ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

THE IMPACT OF INCENTIVES AND SUBSIDIES ON FIRMS' INNOVATION PERFORMANCE IN TURKEY

M.Sc. THESIS

Ahmet İSKENDER

Department of Management Engineering

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ISTANBUL TEKNİK ÜNİVERSİTESİ ★ LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ

TÜRKİYE'DE TEŞVİK VE SÜBVANSİYONLARIN FİRMALARIN YENİLİK PERFORMANSI ÜZERİNDEKİ ETKİSİ

YÜKSEK LİSANS TEZİ

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Ahmet-İskender, a M.Sc. student of İTU Graduate School student ID 507221015, successfully defended the thesis/dissertation entitled "THE IMPACT OF INCENTIVES AND SUBSIDIES ON FIRMS' INNOVATION PERFORMANCE IN TURKEY", which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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To my spouse and children,

FOREWORD

As I complete this work, I wish to express my gratitude to everyone who has been by my side. With a heart full of appreciation, I am attempting to push the boundaries of words as I write this preface.

First and foremost, I would like to thank my greatest supporter and most cherished companion, my spouse, for their unwavering love and patience. I am grateful for your constant presence by my side.

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This thesis has been the result of the contributions and support of many individuals. I hope this work adequately expresses my gratitude for their efforts.

With love and gratitude,

February 2025

Ahmet İSKENDER
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TABLE OF CONTENTS

Page

ABBREVIATIONS

AGE	**:** Age of The Company
CSIZE	**:** Company Size by Number of Employees
EMPX	**:** Number of Permanent Full-Time Workers
GDP	**:** Gross Domestic Product
GERD	**:** Gross Domestic Expenditure on R&D
INOV	**:** Company Innovation Status
KOSGEB	**:** Small and Medium Enterprises Development Organization
LPM	**:** Linear Probability Model
NaN	**:** Missing Value
OLS	**:** Ordinary Least Squares
RD	**:** Total Annual R&D Expenses of The Company
SMEs	**:** Small and Medium Size Enterprises
SUBS	**:** Company Threatment Status
SVM	**:** Support Vector Machine
TSALE	**:** Company’s Annual Total Sales
VAT	**:** Value Added Tax
WBES	**:** World Bank Enterprise Survey

SYMBOLS

i	: Company
t	: Time
X	: Independent variable
Y	: Dependent variable, company innovation status
Z	: Independent variable, company incentive status
β0	: Intercept
β1, β2, β3, β4, β5, β6, β7	: Slope coefficient
ε	: Error term

LIST OF TABLES

Page

LIST OF FIGURES

THE IMPACT OF INVENTIONS AND SUBSIDIES ON FIRMS' INNOVATION PERFORMANCE IN TURKEY

SUMMARY

Countries' economic growth and global competitiveness are largely dependent on their innovation capabilities. Innovation adds dynamism to economies through the development of new products, processes, and services, playing a critical role in achieving sustainable development goals. Companies can quickly adapt to market conditions and become competitive internationally through innovation. In this process, government incentives encourage investment in R&D and innovation activities, accelerating technological progress and enhancing economic growth potential. Understanding the effects of government support on firm innovation performance allows policymakers to design efficient and effective support mechanisms.

Governments use various policy tools to encourage innovation, including direct financial support, tax reductions, grants, and subsidies. These supports are vital, especially for SMEs with limited access to financial resources. There is ongoing debate in academic and political circles about whether government incentives actually enhance firms' innovation capacities. The effectiveness of incentives can vary depending on the industry, company size, and technology intensity. Therefore, a thorough analysis of the real effects of government supports is crucial for implementing these policies more accurately and effectively.

The aim of this thesis is to comprehensively examine the impact of government incentives and subsidies on firm innovation performance in Turkey. The research seeks to provide a clear understanding of the effectiveness of these policies by evaluating the effects of various incentive mechanisms on firms' innovative outputs. The lack of a full understanding of the outcomes and performance of incentives and subsidies constitutes the main problem area of this study. In this context, the thesis aims to offer recommendations to policymakers for making incentive policies in Turkey more strategic and targeted. By providing valuable insights that will enable the more effective design and implementation of support mechanisms, this study aims to contribute to both academic research and policy development.

In this study, a comprehensive literature review was conducted, covering the impact of innovation on economic progress, various forms of government incentives, and methods for measuring innovation performance. The historical developments related to the research topic were examined in detail, and existing academic studies on the factors influencing innovation performance were analyzed. The literature review revealed that innovation performance is shaped by multiple variables and highlighted the importance of understanding the complex nature of these interactions. This extensive review serves as a foundation for developing the theoretical and methodological framework of the thesis.

Based on the literature review, a model suitable for the research topic and dataset was developed. In this model, the presence of innovation in firms was considered as the

dependent variable. Frequently mentioned firm characteristics in the literature were selected as control variables, while government incentives and subsidies were identified as the main independent variable. The dataset used in the analysis comes from the World Bank Enterprise Survey (WBES), which covers more than 150 countries. These surveys provide insights into various aspects of the business environment, including access to finance, corruption, infrastructure, competition, and firm performance factors that are not typically found in financial reports.

The developed model was evaluated using the Logit regression analysis technique in Python. Model fit and statistical significance were examined using diagnostic measures such as Pseudo R-squared, Log-Likelihood, LL-Null, and the LLR p-value. The results indicate that the independent variables have a statistically significant effect on the dependent variable.

According to the findings, the most significant impact on innovation performance comes from the ratio of R&D expenditures to total revenue. The effect of firm size is minimal. Subsidies and export rates have been observed to positively influence the probability of innovation, aligning with the existing literature. The effect of firm age, although very low, is positive and thus considered statistically significant.

In the Logit regression model, calculating the actual probability requires considering the simultaneous effects of all variables. Therefore, the survey data of firms were applied to the model using mean and median values to estimate the probability of innovation in Turkey over the years, based on whether firms received subsidies. The calculations indicate an increase in innovation probability between 2002 and 2005, followed by a continuous decline after 2005. While outliers elevated overall performance in all years, the median-based calculation for 2019 shows that the innovation probability remained at only 5% for non-subsidized firms and 19% for subsidized firms.

To test the developed model, sample firms were selected from one of Turkey's leading conglomerates, and their annual data for the selected variables were used to calculate innovation probabilities. The obtained probabilities were then compared with the results derived from the mean and median values of firms across Turkey. The test confirmed that the model's results align with actual data. By testing this method, it was assessed that the model could be used to evaluate a company applying for subsidies, estimate its probability of innovation before receiving support, and determine its position relative to the national average.

For international comparisons, the 48 countries surveyed in the most recent 2019 survey were ranked based on their Gross Domestic Expenditure on R&D (GERD) as a percentage of GDP. According to this ranking, six countries with a higher GERD/GDP ratio than Turkey and seven countries with a lower ratio were selected. The model was applied to these selected countries, and the effects and consistency of all variables were analyzed. The marginal effects of the variables were calculated and compared. Subsequently, the model was run using the mean and median values of surveyed firms in each country, and the average innovation performance was determined based on whether firms received subsidies. These results were then compared with the findings for Turkey.

In this study, the performance results of firms from 13 selected countries were compared. According to these results, Turkey has the lowest probability of innovation in the absence of subsidies. While subsidies have a positive effect in Turkey, the innovation performance increases only to 19% when subsidies are provided, indicating a limited impact of financial support.

The country with the strongest effect of subsidies is Slovenia. In all countries, the model is statistically significant, and the effect of subsidies is positive. Similar to Turkey, the most influential variable on innovation performance in the selected countries has been the proportion of R&D expenditures. The effect of the number of employees is close to zero in all countries. The effect of firm age is negative in five countries, indicating that as firms grow older, their innovation performance decreases in these countries. Overall, the impact of firm age on innovation is minimal across all countries. The effect of exports is positive in all countries except for three.

Limitations; The World Bank conducts Enterprise Surveys in over 150 countries. However, surveys are not conducted in the same year for all countries. This creates limitations in accessing data for specific years, such as 2019, for countries like the USA, China, OECD averages, Japan, and Korea, which constrains the scope of the research. While the literature highlights regional differences, dividing the dataset by regions results in an insufficient number of incentivized firms for meaningful analysis. Since some questions were not asked every year, they lacked continuity, and certain variables mentioned in the literature could not be included in the model.

TÜRKİYE'DE TEŞVİK VE SÜBVANSİYONLARIN FİRMALARIN YENİLİK PERFORMANSI ÜZERİNDEKİ ETKİSİ

ÖZET

Ülkelerin ekonomik büyümesi ve küresel rekabet gücü, yenilik yeteneklerine büyük ölçüde bağlıdır. Yenilikçilik, yeni ürünler, süreçler ve hizmetler geliştirerek ekonomilere dinamizm katar ve sürdürülebilir kalkınma hedeflerine ulaşmada önemli bir role sahiptir. Şirketler, yenilik sayesinde piyasa koşullarına hızla adapte olabilir ve uluslararası arenada rekabet edebilir hale gelir. Bu süreçte, hükümetlerin sağladığı teşvikler, Ar-Ge ve yenilik faaliyetlerine yatırım yapılmasını teşvik ederek teknolojik ilerlemeyi hızlandırır ve ekonomik büyüme potansiyelini artırır. Hükümet desteklerinin, firma yenilik performansı üzerindeki etkilerini anlamak, politika yapıcılar için verimli ve etkili destek mekanizmaları tasarlamalarına olanak tanır.

Hükümetler, yenilikçiliği teşvik etmek amacıyla çeşitli politika araçları kullanır; bunlar arasında doğrudan finansal destekler, vergi indirimleri, hibeler ve sübvansiyonlar yer alır. Özellikle finansal kaynaklara erişimi sınırlı olan KOBİ'ler için bu destekler hayati öneme sahiptir. Akademik ve politik alanlarda, hükümet teşviklerinin firmaların yenilik kapasitelerini artırıp artırmadığı konusunda tartışmalar devam etmektedir. Teşviklerin etkinliği, endüstriye, şirket büyüklüğüne ve teknoloji yoğunluğuna göre değişiklik gösterebilir. Bu nedenle, hükümet desteklerinin gerçek etkilerini derinlemesine analiz etmek, bu politikaların daha doğru ve etkili bir şekilde uygulanmasını sağlayabilir.

Bu tezin amacı, Türkiye'deki hükümet teşvik ve sübvansiyonlarının firma yenilik performansına olan etkilerini kapsamlı bir şekilde incelemektir. Araştırma, desteklerin çeşitli teşvik mekanizmaları aracılığıyla firmaların yenilikçi çıktıları üzerindeki etkilerini değerlendirerek, bu politikaların etkinliğine dair net bir anlayış sunmayı hedeflemektedir. Teşvik ve sübvansiyonların sonuç ve performansının tam olarak anlaşılamaması, bu çalışmanın temel problem alanını oluşturmaktadır. Bu bağlamda, tez, Türkiye'deki teşvik politikalarını daha stratejik ve hedef odaklı hale getirme yönünde politika yapıcılara önerilerde bulunmayı amaçlamaktadır. Bu çalışma, desteklerin daha etkili bir şekilde tasarlanması ve uygulanmasına olanak tanıyacak değerli bilgiler sağlayarak hem akademik hem de politika alanlarında katkıda bulunmayı hedeflemektedir.

Bu çalışmada öncelikle, yenilikçiliğin ekonomik ilerleme üzerindeki etkisini, devletin sunduğu çeşitli teşvik biçimlerini ve yenilik performansının ölçüm yöntemlerini içeren geniş kapsamlı bir literatür taraması gerçekleştirilmiştir. Araştırma konusuyla ilgili tarihsel gelişimler detaylı bir şekilde incelenmiş, yenilik performansını etkileyen çeşitli faktörler üzerine mevcut akademik çalışmalar analiz edilmiştir. Literatür taraması sonucunda, yenilik performansının birçok değişkene bağlı olarak şekillendiği ve bu etkileşimlerin karmaşık doğasının anlaşılmasının önemi ortaya çıkmıştır. Bu kapsamlı inceleme, tezin temelini oluşturan teorik ve metodolojik çerçevenin geliştirilmesine zemin hazırlamaktadır.

Yapılan literatür taramasına dayanarak, araştırma konusuna ve veri setimize uygun bir model oluşturulmuştur. Bu modelde bağımlı değişken olarak firmalarda inovasyon varlığı ele alınmıştır. Kontrol değişkenleri olarak literatürde sıklıkla değinilen firma özellikleri seçilirken, ana bağımsız değişken olarak teşvik ve sübvansiyonlar belirlenmiştir. Analizde kullanılan veri seti, Dünya Bankası'nın 150'den fazla ülkede gerçekleştirdiği Enterprise Survey (WBES) verileridir. Bu anketler, finansal raporlarda bulunmayan, finansa erişim, yolsuzluk, altyapı, rekabet ve performans gibi iş ortamıyla ilgili çeşitli konuları kapsar.

Oluşturulan model, Python programında Logit regresyon analizi tekniği ile değerlendirilmiş ve model uyumu ile istatistiksel anlamlılık Pseudo R-kare, Log-Olasılık, LL-Null ve LLR p-değeri gibi tanı ölçütleri ile incelenmiştir. Bağımsız değişkenlerin, bağımlı değişken üzerinde istatistiksel olarak anlamlı etkileri olduğu tespit edilmiştir.

Elde edilen bulgulara göre, inovasyon performansı üzerinde en belirgin etkiyi Ar-Ge harcamalarının toplam hasılata oranı göstermiştir. Firma büyüklüğünün etkisi çok azdır. Desteklerin ve ihracat oranının inovasyon olasılığını pozitif yönde etkilediği gözlemlenmiştir ve bu bulgular literatürle tutarlılık göstermektedir. Firma yaşının etkisi ise çok düşük fakat pozitif olduğundan anlamlı olarak değerlendirilmiştir.

Logit regresyon modelinde gerçek olasılığı hesaplamak için tüm değişkenlerin etkisinin aynı anda kullanılması gerektiğinden, ankete katılan firma verilerinin mean ve median değerlerine göre modele uygulanarak yıllara göre Türkiye'deki firmaların teşvik alıp almama durumuna göre inovasyon olasılığı hesaplanmıştır. Yapılan hesaplamalara göre 2002-2005 seneleri arasında artış, 2005 sonrasında ise sürekli azalma görülmüştür. Tüm yıllarda uç değerler performansı yukarı taşısa da 2019 verilerinin median değerlerine göre yapılan hesapta teşvik edilmeyen firmalarda performans %5 seviyesinde, teşvik alan firmalarda ise %19'da kalmıştır.

Oluşturulan modeli test etmek için, Türkiye'nin önde gelen holdinglerinden birinden örnek firmalar seçilerek, bu firmaların seçilen değişkenleri ile ilgili yıllık verilere göre inovasyon olasılıkları hesaplanmıştır. Elde edilen olasılıklar, Türkiye geneli firma verilerinin mean ve median değerleri ile yapılan hesap sonuçları ile karşılaştırılarak değerlendirilmiştir. Yapılan test ile model sonuçlarının gerçek veriler ile uyumlu olduğu görülmüştür. Bu yöntemin test edilmesiyle, teşvik başvurusunda bulunan bir şirket için modelin nasıl çalıştırılacağı ve firmanın teşvik almadan önce inovasyon yapma olasılığının yanı sıra ülke ortalamasına göre durumunun belirlenmesinin mümkün olabileceği değerlendirilmiştir.

Uluslararası ülkelerle karşılaştırma yapmak için, en son anket yapılan 2019 yılında anket yapılan 48 ülke brüt Ar-Ge harcamalarının GSMH'ya oranına göre sıralanmıştır. Bu sıralamaya göre harcama oranı Türkiye'den yüksek altı ülke, Türkiye'den düşük yedi ülke belirlenmiştir. Seçilen bu ülkelerin verileri ile model çalıştırılmış, tüm değişkenlerin etkileri ve tutarlılığı hesaplanmıştır. Değişkenlerin marjinal etkileri hesaplanmış ve karşılaştırılmıştır. Daha sonra ülkelerde ankete katılan firma verilerinin mean ve median değerlerine göre model çalıştırılmış ve ülkelerin teşvik alıp almama durumuna göre ortalama yenilik performansı hesaplanmıştır. Bu sonuçlar Türkiye için yapılan hesap sonuçları ile karşılaştırılmıştır.

Bu çalışmada, seçilen 13 ülkenin firmalarının performans sonuçlarını kıyaslamıştır. Bu sonuçlara göre teşvik edilmemesi halinde inovasyon yapma olasılığının en düşük olduğu ülke Türkiye'dir. Türkiye'de teşviklerin etkisi pozitiftir fakat teşvik verilmesi halinde performans %19'a çıkmakta ve teşvik etkisi sınırlı kalmaktadır.

Teşviklerin etkisinin en güçlü olduğu ülke ise Slovenya'dır. Modelin istatiksel olarak anlamlı oldu tüm ülkelerde teşviklerin etkisi pozitiftir. Seçilen ülkelerde inovasyon performansını etkileyen en güçlü değişken Türkiye'de olduğu gibi oransal Ar-Ge harcamaları olmuştur. Çalışan sayısının etkisi ise tüm ülkelerde sıfıra yakındır. Firma yaşının etkisi beş ülkede negatiftir, bu ülkelerde firma büyüdükçe inovasyon performansı azalmaktadır. Genel olarak firma yaşının inovasyona etkisi tüm ülkelerde çok azdır. İhracatın etkisi ise üç ülke hariç pozitiftir.

Kısıtlar; Dünya Bankası, 150'den fazla ülkede İşletme Anketi yapmaktadır, ancak her ülkede aynı yıl için anket yapılmamıştır. Bu durum, 2019 gibi belirli bir yıl için ABD, Çin, OECD ortalaması, Japonya ve Kore gibi ülkelerin verilerini bulmada eksikliklere sebep olmakta ve araştırmamı kısıtlamaktadır. Ayrıca, literatür bölgesel farklılıkları belirtse de veri seti bölgelere ayrıldığında, teşvik alan firmaların sayısı analiz edilemeyecek düzeylere düşmektedir. Soruların bazıları her sene sorulmadığından süreklilik arz etmemiştir ve literatürde geçen bazı değişkenler modele eklenememiştir.

1. INTRODUCTION

Countries' economic growth and global competitiveness largely depend on their innovation capabilities. Innovation adds dynamism to economic structures through the development of new and improved products, processes, and services, playing a critical role in achieving sustainable development goals. Additionally, through innovation, companies can quickly adapt to changing market conditions and enhance their ability to compete in the international market. Government incentives in this process encourage firms to invest in R&D and innovation activities, accelerating technological advancements and increasing economic growth potential (Romer, 1990). In this context, examining the effects of government support on firm innovation performance is of strategic importance for policymakers, as this can lead to the design of more effective and efficient support mechanisms.

Governments use various policy tools to encourage innovation. These tools include direct financial support, tax incentives, grants, and subsidies. Direct financial support is generally used to finance specific research and development projects, while tax incentives allow companies to deduct their R&D expenditures from their tax burdens (Howell, 2021). Grants and subsidies are critically important, especially for startups and small to medium-sized enterprises (SMEs) with limited access to financial resources. Additionally, governments provide support targeted at specific industries or regions through various sectoral and regional incentive programs, strengthening local innovation ecosystems and accelerating technological transformation.

There is an ongoing debate in academic and political circles about the effects of government incentives on firm innovation performance. While various studies have shown that government supports enhance firms' research and development activities and strengthen their innovation capacities, some studies indicate that these incentives do not create the expected impact or even lead to the misallocation of resources (Jones & Williams, 1998). These conflicting findings suggest that the effectiveness of incentives can vary depending on factors such as industry, company size, and technology intensity. Therefore, understanding the real impact of government supports on firm innovation performance is critical for designing and implementing these incentives more accurately and effectively (Guellec, 2003).

The primary goal of this study is to conduct an in-depth analysis of the effects of government incentives on firm innovation performance. The research aims to evaluate how various incentive mechanisms affect firms' innovative outputs, thereby providing a clearer understanding of the effectiveness of these incentives (Hottenrott, 2012; Müller, 2018). Through analyses conducted on firms from different sectors and of different sizes, this study will examine how incentives influence firms' R&D investments, product innovations, and process improvements. The outcomes of this study will provide policymakers with data-backed recommendations, contributing to making government supports more strategic and targeted (Zhang, 2017).

1.1 Purpose of Thesis

This thesis aims to provide a framework for understanding and evaluating the impact of government incentives and subsidies on firm innovation performance in Turkey. The framework intends to offer an analytical foundation to assess the effectiveness of incentive programs and their impact at the firm level, contributing to a deeper knowledge and understanding of government incentives. The thesis aims to contribute both academically and in the policymaking realm, providing recommendations to enhance and optimize Turkey's government incentive policies.

1.1.1 Problem definition

The incentives and subsidies provided to support firm’s activities in Turkey have the potential to enhance firms' innovation capabilities, gain competitive advantages, and support economic growth. However, the effectiveness of these incentives, their application processes, distribution, and outcomes are not fully understood.

1.1.2 Research question

What is the impact of incentives and subsidies on firms' innovation performance in Turkey?

1.2 Hypothesis

Main Hypotesis:

H0(main); Public supports received by firms have an positive impact on firm innovation performance.

Sub-Hypothesis:

H0a; The increase in the ratio of R&D expenditures to annual revenue positively the likelihood of a firm innovating.

H0b; Firm size does not affect the likelihood of a firm innovating.

H0c; As the firm age increases, the likelihood of innovations positively affected.

H0d; The increase in the firm's export ratio, positively affects the likelihood of innovation.

2. LITERATURE REVIEW

2.1 Definitions and Historical Background

2.1.1 Role of innovation in development

The impact of research and development (R&D) and technological advancement on economic growth and national development is a widely studied topic, offering insights into how innovation drives progress. This literature review synthesizes findings from both Turkish and international sources, demonstrating the pivotal role of innovation and R&D in fostering economic expansion and development.

Globally, the consensus among economists and scholars is that R&D and technological innovation are key drivers of economic growth. A seminal work by Romer, P. M. (1990) introduced the idea that technological innovation, fueled by R&D activities, is a crucial element of endogenous growth theory. This theory posits that economic growth is primarily generated from within an economy through technological progress, rather than from external factors. Romer's model emphasizes the importance of knowledge creation and its spillover effects, which can lead to sustainable growth.

