış, teknolojik farklılıklar, ülkeler, sektörler ve endüstriler arasındaki verimlilik farklılıklarının kaynağı olarak kabul edilmiştir.

Teknolojik değişim, verimliliğin kaynağı olarak görüldüğünden ekonomik büyümenin de temel itici gücü olarak kabul edilmiş ve zamanla büyüme teorilerindeki gelişmelerle de teknolojik değişim ve yeniliğin önemi artmıştır.

Tüm bu gelişmelere paralel olarak birçok ülke, daha yüksek ve sürdürülebilir büyüme oranlarına ulaşmak için Ar-Ge faaliyetlerini artırmayı hedeflemişlerdir.

Zaman içerisinde ülkelerin Ar-Ge yoğunluğunda, bu faaliyetler için bütçeden ayırdıkları kaynaklarda ve özel sektörünün Ar-Ge harcamalarında artış kaydedilmiştir.

Ancak Ar-Ge faaliyetlerindeki piyasa başarısızlıkları (Arrow, 1962; Nelson, 1959), küçük ve/veya yeni kurulmuş firmaların finansman kısıtları, bazı teknolojilerin yüksek maliyetleri gibi nedenlerle özel sektörün Ar-Ge faaliyetleri için devlet desteğine ihtiyaç duyulmaktadır.

Bu nedenle devletler özel sektörün Ar-Ge faaliyetlerini hibe ve sübvansiyon alımı gibi doğrudan finansman mekanizmaları ve bir dolaylı finansman mekanizması olan Ar-Ge vergi teşvikleri yoluyla desteklemektedir.

Ülkelerin özel sektörün Ar-Ge faaliyetleri için sağladığı doğrudan finansman destekleri ve Ar-Ge vergi teşviklerinin seyri ülkelerin Gayri Safi Yurtiçi Hasıla (GSYH)'larına oranla yıllar itibarıyla incelendiğinde, 2018 yılı itibarıyla çoğu ülkede söz konusu desteklerin 2006 yılına kıyasla arttığı gözlenmektedir.

Son 20 yılda özel sektör Ar-Ge faaliyetlerini desteklemeye yönelik kamu politikalarındaki eğilim incelendiğinde Ar-Ge vergi teşviklerinin kullanımındaki artış dikkat çekicidir.

2020 yılı itibarıyla 37 OECD ülkesinden 32'si ve 21 AB ülkesi özel sektörün Ar-Ge faaliyetleri için vergi teşviki sağlamaktadır. Bu rakamlar 2000 yılı rakamları ile kıyaslandığında, Ar-Ge vergi teşviki sağlayan ülke sayısında OECD ülkeleri için yüzde 65 AB ülkeleri için ise yüzde 100'e yakın bir artışa işaret etmektedir.

Son yirmi yılda, Ar-Ge vergi teşvikleri sadece uygulayıcı ülke sayısı olarak değil, aynı zamanda Ar-Ge vergi teşvik tutarının GSYH içindeki payı olarak da artmıştır.

2000 yılında OECD Ar-Ge vergi teşvik tutarının GSYH'ye oranı yüzde 0,04 iken bu oran 2018 yılında yüzde 0,1'e yükselmiştir. Aynı dönemde özel sektör Ar-Ge harcamalarının doğrudan finansmanının GSYH'ye oranı sırasıyla yüzde 0,1 ve yüzde 0,08'dir.

Ar-Ge vergi teşviklerinde doğrudan finansmana kıyasla gözlenen bu artış son yıllarda devletlerin özel sektör Ar-Ge faaliyetlerini fonlama tercihlerindeki değişimi açıkça göstermektedir.

Ar-Ge vergi teşviklerinin uluslararası anlaşmalardan muaf olması, doğrudan finansmana kıyasla daha piyasa temelli ve tarafsız olmaları, Ar-Ge vergi teşvik süreçlerinin yönetim maliyetinin hibe ve sübvansiyon süreçlerinin yönetim maliyetine kıyasla daha düşük olması zaman içerisinde söz konusu teşviklerin doğrudan finansmana kıyasla daha çok tercih edilmesinde etkili olmuştur.