Research and development (R&D) activities and technological advancements play a pivotal role in a country's economic growth and social development. R&D activities serve as a significant driver in various areas such as the development of new products and services, improvement of existing processes, and the discovery of innovative solutions to gain competitive advantages (Mowery & Rosenberg, 1998). Moreover, technological advancements have been associated with economic indicators such as increased productivity, income growth, and enhanced welfare (Acemoglu & Robinson, 2012).

The impact of R&D and technological advancements on economic growth reflects a long-term and comprehensive process. Studies have shown that R&D expenditures and technological innovations contribute to enhancing countries' economic growth performance (Aghion & Howitt, 1998). It is observed that R&D-intensive sectors generally exhibit higher growth rates and achieve a more competitive position (Griliches, 1998).

Promoting R&D and technological development holds strategic importance in reducing economic disparities among countries and fostering sustainable development (Romer, 1990). Hence, many countries employ various policy measures to encourage R&D and technological development. Policy instruments such as tax incentives, R&D grants, university-industry collaborations, and science parks are utilized to support R&D and technological development efforts (Hall & Khan, 2003).

Government incentives, such as R&D subsidies and tax credits, have been found to have a positive impact on innovation performance. Almus (2003) and Bronzini (2014) both found that public R&D subsidies led to an increase in innovation activities and patent applications. Lerner (2007) and Guellec (2003) further support this, with Lerner noting that long-term incentives are associated with more heavily cited patents, and Guellec finding that direct government funding and R&D tax incentives have a positive effect on business-financed R&D. However, Bronzini (2011) found no significant increase in investment spending as a result of an investment subsidy program, suggesting that the effectiveness of incentives may vary. Wörter (2010) added that "our results indicate that innovation and competition tend to reinforce each other (positively or negatively), and it is difficult for firms to change a chosen path." Howell (2015) and Feldman (2006) both found that R&D subsidies can have a positive impact on subsequent venture capital, patenting, and revenue, particularly for financially constrained firms.

In a study conducted in Norway, Nilsen et al. (2018) concluded that "since government funding and therefore the sustainability of the welfare states both in Norway and most industrialized countries are under severe pressure in the years to come, further economic growth is likely to depend increasingly on R&D investments and innovation activities in the industries" (p. 26).

In the context of Turkey, a study by Acaravcı, A. et al. (2019) highlights the significant positive impact of R&D expenditures on economic growth. By examining the period from 1990 to 2014, their research demonstrates that increases in R&D investment are strongly correlated with economic expansion, suggesting that policies aimed at enhancing R&D activities can play a vital role in Turkey's development strategy.

Further evidence supporting the relationship between technological innovation and economic performance comes from the OECD, which consistently finds that countries investing heavily in R&D and innovation tend to experience higher rates of economic growth and development. The OECD's Science, Technology and Industry Scoreboard provides comparative data showing that countries with robust innovation policies and substantial R&D investments, such as South Korea and Israel, also enjoy strong economic performance and competitive advantages in global markets.

Moreover, the role of technological advancement in national development extends beyond economic metrics. As Naudé, (2013) argue, technology not only contributes to GDP growth but also to improving the quality of life, enhancing social welfare, and addressing environmental challenges. Their analysis suggests that technological innovation can lead to more efficient resource use, better health outcomes, and more inclusive economic development.

2.1.2 Government incentives and subsidies

The financial and non-financial state incentives and subsidies in Turkey are designed to increase the country's innovation capacity, strengthen competitiveness,and support economic growth. These mechanisms aim to facilitate research and development activities, especially for firms and startups in technology-intensive sectors, helping them develop new products and services.

Financial incentives; typically take the form of tax reductions, tax deductions, insurance premium support for personnel, and direct financial aids such as grants and subsidies.

TÜBİTAK (The Scientific and Technological Research Council of Turkey) Supports; TÜBİTAK offers various support programs for R&D projects. These supports are provided through programs like the 1501 - Technology and Innovation Support Programs Directorate and 1507 - SME R&D Start-up Support Program, offering financial assistance that covers a portion of the project costs.

KOSGEB (Small and Medium Enterprises Development Organization) Supports; KOSGEB offers various grant and incentive programs for small and medium-sized enterprises, including support for international market research, business development programs, and R&D, technological development, and innovation support programs. For example, companies looking to export or increase their exports can receive 100%

support (partially grants and interest-free loans), covering expenses such as personnel, software, and hardware.

Ministry of Industry and Technology Supports; This ministry provides incentives such as investment incentive certificates and tax exemptions. Additionally, it offers tax advantages for regional management centers and liaison offices. Other supports from the ministry include corporate tax exemption, stamp duty exemption, and income tax withholding support.

Ministry of Trade Supports; The Ministry of Trade provides various incentives to support exports. These include support for overseas units, promotional activities, and international trademark registration. It also offers financial support for participation in both domestic and international fairs.

Sectoral Incentives; Sectoral incentives in Turkey are designed to support specific industries or sectors. For example, there are special incentives for strategic sectors such as technology, renewable energy, automotive, and tourism. These incentives can be offered for various purposes such as R&D activities, expanding production capacity, and increasing exports, and they usually come in the form of tax reductions, credit supports, or direct grants.

Investment Incentives; Looking at Turkey's investment incentive system as a whole, these incentives are provided to encourage investors to make capital investments in the country. These incentives typically include financial advantages such as tax exemptions, VAT exceptions, customs duty exemptions, and interest supports. Particularly for foreign investors, incentives are also provided that facilitate investment processes and reduce costs.

Non-financial incentives; include services such as training, mentoring, consultancy, and promotion of business activities in national and international markets.

Technology Development Zones (Technoparks); Technoparks offer office space, infrastructure, and administrative support to R&D-focused firms and startups, aiding in the commercialization of innovative products and services. Firms located in technoparks also benefit from certain tax advantages and incentives.

R&D Centers; Certified by the Ministry of Industry and Technology, R&D centers provide an environment for firms to develop their R&D projects. Activities conducted in these centers are eligible for various tax deductions and incentives.

These incentives demonstrate Turkey's commitment to supporting its R&D and innovation ecosystem. The financial and non-financial supports available for firms and researchers are expected to strengthen the country's innovation and technological development. However, the effectiveness and applicability of these incentives should be continuously monitored and evaluated to ensure they meet their objectives.

2.2 Financial Incentives

Research and Development (R&D) financial incentives are pivotal in fostering innovation, enhancing competitiveness, and driving economic growth across various industries worldwide. This literature review delves into the role and effectiveness of Government financial supports, drawing from a range of academic sources and studies.

A study by Hall and Van Reenen (2000) provides a comprehensive analysis of how tax policies and direct subsidies for R&D can significantly influence the amount of innovation within an economy. They conclude that both tax incentives and direct subsidies are effective tools for stimulating R&D activities, though their impact varies across different industries and countries. This study underscores the importance of well-designed fiscal policies in promoting R&D investments.

In exploring the specific context of developing countries, Görg and Strobl (2007) highlight the challenges and opportunities associated with implementing R&D subsidies. Their findings suggest that while R&D subsidies can lead to increased innovation activities, their effectiveness is contingent upon the existence of a supportive institutional framework and the ability of firms to absorb and utilize new knowledge.

The dynamic relationship between R&D tax incentives and private R&D expenditure is further explored by Czarnitzki, D. et al. (2011). Their empirical analysis across OECD countries reveals that R&D tax incentives play a crucial role in leveraging private R&D spending, particularly in sectors characterized by high levels of technological advancement.

Moreover, a recent study by Akçomak and Erdil (2016) examines the long-term effects of R&D incentives on economic performance in Turkey. The research indicates that R&D incentives not only boost innovation activities but also contribute to the overall productivity and competitiveness of the Turkish economy.

In summary, the literature on financial incentives consistently emphasizes their critical role in stimulating innovation and economic growth. Effective implementation of these incentives, tailored to the specific needs of industries and economies, can significantly enhance the innovative capacity and competitiveness of firms. This review underscores the necessity for policymakers to carefully design and evaluate incentives to maximize their impact on innovation and economic development.

2.3 Non-Financial Incentives

Non-financial incentives are crucial for fostering an environment that promotes innovation and technological progress within industries and research institutions. These incentives include but are not limited to, regulatory support, access to research infrastructure, networking opportunities, training, and development programs.

One study by Bozeman and Link (2016) emphasizes the role of public policies in creating an ecosystem conducive to R&D activities. They argue that non-financial incentives such as regulatory environment, intellectual property rights protection, and establishment of research parks significantly contribute to stimulating innovation. The research suggests that such policy tools can be as impactful as direct financial support in encouraging firms and researchers to engage in R&D.

Another aspect of non-financial incentives is the provision of infrastructure and resources for research. According to Siegel, D.S. et al. (2003), access to state-of-the-art laboratories, research facilities, and technological resources is critical for the advancement of scientific and technological research. Their study highlights how universities and public research institutions play a pivotal role in providing these resources, thereby facilitating the commercialization of research and encouraging collaborative projects between academia and industry.

Networking and collaboration opportunities also stand out as significant non-financial incentives. Cunningham, J. A. et al. (2014) delve into how networking between researchers, industry professionals, and policymakers can enhance the R&D landscape by fostering collaboration, knowledge exchange, and the development of innovative solutions to complex problems. Their research underlines the importance of conferences, workshops, and industry-academia partnerships in creating a vibrant R&D ecosystem.

Furthermore, training and development programs are identified as key non-financial incentives that equip researchers and innovators with the necessary skills and knowledge to pursue cutting-edge research. Wright, M. et al. (2007) explore the impact of such programs on the capabilities of researchers, particularly in the early stages of their careers. They find that specialized training programs in project management, entrepreneurship, and technology commercialization can significantly enhance the research output and innovation potential of individuals and teams.

2.4 Word Cloud

This word cloud displays the fundamental concepts and terms frequently encountered during a literature review on the topic of a thesis about the impact of Government incentives and subsidies on firm's innovative performance. Based on the word cloud, some of the prominent themes and areas in my research can be interpreted as follows (Figure 2.1).

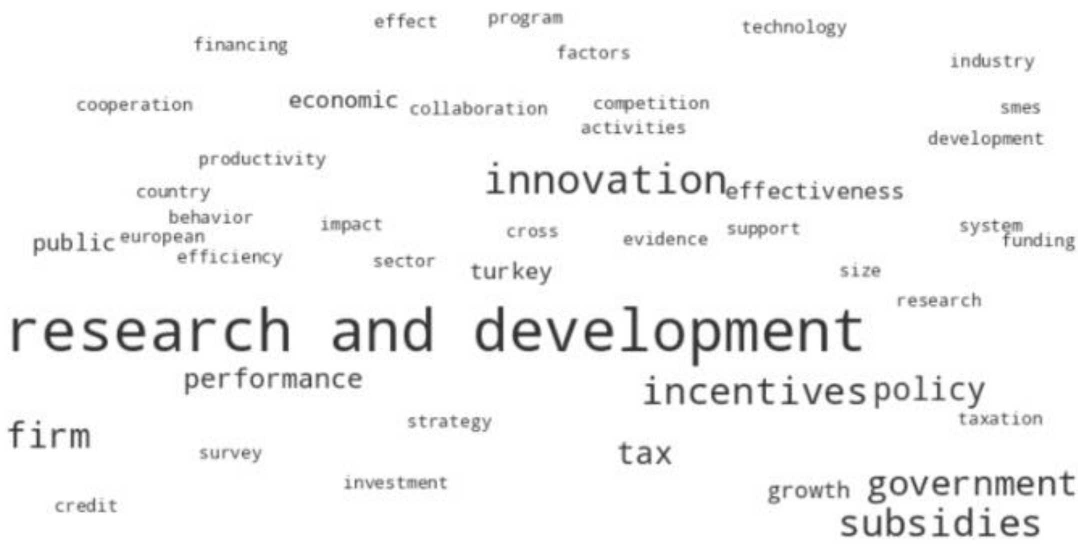


Figure 2.1 : Word cloud.

Research and Development (R&D); At the core of the research, "R&D" stands as the primary focus for examining the effects of state-provided incentives and subsidies on innovation in science and technology. This plays a crucial role in promoting technological innovations and economic growth. In 95% of the reviewed literature, the keyword "R&D" has been encountered. The reason for its absence in 5% of cases is that in the pre-90s era, this term was not in vogue, and instead, words such as "technological development," "progress," and "research" were used. Examples of popular research utilizing the keyword "R&D" include Dechezleprêtre et al. (2016); Bozeman & Link (1984); Guan & Yam (2015); Zhu et al. (2006); Larédo et al. (2016); Hu, Y. (2019); Chen & Gupta (2010); Martínez Ros & Martínez-Azúa (2009); Jia & Ma (2017); Russo, B. (2004).

Incentives and Subsidies; The financial support provided by the state serves as an important tool to encourage companies to invest in innovation, R&D activities and to accelerate economic development. Incentives and subsidies helpreduce firms' perception of risk, encouraging them to undertake innovative projects. Popular research utilizing the keyword "subsidies" includes Clausen, T. H. (2009); Xu, J. et al. (2020); Wu, R. et al. (2019); Colombo, M. G. et al. (2011); Hussinger, K. (2008).

Performance and Effectiveness; The research likely focuses on assessing the impact of state supports on firms' innovation capacity and overall economic growth. Performance and effectiveness are key indicators used to measure whether these supports achieve their objectives, with references including Nilsen, O. A. et al. (2018); Köhler, C. et al. (2012); Guceri, I., & Liu, L. (2019); Bronzini, R., & Iachini, E. (2014).

Economic Growth and Development; Terms like "economic", "growth", and "development" in the word cloud indicate that exploring the impact of state supports on the country's economic performance is a crucial part of the research, with references including Le, T., & Jaffe, A. B. (2016); Merito, M. et al. (2010); Ernst, C. et al. (2013).

Sectoral and Geographical Scope; Words such as "technology", "industry", and "country" suggest that the research could examine the distribution and impact of technological innovations across various industries and geographical regions, with references including Fernández-Sastre, J., & Montalvo-Quizhpi, F. (2019); Segerstrom, P. S., & Zolnierek, J. M. (1999); Crespi, G. et al. (2016).

Government Policy; The terms "government" and "policy" highlight the role of public policy in shaping state supports. The research may examine the effectiveness of specific policy designs and their impacts on firms' innovative activities, with references including Fölster, S. (1988); Correa, P. et al. (2013); Meyer-Krahmer, F. et al. (1983); Hong, J. et al. (2015); Pottelsberghe, B. V., & Guellec, D. (1999); Conti, A. (2016).

2.5 Citations

The study by Bloom, N. et al. (2002) examines the effectiveness of R&D tax credits across multiple countries and evaluates R&D policies. Since 2002, it has received a total of 683 citations, becoming one of the most important references in the field (Figure 2.2).

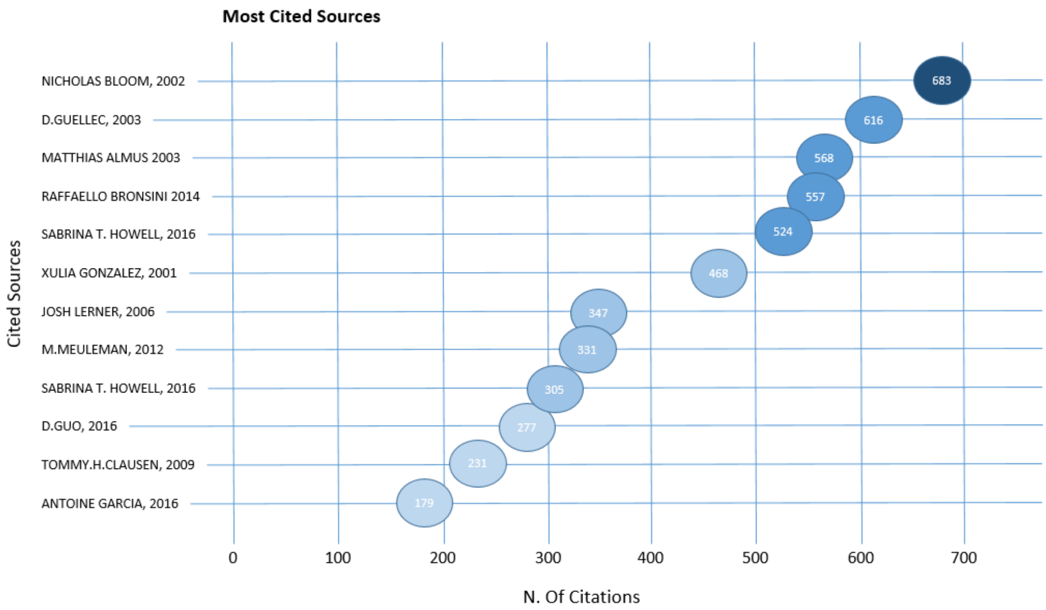


Figure 2.2 : Most cited sources.

The work of Guellec and Van Pottelsberghe De La Potterie (2003) has garnered a total of 616 citations since 2003, providing a significant contribution to the literature on the impact of public R&D expenditures on firms' R&D activities.

Almus and Czarnitzki's (2003) study, with 568 citations since 2003, has become an important reference for investigating the effects of public R&D subsidies on firms' innovation activities.

Bronzini and Piselli's (2014) research, with 557 citations since 2014, is considered an important study evaluating the impact of public R&D incentives on firms' innovation performance.

2.6 Innovation Performance Metrics

Government support programs play a crucial role in fostering innovation and economic growth. Assessing the performance of these programs requires the use of various metrics, which can be broadly categorized into input, output, and outcome indicators.

2.6.1 Input metrics

Input metrics focus on the resources allocated to R&D activities, such as funding, personnel, and infrastructure. These metrics provide insights into the scale and intensity of innovation efforts. However, some scholars argue that input metrics alone may not accurately capture the effectiveness of R&D support programs, as they do not measure the actual outcomes and impacts of innovation activities (Cohen & Levinthal, 1990).

2.6.2 Output metrics

Output metrics, on the other hand, measure the tangible outputs generated from R&D investments, such as the number of patents, publications, and prototypes developed. While output metrics provide valuable information about the immediate results of R&D efforts, they may not fully capture the long-term impacts and benefits of innovation (Mansfield, 1991).

2.6.3 Outcome metrics

Outcome metrics assess the broader socio-economic impacts of innovation activities, including job creation, economic growth, and societal welfare. These metrics aim to evaluate the ultimate effectiveness and value of Government support programs in achieving their intended objectives. However, measuring outcomes can be challenging due to the complex and long-term nature of innovation processes (Hall et al., 2010).

Despite the importance of outcome metrics, some scholars argue that attributing socio-economic impacts solely to R&D support programs can be problematic, as other factors, such as market conditions and policy environment, also influence innovation outcomes (Mowery & Rosenberg, 1998). Therefore, there is ongoing debate among researchers and policymakers about the most appropriate performance metrics for evaluating Government support programs.

2.6.4 Output effects of public support

Academic studies on the productivity levels, R&D expenditures, patent applications, and other output levels of firms financed by the public sector provide valuable insights both from Turkey and globally. These studies play a crucial role in understanding the effects of public support on firms and guiding policymakers in formulating effective strategies.

A study conducted in Turkey by Yıldız and Ekinci (2018) examined the productivity levels of firms participating in publicly funded R&D projects. Their findings suggest that firms involved in such projects generally exhibit higher productivity levels. Similarly, Yıldız et al. (2020) found evidence indicating that publicly supported R&D projects lead to an increase in firms' patent applications.

Czarnitzki and Lopes Bento (2014) conducted a study in Europe, examining the impact of R&D subsidies on firm collaboration. Their findings suggest that R&D subsidies promote inter-firm collaboration and support innovation activities.

Finally, Czarnitzki and Hussinger (2018) investigated the impact of R&D subsidies on firm innovation. Their findings suggest that R&D subsidies enhance firms' innovation capacities and stimulate new product development processes.

2.6.5 Firms with high output supported by public assistance

Academic studies provide significant evidence that government incentives contribute to firms achieving high output levels. A study from Turkey conducted by Ela (2019) indicates that firms tend to exhibit increased productivity levels when they receive government support. Similarly, Czarnitzki et al. (2011a) found that government support leads to higher R&D activities and innovation. Guo,Y. et al. (2016) also demonstrated that government incentives enhance firms' competitiveness.

There is also evidence from global studies indicating a tendency of governments to encourage R&D expenditures. For instance, Hall and Van Reenen (2000) found that government support increases R&D expenditures and fosters innovation. Almus and Czarnitzki (2003) showed that government incentives promote R&D activities and enhance firms' innovativeness. Similarly, Czarnitzki and Hussinger (2004) revealed that government subsidies effectively boost R&D expenditures and improve technological performance.

Important studies from Turkey also support these findings. Erzanoglu and Cetin (2021) reported that government incentives in Turkey increase R&D activities and promote innovation.

2.7 History of R&D Supports

Research and development (R&D) incentives have been implemented by various countries at different periods over the years with the aim of promoting innovation, increasing economic growth, and enhancing competitiveness (Jones, 2005). These incentives are typically provided by the government and may include various mechanisms such as incentives, grant programs, and tax incentives to support R&D activities.

Historically, the origins of R&D incentives date back to the late 19th and early 20th centuries. Particularly, in countries like the United Kingdom and Germany, the first R&D incentives were provided to promote industrial and military innovations (Smith & Johnson, 2010).

In the post-World War II era, R&D incentives gained further importance. With the intensification of competition in the defense sector during the Cold War period, many countries made significant investments in military R&D activities (Jones, 2005). During this period, R&D incentives were often focused on the defense industry.

In the subsequent years, the scope and diversity of R&D incentives increased. R&D supports evolved beyond defense to encourage innovation in civilian sectors through tax breaks, grants, subsidies, and special funds for R&D. Especially from the 1980s onwards, many countries expanded and diversified their R&D incentives (Jones, 2005). During this period, policies emphasizing the contribution of technological innovations to economic growth were adopted.

Today, R&D incentives are widely used globally and have been adopted by almost all developed and developing countries (Smith & Johnson, 2010). These incentives are directed towards various sectors to promote industrial R&D activities, enhance competitiveness, support sustainable development, and provide societal benefits.

2.8 Importance of R&D Supports

2.8.1 Importance of R&D in international competition

Among the factors determining countries' competitiveness, the levels of current technology and technological progress hold a significant position. Technology levels refer to the existing level of technology a country possesses and the prevalence of these technologies, while technological progress involves the development and adoption of new and more effective technologies (Dosi, 1988).

Numerous studies indicate that technological progress and R&D activities enhance a country's competitiveness (Keller, 1997). Research demonstrates that as R&D expenditures increase, countries become more innovative and efficient, consequently enhancing their competitiveness (Branstetter, 2001).

The impact of technological progress on a country's economic performance plays a critical role in increasing competitiveness (Bloom, N. et al., 2014). Sectors with high technological intensity tend to create higher value-added and enhance a country's economic growth potential (Bresnahan, T. F. et al., 2002).

However, effective management of R&D expenditures and sustainable technological progress is essential (Lichtenberg, 1995). Successful R&D policies and investments can enhance a country's competitiveness, while technological regression or inadequate R&D investments can adversely affect competitiveness (Haskel & Westlake, 2017).

2.8.2 Relationship between R&D expenditures and economic growth

Research findings on the nature of the relationship between R&D expenditures and economic growth and country development vary. Some studies argue that R&D expenditures positively influence economic growth and country development (Wang & Huang, 2015; Samimi ve Alerasoul, 2009; Horvath 2011; Eid, 2012; Ülger ve Durgun, 2017; Canbay, 2020). These studies suggest that R&D activities stimulate innovation, thereby supporting economic growth.

On the other hand, some research claims that the impact of R&D expenditures on economic growth is limited or negative (Jones & Williams, 1998; Barro & Sala-i-Martin, 1995). These studies propose that high R&D expenditures may divert economic resources from other areas, negatively affecting economic growth.

Additionally, there are studies suggesting a neutral relationship between R&D expenditures and economic growth (Nelson, 1981; Solow, 1956). These researches argue that R&D expenditures do not have a significant impact on economic growth, and other factors determine this relationship.

Although there were studies before 1990 suggesting that the relationship between R&D expenditures and economic growth and country development was neutral, during the period between 1990 and 2000, there were studies arguing that this relationship was limited, negative or positive. However, in studies conducted after 2000, research supporting the positive impact of R&D expenditures on economic growth has gained prominence.

2.8.3 R&D risks and the importance of incentives

Research has shown that due to the high costs and risks associated with R&D and innovation activities, many companies face challenges in undertaking such endeavors. A study conducted in Turkey by Aydın et al. (2019) highlights that Turkish companies make limited investments in R&D and innovation activities due to their high costs and that incentives play a significant role in encouraging such activities. Additionally, they emphasize the importance of incentives in promoting R&D and innovation activities.

Similarly, a global study by Johnson and Smith (2020) notes that the high costs and risks of R&D and innovation activities influence companies' decisions regarding innovation. However, they argue that incentives support R&D and innovation activities by encouraging companies to invest more in these areas. This research suggests that incentives increase companies' capacity to finance R&D and innovation activities and promote a culture of innovation.

2.9 Factors Affecting Innovation Performance

2.9.1 Financial resources

Financial resources are considered a critical factor in supporting innovation activities. Research both in Turkey and worldwide indicates that financial resources play a significant role in determining innovation performance.

One study conducted in Turkey found that financial resources have a positive impact on innovation and R&D performance. For example, in a study by Demirci and Şahin (2018), it was found that firms in the Turkish manufacturing sector allocate more funds to innovation activities when they have access to adequate financial resources.

Similarly, Özkan, A. et al. (2016) provided evidence suggesting that financial resources positively influence innovation performance among Turkish firms.

Studies conducted worldwide also support the importance of financial resources in driving innovation and R&D activities. Göktepe-Hultén and Mahagaonkar (2018) found a strong relationship between financial resources and R&D expenditure among firms in European countries. Similarly, Hottenrott and Lopes-Bento (2016) highlighted the role of financial resources in financing innovation activities among European firms.

However, the relationship between financial resources and innovation performance can be complex, leading to mixed results in some cases. For instance, Çolpan et al. (2017) conducted a study on SMEs in Turkey and found that while financial resources influence R&D expenditures, the effect may vary across industrial sectors.

2.9.2 Human resources

Human resource competency, managerial experience, and graduation are among the important factors that affect the performance of innovation. These factors have both direct and indirect impacts on the success of innovative projects.

Firstly, human resource competency plays a critical role in the execution of innovative projects. Qualified and expert personnel are necessary to solve complex problems, generate creative solutions, and implement innovative ideas. A study conducted in Turkey evaluating the effectiveness of R&D incentives by Yıldız and Ekinci (2018), Özgür ve Ekinci (2017), indicated that the qualifications of R&D teams significantly affect R&D performance. Similarly, studies conducted worldwide also emphasize the impact of human resources on R&D performance (Damanpour & Schneider, 2006; Huang, C. H. et al., 2017).

Managerial experience and graduation are also crucial factors influencing the performance of Innovation. Qualified and experienced managers can effectively manage R&D projects, allocate resources efficiently, and make strategic decisions. A study by Yıldız, A. et al. (2020) in Turkey highlighted that criteria such as economic efficiency and innovation performance are generally used to assess the effectiveness of incentives. Additionally, this study concluded that Government incentives increase firms' R&D expenditures and strengthen their innovation capacities.

2.9.3 Technological infrastructure

Among the factors influencing innovation performance, the importance of technological infrastructure is increasingly recognized. Research conducted in Turkey and worldwide indicates that a robust technological infrastructure plays a crucial role in supporting innovation activities.

In a study conducted in Turkey, Tekin and Özkan (2019) found that technological infrastructure positively affects the innovation performance of Turkish firms. This study suggests that firms in the Turkish manufacturing sector with more advanced technological infrastructure tend to increase their R&D activities and strengthen their innovative capacities.

Similar findings have been reported in research conducted worldwide. For instance, Wu and Wang (2019), in their study on Chinese firms, highlighted that a strong technological infrastructure enhances innovation performance and provides a competitive advantage. Similarly, Krammer (2015) demonstrated, through research on European firms, that advanced technological infrastructure supports R&D activities and enhances innovative capabilities.

However, the impact of technological infrastructure on innovation performance is not unidirectional. Some studies suggest that its role in influencing innovative activities may be limited. For example, Gölgeci and Kuşakçı (2016) found in their study on Turkish manufacturing firms that the effect of technological infrastructure on innovation performance is constrained.

2.9.4 Collaborations and networks

University-industry collaboration is frequently acknowledged in the literature to have a significant impact on innovation performance. This collaboration enables the industry sector to benefit from the knowledge and technological infrastructure of universities and facilitates the application of academic research to industry. Research conducted both in Turkey and globally indicates that university-industry collaboration enhances R&D performance and fosters innovation.

In a study conducted in Turkey, Özkan, A., et al. (2016) indicated that university-industry collaboration enhances the R&D performance of Turkish firms and promotes innovation. This study demonstrates that collaboration between Turkish universities and industrial firms enhances the success of R&D projects and supports the development of new products.

Similar findings have been reported in global research. Carayannis and Campbell (2012), as well as Etzkowitz (2003), highlighted that university-industry collaboration in the United States enhances innovation and R&D performance and contributes to economic growth. Seppo and Lilles (2012) found in their study in Finland that university-industry collaboration helps in the successful execution of R&D projects and supports the development of new technologies. Similarly, a study conducted by the European Commission (2014) emphasized that university-industry collaboration in Europe promotes innovation and enhances competitiveness.

2.9.5 Export effect

Export activity has long been recognized as a factor influencing innovation and R&D performance for firms in Turkey and worldwide. Many studies conducted in Turkey suggest that export activity enhances firms' innovation and R&D performance. However, alongside the positive effects, some studies indicate that the relationship between export activity and innovation-R&D performance is not straightforward.

For instance, Smith, Madsen, and Dilling-Hansen (2002) found that firms engaged in export allocate more resources to R&D activities and make higher levels of investment in innovation and R&D compared to non-exporting firms, based on a study conducted on Danish firms. They emphasized that "focusing on the R&D behavior, sales market concentration, firm size, and minimum efficient scale are all together with the export performance expected to affect the R&D decision of the firm" (p. 13-14). Similarly, Wagner (2008) observed a positive relationship between export activity and innovation/R&D performance in a study conducted in Germany.

Another study conducted in Turkey by Sungur, Aydın and Eren (2016) identified a positive impact of export on innovation activities in the Turkish manufacturing sector. This study revealed that firms oriented towards exports invest more in R&D activities and achieve higher levels of innovation.

However, some studies in the literature suggest ambiguity in the relationship between export activity and innovation/R&D performance. For example, Yüksel (2017) suggests uncertainties regarding the influence of export intensity on innovationperformance based on a study conducted in Turkey. Additionally, a study by Uzay, N. et al. (2012) indicates that the effects of engaging in export activities on R&D and innovation performance are not clear. This study shows that results from studies conducted in different industries and countries are conflicting, highlighting the complexity of the relationship between export activity and innovation/R&D performance.

2.9.6 Company size

In the literature, there are studies favoring small firms, those favoring large firms, and those indicating that innovation outputs are independent of firm size. Various studies from Turkey and around the world provide insights into this matter.

One study favoring small firms is conducted in Turkey by Yılmaz and Ekinci (2018). They show that small-scale firms exhibit higher innovation capabilities compared to large firms and are more effective in R&D activities. Similarly, a study by Ahn et al. (2020) indicates that "the impact of subsidies on innovation collaboration followed an inverted U-shaped curve: the impact in highly funded firms was smaller than that in firms that received a more modest amount" (p. 2).

An example of a study favoring large firms is the work by Johnson et al. (2020). Their research suggests that large-scale firms have greater resources and capacity for R&D activities, thus achieving higher innovative outputs. Another study from Turkey, conducted by Aksoy, B. et al. (2017), also reaches similar conclusions, stating that large firms in Turkey lead in R&D activities and attain significant innovative outputs.

Regarding studies indicating independence from firm size, Aerts and Czarnitzki (2016) conducted research showing that firm size does not determine R&D outputs. Similarly, another study from Turkey by Demir and Ustun (2018) found no significant difference in innovative outputs among firms of different sizes.

2.9.7 Company age

Academic research examining the impact of firm age on innovation performance constitutes an important area of study both in Turkey and globally. In a study conducted in Turkey, Özdemir and Ekinci (2018) evaluated the influence of firm age on R&D performance. This study examined how Turkish firms adjust their R&D expenditures based on firm age and found that younger firms tend to allocate more funds towards R&D activities.

In a study conducted in the United Kingdom, Guceri and Liu (2019) explored the effects of firm age on R&D performance. This research investigated how firms adjust their R&D expenditures based on their age and indicated that "young firms responded very strongly by increasing their R&D spending after the reform" (p. 33).

2.9.8 Innovation culture and management

In a study conducted in Turkey, Özdemir and Kızılkaya (2020) found that companies with a strong innovation culture tend to have higher R&D performance. This study suggests that fostering an environment that encourages creativity, risk-taking, and openness to new ideas positively impacts innovative outcomes in Turkish firms.

Similar findings have been reported in research conducted worldwide. For example, Janssen et al. (2019) demonstrated in their study on European firms that organizations with a clear innovation strategy and supportive culture achieve better R&D performance. Additionally, Kim and Park (2018) found in their research on South Korean companies that a strong innovation orientation is positively associated with R&D investment and innovation output.

However, the development of an innovation culture and orientation can be influenced by various contextual factors, including organizational structure, leadership style, and industry dynamics. Therefore, further research is needed to explore the complex relationship between innovation culture and R&D performance.

2.9.9 Market and competitive conditions

In a study conducted in Turkey, Aydın and Gungor (2018) found that firms operating in sectors with intense competition generally have higher innovation performance. This study demonstrates that competition encourages companies to increase R&D activities and has a positive effect on innovation.

Similarly, global-scale studies have yielded similar results. For instance, Cefis and Marsili (2015), in their research on European firms, discovered that competition has a positive impact on R&D investments, with companies allocating more resources to R&D to gain competitive advantage.

2.9.10 Legal and regulatory framework

Research suggests that the legal and regulatory framework significantly influences innovation performance by shaping the incentives and constraints for innovation activities. In Turkey, studies have shown that a supportive legal environment, including intellectual property protection and R&D incentives, positively impacts R&D investment and innovation outcomes (Özcan et al., 2019).

Similarly, in Europe, regulations such as the European Union's Horizon 2020 program and supportive policies for innovation and technology transfer have been linked to higher R&D spending and innovation performance (Crespi & Zuniga, 2012).

In the United States, the Bayh-Dole Act of 1980, which allowed universities to retain ownership of inventions resulting from federally funded research, has been credited with stimulating R&D investments and technology transfer from academia to industry (Mowery et al., 2001).

In China, the government's policies promoting indigenous innovation and providing financial incentives for R&D have contributed to the country's rapid rise as a global innovation hub (Guo et al. 2018).

Furthermore, studies from various other countries have highlighted the importance of clear and effective regulations, strong intellectual property rights protection, and supportive government policies in fostering R&D activities and innovation (Chadha & Narula, 2017; Kim & Lee, 2019).

These findings underscore the critical role of the legal and regulatory framework in shaping innovation performance across different countries and regions.

2.10 Sectoral and Regional Differences

2.10.1 Research in different industrial sectors

Research on the response of industrial sectors to Government supports performance reveals varied outcomes across different sectors. In Turkey, studies have shown that certain industries exhibit a more positive response to subsidies and incentives compared to others. For example, in the automotive sector, firms have been found to significantly increase their R&D investments in response to government incentives (Özçam & Erdil, 2015). Similarly, in the technology sector, incentives have been effective in stimulating innovation and fostering growth (Özdemir & Uğurlu, 2019). These findings suggest that certain industries are more receptive to incentives, likely due to their innovation-driven nature and competitive dynamics.

Conversely, studies from around the world have identified disparities in the response of industrial sectors to Government supports. In the pharmaceutical industry, for instance, firms may be less inclined to increase R&D spending in response to incentives due to the lengthy and costly nature of drug development (Dechezleprêtre et al., 2017). Similarly, in traditional manufacturing sectors, firms may face barriers such as technological obsolescence or market saturation, which limit their ability to leverage incentives effectively (Klette & Moen, 2010). These findings underscore the importance of considering sector-specific characteristics and challenges when designing incentive programs.

Overall, the literature suggests that the response of industrial sectors to incentive performance on innovation varies widely and is influenced by factors such as industry structure, technological complexity, and market conditions. Understanding these dynamics is crucial for policymakers seeking to design effective incentive programs tailored to the needs of different sectors.

2.10.2 Regional differences

There is a wide range of literature on how regional subsidies and incentives affect company investments and innovative outputs. Research in this area indicates that regional incentives and subsidies have a significant impact on firms' investment decisions.

In a study conducted by Wörter at al., (2010) in Germany and Switzerland, the authors concluded that "This result indicates that it is product innovation that drives technology competition, which points to the fact that a lack of product innovations urges firms into substitution competition. We find different results by country in terms of process innovation." The study emphasizes that different results emerged between countries in the same region regarding product and process innovation. This suggests that the effects of different types of innovation on competition dynamics can vary according to the specific conditions of each country.

In a study by Bedu and Vanderstocken (2019), it was observed that regional subsidies in Belgium increased R&D outputs. This study concluded that regional incentives stimulate R&D activities and support innovation.

Other research also supports the notion that regional subsidies positively influence company investments and R&D outputs. In this context, there is significant evidence that regional subsidies and incentives contribute to local economies and regional development.

These studies demonstrate that regional incentives significantly affect firms' investment decisions and innovative activities. Therefore, further research is needed to evaluate the effectiveness of regional incentive policies and support local economic development.

2.10.3 Studies conducted in Turkey

Academic studies in Turkey on Government incentives and subsidies focus on various areas such as economic growth, export performance, and technological advancements. These studies emphasize the importance of promoting R&D activities while analyzing the impacts of the government's policies in this direction on the economy.

Çetin and Gedik (2017) analyzed the factors affecting firms' innovation activities through a survey conducted in Karaman province. The study found no significant relationship between innovation and firm age, while a significant relationship was observed with the number of employees in the firm. "As a result of analysis, there is not a significant relationship between the age of enterprise and innovation. But there is a significant relationship between the number of employees and innovation. Innovation can be change according to the features of enterprises, size of the sector, local and internal-external factors" (Çetin & Gedik, 2017, p. 160).

In a study conducted on the effects of tax incentives on innovation in Turkey:

> As a result of the study done for this purpose, R&D tax incentives in Turkey were found to have significantly correlated with innovation. Also, in the descriptive analysis, in Turkey, R&D tax incentives and similarly innovation has seen at moderate level compared to many other countries. In this regard, it has been observed that R&D tax incentives is effective in Turkey (Ela, 2019a, p. 228).

Kalay and Kızıldere (2015) analyzed data from the 2010-2012 Innovation Survey by TÜİK (Turkish Statistical Institute). Their study examined the effects of various factors such as activities, expenditures for innovation, financial support, information sources, collaborations, methods for maintaining or increasing competitiveness, objectives, strategies, barriers, and firm size on innovation performance. Although there are contradictions in the literatureon the subsect, according to Kalay and Kızıldere (2015) “It has been determined that as the size of the business increases in terms of the number of employees, the organizational, product, process and marketing innovation performances of the companies increase” (p. 65).

One study by Canbay, Ş. (2020) examines the effects of R&D expenditures on exports in Turkey. Focusing on the period from 2004 to 2017, the research indicates a positive relationship between R&D expenditures and exports. The study suggests that R&D investments support economic growth by enhancing export performance. Another study found the following results:

> Another finding obtained is the presence of a significant and strong relationship between innovation and R&D. In practice, the intertwined nature of R&D and innovation activities has once again been empirically proven. The study found that participating companies perceive their export performance in two dimensions: competitive and financial export performance. One of the conclusions of the study is that innovation and R&D activities positively affect export performance (Ayar & Erdil, 2018, p. 65).

In a study based on data obtained from the 2015 World Bank Turkey Regional Enterprise Survey, Mercan and Çetin (2019) discussed the following results “According to the findings, it was concluded that, in general, businesses that received grants are more likely to innovate compared to those that did not, and when grants are received from different institutions, the likelihood of performing different types of innovation is higher compared to those that did not receive any grants” (p. 70). Furthermore, they observed that grants provided by different institutions impact different types of innovation.

Sungur, Aydın and Eren (2016) analyzed the impact of R&D expenditures, the number of R&D researchers, patents, and innovation activities on exports and economic growth in Turkey during the period 1990-2013. The study identified a unidirectional causal relationship from exports to the share of R&D expenditures in GDP, patent numbers, and the number of workers employed in R&D.

3. MODEL, DATA AND METHODOLOGY

3.1 Model Explanation

In this study, since we aim to investigate the impact of incentives and subsidies on firm innovation performance in Turkey, we have assessed that considering this effect alongside other variables would result in a statistically more meaningful model after conducting a literature review. As emphasized in the literature, various factors influence innovation. In the econometric model we developed, innovation is used as the dependent variable, incentives are used as the main independent variable, and the variables identified in the literature that are available in our dataset are included as control variables.

$$Y_{it} = \beta 0 + \beta 1.Xcontrol_{it} + \beta 2.Z.subsidies_{it} + \varepsilon_{it} \tag{3.1}$$

In order to examine the impact of incentives on innovation, the model shown in equation 3.1 has been established.

Dependent variable (Y):

Y; Firm innovation status (binary).

Independent variables (X, Z):

Z; Firm incentive status (binary).

X; Firm size, firm age, annual total sales, annual export ratio, ratio of R&D expenditures to annual revenue, number of permanent employees.

The model shown in equation 3.1 transforms into the model in equation 3.2 when dependent, independent, and control variables are added.

$$\begin{gathered} Inovation\_status_{it} = \beta 0 + \beta 1.\ Firm\_size_{it} + \beta 2.\ Firm\_age_{it} + \beta 3. \\ Export\_ratio_{it} + \beta 4.\ R\&D\_expenditure\_ratio_{it} + \beta 5.\ Incentive\_ratio_{it} + \\ \beta 6.Number\_of\_emp + \beta 7.\ Incentive\_status_{it} + \varepsilon_{it} \end{gathered} \tag{3.2}$$

$\beta 0$ is the intercept.

$\beta 1$, $\beta 2$, $\beta 3$, $\beta 4$, $\beta 5$, $\beta 6$, $\beta 7$ is the slope coefficient.

ε is the error term.

While comparing the innovation performance of treated and untreated firms, the performance of firms treated and untreated in the same year has been compared due to changing economic conditions over the years. The view presented in the literature on this subject is as follows:

> We apply a nearest neighbor propensity score matching. This means that we match each subsidy recipient with the single most similar SME in the control group of the non subsidized SMEs. The pairs are chosen based on the similarity in the estimated probability of receiving a subsidy, i.e., the propensity score. Matching on the propensity score avoids a "curse of dimensionality" because all information is bundled in the propensity score which is then used as the single matching argument (Rosenbaum and Rubin, 1983). In addition, we require that the selected control observation is observed in the same year as the treated observation. This is crucial for our analysis because we are interested in comparing treatment effects across years (Hud and Hussinger, 2015, p. 1847).

3.2 Data

To test the hypotheses in this research, data from the World Bank's Enterprise Survey conducted at the firm level across 150 countries worldwide were used (Url-1). The World Bank conducted this survey for Turkey in the years 2002, 2005, 2008, 2009, 2010, 2013, 2015, and 2019.

The purpose of the World Bank's Enterprise Survey conducted worldwide is to collect data to understand the economic activities and business environments of enterprises. These surveys provide comprehensive information to identify the challenges faced by firms, the conditions for doing business, and the factors hindering their growth. The surveys assess the operations of firms in different sectors, their access to finance, access to infrastructure services, regulatory environment, labor market conditions, and innovation activities. This data is used by policymakers, researchers, and international development organizations to improve the business environment and promote economic growth.

The surveys conducted in 2009 and 2010 investigate the firm-level impacts of the global economic crisis that occurred during that period and contain limited data compared to other surveys. As the data from these surveys do not fit our model, they have been excluded from the scope of the research.