Ar-Ge vergi teşviklerinin zaman içerisinde yaygın olarak kullanılması ve özellikle mali krizler sonrası kamu harcamalarının artan önemi ile birlikte Ar-Ge vergi teşviklerinin etkinliği konusu önem kazanmıştır. Ar-Ge vergi teşviklerinin etkin olmaları halinde yenilik ve ekonomik büyüme kanalı ile bütçe açıklarını azaltıcı etki yapabilecek olmaları nedeniyle de söz konusu kamu politikasının etkinliğine ilişkin araştırmalar önem kazanmıştır.

Ancak kamu politikalarının etkinliğinin ölçülmesi uygulamada oldukça zordur. Katkısallık Ar-Ge politikalarının değerlendirilmesinde sıklıkla kullanılan bir kavramdır ve kamunun Ar-Ge politikalarının firmalar üzerinde yarattığı ilave katkının ölçülmesini sağlamaktadır. Katkısallık, Ar-Ge politikasının etkisinin gözlemlendiği yere bağlı olarak;

1) Girdi Katkısallığı
2) Çıktı Katkısallığı
3) Davranışsal Katkısallık olarak gruplandırılabilir.

Girdi katkısallığında Ar-Ge politikalarının etkisinin firma harcamalarında gözlenmesi beklenirken, çıktı katkısallığında söz konusu etkinin patent, yeni ürün/hizmet gibi yenilik faaliyetinin çıktılarında gözlenmesi beklenmektedir. Davranışsal katkısallıkta ise Ar-Ge politikalarının firmaların davranışlarında değişiklik yaratması beklenmektedir.

Ampirik literatürde, Ar-Ge vergi teşviklerinin etkinliğini araştırmak için çeşitli çalışmalar yapılmıştır.

Bu çalışmada, Ar-Ge vergi teşviklerinin etkinliğine ilişkin olarak son 20 yıla ait ampirik literatüre odaklanılmıştır.

Yirmi yıldan öncesi için Hall ve Van Reenen'in 2000 yılında yapmış oldukları çalışma Ar-Ge vergi teşviklerinin etkinliğini araştıran çalışmaları özetlemektedir. Bu çalışmada, bir dolar Ar-Ge vergi kredisinin özel sektör Ar-Ge yatırımlarını bir dolar artırdığı sonucuna ulaşmaktadır.

Çalışmada ampirik literatür, son yirmi yıl için makro verilerle çalışılan ülkelerarası çalışmalar ve mikro verilerle çalışılan firma düzeyindeki çalışmalar ayrımında başlıca iki kategoride incelenmektedir.

Yapılan çalışmaların sonuçlarının büyük ölçüde farklılık gösterdiği görülmektedir. Literatürdeki çalışmalar sadece veri düzeyine (firma veya ülkeler arası) ve sonuçlara göre değil, aynı zamanda çalışmalarda kullanılan yöntemlere ve etkinliğin araştırıldığı çıktılara göre de farklılaşmaktadır.

Makro veriler kullanılarak yapılan ülkelerarası çalışmalarda genellikle OECD B-endeksi ve devletlerin Ar-Ge vergi indirim tutarı verisi (GTARD) kullanılmaktadır. Bu çalışmalarda genellikle yapısal modeller uygulanmış ve etkinin değerlendirildiği çıktı olarak özel sektör Ar-Ge harcamaları kullanılmıştır. Söz konusu etki çoğu çalışmada hem kısa vade hem de uzun vade için özel sektör Ar-Ge harcamalarının Ar-Ge vergi indirimine esnekliği hesaplanarak incelenmiştir. Çalışmalar esnekliği kısa dönemde 0,1 ile 0,5 arasında bulurken uzun dönemde söz konusu esnekliğin artarak 1'e yaklaştığını göstermektedir.

Literatürdeki firma düzeyindeki çalışmalar incelendiğinde ise söz konusu çalışmaların ülkelerin Ar-Ge vergi teşvik politikaları hakkında daha ayrıntılı bilgi sağlayabilecekleri ve böylece ülkelerin Ar-Ge kamu politikalarını geliştirmelerine olanak tanıyabilecekleri görülmektedir. Ancak söz konusu çalışmalar firma düzeyinde detaylı mikro veri kullanımı gerektirmektedir. Bu verilerde gözlemlenen eksiklik ve/veya kısıtlamalar mikro düzeyde firma verileri ile yapılan çalışmalarda karşılaşılan zorluklardandır. Bu durum aynı zamanda ülkelerin Ar-Ge vergi teşvik politikalarını mikro bir perspektiften karşılaştırmayı da zorlaştırmaktadır.

Firma düzeyindeki çalışmaların sonuçları arasındaki heterojenlik, ülkelerarası çalışmalara kıyasla daha yüksektir. Sonuçlardaki bu farklılığın bir nedeni, firma düzeyindeki çalışmaların ülkelere özgü Ar-Ge vergi programlarına odaklanması ve ülkelerin Ar-Ge vergi politikalarının hedeflenen gruplar (KOBİ'ler veya büyük firmalar gibi), coğrafi uygulama alanları ve Ar-Ge vergi teşviklerinin yapısı (vergi kredisi/vergi indirimi) gibi birçok açıdan farklılıklar göstermesi olabilir.

Firma düzeyindeki çalışmalar söz konusu etkiyi ölçmek için genellikle, ilgili teşvikten yararlanan ve yararlanmayanların durumlarının karşılaştırılmasına dayanan eşleştirme teknikleri ve farkın farkı yöntemlerini kullanmaktadır. Çalışmalar genellikle Ar-Ge vergi teşviklerinin firmaların Ar-Ge harcamaları üzerindeki etkisine odaklanırken, çok az sayıda çalışma patent ve yeni ürün/hizmetler gibi yenilik çıktılarına odaklanmaktadır. Çalışmalar ülkelerarası düzeyde yapılan çalışmalarda olduğu gibi genellikle Ar-Ge vergi teşviklerini özel sektör Ar-Ge harcamalarını artırmada etkili bulmaktadır. Diğer yandan, Ar-Ge vergi teşviklerinin yenilik çıktıları üzerindeki etkisi çoğunlukla sınırlı veya istatistiksel olarak anlamsız bulunmuştur. Bu durum, söz konusu politikanın olumlu etkisinin yenilik faaliyetinin girdi tarafında gözlenebilirken, yenilik sürecinin çıktı tarafında gözlemlenmesinin zor olduğuna ya da daha uzun bir zaman dilimi gerektirdiğine işaret etmektedir.

Ayrıca, firma düzeyindeki çalışmalar Ar-Ge vergi teşviklerinin özel sektör Ar-Ge harcamaları üzerine etkisini incelerken söz konusu etkinin katkısallığını hesaplayan çalışmalar görece sınırlıdır. Bu durumun katkısallık hesaplamaları için gereken verilerdeki kısıtlamalar veya yetersizlikler kaynaklı olabileceği değerlendirilmektedir.

Ar-Ge vergi teşviklerinin katkısallığını hesaplayabilen çalışmalar çarpan çerçevesinde değerlendirildiğinde sonuçların ülkeden ülkeye farklılık göstermekle birlikte genellikle 1 veya 0 ile 1 arasında olduğu görülmektedir.

 Tüm bunlara ek olarak, Ar-Ge vergi teşviklerinin etkinliğine ilişkin ampirik literatür çoğunlukla gelişmiş ülkelere odaklanmaktadır. Oysa söz konusu enstrüman gelişmekte olan ülkelerde de yaygın olarak kullanılmaktadır.

Türkiye için, Ar-Ge hibelerinin etkinliği konusu literatürde sıklıkla araştırılmaktadır (Dünya Bankası, 2019; Gök, 2006; Gürbüz, 2018; Özçelik ve Taymaz, 2008; Tandoğan, 2011). Ar-Ge vergi teşviklerinin etkinliği konusunda ise literatürde eksiklik olduğu görülmektedir. Bu çalışma ile literatürdeki bu boşluğun doldurulması amaçlanmaktadır.

Türkiye için Ar-Ge alanındaki gelişmeler ve Ar-Ge devlet destekleri incelendiğinde, son 50 yılda dünya ekonomisindeki gelişmelere ve büyüme teorilerine paralel olarak özellikle özel sektör Ar-Ge faaliyetlerinin teşvik edilmesi için çeşitli girişimlerde bulunulduğu ancak bu konuda önemli adımların 2000'li yıllarla birlikte atıldığı görülmektedir.

Ar-Ge faaliyetlerini artırma amacına paralel olarak, Ar-Ge harcamaları GSYH'ye oran olarak 2001 yılına kıyasla iki katına çıkmış ve yüzde 1,06 olarak gerçekleşmiştir. Aynı dönemde tam zamanlı Ar-Ge personeli sayısı da yedi kat artarak 182.847'ye ulaşmıştır.