3.2.1 Variables and descriptions

The survey data, consisting of responses from private sector firms located in various geographic regions of Turkey during the period 2002-2019, will be used to measure the impact of R&D data on firm innovation performance in Turkey. The descriptions of the variables are provided in Table 3.1, Table 3.2 and Table 3.3.

3.2.2 Complementary data

As seen in the complementary data, the number of observations in the surveys conducted in 2002 and 2005 is significantly lower compared to other years. Additionally, in 2005, while the number of observations was 557, data for the RD (presence of R&D) variable was missing for 336 firms (Table 3.4).

In the survey conducted in 2008, data for the RD variable was missing for 5 firms, and for the SUBS variable, data was missing for 15 firms. In 2013, data for the RD variable was missing for 136 firms, and for the SUBS variable, data was missing for 28 firms.

In the survey conducted in 2015, data for the RD variable was missing for 127 firms; however, it was noted that 112 of these firms had employees in their R&D departments, leading to the conclusion that these firms did have R&D activities. For the SUBS variable, data was missing for 80 firms. Since the amount of incentives received by these firms was zero, it was concluded that they did not receive any incentives.

In the survey conducted in 2019, data for the RD variable was missing for 21 firms. Six of these firms had engaged in innovation that year.

The firm size variable, CSIZE, was assessed in 3 categories in the years 2002, 2005, and 2008, whereas it was assessed in 4 categories in 2013 and subsequent years. The size ranking was done from smallest to largest as 0, 1, 2, and 3. Since 0 indicates absence in the calculations, the ranking in the table was adjusted to 1, 2, 3, and 4 respectively.

Table 3.1 : Dependent variable and descriptions.

Dependent Variable	Descriptions, Survey Question	Survey Question Number by Year					
		2002	2005	2008	2015	2013	2019
INOV	If innovation = 0; 0, else; 1						
innovation	pinov + ninov + minov + linov + oinov + uinov + kinov + tinov						
pinov	During the last three years, has this establishment introduced new or significantly improved products or services?	Q60a1		Q1	H1		H1
ninov	Were any of the new or significantly improved products or services also new for the establishment’s main market?				H2		H2
minov	During the last three years, has this establishment introduced any new or significantly improved methods of manufacturing products or offering services?				H3		H3
linov	During the last three years, has this establishment introduced any new or significantly improved logistics, delivery, or distribution methods for inputs, products, or services?				H4a		H4
oinov	During the last three years, has this establishment introduced any new or significantly improved organizational structures or management practices?				H5		H5
uinov	Upgraded an existing product line/service	Q60a2					
kinov	Obtained a new product licensing agreement	Q60a5					
tinov	Has your firm acquired new production technology over the last 36 months?	Q61a					

Table 3.2 : Independent variable and descriptions.

Independent Variable	Descriptions	Survey Question Number by Year					
		2002	2005	2008	2013	2015	2019
CSIZE	Size by number of employees	S4a2	S4b	A6b	A6b	A6b	A6b
AGE	Age of the company at the time of the survey	S1a	S1a	B5	B5	B5	B5
TSALE	Firm's annual total sales	Q82a	Q57a	D2	D2	D2	D2
EXPO	Percentage of Firm's annual direct and indirect export	Q14	Q7	D3	D3	D3	D3
RD	Total annual R&D expenses of the company	Q83b	Q58b	ECAo4	ECAo17 ECAo19	H8	H9
EMPX	Number of permanent full-time workers	Q91a1	Q66a	L1	L1	L1	L1

Table 3.3 : Control variable and description.

Control Variable	Description, Survey Question	Survey Question Number by Year					
		2002	2005	2008	2013	2015	2019
SUBS	During the last two years, did this establishment receive any direct or indirect government grant? (binary)	Q79a1 Q79a2 Q79a3	Q53a1 Q53a2 Q53a3 Q53a4	Q53	ECAq53	TU_h.4	BMk5a

Table 3.4 : Supplementary data.

Supplementary Data	2002	2005	2008	2013	2015	2019
	Survey Year					
Number of observations	514	557	1152	1344	6006	1663
Number of micro firms <5				22	2786	6
Number of small firms (5-19)				544	1773	481
Number of small firms (1-49)	342	399	353			
Number of medium firms (20-99)				469	931	594
Number of medium firms (50-249)	108	105	442			
Number of large firms (+101)				309	516	382
Number of large firms (+250)	64	53	357			
Number of treated firms	22	15	102	129	235	100
Number of firms with R&D	90	28	313	58	316	490

3.2.3 Descriptive statistics of variables

When examining the descriptive statistics for the variables, it is observed that the firm innovation rate was 34% in 2002. Although it increased over time, it declined to 16.4% in 2015 and 8.95% in 2019. The age of the firms participating in the surveys ranged between 14 and 20 years, with the youngest firm being newly established and the oldest firm being 159 years old. The average percentage of firms receiving government incentives varied over the years, ranging between 2.69% and 9.8% (Table 3.5).

Table 3.5 : Descriptive statistics of variable by years.

Variables	Mean	Median	Std. Dev.	Min	Max
2002 CSIZE	1,459144	1	0,705236	1	3
2002 SUBS	0,042802	0	0,202409	0	1
2002 INOV	0,34241245	0	0,47451677	0	1
2002 AGE	14,400078	11	12,17731	3	122
2002 TSALE	$6.502.658	$206	$45.962.130	0	$682.010.000
2002 EXPO	11,94%	0,00%	0,255029	0,00%	100,00%
2002 RD	$ 996.109	0	$4.660,141	0	$90.000
2002 EMPX	190,4416	20	804,2471	2	8100
2005 CSIZE	1,378815	1	0,652395	1	3
2005 SUBS	0,02693	0	0,161879	0	1

Table 3.5 (continued) : Descriptive statistics of variable by years.

Variables	Mean	Median	Std. Dev.	Min	Max
2005 INOV	0,520646	1	0,499574	0	1
2005 AGE	15,87612	11	16,44372	4	92
2005 TSALE	$ 2.645.235	$ 400.000	$ 8.620.820	$ 2	$ 71.500.000
2005 EXPO	12,96%	0,00%	0,248651	0,00%	100,00%
2005 RD	$ 12.067,87	0	$58.066,98	0	$ 500.000
2005 EMPX	112,6104	13	525,7383	2	9.000
2008 CSIZE	1,99305556	2	0,785029438	1	3
2008 SUBS	0,08970976	0	0,2857655	0	1
2008 INOV	0,44773519	0	0,497260887	0	1
2008 AGE	17,8923885	15	11,789335	0	83
2008 TSALE	₺41.292.423,80	₺6.171.000	₺337.766.442,20	₺12.000	₺10.000.000.000
2008 EXPO	24,11%	2,00%	0,342833132	0,00%	100,00%
2008 RD	₺295.825,19	0	₺7.560.117,05	0	₺250.000.000
2008 EMPX	170,522727	40	760,611698	2	20.843
2013 CSIZE	2,792411	3	2,79241071	1	4
2013 SUBS	0,09802432	0	0,297347523	0	1
2013 INOV	0,29241071	0	0,454869969	0	1
2013 AGE	18,16031	16	18,1603053	0	90
2013 TSALE	₺28.291.730,90	₺2.300.000	₺28.291.730,90	₺1	₺4.348.910.000
2013 EXPO	29,72%	5,00%	29,72%	0,00%	100,00%
2013 RD	₺11.993,46	0	₺208.692,20	0	₺6.750.000
2013 EMPX	110,155873	25	338,9668333	1	5.200
2015 CSIZE	1,862970363	2	0,971473284	1	4
2015 SUBS	0,039655754	0	0,195149111	0	1
2015 INOV	0,167832168	0	0,373717181	0	1
2015 AGE	14,268999	11	11,75809858	1	159
2015 TSALE	₺39.328.119,23	t500.000	₺2.366.297.604,96	₺5.000	1,80E+11
2015 EXPO	4,53%	0,00%	0,168750715	0,00%	100,00%
2015 RD	₺15.356,07	0	₺651.935,88	0	₺49.271.208
2015 EMPX	32,43028886	5	298,0723123	1	22.000
2019 CSIZE	2,812988575	3	0,786552433	1	4

Table 3.5 (continued) : Descriptive statistics of variable by years.

Variables	Mean	Median	Std. Dev.	Min	Max
2019 SUBS	0,060132291	0	0,237731779	0	1
2019 INOV	0,089597114	0	0,285603695	0	1
2019 AGE	19,8015873	17	14,28235495	2	99
2019 TSALE	₺36.469.543,45	₺18.497.000	₺198.743.538,90	₺50.000	₺8.000.000.000
2019 EXPO	16,13%	0,00%	0,29768237	0,00%	100,00%
2019 RD	₺26.162,61	0	₺305.224,58	0	₺7.000.000
20019 EMPX	84,29343864	23	232,8096356	2	4.100

3.2.4 Adjustments made to the dataset

In the Enterprise Survey, responses to questions have been numerically coded as follows: 1 for "yes", 2 for "no", -9 or 3 for "don't know". To ensure the Python program can interpret the data correctly, in the columns containing variable data, the number 2 has been replaced with 0 "zero", and -9 and 3 have been replaced with "NaN".

The annual export ratios of the companies have been provided in two separate columns, directly and indirectly. A new column has been created for the EXPO variable by summing these two data points and converting it to a percentage.

For classifying company size, some surveys used the numbers 0, 1, 2, and 3. Since the number 0 represents non-existence, these numbers have been changed to 1, 2, 3, and 4, respectively.

The variable RD/TSALE, which represents the ratio of annual R&D spending to total annual revenue, was not found in the data file but has been calculated within the Python code.

3.3 Methodology

The impact of subsidies on firms' innovative performance is primarily examined using two main methods: econometric analysis and experimental/quasi-experimental methods (Angrist & Pischke, 2009; Baltagi, 2008; Hosmer, Lemeshow, & Sturdivant, 2013; Rosenbaum & Rubin, 1983).

3.3.1 Regression analyses

The regression calculations in this study were performed using Python programming.

OLS (Ordinary Least Squares) Regression (Figure 3.1):

OLS regression is used to measure the relationship between the dependent variable (innovation performance) and independent variables (R&D subsidies, firm size, etc.).

```python
Y = β0 + β1*X1 + β2*X2 + ... + βn*Xn + ε
```

Figure 3.1 : Python code for model of OLS pregression technique.

Here, Y represents innovation performance, X1, X2, ..., represent independent variables, and ε represents the error term.

Panel Data Analysis:

Panel data analysis is used for datasets containing multiple observations over time. It can be analyzed using fixed effects and random effects models (Figure 3.2).

```python
Yit = α + βXit + ui + εit
```

Figure 3.2 : Python code for model of panel data analysis technique.

Here, i represents the firm and t represents time (Baltagi, 2008).

Logistic Regression (Logit):

Logistic regression is used to estimate the probability of an event occurring, such as the likelihood of innovation (Figure 3.3). It is used when the dependent variable is binary (0 or 1).

```python
logit(P) = β0 + β1*X1 + β2*X2 + ... + βn*Xn
```

Figure 3.3 : Python code for model of logit.

Here, P represents the probability of innovation (Hosmer, Lemeshow, & Sturdivant, 2013).

In our model, since the dependent variable INOV takes the values of 0 and 1, the logit regression technique has been applied as the most suitable technique for our model. The log-odds (or logit) is the foundation of the logistic regression model because this model chooses between two possible outcomes of the dependent variable (innovation or no innovation). Logistic regression assesses the impact of each unit change in the independent variables on the dependent variable in terms of log-odds.

A positive and large value of the log-odds indicates that the probability is quite high for the given observation. Using the log-odds, the odds (probability ratio) can be easily calculated;

Calculating Log-odds (Logit):

$$\text{Log-odds} = \beta 0 + \beta 1 \text{ x } X1 + \beta 2 \text{ x } X2 + ... + \beta n \text{ x } Xn \tag{3.3}$$

Calculationg Probability (p):

$$p = \frac{e^{log-odds}}{1 + e^{log-odds}} \tag{3.4}$$

Here, e is Euler's number, approximately equal to 2.71828.

There are various techniques available for analyzing binary dependent variables (0 and 1). These techniques include Probit Regression, Linear Probability Model (LPM), Discriminant Analysis, Support Vector Machine (SVM) for binary classification, Decision Trees, Neural Networks, and Naive Bayes. Each technique has its own advantages and application areas. However, I have chosen the Logit (Logistic Regression) method for my analysis. The reason for this is that logistic regression is highly suitable for modeling the probabilities of binary dependent variables, and the logistic function ensures that the dependent variable remains between 0 and 1. Additionally, the logistic regression model offers the advantage of interpretability of parameter estimates, allowing for probability-based interpretations of the model's results (Hosmer, 2013; Long, 1997; Peng, 2002). Therefore, I have preferred the logit model for analyzing binary variables.

3.3.2 The explanation of fundemental terms for the logit technique

Pseudo R-squared (Pseudo R^2); Pseudo R^2 is a statistic that measures the explanatory power of the model in logistic regression. Unlike the traditional R^2 used in linear regression models, Pseudo R^2 is adapted for non-linear models like logistic regression. There are different types of Pseudo R^2 (e.g., McFadden's R^2), but they all indicate how well the independent variables explain the dependent variable. Values range from 0 to 1, with values closer to 1 indicating better model fit.

Log-Likelihood; The log-likelihood measures how well the model's parameters fit the observed data. Higher values indicate that the model explains the data better. Maximum likelihood estimation aims to maximize the log-likelihood value.

LL-Null (Null Log-Likelihood); LL-Null is the log-likelihood value of the null model, which includes only the intercept (no independent variables). This value is used to assess how much better the full model fits the data compared to the null model.

LLR p-value (Likelihood Ratio Test p-value); The LLR p-value is used to compare the fit of two models (the full model and the null model). This test evaluates whether the independent variables significantly improve the model fit. A low p-value (< 0.05) indicates that the independent variables contribute significantly to the model.

Coef (Coefficients); Coefficients measure the effect of the independent variables on the dependent variable. A positive coefficient indicates that an increase in the independent variable increases the probability of the dependent variable, while a negative coefficient indicates the opposite.

Std Err (Standard Error); The standard error measures the standard deviation of the coefficient estimate. Smaller standard errors indicate more precise coefficient estimates.

z (z-score); The z-score indicates how many standard errors the coefficient is away from zero. It is used to test the significance of the coefficient.

P>|z| (P-value); The p-value determines whether the z-score is statistically significant. A small p-value (< 0.05) indicates that the coefficient is significantly different from zero, meaning the independent variable has a significant effect on the dependent variable.

Confidence Interval; The confidence interval indicates the range within which the true value of the coefficient is likely to fall at a certain confidence level (usually 95%). Narrow confidence intervals suggest more precise coefficient estimates.

3.3.3 Calculation of actual probability in logit technique

The above probability calculations were made to show the effect of variables individually. To calculate the actual probabilities, it is necessary to combine the effects of all variables. Since the effects of the coefficients in the Logit model are non-linear, calculating the effect of each independent variable separately may not be entirely accurate. Therefore, it is more appropriate to combine all coefficients and the intercept to understand how the model overall affects the probability of innovation.

When the coefficients of the independent variables in the model applied for a specific year's survey are calculated, the probability of an example company innovating before and after treatment can be calculated for the year and location of the survey. Additionally, the probability values calculated according to the mean and median values for the same year's data can be compared, and the success probability of a company applying for incentives can be evaluated without incentives. Although these are not definitive statements, they can provide preliminary insights about the firm applying for incentives.

3.3.4 Limitations

The World Bank conducts the Enterprise Survey in over 150 countries worldwide, but not every country is surveyed in the same year. When I want to compare the results of my analysis with those of other countries, there is a limited amount of data from countries that have surveys from the same year. For instance, I have faced limitations in finding data from the same year (ex 2019) for countries like the USA, China, OECD average, Japan, and Korea, which has restricted my research.

Although literature indicates regional differences, when the dataset is divided into regions, the number of firms receiving incentives drops to levels that cannot be analyzed. Similarly, while the literature emphasizes the importance of managerial education level and managerial sector experience, the survey includes data on managerial education level only for the years 2002, 2005, and 2015, and data on managerial experience only from 2008 to 2019. Since this information lacks continuity, it was excluded from the model to be analyzed separately.

4. ECONOMETRIC ANALYSIS

In this section, the data from the World Bank's Enterprise Survey for Turkey have been analyzed using the logit regression technique, and the results have been interpreted and compared. Additionally, the probabilities of firms in Turkey innovating before and after treatment have been evaluated based on the mean and median values of the data for the relevant years.

4.1 Python Analysis for the Logit Technique

4.1.1 Python coding

To begin the logit regression analysis, we start by importing the necessary libraries:

```
import pandas as pd
import statsmodels.api as sm
import numpy as np
```

The pandas library, aliased as pd, is crucial for data manipulation and analysis, offering data structures like DataFrames. It is also used for statistical modeling and hypothesis testing, including logistic regression. The statsmodels library, aliased as sm, includes functions for various tests and models. The numpy library, aliased as np, supports large, multi-dimensional arrays and matrices, essential for Python numerical computations.

Loading the dataset:

```
df = pd.read_excel('2019.xlsx')
```

Performing calculations for proportional variables and adding new columns:

```
df['RD/TSALE'] = df['RD'] / df['TSALE']
```

Selecting columns with relevant variables and dropping other data due to the large dataset:

```
df_cleaned = df[['EXPO', 'RD/TSALE', 'CSIZE', 'INOV', 'SUBS', 'AGE', 'EMPX']].dropna()
```

Identifying the dependent and independent variables:

```
y = df_cleaned['INOV']

X = df_cleaned[['RD/TSALE', 'EXPO', 'CSIZE', 'SUBS', 'AGE', 'EMPX', ]]
```

Adding the intercept term to the independent variables (X):

```
X = sm.add_constant(X)
```

Building the logit regression model:

```
logit_model = sm.Logit(y, X)

result = logit_model.fit()

print(result.summary())
```

Marginal effect calculation:

```
marginal_effects = result.get_margeff(method='dydx', at='mean')

print("\nMarjinal Effects:")

print(marginal_effects.summary())
```

4.1.2 Logit regression results

Below is an example of Logit Regression Results for the 2015 data (Figure 4.1). All results for all survey years can be seen in (Appendix A (Figure A.1, Figure A.2 and Figure A.3)).

When we examine the results, we see that the p-value of the constant (intercept) term is less than 0.05 and almost zero. This indicates that the tested variable has a statistically significant effect on the dependent variable. However, this does not imply a causal relationship; it only indicates a strong correlation.

As seen in Table 4.1, which presents the results for all years, the constant value is negative for all years. A negative constant value indicates that when all independent variables are zero, the probability of the dependent variable being 1 is low. In other words, the probability value (p) is less than 0.5.

```
Optimization terminated successfully.
         Current function value: 0.391544
         Iterations 8
Turkey 2015
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                 5537
Model:                          Logit   Df Residuals:                     5530
Method:                           MLE   Df Model:                            6
Date:                Thu, 19 Dec 2024   Pseudo R-squ.:                 0.08215
Time:                        14:45:50   Log-Likelihood:                -2168.0
converged:                       True   LL-Null:                       -2362.0
Covariance Type:            nonrobust   LLR p-value:                 1.010e-80
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -2.7788      0.098    -28.414      0.000      -2.970      -2.587
RD/TSALE      19.4432      3.514      5.533      0.000      12.556      26.331
EXPO           0.9082      0.191      4.763      0.000       0.534       1.282
CSIZE          0.4228      0.041     10.203      0.000       0.342       0.504
SUBS           1.1758      0.160      7.339      0.000       0.862       1.490
AGE            0.0034      0.003      1.029      0.304      -0.003       0.010
EMPX           0.0001      0.000      0.725      0.468      -0.000       0.000
==============================================================================
```

Figure 4.1 : Example of logit regression results.

The logit regression results for all survey years are presented in Table 4.1.

Table 4.1 : Logit regression results by years.

Variables	2002	2005	2008	2013	2015	2019
	Coef (P>|z|)	Coef (P>|z|)	Coef (P>|z|)	Coef (P>|z|)	Coef (P>|z|)	Coef (P>|z|)
Const.	-1,4533	-0,6874	-0,8163	-1,5558	-2,7788	-3,1727
	(0,000)	(0,004)	(0,000)	(0,000)	(0,000)	(0,000)
RD/TSALE	15,5922	35,3256	21,6824	30,072	19,4432	46,3369
	(0,184)	(0,029)	(0,000)	(0,011)	(0,000)	(0,000)
EXPO	1,4557	2,017	-0,2943	0,2478	0,9082	1,2231
	(0,000)	(0,000)	(0,176)	(0,309)	(0,000)	(0,000)
CSIZE	0,4354	0,2948	0,1597	0,0780	0,4228	0,0101
	(0,004)	(0,059)	(0,114)	(0,533)	(0,000)	(0,942)
SUBS	0,5469	0,5827	0,8266	1,0273	1,1758	1,2970
	(0,232)	(0,357)	(0,001)	(0,000)	(0,000)	(0,000)
AGE	-0,0038	-0,0029	0,0096	-0,0021	0,0034	0,0163
	(0,644)	(0,591)	(0,116)	(0,769)	(0,304)	(0,007)
EMPX	-0,0002	-9,15E-02	2,44E-03	0,0006	0,0001	5,83E-02
	(0,270)	(0,618)	(0,987)	(0,030)	(0,468)	(0,880)

4.1.3 Marginal effect

Marginal effects provide a directly interpretable way to understand the impact of independent variables on the dependent variable. Especially in non-linear models like logistic regression, coefficients cannot be interpreted directly; however, marginal effects allow us to understand the impact of independent variables on the dependent variable in percentage terms. This way, we can identify which variables significantly influence innovation and offer clearer recommendations for policymakers and businesses.