Özel sektörünün Ar-Ge harcamalarını artırmaya yönelik politikaların bir sonucu olarak, 2001-2019 döneminde finansal ve finansal olmayan kuruluşların toplam Ar-Ge harcamaları içindeki payı artmıştır. 2019 yılı itibarıyla toplam Ar-Ge harcamalarının yüzde 50'den fazlasının finansal ve finansal olmayan kuruluşlardan geldiği görülmektedir.

Devlet destekleri tarafında ise 2008-2018 döneminde özel sektör Ar-Ge harcamalarının doğrudan finansmanının özel sektör Ar-Ge harcamaları içerisinde payı neredeyse sabit kalırken, aynı dönemde Ar-Ge vergi teşviklerinin özel sektör Ar-Ge harcamaları içerisinde payı önemli ölçüde artmıştır.

Söz konusu dönemde Ar-Ge vergi teşvikleri, bir politika aracı olarak yaygın bir şekilde kullanılmaya başlanmış ve Ar-Ge vergi teşvik tutarının GSYH'ye oranı dört kattan fazla artış göstermiştir.

Ar-Ge vergi teşvikleri yıllar içerisinde sadece tutar olarak değil, aynı zamanda yararlanıcıların sayısı açısında da artış göstermiştir. 2018 yılı itibarıyla Ar-Ge vergi teşviklerinden yararlananların sayısı 5.000'in üzerindedir.

Türkiye'de son yıllarda sıklıkla kullanılan bir politika aracı olan Ar-Ge vergi teşviklerinin etkinliğinin araştırıldığı bu çalışma ile ampirik literatüre aşağıdaki şekillerde katkı sağlanması amaçlanmaktadır.

Öncelikle, Türkiye'de Ar-Ge vergi teşviklerinin artan kullanımına rağmen, literatür söz konusu teşviklerin etkinliğinin ölçülmesi açısından eksiktir. Çalışma, "Ar-Ge vergi teşvikleri özel sektör Ar-Ge yoğunluğunu artırmada etkilidir" hipotezini test ederek literatürdeki boşluğu doldurmayı hedeflemektedir.

İkinci olarak, Ar-Ge vergi teşvik çarpanı yardımıyla söz konusu teşvikin girdi katkısallığı hesaplanmaktadır.

Son olarak, çalışmada, seçim yanlılığı sorununu ortadan kaldırmak ve Ar-Ge vergi teşviklerinin teşvikten yararlanan firmalar ile yararlanmayan firmaların Ar-Ge yoğunlukları üzerindeki ortalama tedavi etkisini (ATT) tahmin ederek karşılaştırmak için eğilim skoru eşleştirme (PSM) yöntemi kullanılmıştır.

Literatürde Ar-Ge vergi teşviklerinin etkinliğini araştırmak için kullanılan yöntemler;
1) Anket analizleri
2) Zaman ve politika tasarım değişikliğine dayanan yarı deneysel yöntemler
3) Kukla değişken regresyonları ve eşleştirme teknikleri
4) Yapısal ekonometrik modelleme yöntemleri olarak sıralanabilir.

Bununla birlikte, bir politikanın etkisini araştırmak için uygulanacak yöntem çalışmada kullanılacak verinin yapısına bağlıdır.

Türkiye'de Ar-Ge vergi teşvikleri için kullanılabilen veriler değerlendirildiğinde eğilim skoru eşleştirme (PSM) yönteminin en uygun yöntem olduğu değerlendirilmiştir.

Söz konusu yöntem, Ar-Ge vergi teşviklerinin etkisini araştırmak için literatürde yaygın olarak kullanılmaktadır. Literatürde PSM yöntemini kullanan ampirik çalışmalar;
1) Çıktı değişkeni
2) Kontrol değişkenleri
3) Eşleştirme yöntemleri göz önünde bulundurularak gruplandırılmıştır.

Yapılan gruplandırma sonuçlarına göre, çıktı değişkeni olarak firmaların Ar-Ge harcamalarının satışlarına veya cirolarına oranı öne çıkmaktadır.