Marginal effects indicate which variables in the model are meaningful and strong, making the effects of independent variables directly interpretable. This information serves as guidance for strategic decision-making for policymakers and firms. Furthermore, it helps measure the impact of factors such as R&D, incentives, exports, and firm size on innovation. Overall, marginal effects make the results of econometric analysis more understandable and actionable, making them highly valuable.

```
Marginal Effects of Turkey 2015:
        Logit Marginal Effects
=====================================
Dep. Variable:                   INOV
Method:                          dydx
At:                              mean
==============================================================================
                dy/dx    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
RD/TSALE       2.3108      0.426      5.422      0.000       1.475       3.146
EXPO           0.1079      0.023      4.752      0.000       0.063       0.152
CSIZE          0.0502      0.005     10.505      0.000       0.041       0.060
SUBS           0.1397      0.019      7.254      0.000       0.102       0.178
AGE            0.0004      0.000      1.029      0.303      -0.000       0.001
EMPX        1.526e-05   2.11e-05      0.725      0.469    -2.6e-05    5.65e-05
==============================================================================
```

Figure 4.2 : Example of marginal effect results of Turkey.

Above is an example of Marginal Effects Results for the 2015 data (Figure 4.2). All results for all survey years can be seen in (Appendix B (Figure B.1 and Figure B.2)). The dy/dx value represents the marginal effect in proportional terms.

Table 4.2 contains the marginal effect calculations for all survey years and variables, along with their corresponding p-values.When we examine the marginal effect results, we first observe that the effect probability of the RD/TSALE variable is greater than 1. Except for the year 2002, the p-value is close to zero. This means that the relationship between RD/TSALE and INOV is statistically significant at all commonly used significance levels (e.g., 1%, 5%, 10%). The RD/TSALE variable has a statistically significant positive effect on the probability of innovation. Increasing R&D expenditures relative to total sales is likely to enhance the innovation activities of a firm in Turkey (Figure 4.3).

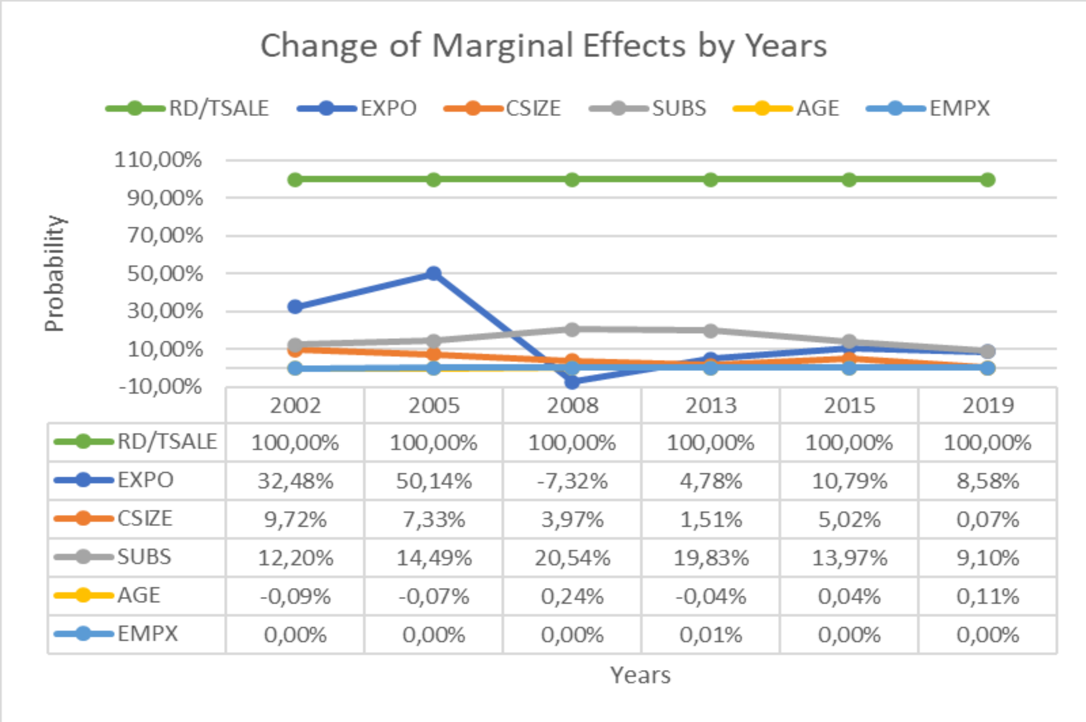
Table 4.2 : Marginal effects results by years.

Variables	2002	2005	2008	2013	2015	2019
	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx
RD/TSALE	3,4788 (0,184)	8,7819** (0,029)	5,3889*** (0,000)	5,8051** (0,011)	2,3108*** (0,000)	3,2509*** (0,000)
EXPO	0,3248*** (0,000)	0,5014*** (0,000)	-0,0732 (0,176)	0,0478 (0,309)	0,1079*** (0,000)	0,0858*** (0,000)
CSIZE	0,0972*** (0,004)	0,0733* (0,059)	0,0397 (0,114)	0,0151 (0,533)	0,0502*** (0,000)	0,0007 (0,942)
SUBS	0,1220 (0,232)	0,1449 (0,357)	0,2054*** (0,001)	0,1983*** (0,000)	0,1397*** (0,000)	0,0910*** (0,000)
AGE	-0,0009 (0,644)	-0,0007 (0,591)	0,0024 (0,116)	-0,0004 (0,769)	0,0004 (0,304)	0,0011*** (0,007)
EMPX	-3,432E-05 (0,270)	-2,274E-05 (0,618)	6,056E-07 (0,987)	0,0001** (0,030)	1,526E-05 (0,468)	4,092E-06 (0,880)

In the table, ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

We observe that the SUBS variable, representing incentives and subsidies, increased from 2002 to 2008 and remained around 20% between 2008 and 2013. After that, the effect of this variable decreased and dropped to 9% in 2019. The p-value for this variable is close to zero from 2008 onwards. Its effect on innovation is statistically significant after 2005. A one-unit increase in the SUBS variable results in a 0.091-unit increase in innovation in 2019.

The marginal effects of the EXPO (export ratio) variable in the table show different levels of significance across various years and models. In the first two years (2002 and 2005), the effect of EXPO on innovation is positive and statistically significant. Specifically, the p-values in these years are very close to zero ($p < 0.01$), indicating that exports have a significant positive effect on firms' innovation activities. However, in 2008 and 2013, the effect of EXPO is not statistically significant, as the p-values are relatively high (0.176 and 0.309, respectively).



	2002	2005	2008	2013	2015	2019
RD/TSALE	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%
EXPO	32,48%	50,14%	-7,32%	4,78%	10,79%	8,58%
CSIZE	9,72%	7,33%	3,97%	1,51%	5,02%	0,07%
SUBS	12,20%	14,49%	20,54%	19,83%	13,97%	9,10%
AGE	-0,09%	-0,07%	0,24%	-0,04%	0,04%	0,11%
EMPX	0,00%	0,00%	0,00%	0,01%	0,00%	0,00%

Figure 4.3 : Change of marginal effects by years.

In the following years, 2015 and 2019, the effect of EXPO is again positive and statistically significant ($p < 0.01$). This finding suggests that increases in export ratios are associated with a higher likelihood of innovation. In 2015, the marginal effect of EXPO was 10.79%, showing a clear positive effect of exports on innovation. However, by 2019, the effect decreased to 8.58%, although it remained positive and statistically significant. This indicates that the impact of exports on innovation has slightly diminished over time, but still retains considerable significance.

The marginal effects of the CSIZE (firm size) variable in the table vary in significance across different years. In 2002 and 2015, the effect of CSIZE on innovation is statistically significant and positive ($p < 0.01$). This indicates that larger firms are more likely to engage in innovation. However, in 2005, the effect of CSIZE is significant at the 5% significance level, with a p-value of 0.059, indicating lower statistical significance. In 2008 and 2013, the effect of CSIZE is not statistically significant ($p > 0.1$), meaning that the impact of firm size on innovation is not evident in these years. In 2019, CSIZE is not statistically significant ($p = 0.942$), suggesting that the effect of firm size on innovation is nearly zero in that year.

The effect of the AGE (firm age) variable on innovation also varies over time. In 2002, 2005, 2008, 2013, and 2015, the effect of AGE is not statistically significant ($p > 0.1$), indicating that the age of a firm does not have a significant effect on its likelihood of innovating. However, in 2019, the effect of AGE is statistically significant ($p = 0.007$) and positive, suggesting that older firms are more likely to engage in innovation. This finding indicates that the effect of firm age on innovation is close to zero in most years, with a significant effect only in 2019.

The EMPX (number of employees) variable also shows varying effects over time. In 2002, 2005, 2015, and 2019, the effect of EMPX on innovation is not statistically significant ($p > 0.1$), meaning that the number of employees does not have a significant impact on innovation in these years. However, in 2008, the effect of EMPX is statistically significant ($p = 0.030$) and positive, indicating that an increase in the number of employees is associated with an increase in innovation activities. This finding suggests that the increase in employee numbers has a minimal effect on innovation.

4.2 Assessment of Model Fit and Statistical Significance in Logit Regression

In the methodology section, the values and interpretations of the model fit and diagnostic measures—Pseudo R-squared, Log-Likelihood, LL-Null (Null Log-Likelihood), and LLR p-value (Likelihood Ratio Test p-value)—used in the Logit regression technique executed in Python are provided below for each year (Table 4.3).

Table 4.3 : Model fit and statistical significance.

Years	Pseudo R-square	Log- Likelihood	LL- Null	LLR p-value
2002	0,04914	-314,08	-330,31	1,33E-02
2005	0,06475	-360,64	-385,61	4,84E-06
2008	0,03857	-575,02	-598,09	2,78E-05
2013	0,06031	-403,14	-429,01	2,10E-06
2015	0,08215	-2168	-2362	1,01E-77
2019	0,09724	-415,23	-459,96	3,95E-14

Throughout the years, there have been fluctuations in the pseudo R-square values, but the highest value was observed in 2019 (0.09724). This indicates that in 2019, the model's capacity to explain the dependent variable was higher compared to other years.

The low values in 2002 and 2008 (0.04914 and 0.03857) suggest that the model's explanatory power for the dependent variable was limited during those years. The higher values in 2015 and 2019 (0.08215 and 0.09724) indicate that the model contained more information or achieved a better fit. Overall, there is an upward trend from 2002 to 2019. This suggests that the independent variables used in the model became more explanatory over time. However, the drop in 2008 is noteworthy. This could be due to an extraordinary situation, such as an economic or sectoral crisis, affecting that particular year.

The Log-Likelihood values vary over the years, but generally indicate that the model's fit with the data is weak. The Log-Likelihood statistic represents the logarithmic likelihood values, and in a good model, this value is expected to be high.

Our LL-Null and LLR p-value results indicate that the independent variables make significant contributions to the model and substantially enhance the explanatory power of the dependent variable. The very low LLR p-values for all years suggest that the independent variables play a crucial role in the model and that the model is generally statistically significant.

4.3 Calculation of Actual Probabilities

In the logit regression technique, calculating the actual probability requires combining the effects of all variables. Therefore, we will combine all coefficients and intercepts to perform the calculation. Steps are below;

Review Logit Regression Results:

> In the previous work, we calculated the coefficients and intercept for the logit regression model. We will use these calculations to perform probability calculations.

Determine Sample Company:

> We will determine the independent variables for the sample company. Since we are calculating the probability for companies in Turkey, we will use the mean and median values of the firms participating in the survey.

Determine Incentive Status:

> We will calculate the innovation probability for the SUBS variable in both cases, 0 and 1.

Probability Calculation Using Logit Model;

$$P(y=1|X) = \frac{1}{1 + e^{-(\beta 0 + \beta 1X1 + \beta 2X2 + \cdots + \beta nXn)}} \tag{4.2}$$

Comparison and Interpretation of Results:

We will compare and interpret the innovation probabilities based on whether or not the firm receives incentives (Table 4.4).

Table 4.4 : Actual probability based on mean and median values of firms data.

Years	Mean		Median	
	Subs=0	Subs=1	Subs=0	Subs=1
2002	32,94%	44,70%	25,64%	37,38%
2005	52,90%	79,59%	39,51%	61,70%
2008	43,02%	76,02%	41,19%	60,05%
2013	23,56%	52,00%	20,94%	44,98%
2015	11,44%	51,06%	13,06%	43,38%
2019	7,00%	32,13%	5,31%	19,16%

The graph shows the innovation probabilities (calculated by using equation 4.2) of sample companies created from the median values of the firms participating in the survey, adjusted for outliers, according to whether they received incentives or not over the years. According to the graph, the probability of innovation for firms that received treatment is higher than for those that did not, and this gap widens in 2015 but shows a decreasing trend in 2019. This trend indicates that government incentive policies are effective in promoting innovation among firms. The probability of innovating increases by about 20% when the firm is theated by the Government. According to the 2019 data, firms that did not receive treatment have an 5.31% probability of innovating, while for those that received treatment, this probability reaches 19.16%. Another notable aspect of the graph is the steady decline in the probability of innovation among firms that did not receive treatment over time (Figure 4.4).

As seen in Figure 4.4 and Figure 4.5, the probability of innovation for treated firms is higher than that for untreated firms in all survey years, based on both median and mean values. Although the treatment effect varies across years, it is clearly positive. The probability values calculated using mean values are higher than those calculated using median values in all years, due to the influence of outliers. This indicates that outliers push the probability average upward.

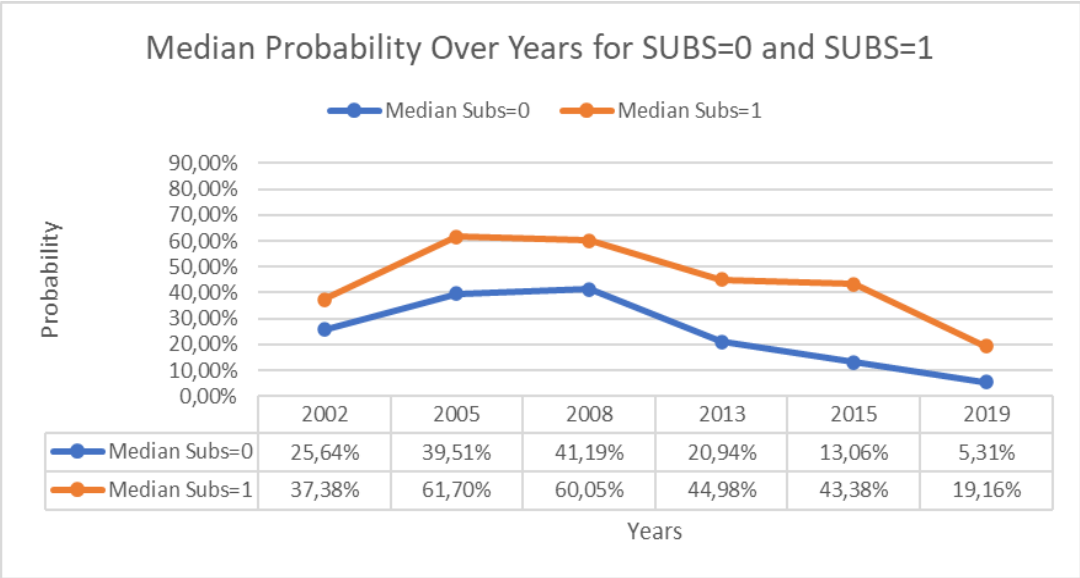


Figure 4.4 : Probability graph based on the median values of firm variables.

According to the graph, the highest probability for both treated and untreated firms occurred in 2005 and 2008, after which performance declined. For untreated firms, the probabilities calculated using mean and median values are low and close to each other. However, in the last survey year, the performance for treated firms, calculated with median values, was at 19%, whereas when outliers are accounted for, this performance increases to 32%.

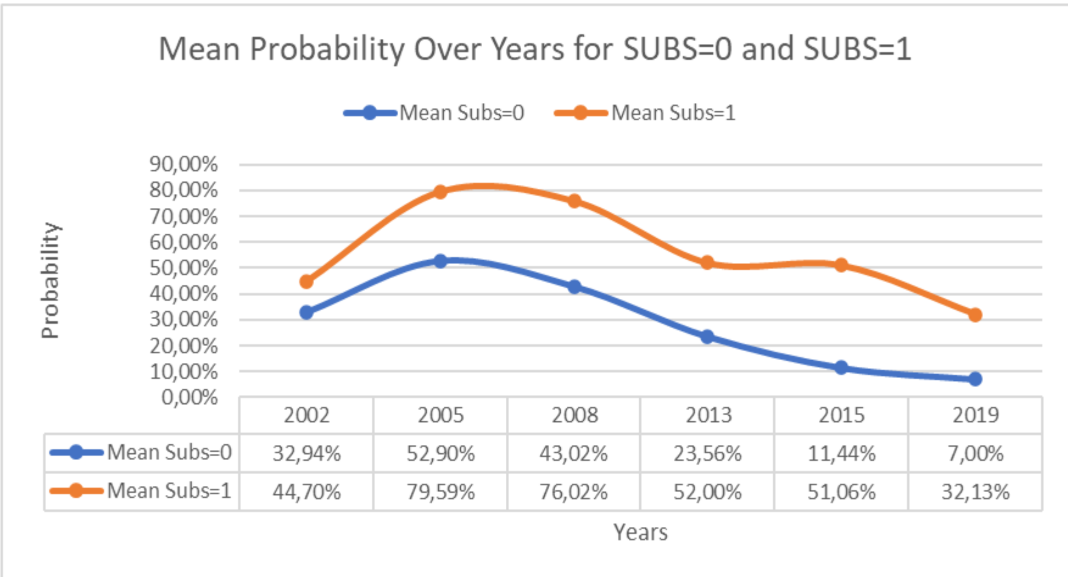


Figure 4.5 : Probability graph based on the mean values of firm variables.

4.4 Innovation Probabilities for Sample Firms Using Logit Regression Results

In this section, the data of companies affiliated with one of Turkey's leading conglomerates will be applied to the model calculated for the most recent survey year, 2019. The innovation probabilities of these firms will be calculated according to whether they received treatment or not, and these probabilities will be compared with the probability values calculated using the mean and median values of firms across Turkey, as calculated in Section 4.3.

This analysis will not only allow us to estimate the innovation probability of a firm when it applies for government incentives, both in its current state and after receiving treatment, but also provide an understanding of where the firm stands in comparison to the national averages.

Table 4.5 : Variable data for sample firms.

Variables	Firm 1	Firm 2	Firm 3	Firm 4	Firm5	Firm 6
RD/TSALE	4,50%	0,08%	0%	0%	0%	1,29%
EXPO	46%	8%	0%	0%	0%	2,70%
CSIZE	2	3	1	2	1	3
AGE	11	71	3	6	1	49
EMPX	210	390	40	75	5	582

Firm 1 operates in the machinery sector, manufacturing garbage collection vehicles. The share of its R&D expenditures in total revenue increases each year. The company continues its export-focused activities with its fast-growing, dynamic, and innovative structure.

Firm 2 is a 71-year-old sugar factory. It was acquired from the state through privatization in 2019. Its export share is limited to 8% due to quotas. In recent years, the export of sugar has been handled by another entity within the holding, so exports are not reflected in the survey data.

Firm 3 processes the sugar produced by the sugar factory into lump sugar, sugar cubes, and packaged sugar. It is a young facility with a small workforce. Firm 4 is an agricultural company. It rents and cultivates unused lands from farmers and has a strong agricultural machinery and equipment setup. Firm 5 is a livestock farm for cattle and sheep. It is newly established and has a small workforce.

Firm 6 is a publicly traded company manufacturing diesel engines and tractors. Established in 1975, it has 582 employees and a robust R&D facility (Table 4.5).

Table 4.6 : Innovation probabilities of sample firms.

Companies	SUBS = 0	SUBS = 1
Firm 1	42,73%	72,19%
Firm 2	13,98%	37,28%
Firm 3	4,35%	14,26%
Firm 4	4,56%	14,89%
Firm 5	4,17%	13,72%
Firm 6	15,86%	40,81%

When the innovation probabilities of the selected firms are evaluated based on their variable data, it is observed that Firm 1 has the highest probability. This firm demonstrates a higher likelihood of success compared to treated firms, even without treatment. Over the past three years, the firm has shown a consistent increase in both the number of employees and R&D investments. As a dynamic and agile entity, if treated, the firm is likely to achieve a success probability of approximately 72%, well above the Turkish average, aligning with actual values.

Firm 6 ranks second in terms of success probability. Without treatment, it performs close to the Turkish average, but if treated, it is calculated to perform above average. This firm is experienced and has a large workforce. To compete effectively within its sector, it requires R&D; however, its R&D projects are large-scale and costly. The calculated results are consistent with the firm's data.

Firm 2 is an old sugar factory without an R&D unit. It innovates through technology transfer. Its investments are high-cost, but if treated, its potential for innovation is above the Turkish average.

Firms 3, 4, and 5 operate in the packaging, agriculture, and livestock sectors, where traditional methods are predominantly used. Even if treated, their probabilities of achieving innovation are calculated to above (Table 4.6).

4.5 International Comparisons

In 2019, the World Bank conducted an enterprise survey in 48 countries, excluding Turkey. To make an international performance comparison, some of these countries were selected as samples. The selected countries and the selection criteria are listed below.

4.5.1 Selected countries and selection criteria

The Gross Domestic Expenditure on R&D (GERD) as a percentage of GDP for the 48 countries surveyed in 2019 has been researched. Based on the obtained data, the countries have been ranked from highest to lowest (Table 4.7). Turkey is highlighted in italic in the table. Additionally, the table includes the average values for OECD and EU countries for the year 2019.

Table 4.7 : GERD of selected countries as a percentage of GDP in 2019 (Url-2).

Percentage (%)	Countries	Percentage (%)	Countries	Percentage (%)	Countries
2,60	OECD average	0,82	Slovak Republic	0,11	Uzbekistan
2,10	EU Average	0,76	Rwanda	0,09	Kyrgyz Republic
2,04	Slovenia	0,71	Cyprus	0,09	Mongolia
1,93	Czech Rep.	0,64	Latvia	0,09	Tajikistan
1,47	Hungary	0,58	Belarus	NaN	Albania
1,46	Italy	0,56	Malta	NaN	Haiti
1,40	Portugal	0,48	Romania	NaN	Jordan
1,32	Poland	0,43	Ukraine	NaN	Kenya
1,32	*Turkey*	0,37	North Macedonia	NaN	Kosovo
1,27	Greece	0,36	Montenegro	NaN	Lebanon
1,07	Croatia	0,28	Georgia	NaN	Morocco
1,04	Russian Federation	0,24	Moldova	NaN	Mozambique
1,00	Lithuania	0,20	Azerbaijan	NaN	Somalia
0,99	Malaysia	0,19	Bosnia-Herzegovina	NaN	Suriname
0,89	Serbia	0,18	Armenia	NaN	West Bank and Gaza
0,83	Bulgaria	0,12	Kazakhstan	NaN	Zambia

As seen in Table 4.7, the 2019 values for 12 countries were unavailable (NaN) and have been added to the end of the list. Additionally, Malaysia's 2019 data was not available; however, since its values were 1.04% in 2018 and 0.95% in 2020, the midpoint of these two figures was estimated for 2019 and positioned accordingly in the table. This data is not used in any calculations, it is only accepted for positioning in the table.