En sık kullanılan kontrol değişkenleri ise;

1) Firma büyüklüğü

2) Sektör

3) Yaş

4) Dış ticaret durumları

5) Firmaların çok uluslu, yerli veya yabancı ortaklı olması

6) Firmaların bir gruba veya holdinge ait olması

7) Yenilikçi faaliyetler için iş birliği yapılıp yapılmadığı

8) Finansal kısıtlamalar, finansal istikrar, borç göstergeleri gibi firmaların finansal durumlarına ilişkin göstergeler

9) Kalifiye personele sahip olup olmamaları

olarak sıralanabilir.

Eşleştirme yöntemleri olarak ise en yakın komşu eşleştirmesi (nearest-neighbour matching) ve kernel eşleştirmesi sıklıkla kullanılan yöntemlerdir. Ancak, ampirik çalışmalarda genellikle birden fazla eşleştirme yönteminin kullanıldığı dikkat çekmektedir. PSM yönteminde, teşvikten yararlanan (treatment) ve yararlanmayan (control) katılımcıların gözlemlenen özellikleri kullanılarak eğilim skorları hesaplanmakta ve benzer eğilim skoruna sahip katılımcılar tercih edilen eşleştirme yöntemi ile eşleştirilerek ortalama çıktılar karşılaştırılmaktadır. Böylece ortalama çıktılar arasındaki fark teşvikten yararlananlar üzerindeki ortalama etkiyi (ATT) vermektedir.

Eşleştirme yöntemlerinin temel mantığı teşvikten (tedaviden) yararlanan gruba gözlemlenen değişkenlerde (kontrol değişkenleri) en çok benzeyen bir yararlanıcı olmayan (kontrol) grubun yaratılmasıdır. Bu sebeple, eşleştirme sonuçlarının geçerliliği için gözlemlenen özelliklerin (kontrol değişkenlerinin) belirlenmesi aşaması oldukça önemlidir.

Eşleştirme sonuçlarının geçerliliğini etkileyen bir diğer önemli faktör ise uygun eşleştirme yönteminin belirlenmesidir.

Eşleştirme yöntemleri en yakın komşu eşleştirmesi (nearest neighbour matching), kernel eşleştirmesi, tabakalı eşleştirme, caliper ve radius eşleştirmesi olarak sıralanabilir.

Çalışmada literatürde sıklıkla kullanılan kernel eşleştirmesi yöntemi kullanılmıştır. Söz konusu yöntem, kontrol grubundaki katılımcıların ağırlıklı ortalamalarını kullandığından kontrol grubundan daha fazla bilgi kullanılmasına olanak sağlamaktadır.

Çalışmada literatüre paralel olarak en yakın komşu eşleştirmesi yöntemi de kullanılmış ve elde edilen sonuçlar kernel eşleştirmesi sonuçları ile karşılaştırılmıştır. Her iki eşleştirme yönteminden elde edilen sonuçlar birbiri ile tutarlıdır.

Heckman, Ichimura, and Todd (1997, 1998)'a göre eğilim skoru eşleştirme yöntemindeki yanlılığı azaltarak yöntemin tahmin performansını iyileştiren koşullar aşağıdaki gibidir:
1) Tedavi ve kontrol grupları için aynı veri kaynağının kullanılması
2) Geniş bir kontrol değişken setinin kullanılması
3) Tedavi ve kontrol gruplarının teşvik koşullarının ve maruz kaldıkları ekonomik koşulların aynı olması (Cintina & Love, 2019; Khandker et al., 2010).

Yukarıda açıklanan koşullar çalışmada sağlanmıştır.

PSM yöntemi ile teşvikten yararlananlar üzerindeki ortalama etki TÜİK'in;
1)   Yenilik Araştırması Mikro Veri Seti (2018)
2)   Mali ve Mali Olmayan Şirketler Araştırma ve Geliştirme Faaliyetleri Araştırması Mikro Veri Seti (2018)
3)   Dış Ticaret İstatistikleri Mikro Veri Seti (2018)
4)   Sektör Bilançoları İstatistikleri Mikro Veri Seti (2017-2018)

5)   Yıllık İş Kayıtları Çerçevesin (2018) verileri kullanılarak oluşturulan iki farklı veri seti ile hesaplanmıştır.

Yenilik istatistiklerinin derlenmesinde ana kaynak olarak kullanılan Oslo Kılavuzunda yapılan güncellemeler kaynaklı yenilik tanımında ve türlerinde yapılan değişiklik nedeniyle, yenilik araştırması zaman serisi olarak kullanılamamaktadır. Ayrıca, firmaların Ar-Ge vergi teşviklerinden yararlanma durumlarına ilk kez Aralık 2019 tarihinde yayımlanan 2018 yılı Yenilik Araştırması'nda yer verilmiştir.