The countries listed in the left column of Table 4.7 have been selected for comparison. Accordingly, the countries with a higher R&D expenditure ratio than Turkey—Slovenia, the Czech Republic, Hungary, Italy, Portugal, and Poland—will be analyzed. Meanwhile, the countries with a lower R&D expenditure ratio than Turkey—Greece, Croatia, Russia, Lithuania, Malaysia, Serbia, and Bulgaria—will also be examined.

4.5.2 Logit regression results of selected countries

Logit regression results for selected countries show that all the intercepts except for Slovenia are negative, which means that when all independent variables are zero, the probability of the event occurring is less that 50% (Table 4.8 and Table 4.9). We will evaluate the impact of the intercept for Slovenia in the marginal effect calculation. All Logit Regression results related to the selected countries are in (Appendix C (Figure C.1, Figure C.2, Figure C.3, Figure C.4, Figure C.5, Figure C.6 and Figure C.7)).

Table 4.8 : Logit regression results of countries with GERD as a percentage of GDP higher than Turkey.

Variables	Turkey	Poland	Portugal	Italy	Hungary	Czech Rep.	Slovenia
	Coef (P> |z|)	Coef (P> |z|)	Coef (P> |z|)	Coef (P> |z|)	Coef (P> |z|)	Coef (P> |z|)	Coef (P> |z|)
Const	-3,1727 (0,000)	-0,9294 (0,012)	-1,6594 (0,000)	-1,8105 (0,000)	-1,5042 (0,000)	-2,4898 (0,000)	0,3054 (0,457)
RD/TSALE	46,3369 (0,000)	70,1906 (0,015)	9,0296 (0,099)	-7,2907 (0,472)	23,2172 (0,000)	3,2145 (0,422)	-1,3218 (0,492)
EXPO	1,2231 (0,000)	0,1633 (0,000)	-0,1601 (0,488)	2,5601 (0,000)	0,2085 (0,447)	-0,3241 (0,332)	0,0411 (0,915)
CSIZE	0,0101 (0,942)	-0.1957 (0,165)	0,3090 (0,010)	-0,3985 (0,026)	0,1901 (0,160)	1,0217 (0,000)	0,3792 (0,160)
SUBS	1,2970 (0,000)	1,4163 (0,001)	-0,2162 (0,649)	2,0860 (0,063)	0,3322 (0,260)	1,5008 (0,052)	20,0331 (0,999)
AGE	0,0163 (0,007)	0,0066 (0,303)	0,0052 (0,145)	0,0081 (0,069)	-0,0089 (0,362)	-0,0032 (0,578)	0,0039 (0,651)
EMPX	-5,83E-02 (0,000)	-0,0003 (0,630)	0,0003 (0,598)	0,0009 (0,197)	-0,0002 (0,758)	-0,0013 (0,094)	0,0029 (0,364)

The following table shows the results of the logit regression analysis for countries with a ratio of gross domestic R&D expenditures to GDP lower than Turkey's.

Table 4.9 : Logit regression results of countries with GERD as a percentage of GDP lower than Turkey.

Variables	Bulgaria	Serbia	Malaysia	Lithuania	Russia	Croatia	Greece	Turkey
	Coef (P> |z|)	Coef (P> |z|)	Coef (P> |z|)	Coef (P> |z|)	Coef (P> |z|)	Coef (P> |z|)	Coef (P> |z|)	Coef (P> |z|)
Const.	-2,9682 (0,000)	-1,4829 (0,001)	-1,5290 (0,000)	-1,4569 (0,003)	-2,3909 (0,000)	-1,5741 (0,000)	-1,1172 (0,003)	-3,1727 (0,000)
RD/TSALE	105,5872 (0,000)	-0,5984 (0,952)	77,8864 (0,000)	402,3668 (0,159)	29,0114 (0,000)	144,5631 (0,132)	-0,0467 (0,895)	46,3369 (0,000)
EXPO	1,0842 (0,000)	0,5583 (0,189)	0,1566 (0,489)	-0,5885 (0,108)	0,7721 (0,133)	0,7586 (0,029)	0,1858 (0,539)	1,2231 (0,000)
CSIZE	0,3658 (0,013)	0,4691 (0,003)	0,3140 (0,003)	0,5579 (0,005)	0,0802 (0,453)	0,3122 (0,055)	0,1436 (0,315)	0,0101 (0,942)
SUBS	1,3121 (0,156)	-0,5963 (0,299)	0,7132 (0,069)	-0,9406 (0,319)	1,3370 (0,003)	0,8015 (0,383)	1,0635 (0,017)	1,2970 (0,000)
AGE	0,0193 (0,012)	0,0008 (0,908)	-0,0031 (0,590)	-0,0106 (0,258)	0,0347 (0,000)	-0,0012 (0,853)	-0,0029 (0,584)	0,0163 (0,007)
EMPX	-0,0004 (0,480)	-5,34E-05 (0,928)	1,38E-02 (0,937)	-0,0003 (0,857)	4,60E-03 (0,966)	0,0007 (0,272)	0,0007 (0,439)	-5,83E-02 (0,000)

4.5.3 Marginal effects

As explained in Section 4.1.3, in order to interpret the effect of independent variables on the dependent variable based on the results calculated in Section 5.2, we need to calculate the marginal effects.

Table 4.10 : Marginal effects of countries with GERD as a percentage of GDP higher than Turkey.

Variables	Turkey	Poland	Portugal	Italy	Hungary	Czech Rep.	Slovenia
	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx
RD/TSALE	3,2509*** (0,000)	14,2543** (0,015)	1,7981* (0,099)	-0,8749 (0,472)	4,4644*** (0,000)	0,8004 (0,422)	-0,1571 (0,492)
EXPO	0,0858*** (0,000)	0,3316*** (0,000)	-0,0319 (0,488)	0,3072*** (0,000)	0,0401 (0,447)	-0,0807 (0,332)	0,0049 (0,915)
CSIZE	0,0007 (0,942)	-0,0397 (0,165)	0,0615** (0,010)	-0,0478** (0,026)	0,0366 (0,160)	0,2544*** (0,000)	0,0451 (0,160)
SUBS	0,0910*** (0,000)	0,2876*** (0,001)	-0,0430 (0,649)	0,2503* (0,063)	0,0639 (0,260)	0,3737* (0,052)	2,3813 (0,999)
AGE	0,0011*** (0,007)	0,0013 (0,303)	0,0010 (0,145)	0,0010* (0,069)	-0,0017 (0,362)	-0,0008 (0,578)	0,0005 (0,651)
EMPX	4,092E-06 (0,000)	-5,389E-05 (0,630)	5,409E-05 (0,598)	0,0001 (0,197)	-3,407E-05 (0,758)	-0,0003* (0,094)	0,0003 (0,364)

In the table, ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

The marginal effect values for countries with GERD as a percentage of GDP higher than that of Turkey have been calculated and presented in Table 4.10. All calculation results are in (Appendix D (Figure D.1 and Figure D.2)).

Table 4.11 : Marginal effects of countries with GERD as a percentage of GDP lower than Turkey.

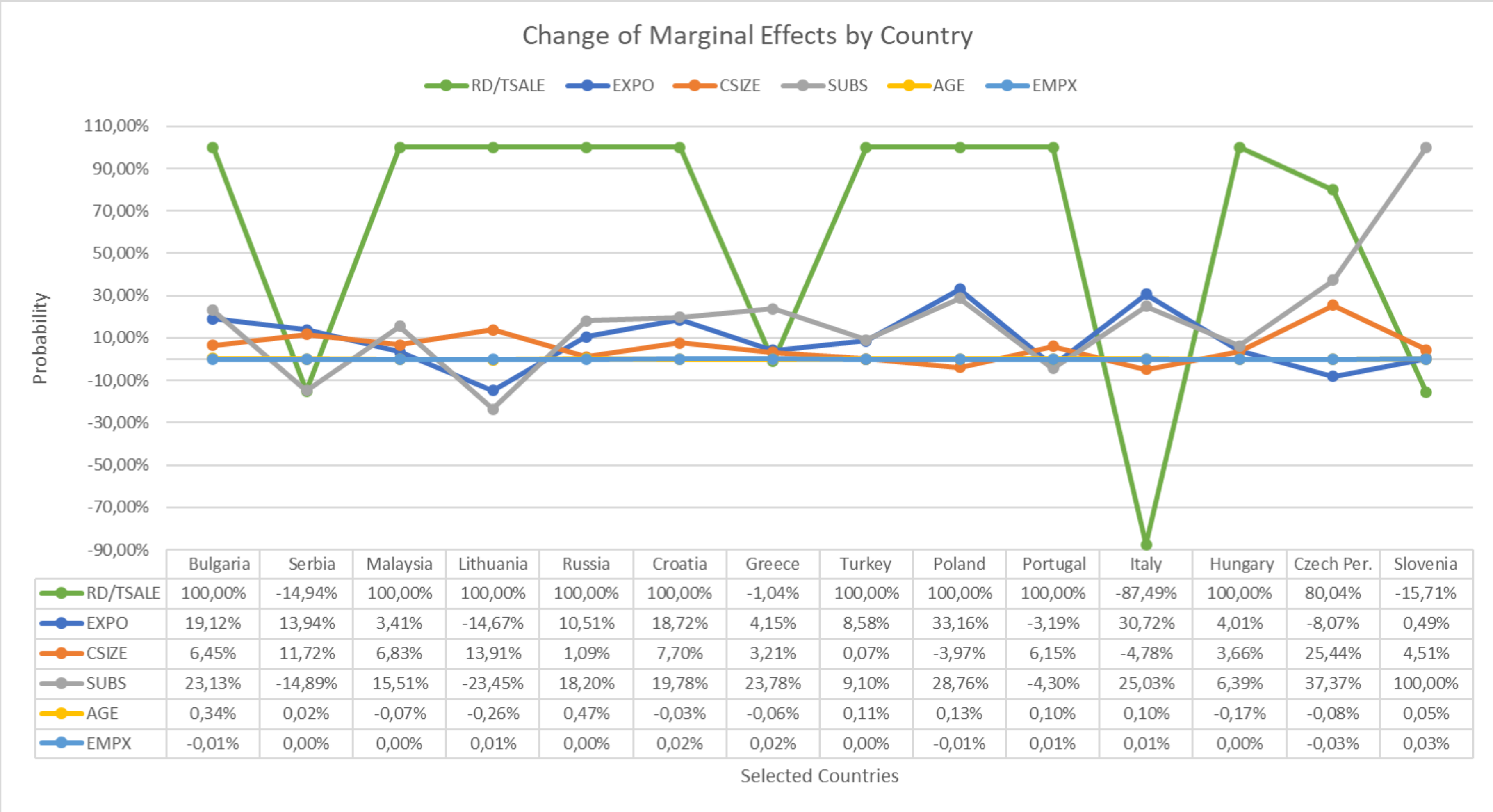
Variables	Bulgaria	Serbia	Malaysia	Lithuania	Russia	Croatia	Greece	Turkey
	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx	dy/dx
RD/TSALE	18,6176***	-0,1494	16,9416***	100,3262	3,9501***	35,6708	-0,0104	3,2509***
	(0,000)	(0,952)	(0,000)	(0,159)	(0,000)	(0,132)	(0,895)	(0,000)
EXPO	0,1912***	0,1394	0,0341	-0,1467	0,1051	0,1872**	0,0415	0,0858***
	(0,000)	(0,189)	(0,489)	(0,108)	(0,133)	(0,029)	(0,539)	(0,000)
CSIZE	0,0645**	0,1172***	0,0683***	0,1391***	0,0109	0,0770*	0,0321	0,0007
	(0,013)	(0,003)	(0,003)	(0,005)	(0,453)	(0,055)	(0,315)	(0,942)
SUBS	0,2313	-0,1489	0,1551*	-0,2345	0,1820***	0,1978	0,2378**	0,0910***
	(0,156)	(0,299)	(0,069)	(0,319)	(0,003)	(0,383)	(0,017)	(0,000)
AGE	0,0034**	0,0002	-0,0007	-0,0026	0,0047***	-0,0003	-0,0006	0,0011***
	(0,012)	(0,908)	(0,590)	(0,258)	(0,000)	(0,853)	(0,584)	(0,007)
EMPX	-7,82E-05	-1,33E-05	2,99E-06	6,601E-05	6,265E-07	0,0002	0,0002	4,09E-06***
	(0,480)	(0,928)	(0,937)	(0,857)	(0,966)	(0,272)	(0,439)	(0,000)

In the table, ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

The marginal effect values for countries with GERD as a percentage of GDP lower than that of Turkey have been calculated and presented in Table 4.11. All calculation results are in (Appendix D (Figure D.3, Figure D.4 and Figure D.5)).

When evaluating the marginal effect values of the countries shown collectively in Figure 4.6 along with their statistical significance, we can directly interpret the effect of independent variables on the dependent variable. Looking at the RD/TSALE variable, it is observed to be negative in Serbia, Greece, Italy, and Slovenia, while it reaches 80% in the Czech Republic. However, the p-values for these countries are not statistically significant. In other countries, both the p-value is very small, and RD/TSALE stands out as the most influential variable.

The SUBS (incentives and subsidies) variable is negative for Serbia, Lithuania, and Portugal, with high p-values. These results are not statistically significant. However, in general, the effect of incentives and subsidies varies by country but remains positive and significant. In terms of impact ranking, Turkey, along with Hungary, has the lowest effect. The country with the highest effect is Slovenia, followed by the Czech Republic with a 37% effect. Overall, the impact ranges between 15% and 28%, while in Turkey, it remains at 9%.



	Bulgaria	Serbia	Malaysia	Lithuania	Russia	Croatia	Greece	Turkey	Poland	Portugal	Italy	Hungary	Czech Per.	Slovenia
RD/TSALE	100,00%	-14,94%	100,00%	100,00%	100,00%	100,00%	-1,04%	100,00%	100,00%	100,00%	-87,49%	100,00%	80,04%	-15,71%
EXPO	19,12%	13,94%	3,41%	-14,67%	10,51%	18,72%	4,15%	8,58%	33,16%	-3,19%	30,72%	4,01%	-8,07%	0,49%
CSIZE	6,45%	11,72%	6,83%	13,91%	1,09%	7,70%	3,21%	0,07%	-3,97%	6,15%	-4,78%	3,66%	25,44%	4,51%
SUBS	23,13%	-14,89%	15,51%	-23,45%	18,20%	19,78%	23,78%	9,10%	28,76%	-4,30%	25,03%	6,39%	37,37%	100,00%
AGE	0,34%	0,02%	-0,07%	-0,26%	0,47%	-0,03%	-0,06%	0,11%	0,13%	0,10%	0,10%	-0,17%	-0,08%	0,05%
EMPX	-0,01%	0,00%	0,00%	0,01%	0,00%	0,02%	0,02%	0,00%	-0,01%	0,01%	0,01%	0,00%	-0,03%	0,03%

Figure 4.6 : Change of marginal effects by selected countries.

The effect of the EXPO (export ratio) variable does not vary significantly across countries and is generally positive and significant. In Hungary, the Czech Republic, Slovenia, and Portugal, the effect is low, but these results are not statistically significant. On the other hand, Malaysia, Lithuania, and Greece, which are to the left of Turkey on the list, also show low values, but these are not statistically significant either. Among the countries where the results are statistically significant, Turkey has the lowest effect. Russia follows Turkey with 10%. In Poland and Italy, where GERD/GDP is higher than in Turkey and the results are significant, the effect exceeds 30%. At the bottom of the list, Bulgaria has an effect of 19%, which is also statistically significant.

The CSIZE variable, representing firm size, varies across countries. In Poland and Italy, the effect is negative, which can be interpreted as smaller firms having a higher probability of innovation. On the left side of the list, in Serbia and Lithuania, innovation performance increases significantly as firm size grows, and the results are statistically significant. On the right side, the Czech Republic shows the strongest positive effect, with firm size increasing innovation performance by approximately 25%. In other countries, the effect is positive and statistically significant, ranging between 3% and 6%. In Turkey, however, the effect is close to zero.

The AGE variable, representing firm age, is generally significant, but its effect is well below 1%. In four of the selected countries, the value is negative, indicating that as firms age, their innovation performance declines. The EMPX variable, representing the number of employees, has a marginal effect close to zero, ranging between 0.01% and 0.03% across all countries. This suggests that the number of employees has little to no impact on innovation performance. In Turkey, the effect of this variable is exactly zero.

4.5.4 Assessment of model fit and statistical significance in logit regression

The table presents the key indicator of logit regression analysis results for selected countries (Table 4.12). The key indicators in the table include Pseudo R-square, Log-Likelihood, LL-Null, and LLR p-value, which provide insights into the model's goodness-of-fit and explanatory power.

The Pseudo R-square values vary across countries, indicating differences in how well the independent variables explain the probability of innovation. Bulgaria has the highest Pseudo R-square value (0.12000), suggesting that the model has the strongest explanatory power in this country. Turkey follows with a relatively high Pseudo R-square of 0.09724, indicating a moderately strong fit. On the other hand, Greece (0.01495) and Portugal (0.01863) have the lowest Pseudo R-square values, suggesting that the independent variables have a weaker explanatory effect on innovation in these countries.

The Log-Likelihood values represent the goodness-of-fit of the estimated model, with more negative values indicating lower likelihoods. Malaysia (-621.98) and Russia (-499.48) have the lowest Log-Likelihood values, implying that the model may not fit as well as in other countries. In contrast, Serbia (-194.09) and Slovenia (-195.54) show the least negative Log-Likelihood values, suggesting a relatively better fit in these countries.

Table 4.12 : Model fit and statistical signifiance for selected countries.

Countries	Pseudo R-square	Log- Likelihood	LL- Null	LLR p-value
Slovenia	0,04669	-195,54	-205,12	0,003912
Czech Rep.	0,07951	-313,37	-340,44	6,912E-10
Hungary	0,03500	-430,08	-445,68	2,320E-05
Italy	0,07992	-276,51	-300,52	1,162E-08
Portugal	0,01863	-556,31	-566,87	0,001745
Poland	0,06641	-378,81	-405,76	7,759E-10
Turkey	0,09724	-415,23	-459,96	3,95E-14
Greece	0,01495	-375,52	-381,22	0,07689
Croatia	0,07216	-251,70	-271,27	6,696E-27
Russia	0,05440	-499,48	-528,21	1,470E-10
Lithuania	0,05736	-225,81	-239,55	0,0001176
Malaysia	0,06567	-621,98	-665,70	1,030E-16
Serbia	0,03710	-194,09	-201,57	0,02060
Bulgaria	0,12000	-319,96	-363,60	1,120E-16

The LLR p-values indicate whether the independent variables as a whole significantly improve the model compared to a model with only the intercept. In most countries, the p-values are close to zero, indicating that the model is statistically significant. For instance, Turkey (3.95E-14), Croatia (6.696E-27), Poland (7.759E-10), and Malaysia (1.030E-16) have extremely small p-values, confirming strong statistical significance. However, Greece stands out with a p-value of 0.07689, which is above the conventional 5% significance threshold, suggesting that the model's explanatory variables may not significantly predict innovation in Greece.

4.5.5 Comparative analysis of logit model based on the mean and median values of variables for firms in selected international countries

As indicated in Section 4.3, to calculate the actual probabilities, it is necessary to combine the effects of all variables. Therefore, for the model created based on the data from 2019, variables from firms in selected international countries dataset have been selected.

Using the mean and median values of firm data, the probabilities of innovating in treated and untreated scenarios were calculated using the coefficients obtained from the Logit regression results of the selected countries, run as Log-odds in a Python program (Table 4.13).

Table 4.13 : The innovation probabilities based on mean and median values of the firms on selected countries.

Countries	Mean		Median	
	SUBS=0	SUBS=1	SUBS=0	SUBS=1
Slovenia	77,59%	99,99%	77,47%	99,99%
Czech Rep.	51,49%	88,30%	61,73%	86,63%
Hungary	25,01%	37,03%	21,18%	31,65%
Italy	13,83%	49,83%	8,45%	52,23%
Portugal	27,45%	28,58%	28,59%	26,48%
Poland	21,83%	63,64%	23,38%	54,28%
Turkey	7,00%	32,13%	5,31%	19,17%
Greece	33,78%	59,10%	32,38%	58,43%
Croatia	43,50%	81,08%	34,40%	71,00%
Russia	15,92%	42,77%	14,44%	42,74%
Lithuania	51,70%	84,38%	50,23%	23,89%
Malaysia	31,13%	61,12%	27,64%	52,03%
Serbia	48,66%	42,45%	48,49%	46,63%
Bulgaria	22,58%	71,14%	17,20%	64,21%

4.5.6 Interpretation of results

According to the Figure 4.7 and Figure 4.8, in Turkey, the innovation performance of firms that do not receive subsidies is, on average, 7%, while for subsidized firms, it is 32.13%. Based on median values, the innovation performance of non-subsidized firms is 5.31%, whereas for subsidized firms, it is 19.17%. This indicates that subsidies have an impact on innovation performance in Turkey, but this impact is relatively low compared to other countries.

Countries with high innovation performance; Slovenia, the Czech Republic, and Lithuania have the highest innovation performance among the listed countries. In Slovenia, the innovation probability for subsidized firms is 99.99%, while for non-subsidized firms, it is 77.59%. In the Czech Republic, subsidies have a significant effect, with subsidized firms showing an innovation probability of 88.30%, compared to 51.49% for non-subsidized firms. A similar pattern is observed in Lithuania, where subsidized firms have an innovation probability of 84.38%, while non-subsidized firms have 51.70%. Compared to these countries, the impact of subsidies on innovation performance in Turkey is significantly lower.