Bu nedenle, çalışmayı sınırlayan önemli bir faktör, veri setinin yatay kesit olmasıdır. Bu durum uzun vadeli değerlendirmeler yapılmasını engellemekte ve nedensellik incelemelerini zorlaştırmaktadır.

Çalışmada tedavi değişkeni olarak firmaların Ar-Ge vergi teşviklerinden yararlanma durumları kullanılmıştır. Firmaların Ar-Ge vergi teşvikinden yararlanma durumları yenilik araştırmasında iki sonuçlu değişken olarak yer aldığından çalışmada söz konusu değişkene kukla değişken olarak yer verilmiştir. Çalışmanın tedavi değişkeni olan Ar-Ge vergi teşvikleri değişkeni (rd_tax_incentives), 2016-2018 döneminde firmaların Ar-Ge vergi teşviklerinden yararlanması durumunda "1", yararlanmamaları durumunda ise "0" değerini almıştır.

Çalışmada, kontrol değişkenlerinin belirlenmesi için probit model kullanılmıştır. Önemli kontrol değişkenlerinin ihmal edilmesi tahmindeki yanlılığı artırabileceğinden, en benzer özelliklere sahip kontrol grubunun oluşturulabilmesi için geniş bir kontrol değişkeni seti kullanılmıştır.

Çalışmada kullanılan kontrol değişkenleri;
1)   İmalatçı firma (d_manu)
2)   Küçük ölçekli firma (small)
3)   Orta ölçekli firma (medium)
4)   Firma yaşı (age)
5)   Bir gruba veya holdinge ait olma (belongs_to_group)
6)   Yerli firma (domestic_firm)

7) Yenilikçi faaliyetler için iş birliği yapılması (cooperation)

8) Diğer Ar-Ge teşviklerinden yararlanılması (other_subsidy)

9) Uluslararası piyasalara entegrasyon (international_markets)

10) Kalifiye personele sahip olma (qualified_employees)

11) Finansal kısıt (financial_constraints)

12) Finansal kaldıraç (financial_leverage)

13) Karlılık (profitability)'tır.

Çalışmada Ar-Ge vergi teşviklerinin firmaların Ar-Ge yoğunluğu üzerine etkisi incelendiğinden çıktı değişkeni olarak firmaların net Ar-Ge harcamalarının toplam cirolarına oranı kullanılmıştır.

Çalışmada ilk veri setinde 917 firma verisi ile çalışılmıştır. İkinci veri seti finansal kaldıraç ve karlılık kontrol değişkenlerinin eklenmesi ile oluşturulmuş, söz konusu değişkenler 917 firma için sağlanamadığından ikinci veri setinde 617 firma ile çalışılmıştır.

Çalışma sonuçlarına göre, Ar-Ge vergi teşvikleri firmaların Ar-Ge yoğunluğu üzerinde pozitif ve istatistiksel olarak anlamlı bir etkiye sahiptir. Ar-Ge vergi teşviki yararlanıcısı firmalar, Ar-Ge vergi teşvikleri olmasaydı elde edecekleri Ar-Ge yoğunluğuna göre yüzde 7 daha yüksek Ar-Ge yoğunluğuna sahiptir.

Finansal kaldıraç ve karlılık gibi firmaların finansal koşullarının da göz önünde bulundurulduğu ikinci veri seti ile yapılan hesaplamalara göre de Ar-Ge vergi teşvikleri firmaların Ar-Ge yoğunluğuna pozitif etki etmektedir. Ancak firmaların finansal koşulları göz önüne bulundurulduğunda söz konusu etki yüzde 6'ya gerilemektedir.

PSM ile hesaplanan yararlananlar üzerindeki ortalama etkiye göre Ar-Ge vergi teşvikinden yararlanan firmaların Ar-Ge vergi teşvikleri olmadan sahip olacaklarından daha yüksek bir Ar-Ge yoğunluğuna sahip oldukları açıktır.

Bu sonuç, Ar-Ge vergi teşviklerinin firmaların Ar-Ge yoğunluğu üzerinde olumlu bir etkisi olduğunu gösterse de girdi katkısallığını yani vazgeçilen 1 TL'lik vergi karşılığında firmaların Ar-Ge yoğunluklarının ne kadar arttığını yansıtmamaktadır.