Countries with moderate innovation performance; Countries such as Hungary, Poland, Greece, and Croatia show a stronger effect of subsidies on innovation than Turkey, but their impact is not as high as in the top-performing countries. For example, in Hungary, the innovation probability is 37.03% for subsidized firms and 25.01% for non-subsidized firms. In Poland, the innovation probability for subsidized firms is 63.64%, whereas for non-subsidized firms, it is 21.83%. For Greece, the p-value of the model is 0.076, which is at the threshold of statistical significance. In contrast, for other countries, the p-values are significantly lower and statistically meaningful. Compared to Turkey, these countries exhibit a more noticeable effect of subsidies, although in some cases, the difference between subsidized and non-subsidized firms is not substantial.

Countries with Low Innovation Performance; Italy, Portugal, and Russia also show an impact of subsidies on innovation, though at a lower level than other countries. In Italy, subsidized firms have an innovation probability of 49.83%, while non-subsidized firms have 13.83%. In Portugal, the probability is 28.58% for subsidized firms, with a minor difference from non-subsidized firms (27.45%). Although the impact of subsidies on innovation performance in these countries is higher than in Turkey, it is not as significant as in the top-performing nations.

Countries with higher GERD/GDP than Turkey; Among these countries, the Czech Republic (88.30%), Poland (63.64%), and Italy (49.83%) show a significantly higher impact of subsidies on innovation performance compared to Turkey. Particularly in

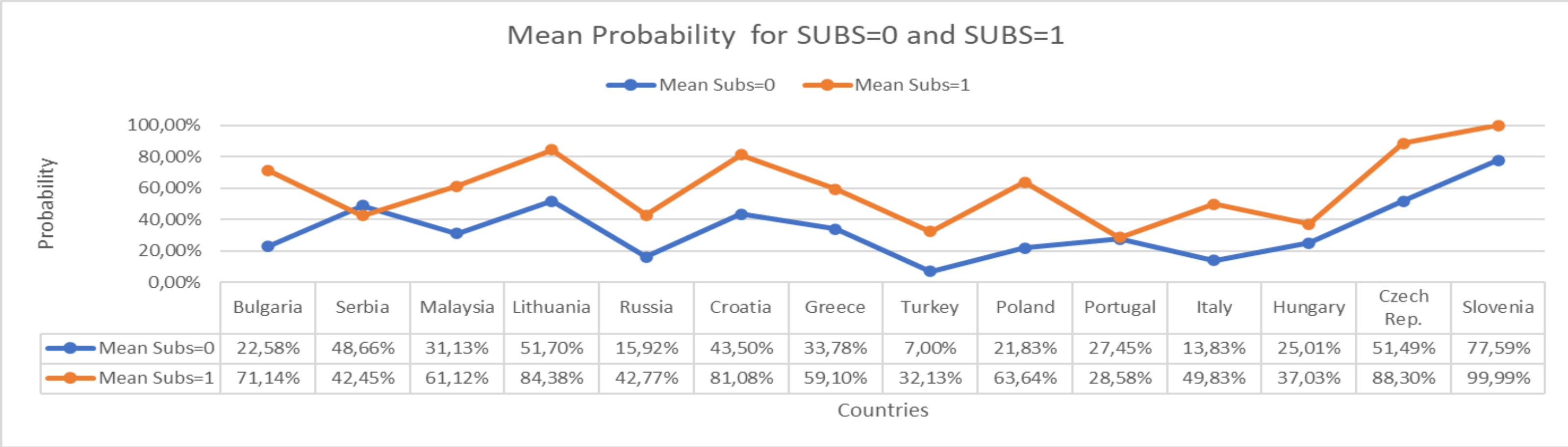


Figure 4.7 : Innovation probabilities based on mean values.

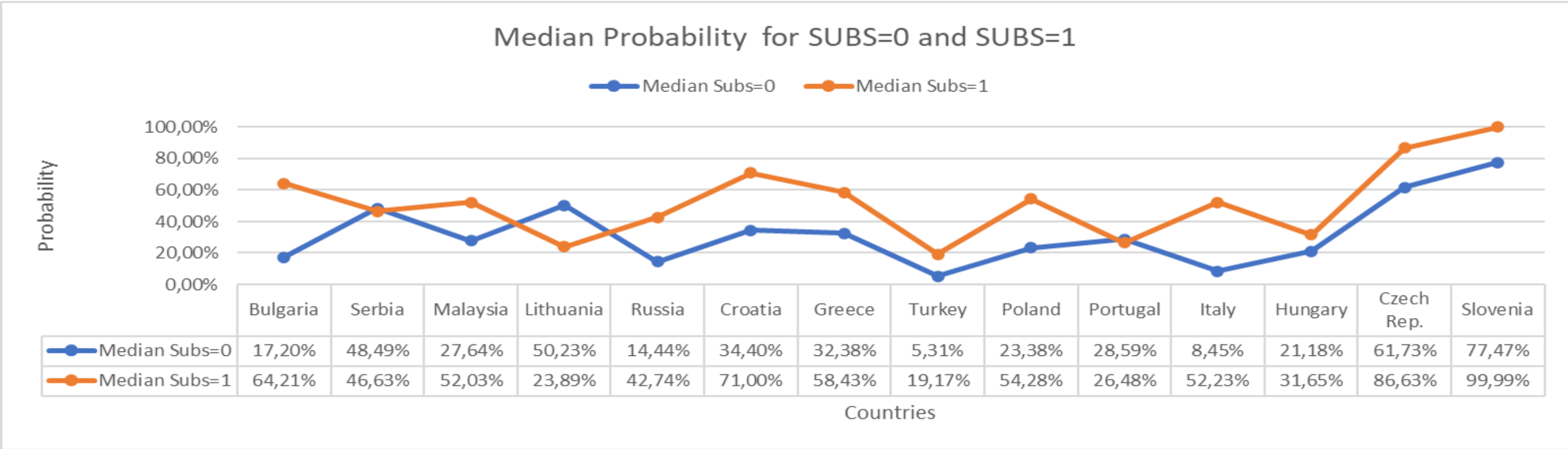


Figure 4.8 : Innovation probabilities based on median values.

the Czech Republic, the innovation probability for subsidized firms is 88.30%, which is substantially higher than Turkey’s 32.13%. Similarly, in Poland and Italy, the effect of subsidies on innovation is well above Turkey’s levels.

Countries with lower GERD/GDP than Turkey; Countries in this group include Hungary (37.03%), Bulgaria (71.14%), and Greece (59.10%). Compared to Turkey, these countries exhibit a stronger effect of subsidies on innovation performance. Particularly in Bulgaria, the innovation probability for subsidized firms is 71.14%, more than twice as high as in Turkey. In Greece, the model’s p-value is 0.076, making it statistically borderline.

Overall, while subsidies do have an impact on innovation performance in Turkey, this effect is relatively weak compared to other countries. In particular, countries such as Slovenia, the Czech Republic, and Lithuania demonstrate significantly higher innovation performance for subsidized firms, whereas in Turkey, the difference is much smaller. Additionally, non-subsidized firms in Turkey have a notably low innovation probability. Countries with higher GERD/GDP than Turkey show a considerably stronger effect of subsidies, while even those with lower GERD/GDP tend to exhibit a greater impact than Turkey. This suggests the need to enhance the effectiveness of subsidies and strengthen firms' innovation capabilities in Turkey.

5. CONCLUSIONS AND RECOMMENDATIONS

This study examines the impact of incentives and subsidies on firms' innovation performance. The dataset used consists of the Enterprise Survey conducted by the World Bank between 2002 and 2019 in Turkey and in 2019 across 48 countries. These surveys cover various aspects of the business environment, such as access to finance, corruption, infrastructure, competition, and performance—factors that are typically not included in financial reports. Therefore, the effects of factors identified in the literature as influencing innovation performance have been analyzed using these data.

The model results for Turkey were tested using selected sample firms, and the findings were consistent with the calculations. Subsequently, the countries surveyed in 2019 were examined. Countries were ranked based on the ratio of gross domestic R&D expenditures to GDP. Thirteen countries with both higher and lower values than Turkey were selected, and the model was applied to these countries for comparative analysis.

5.1 Evaluatin of Hypotheses According to Logit Regression Analysis Results

The main independent variable representing whether firms receive government support, SUBS, has a p-value well below 0.05 since 2008, approaching zero and showing statistically significant results. Looking at the marginal effect of the variable, it increased until 2008, reaching a level of 20.54%. A one-unit increase in this variable led to a 0.2 increase in innovation. Although the effect decreased in subsequent years, it remained positive and significant. In the final survey year, the value was 9.10%. According to the results, receiving government incentives has a positive impact on innovation performance; the main hypothesis (H0) has been accepted.

The variable RD/TSALE, which represents the ratio of firm R&D expenditures to total sales, is the most influential variable in innovation performance. Its p-value is less than 0.05, except for 2002, and is statistically significant. The constant term of the variable is above 1, and the marginal effect value can practically be considered as 100%. The hypothesis (H0a) has been accepted.

The independent variable CSIZE, which categorizes firm size, has a p-value greater than 0.05 for all years except 2002 and 2015. This indicates that the independent variable does not have a significant effect on the dependent variable in certain years. When examining the marginal effect of the variable, it is positive in all survey years, although the value is very low in the final survey year. However, it is only significant in two survey years. There are conflicting explanations in the literature on this matter. This contradiction also emerged in the international comparison section of this study. On the other hand, the independent variable EMPX, representing the number of employees, has a p-value greater than 0.05 for all years except 2013. The marginal effect of the variable is zero for all years. The relationship between this variable and the dependent variable remains a topic of discussion. The hypothesis (H0b) has been accepted.

The independent variable AGE, representing firm age, has a p-value smaller than 0.05 only in the final survey year, 2019. In other years, the independent variable does not have a significant effect on the dependent variable. However, in 2019, the p-value is close to zero, and the marginal effect is 0.11%. Although there are conflicting evaluations in the literature on this subject and despite the very low effect for Turkey, the effect is positive. The null hypothesis (H0c) has been accepted.

The p-value for the variable EXPO, which represents the export ratio of the firm, is very low, except for the years 2008 and 2013. In other years, the independent variable has a strong relationship with the dependent variable. The constant term of the variable is only negative in 2008. During the global financial crisis in 2008, a 1-unit increase in the export ratio resulted in a 0.07-unit decrease in the likelihood of innovation. When examining the marginal effect, it increased from 2002 to 2005, reaching 50%. In the following years, the effect decreased, and in the last survey year, it fell to 8.58%. This shows a strong and positive relationship between the dependent and independent variables. Based on the results, the hypothesis (H0d) has been accepted.

5.2 Evaluation of Actual Probability Calculation Results for Turkey

In Logit regression technique, the true probability of the dependent variable can be calculated by considering all the independent variables used in the model. Using our model and the Logit technique, we calculated the coef values of the independent variables, which allows us to estimate the likelihood of innovation for any firm in the model year, depending on whether they were treated or not.

To make this information more practical and to gain an understanding of the current situation, we first calculated the mean and median values of the independent variables used in the survey data over the years. Using these values, we ran the log-odds algorithm with the current coefs and calculated the average probability of firms in Turkey innovating depending on whether they were treated or not.

According to the results obtained using mean values, in Turkey, the probability of firms engaging in innovation when they receive treatment (subsidies) was approximately 75% in 2005 and 2008. However, this probability gradually decreased to 32.13% in the final survey year of 2019. Similarly, the probability of firms not receiving treatment engaging in innovation decreased from approximately 50% to 7%.

On the other hand, when considering the probabilities calculated using median values, there was a continuous decline for untreated firms after 2005, reaching 5.31% in 2019. For treated firms, this probability decreased to 19.16% in 2019. This difference suggests that extreme values may have inflated the probability results when using mean values, and the use of medians provides a more conservative estimate.

These results can serve as a benchmark for comparisons with the data of firms that have applied for subsidies. The approach offers useful insight into the probability of innovation for both treated and untreated firms and can assist institutions providing subsidies in understanding the potential impact on innovation before providing financial support.

After these calculations, six sample firms were identified to test the method and findings obtained so far. Among firms with varying R&D expenditures, ages, and employee numbers, the most significant factor influencing performance was the RD/TSALE variable. Firm 1, which had the highest RD/TSALE ratio, was calculated to have a 42,73% probability of success without treatment, which increased to 73,19% after treatment. Additionally, this firm stands out as the one with the highest export ratio at 46%. In reality, this firm is a strong R&D-oriented organization, agile and steadily growing. Its R&D expenditure ratio, number of employees, and revenue increase each year.

Firm 2 is a 49-year-old tractor company. Its RD/TSALE ratio is lower than Firm 1, it has a larger number of employees, and its export ratio is lower. The firm's probability of innovation was calculated to be around 16% without treatment and approximately 42% with treatment, both of which are above Turkey's average. In reality, the firm has a large R&D workforce. Its R&D projects are time-consuming and costly, but with a steady approach, it engages in innovation activities every year.

Firm 3 is a 71-year-old sugar factory. Its R&D expenditure ratio is low compared to its revenue, and its export ratio is fixed at 8% due to quotas. The calculated probability of innovation for this firm is also significantly above Turkey's average. In reality, the firm conducts research and innovation in production technologies every year.

The other firms had innovation probabilities below Turkey's average, in reality, are stagnant in terms of innovation activities. Thus, the accuracy of the model results has been tested.

5.2.1 Evaluation of comparison results with international country data

Firstly, in Turkey, the mean innovation probability for non-subsidized firms is 7%, while for subsidized firms, it is 32.13%. When considering the median values, non-subsidized firms have an innovation probability of 5.31%, and subsidized firms have a probability of 19.17%. These results indicate that subsidies have a positive impact on innovation, but the effect is weaker in Turkey compared to several other countries.

Countries with moderate innovation performance, including Hungary, Poland, Greece, and Croatia, also show stronger effects of subsidies on innovation than Turkey. For example, in Hungary, the innovation probability for subsidized firms is 37.03%, while for non-subsidized firms, it is 25.01%. In Poland, the innovation probability for subsidized firms is 63.64%, compared to 21.83% for non-subsidized firms. Greece shows a borderline statistical significance with a p-value of 0.076, indicating a weaker effect than some other countries. Nevertheless, these countries still exhibit a stronger impact of subsidies on innovation than Turkey.

In countries with lower innovation performance, such as Italy, Portugal, and Russia, subsidies still have an impact, though not as strong as in other nations. In Italy, subsidized firms have an innovation probability of 49.83%, whereas non-subsidized firms have 13.83%. In Portugal, the probability for subsidized firms is 28.58%, with only a slight difference from non-subsidized firms (27.45%). While the subsidy impact in these countries is higher than in Turkey, it is not as significant as in the top-performing countries.

Finally, among countries with higher GERD/GDP than Turkey, the Czech Republic (88.30%), Poland (63.64%), and Italy (49.83%) show a significantly higher impact of subsidies on innovation performance compared to Turkey's 32.13%. Particularly in the Czech Republic, subsidized firms' innovation probability is much higher than in Turkey. On the other hand, countries with lower GERD/GDP than Turkey, such as Hungary (37.03%), Bulgaria (71.14%), and Greece (59.10%), also show stronger subsidy effects on innovation than Turkey, with Bulgaria's impact being more than twice as high as Turkey’s.

In conclusion, although subsidies have a positive impact on innovation performance in Turkey, this effect is relatively weak compared to countries with higher GERD/GDP or even some with lower GERD/GDP. Countries such as Slovenia, the Czech Republic, and Lithuania exhibit a significantly higher innovation probability for subsidized firms. Therefore, these results suggest that Turkey needs to enhance the effectiveness of subsidies and improve firms' innovation capabilities to foster greater innovation.

Based on the findings of this study, several policy recommendations can be made to enhance the effectiveness of government incentives in fostering innovation. Enhancing R&D investment support is crucial to ensuring firms have sufficient resources for innovation. Tailoring incentives to firm characteristics can maximize their impact, as different firms have varying capacities and needs. Improving monitoring and evaluation mechanisms will help policymakers track the efficiency of subsidies and make data-driven adjustments. Additionally, policymakers should adopt best practices from successful countries to refine their approaches. Addressing outlier effects is necessary to ensure that extreme values do not distort the overall impact of incentives. Encouraging firms to collaborate with universities, research centers, and other businesses can enhance knowledge-sharing and drive innovation. Lastly, aligning policies with Sustainable Development Goals (SDGs) can ensure that innovation efforts contribute to broader economic, social, and environmental objectives.

This study serves as a valuable reference for policymakers providing incentives, especially when models are developed using up-to-date and concrete data and analyzed in depth through case studies. By incorporating these recommendations, policymakers can design more effective and targeted innovation support programs, ultimately fostering a more sustainable and dynamic innovation ecosystem.

5.3 Recommendations for Further Research

The dataset used in this analysis can be further enriched by incorporating additional variables such as region, sector, and the number of R&D employees. These factors, frequently highlighted in the literature, would enhance the accuracy of the findings and provide better insights into the impact of applied policies. Additionally, analyzing the ratio of high-tech exports to GDP separately could reveal its specific influence on firm performance, contributing to a more comprehensive evaluation.

Another crucial aspect to consider is the presence of outliers in Turkey, which appear to be elevating the average performance metrics. A detailed examination of these cases could offer valuable success stories and highlight best practices. Similarly, the role of collaborations should be explored in greater depth, as strategic partnerships and joint initiatives may play a significant role in enhancing firm performance.

Lastly, the model has so far been tested on companies from a single group. Expanding the scope to include firms from various categories would provide more generalizable insights. Moreover, studying successful cases from countries with strong innovation performance could yield practical lessons for Turkey, supporting efforts to improve its competitiveness and reduce dependency on foreign markets.

Future research on this topic can focus on emerging diagnostic and treatment methods by continuously monitoring new studies and advancements. By doing so, potential challenges that may arise in the future can be anticipated, and necessary precautions can be taken in advance to mitigate risks and enhance the effectiveness of policies.

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APPENDICES

APPENDIX A

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Optimization terminated successfully.
         Current function value: 0.611047
         Iterations 5
Turkey 2003
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                  514
Model:                          Logit   Df Residuals:                      507
Method:                           MLE   Df Model:                            6
Date:                Thu, 19 Dec 2024   Pseudo R-squ.:                 0.04914
Time:                        14:21:10   Log-Likelihood:                -314.08
converged:                       True   LL-Null:                       -330.31
Covariance Type:            nonrobust   LLR p-value:                 1.332e-05
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -1.4533      0.253     -5.735      0.000      -1.950      -0.957
EXPO           1.4557      0.376      3.869      0.000       0.718       2.193
RD/TSALE      15.5922     11.746      1.328      0.184      -7.429      38.613
CSIZE          0.4354      0.152      2.855      0.004       0.137       0.734
SUBS           0.5469      0.457      1.196      0.232      -0.349       1.443
AGE           -0.0038      0.008     -0.462      0.644      -0.020       0.012
EMPX          -0.0002      0.000     -1.102      0.270      -0.000       0.000
==============================================================================
```

(a)

```
Optimization terminated successfully.
         Current function value: 0.647467
         Iterations 7
Turkey 2005
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                  557
Model:                          Logit   Df Residuals:                      550
Method:                           MLE   Df Model:                            6
Date:                Thu, 19 Dec 2024   Pseudo R-squ.:                 0.06475
Time:                        14:32:35   Log-Likelihood:                -360.64
converged:                       True   LL-Null:                       -385.61
Covariance Type:            nonrobust   LLR p-value:                 4.839e-09
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -0.6874      0.241     -2.849      0.004      -1.160      -0.214
EXPO           2.0170      0.454      4.442      0.000       1.127       2.907
RD/TSALE      35.3256     16.202      2.180      0.029       3.570      67.082
CSIZE          0.2948      0.156      1.891      0.059      -0.011       0.600
SUBS           0.5827      0.633      0.920      0.357      -0.658       1.824
AGE           -0.0029      0.005     -0.537      0.591      -0.013       0.008
EMPX       -9.148e-05      0.000     -0.499      0.618      -0.000       0.000
==============================================================================
```

(b)

Figure A.1 : Logit regression results of Turkey by survey years: (a)2003. (b)2005.

```
Optimization terminated successfully.
         Current function value: 0.660186
         Iterations 8
Turkey 2008
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                  871
Model:                          Logit   Df Residuals:                      864
Method:                           MLE   Df Model:                            6
Date:                Thu, 19 Dec 2024   Pseudo R-squ.:                 0.03857
Time:                        14:38:25   Log-Likelihood:                -575.02
converged:                       True   LL-Null:                       -598.09
Covariance Type:            nonrobust   LLR p-value:                 2.775e-08
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -0.8163      0.211     -3.871      0.000      -1.230      -0.403
RD/TSALE      21.6824      6.109      3.549      0.000       9.709      33.655
EXPO          -0.2943      0.218     -1.353      0.176      -0.721       0.132
CSIZE          0.1597      0.101      1.579      0.114      -0.039       0.358
SUBS           0.8266      0.253      3.261      0.001       0.330       1.323
AGE            0.0096      0.006      1.571      0.116      -0.002       0.021
EMPX        2.437e-06      0.000      0.016      0.987      -0.000       0.000
==============================================================================
```

(a)

```
Optimization terminated successfully.
         Current function value: 0.541851
         Iterations 8
Turkey 2013
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                  744
Model:                          Logit   Df Residuals:                      737
Method:                           MLE   Df Model:                            6
Date:                Thu, 19 Dec 2024   Pseudo R-squ.:                 0.06031
Time:                        14:40:51   Log-Likelihood:                -403.14
converged:                       True   LL-Null:                       -429.01
Covariance Type:            nonrobust   LLR p-value:                 2.099e-09
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -1.5558      0.347     -4.478      0.000      -2.237      -0.875
RD/TSALE      30.0720     11.766      2.556      0.011       7.011      53.133
EXPO           0.2478      0.244      1.017      0.309      -0.230       0.725
CSIZE          0.0780      0.125      0.623      0.533      -0.167       0.323
SUBS           1.0273      0.248      4.144      0.000       0.541       1.513
AGE           -0.0021      0.007     -0.294      0.769      -0.016       0.012
EMPX           0.0006      0.000      2.168      0.030    5.41e-05       0.001
==============================================================================
```

(b)

Figure A.2 : Logit regression results of Turkey by survey years: (a)2008. (b)2013.