Firmanın vazgeçilen her 1 TL'lik vergi geliri karşılığında Ar-Ge yoğunluğundaki artışın ölçüsü olan girdi katkısallığı oranı Ar-Ge vergi teşvik çarpanı olarak yorumlanabilir.

Çarpanın 1'den büyük olması, vazgeçilen her 1 TL'lik vergi gelirinin 1 TL'den fazla Ar-Ge yoğunluğu yarattığı anlamına gelmektedir. Çarpan değerinin 0 ile 1 arasında olması ise, devlet tarafından sağlanan Ar-Ge vergi teşvikinin kısmen firmanın kendi finansmanını azaltmak için kullanıldığı anlamına gelmektedir. Bu durum, devletin Ar-Ge finansmanının özel sektörün Ar-Ge finansmanını kısmen dışladığını göstermektedir. Son olarak, negatif bir çarpan, devletin Ar-Ge finansmanının özel sektör Ar-Ge harcamalarını dışladığını göstermektedir.

Sterlacchini ve Venturini (2019) yaptıkları çalışmada Ar-Ge vergi çarpanını, teşvikten yararlananlar üzerindeki ortalama etkiyi (ATT) teşvikten yararlanan firmaların Ar-Ge yoğunluğunun yüzdesi olarak hesaplamış ve bu değer ile ülkenin geneli için hesaplanan ortalama efektif Ar-Ge vergi kredisi oranını kullanarak Ar-Ge vergi kredisi çarpanı hesaplamışlardır.

Firmaların yararlandıkları Ar-Ge vergi teşvik tutarları TÜİK'in Yenilik Araştırması'nda (2018) yer almadığından, söz konusu verilerde yalnızca firmaların Ar-Ge vergi teşvikinden yararlanıp yararlanmadıkları durumuna yer verildiğinden Ar-Ge vergi teşvik çarpanının hesaplanmasında Sterlacchini ve Venturini (2019) tarafından uygulanan yöntem izlenmiştir.

Çalışmada Ar-Ge vergi teşvikinden yararlanan üzerindeki ortalama etki (ATT) ve teşvikten yararlanan firmaların Ar-Ge yoğunluğu PSM yöntemi ile hesaplanmıştır. Sterlacchini ve Venturini (2019) tarafından uygulanan yöntemin kullanılabilmesi için Türkiye'nin ortalama efektif Ar-Ge vergi teşvik oranına ihtiyaç duyulmaktadır.

TÜİK, Türkiye'nin Ar-Ge vergi teşvik tutarlarını her yıl açıklamaktadır. Buna göre, 2018 yılı itibarıyla Ar-Ge vergi teşviki tutarı 4.599 milyon TL'dir. Ancak, Ar-Ge vergi teşviklerine konu Ar-Ge harcamalarının tutarı (matrah) açıklanmamaktadır.

Söz konusu istatistik çalışma kapsamında TÜİK'ten talep edilmiştir. Ar-Ge vergi teşvikleri kapsamında yapılan Ar-Ge harcamaları (Ar-Ge vergi matrahı) verisi, TÜİK tarafından sadece 2.979 milyon TL'lik Ar-Ge vergi teşviki için sağlanabilmiştir. Veri gizliliği nedeniyle 1.619 milyon TL'lik Ar-Ge vergi teşviki (Gelir vergisi stopajı ve KDV) için vergi matrahı sağlanamamıştır. Bu nedenle ortalama efektif Ar-Ge vergi teşvik oranı, paylaşılan veriler ışığında yüzde 22,2 olarak hesaplanmıştır.

Söz konusu rakamlar kullanılarak 2018 yılı için Türkiye'de Ar-ge vergi teşvik çarpanı ilk modelde 0,4, firmaların finansal durumlarının da dikkate alındığı ikinci modelde ise 0,3 olarak hesaplanmıştır.

Hesaplanan her iki çarpan da 0 ile 1 arasındadır. Buna göre, Türkiye'de Ar-Ge vergi teşvikleri firmalarda ek Ar-Ge yoğunluğu yaratmakla birlikte, söz konusu etki sınırlıdır. Ar-Ge vergi teşvikleri kısmen firmaların kendi Ar-Ge finansmanlarını azaltmak için kullanılmaktadır.

Özetle, Ar-Ge vergi teşvikleri, firmaların Ar-Ge yoğunluğunu olumlu yönde etkilediği için özel sektörünün Ar-Ge yoğunluğunu artırmada etkilidir. Ancak, Ar-Ge vergi teşvik çarpanı değerleri kısmi dışlamayı işaret ettiğinde etkinlikleri sınırlıdır.

Bu durumun ortaya çıkmasında;
• Firmaların Ar-Ge harcaması yapmak yerine vergi yüklerini azaltmaya odaklanmaları
• Bazı firmaların karlılıklarının yetersizliği nedeniyle, Ar-Ge vergi teşviklerinin etkisinin sınırlanması
• Firmaların söz konusu teşvikleri beklenmeyen bir gelir olarak değerlendirmesi ve Ar-Ge politikalarını değiştirememeleri
• Ar-Ge vergi teşviklerinin özellikle finansal sıkıntı yaşayan firmaların Ar-Ge harcamaları için başlangıç finansmanı sağlamaması sebebiyle finansal koşullarını rahatlatmaması gibi faktörlerin etkili olabileceği değerlendirilmektedir.

Bununla birlikte, çalışmanın sonuçlarına aşağıdaki nedenlerle temkinli yaklaşılmalıdır.

Öncelikle, çarpan yaklaşımı özel faydaları dikkate almaktadır. Ar-Ge vergi teşvikleri yardımıyla firmaların artan Ar-Ge yoğunluğu kaynaklı bilgi yayılımları bu yaklaşımda dikkate alınmamaktadır. Bu nedenle, Ar-Ge vergi teşviklerinin özel ve sosyal faydalarının toplamı tahmin edilenden daha yüksek olabilir.

İkinci olarak, firmaların Ar-Ge vergi teşviklerinden yararlanma durumları sadece ikili sonuç değişkeni olarak mevcuttur. Firmalar için Ar-Ge vergi teşviki miktarı olmadığından Ar-Ge vergi teşvik çarpanı ülke geneli Ar-Ge vergi teşviki miktarı ve vergi matrahı kullanılarak hesaplanmıştır. Ar-Ge vergi teşvik verilerinin iyileştirilmesi yoluyla, gelecekteki çalışmalarda firma düzeyinde Ar-Ge vergi teşvik miktar verileri kullanılarak çarpan hesaplaması iyileştirilebilir.

Son olarak, çalışmada Ar-Ge vergi teşviklerinin etkisi, veri kısıtları nedeniyle sadece kısa dönem için hesaplanabilmiştir. Literatürdeki çalışmaların çoğu söz konusu teşviklerin etkisinin uzun vadede arttığını gösterdiğinden, etki uzun vadede daha yüksek olabilir.

Bu alandaki çalışmalar Ar-Ge politikalarının bir bütün olarak değerlendirilmesinin faydalı olduğunu göstermektedir. Bu nedenle Ar-Ge alanını etkileyen politikaların tutarlılığı önemlidir. Bu anlamda, firmaların finansal koşullarını ve öngörülebilirliğini iyileştiren bir politika seti (sadece doğrudan sübvansiyonlar değil, kredi koşulları ve ekonomi politikalarının öngörülebilirliği gibi diğer faktörler) ve vergi politikası Ar-Ge vergi teşviklerinin etkinliğini artırabilir.

Ancak çalışma sonuçları, Ar-Ge vergi teşvik politikasının değerlendirilmesinden ziyade, 2016-2018 dönemi için Ar-Ge vergi teşvikleri ve özel sektörün Ar-Ge yoğunluğuna dayalı çıkarımlar olarak değerlendirilebilir. Söz konusu politikanın değerlendirilmesi, Ar-Ge vergi teşviklerinin özel sektör Ar-Ge yoğunluğu üzerindeki etkisinin hesaplanmasının ötesinde daha geniş bir bakış açısı gerektirebilir. Bu

kapsamda, daha sonraki çalışmalarda çıktı katkısallığı çerçevesinde de Ar-Ge vergi teşviklerinin etkinliğinin incelenmesi faydalı olabilir.

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<u>TEZİN ADI /</u> <u>TITLE OF THE THESIS</u> (**İngilizce** / English): Effectiveness of R&D Tax Incentives in Turkey

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