```
Optimization terminated successfully.
         Current function value: 0.391544
         Iterations 8
Turkey 2015
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                 5537
Model:                          Logit   Df Residuals:                     5530
Method:                           MLE   Df Model:                            6
Date:                Thu, 19 Dec 2024   Pseudo R-squ.:                 0.08215
Time:                        14:45:50   Log-Likelihood:                -2168.0
converged:                       True   LL-Null:                       -2362.0
Covariance Type:            nonrobust   LLR p-value:                 1.010e-80
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -2.7788      0.098    -28.414      0.000      -2.970      -2.587
RD/TSALE      19.4432      3.514      5.533      0.000      12.556      26.331
EXPO           0.9082      0.191      4.763      0.000       0.534       1.282
CSIZE          0.4228      0.041     10.203      0.000       0.342       0.504
SUBS           1.1758      0.160      7.339      0.000       0.862       1.490
AGE            0.0034      0.003      1.029      0.304      -0.003       0.010
EMPX           0.0001      0.000      0.725      0.468      -0.000       0.000
==============================================================================
```

(a)

```
Optimization terminated successfully.
         Current function value: 0.269458
         Iterations 8
Turkey 2019
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                 1541
Model:                          Logit   Df Residuals:                     1534
Method:                           MLE   Df Model:                            6
Date:                Thu, 19 Dec 2024   Pseudo R-squ.:                 0.09724
Time:                        14:47:54   Log-Likelihood:                -415.23
converged:                       True   LL-Null:                       -459.96
Covariance Type:            nonrobust   LLR p-value:                 3.945e-17
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -3.1727      0.388     -8.176      0.000      -3.933      -2.412
RD/TSALE      46.3369     12.434      3.726      0.000      21.966      70.708
EXPO           1.2231      0.279      4.377      0.000       0.675       1.771
CSIZE          0.0101      0.138      0.073      0.942      -0.261       0.281
SUBS           1.2970      0.298      4.356      0.000       0.713       1.881
AGE            0.0163      0.006      2.709      0.007       0.005       0.028
EMPX        5.833e-05      0.000      0.151      0.880      -0.001       0.001
==============================================================================
```

(b)

Figure A.3 : Logit regression results of Turkey by survey years: (a)2015. (b)2019.

APPENDIX B

Marginal Effects of Turkey 2002:
Logit Marginal Effects

Dep. Variable:	INOV
Method:	dydx
At:	mean

	dy/dx	std err	z	P>|z|	[0.025	0.975]
EXPO	0.3248	0.084	3.855	0.000	0.160	0.490
RD/TSALE	3.4788	2.620	1.328	0.184	-1.657	8.615
CSIZE	0.0972	0.034	2.861	0.004	0.031	0.164
SUBS	0.1220	0.102	1.196	0.232	-0.078	0.322
AGE	-0.0009	0.002	-0.462	0.644	-0.004	0.003
EMPX	-3.432e-05	3.11e-05	-1.103	0.270	-9.53e-05	2.67e-05

(a)

Marginal Effects of Turkey 2005:
Logit Marginal Effects

Dep. Variable:	INOV
Method:	dydx
At:	mean

	dy/dx	std err	z	P>|z|	[0.025	0.975]
EXPO	0.5014	0.112	4.460	0.000	0.281	0.722
RD/TSALE	8.7819	4.013	2.188	0.029	0.916	16.647
CSIZE	0.0733	0.039	1.891	0.059	-0.003	0.149
SUBS	0.1449	0.157	0.920	0.357	-0.164	0.453
AGE	-0.0007	0.001	-0.537	0.591	-0.003	0.002
EMPX	-2.274e-05	4.56e-05	-0.499	0.618	-0.000	6.66e-05

(b)

Marginal Effects of Turkey 2008:
Logit Marginal Effects

Dep. Variable:	INOV
Method:	dydx
At:	mean

	dy/dx	std err	z	P>|z|	[0.025	0.975]
RD/TSALE	5.3889	1.531	3.521	0.000	2.389	8.389
EXPO	-0.0732	0.054	-1.353	0.176	-0.179	0.033
CSIZE	0.0397	0.025	1.579	0.114	-0.010	0.089
SUBS	0.2054	0.063	3.260	0.001	0.082	0.329
AGE	0.0024	0.002	1.571	0.116	-0.001	0.005
EMPX	6.056e-07	3.82e-05	0.016	0.987	-7.42e-05	7.54e-05

(c)

Figure B.1 : Marginal effects results of Turkey by survey years: (a)2002. (b)2005. (c)2008.

```
Marginal Effects of Turkey 2013:
       Logit Marginal Effects
=====================================
Dep. Variable:                   INOV
Method:                          dydx
At:                              mean
==============================================================================
                dy/dx    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
RD/TSALE       5.8051      2.339      2.482      0.013       1.221      10.389
EXPO           0.0478      0.047      1.018      0.309      -0.044       0.140
CSIZE          0.0151      0.024      0.624      0.533      -0.032       0.062
SUBS           0.1983      0.048      4.148      0.000       0.105       0.292
AGE           -0.0004      0.001     -0.294      0.769      -0.003       0.002
EMPX           0.0001   5.04e-05      2.158      0.031       1e-05       0.000
==============================================================================
```

(a)

```
Marginal Effects of Turkey 2015:
       Logit Marginal Effects
=====================================
Dep. Variable:                   INOV
Method:                          dydx
At:                              mean
==============================================================================
                dy/dx    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
RD/TSALE       2.3108      0.426      5.422      0.000       1.475       3.146
EXPO           0.1079      0.023      4.752      0.000       0.063       0.152
CSIZE          0.0502      0.005     10.505      0.000       0.041       0.060
SUBS           0.1397      0.019      7.254      0.000       0.102       0.178
AGE            0.0004      0.000      1.029      0.303      -0.000       0.001
EMPX        1.526e-05   2.11e-05      0.725      0.469    -2.6e-05    5.65e-05
==============================================================================
```

(b)

```
Marginal Effects of Turkey 2019:
       Logit Marginal Effects
=====================================
Dep. Variable:                   INOV
Method:                          dydx
At:                              mean
==============================================================================
                dy/dx    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
RD/TSALE       3.2509      0.923      3.522      0.000       1.442       5.060
EXPO           0.0858      0.019      4.486      0.000       0.048       0.123
CSIZE          0.0007      0.010      0.073      0.942      -0.018       0.020
SUBS           0.0910      0.021      4.316      0.000       0.050       0.132
AGE            0.0011      0.000      2.741      0.006       0.000       0.002
EMPX        4.092e-06   2.71e-05      0.151      0.880   -4.91e-05    5.73e-05
==============================================================================
```

(c)

Figure B.2 : Marginal effects results of Turkey by survey years: (a)2013. (b)2015. (c)2019.

APPENDIX C

```
Warning: Maximum number of iterations has been exceeded.
         Current function value: 0.517307
         Iterations: 35
Slovenia 2019
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                  378
Model:                          Logit   Df Residuals:                      371
Method:                           MLE   Df Model:                            6
Date:                Thu, 19 Dec 2024   Pseudo R-squ.:                 0.04669
Time:                        15:22:07   Log-Likelihood:                -195.54
converged:                      False   LL-Null:                       -205.12
Covariance Type:            nonrobust   LLR p-value:                  0.003912
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.3054      0.410      0.744      0.457      -0.499       1.110
RD/TSALE      -1.3218      1.925     -0.687      0.492      -5.094       2.451
EXPO           0.0411      0.384      0.107      0.915      -0.712       0.794
CSIZE          0.3792      0.270      1.405      0.160      -0.150       0.908
SUBS          20.0331   1.27e+04      0.002      0.999   -2.49e+04     2.5e+04
AGE            0.0039      0.009      0.452      0.651      -0.013       0.021
EMPX           0.0029      0.003      0.908      0.364      -0.003       0.009
==============================================================================
```

(a)

```
Optimization terminated successfully.
         Current function value: 0.636936
         Iterations 6
Czech Republic 2019
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                  492
Model:                          Logit   Df Residuals:                      485
Method:                           MLE   Df Model:                            6
Date:                Thu, 19 Dec 2024   Pseudo R-squ.:                 0.07951
Time:                        14:57:35   Log-Likelihood:                -313.37
converged:                       True   LL-Null:                       -340.44
Covariance Type:            nonrobust   LLR p-value:                 6.912e-10
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -2.4898      0.433     -5.749      0.000      -3.339      -1.641
RD/TSALE       3.2145      4.007      0.802      0.422      -4.639      11.068
EXPO          -0.3241      0.334     -0.971      0.332      -0.978       0.330
CSIZE          1.0217      0.184      5.560      0.000       0.662       1.382
SUBS           1.5008      0.774      1.939      0.052      -0.016       3.018
AGE           -0.0032      0.006     -0.556      0.578      -0.015       0.008
EMPX          -0.0013      0.001     -1.677      0.094      -0.003       0.000
==============================================================================
```

(b)

Figure C.1 : Logit regression results of international countries by survey year 2019: (a)Slovenia. (b)Czech Republic.

```
Optimization terminated successfully.
         Current function value: 0.554942
         Iterations 6
Hungary 2019
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                  775
Model:                          Logit   Df Residuals:                      768
Method:                           MLE   Df Model:                            6
Date:                Thu, 19 Dec 2024   Pseudo R-squ.:                 0.03500
Time:                        15:04:37   Log-Likelihood:                -430.08
converged:                       True   LL-Null:                       -445.68
Covariance Type:            nonrobust   LLR p-value:                 2.320e-05
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -1.5042      0.361     -4.166      0.000      -2.212      -0.796
RD/TSALE      23.2172      6.335      3.665      0.000      10.800      35.634
EXPO           0.2085      0.274      0.760      0.447      -0.329       0.746
CSIZE          0.1901      0.135      1.405      0.160      -0.075       0.455
SUBS           0.3322      0.295      1.127      0.260      -0.245       0.910
AGE           -0.0089      0.010     -0.912      0.362      -0.028       0.010
EMPX          -0.0002      0.001     -0.308      0.758      -0.001       0.001
==============================================================================
```

(a)

```
Optimization terminated successfully.
         Current function value: 0.402482
         Iterations 8
Italy 2019
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                  687
Model:                          Logit   Df Residuals:                      680
Method:                           MLE   Df Model:                            6
Date:                Thu, 19 Dec 2024   Pseudo R-squ.:                 0.07992
Time:                        15:07:30   Log-Likelihood:                -276.51
converged:                       True   LL-Null:                       -300.52
Covariance Type:            nonrobust   LLR p-value:                 1.162e-08
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -1.8105      0.298     -6.074      0.000      -2.395      -1.226
RD/TSALE      -7.2907     10.143     -0.719      0.472     -27.170      12.589
EXPO           2.5601      0.447      5.730      0.000       1.684       3.436
CSIZE         -0.3985      0.179     -2.225      0.026      -0.750      -0.047
SUBS           2.0860      1.121      1.860      0.063      -0.112       4.284
AGE            0.0081      0.004      1.821      0.069      -0.001       0.017
EMPX           0.0009      0.001      1.289      0.197      -0.000       0.002
==============================================================================
```

(b)

Figure C.2 : Logit regression results of international countries by survey year 2019: (a)Hungary. (b)Italy.

```
Optimization terminated successfully.
         Current function value: 0.580703
         Iterations 5
Portugal 2019
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                  958
Model:                          Logit   Df Residuals:                      951
Method:                           MLE   Df Model:                            6
Date:                Thu, 19 Dec 2024   Pseudo R-squ.:                 0.01863
Time:                        15:17:50   Log-Likelihood:                -556.31
converged:                       True   LL-Null:                       -566.87
Covariance Type:            nonrobust   LLR p-value:                  0.001745
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -1.6594      0.209     -7.945      0.000      -2.069      -1.250
RD/TSALE       9.0296      5.473      1.650      0.099      -1.698      19.757
EXPO          -0.1601      0.231     -0.694      0.488      -0.612       0.292
CSIZE          0.3090      0.120      2.567      0.010       0.073       0.545
SUBS          -0.2162      0.475     -0.455      0.649      -1.147       0.715
AGE            0.0052      0.004      1.457      0.145      -0.002       0.012
EMPX           0.0003      0.001      0.528      0.598      -0.001       0.001
==============================================================================
```

(a)

```
Optimization terminated successfully.
         Current function value: 0.549798
         Iterations 9
Poland 2019
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                  689
Model:                          Logit   Df Residuals:                      682
Method:                           MLE   Df Model:                            6
Date:                Thu, 19 Dec 2024   Pseudo R-squ.:                 0.06641
Time:                        15:16:29   Log-Likelihood:                -378.81
converged:                       True   LL-Null:                       -405.76
Covariance Type:            nonrobust   LLR p-value:                 7.759e-10
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -0.9294      0.370     -2.510      0.012      -1.655      -0.204
RD/TSALE      70.1906     28.712      2.445      0.015      13.915     126.466
EXPO           1.6327      0.390      4.189      0.000       0.869       2.397
CSIZE         -0.1957      0.141     -1.387      0.165      -0.472       0.081
SUBS           1.4163      0.429      3.305      0.001       0.576       2.256
AGE            0.0066      0.006      1.030      0.303      -0.006       0.019
EMPX          -0.0003      0.001     -0.481      0.630      -0.001       0.001
==============================================================================
```

(b)

Figure C.3 : Logit regression results of international countries by survey year 2019: (a)Portugal. (b)Poland.

```
Optimization terminated successfully.
         Current function value: 0.631124
         Iterations 5
Greece 2019
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                  595
Model:                          Logit   Df Residuals:                      588
Method:                           MLE   Df Model:                            6
Date:                Sun, 05 Jan 2025   Pseudo R-squ.:                 0.01495
Time:                        12:33:52   Log-Likelihood:                -375.52
converged:                       True   LL-Null:                       -381.22
Covariance Type:            nonrobust   LLR p-value:                   0.07689
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -1.1172      0.375     -2.979      0.003      -1.852      -0.382
RD/TSALE      -0.0467      0.355     -0.132      0.895      -0.742       0.649
EXPO           0.1858      0.303      0.614      0.539      -0.408       0.779
CSIZE          0.1436      0.143      1.004      0.315      -0.137       0.424
SUBS           1.0635      0.445      2.390      0.017       0.191       1.936
AGE           -0.0029      0.005     -0.547      0.584      -0.013       0.007
EMPX           0.0007      0.001      0.773      0.439      -0.001       0.003
==============================================================================
```

(a)

```
Optimization terminated successfully.
         Current function value: 0.627672
         Iterations 10
Croatia 2019
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                  401
Model:                          Logit   Df Residuals:                      394
Method:                           MLE   Df Model:                            6
Date:                Sun, 05 Jan 2025   Pseudo R-squ.:                 0.07216
Time:                        12:36:05   Log-Likelihood:                -251.70
converged:                       True   LL-Null:                       -271.27
Covariance Type:            nonrobust   LLR p-value:                 6.696e-07
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -1.5741      0.451     -3.487      0.000      -2.459      -0.689
RD/TSALE     144.5631     95.901      1.507      0.132     -43.400     332.526
EXPO           0.7586      0.347      2.184      0.029       0.078       1.439
CSIZE          0.3122      0.163      1.920      0.055      -0.007       0.631
SUBS           0.8015      0.918      0.873      0.383      -0.999       2.602
AGE           -0.0012      0.006     -0.185      0.853      -0.014       0.011
EMPX           0.0007      0.001      1.099      0.272      -0.001       0.002
==============================================================================
```

(b)

Figure C.4 : Logit regression results of international countries by survey year 2019: (a)Greece. (b)Croatia.

```
Optimization terminated successfully.
         Current function value: 0.434331
         Iterations 6
Russia 2019
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                 1150
Model:                          Logit   Df Residuals:                     1143
Method:                           MLE   Df Model:                            6
Date:                Thu, 19 Dec 2024   Pseudo R-squ.:                 0.05440
Time:                        15:09:08   Log-Likelihood:                -499.48
converged:                       True   LL-Null:                       -528.21
Covariance Type:            nonrobust   LLR p-value:                 1.470e-10
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -2.3909      0.222    -10.781      0.000      -2.826      -1.956
RD/TSALE      29.0114      8.261      3.512      0.000      12.821      45.202
EXPO           0.7721      0.514      1.501      0.133      -0.236       1.780
CSIZE          0.0802      0.107      0.751      0.453      -0.129       0.290
SUBS           1.3370      0.457      2.928      0.003       0.442       2.232
AGE            0.0347      0.008      4.598      0.000       0.020       0.050
EMPX        4.601e-06      0.000      0.043      0.966      -0.000       0.000
==============================================================================
```

(a)

```
Optimization terminated successfully.
         Current function value: 0.648883
         Iterations 11
Lithuania 2019
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                  348
Model:                          Logit   Df Residuals:                      341
Method:                           MLE   Df Model:                            6
Date:                Thu, 19 Dec 2024   Pseudo R-squ.:                 0.05736
Time:                        15:11:24   Log-Likelihood:                -225.81
converged:                       True   LL-Null:                       -239.55
Covariance Type:            nonrobust   LLR p-value:                 0.0001176
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -1.4569      0.490     -2.971      0.003      -2.418      -0.496
RD/TSALE     402.3668    286.009      1.407      0.159    -158.201     962.935
EXPO          -0.5885      0.366     -1.608      0.108      -1.306       0.129
CSIZE          0.5579      0.197      2.830      0.005       0.172       0.944
SUBS          -0.9406      0.945     -0.996      0.319      -2.792       0.911
AGE           -0.0106      0.009     -1.130      0.258      -0.029       0.008
EMPX          -0.0003      0.001     -0.180      0.857      -0.003       0.003
==============================================================================
```

(b)

Figure C.5 : Logit regression results of international countries by survey year 2019: (a)Russia. (b)Lithuania.

```
Optimization terminated successfully.
         Current function value: 0.578052
         Iterations 8
Malaysia 2019
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                 1076
Model:                          Logit   Df Residuals:                     1069
Method:                           MLE   Df Model:                            6
Date:                Thu, 19 Dec 2024   Pseudo R-squ.:                 0.06567
Time:                        15:14:11   Log-Likelihood:                -621.98
converged:                       True   LL-Null:                       -665.70
Covariance Type:            nonrobust   LLR p-value:                 1.030e-16
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -1.5290      0.209     -7.300      0.000      -1.940      -1.118
RD/TSALE      77.8864     16.030      4.859      0.000      46.467     109.305
EXPO           0.1566      0.226      0.692      0.489      -0.287       0.600
CSIZE          0.3140      0.104      3.009      0.003       0.109       0.518
SUBS           0.7132      0.392      1.822      0.069      -0.054       1.481
AGE           -0.0031      0.006     -0.539      0.590      -0.014       0.008
EMPX        1.378e-05      0.000      0.079      0.937      -0.000       0.000
==============================================================================
```

(a)

```
Optimization terminated successfully.
         Current function value: 0.666972
         Iterations 4
Serbia 2019
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                  291
Model:                          Logit   Df Residuals:                      284
Method:                           MLE   Df Model:                            6
Date:                Sun, 05 Jan 2025   Pseudo R-squ.:                 0.03710
Time:                        12:49:05   Log-Likelihood:                -194.09
converged:                       True   LL-Null:                       -201.57
Covariance Type:            nonrobust   LLR p-value:                   0.02060
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -1.4829      0.446     -3.329      0.001      -2.356      -0.610
RD/TSALE      -0.5984      9.877     -0.061      0.952     -19.957      18.760
EXPO           0.5583      0.425      1.313      0.189      -0.275       1.392
CSIZE          0.4691      0.159      2.943      0.003       0.157       0.782
SUBS          -0.5963      0.574     -1.039      0.299      -1.721       0.528
AGE            0.0008      0.007      0.116      0.908      -0.013       0.015
EMPX       -5.339e-05      0.001     -0.090      0.928      -0.001       0.001
==============================================================================
```

(b)

Figure C.6 : Logit regression results of international countries by survey year 2019: (a)Malaysia. (b)Serbia.

```
Optimization terminated successfully.
         Current function value: 0.477557
         Iterations 8
Bulgaria 2019
                           Logit Regression Results
==============================================================================
Dep. Variable:                   INOV   No. Observations:                  670
Model:                          Logit   Df Residuals:                      663
Method:                           MLE   Df Model:                            6
Date:                Sun, 05 Jan 2025   Pseudo R-squ.:                  0.1200
Time:                        12:51:00   Log-Likelihood:                -319.96
converged:                       True   LL-Null:                       -363.60
Covariance Type:            nonrobust   LLR p-value:                 1.120e-16
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const         -2.9682      0.413     -7.182      0.000      -3.778      -2.158
RD/TSALE     105.5872     26.525      3.981      0.000      53.599     157.575
EXPO           1.0842      0.293      3.706      0.000       0.511       1.658
CSIZE          0.3658      0.147      2.490      0.013       0.078       0.654
SUBS           1.3121      0.925      1.418      0.156      -0.502       3.126
AGE            0.0193      0.008      2.513      0.012       0.004       0.034
EMPX          -0.0004      0.001     -0.706      0.480      -0.002       0.001
==============================================================================
```

Figure C.7 : Logit regression results of Bulgaria by survey year 2019.

APPENDIX D

Marginal Effects of Slovenia:

Logit Marginal Effects

Dep. Variable:	INOV
Method:	dydx
At:	mean

	dy/dx	std err	z	P>|z|	[0.025	0.975]
RD/TSALE	-0.1571	42.152	-0.004	0.997	-82.773	82.459
EXPO	0.0049	1.312	0.004	0.997	-2.566	2.576
CSIZE	0.0451	12.093	0.004	0.997	-23.657	23.747
SUBS	2.3813	874.268	0.003	0.998	-1711.153	1715.916
AGE	0.0005	0.125	0.004	0.997	-0.245	0.246
EMPX	0.0003	0.093	0.004	0.997	-0.181	0.182

(a)

Marginal Effects of Czech Republic:

Logit Marginal Effects

Dep. Variable:	INOV
Method:	dydx
At:	mean

	dy/dx	std err	z	P>|z|	[0.025	0.975]
RD/TSALE	0.8004	0.998	0.802	0.422	-1.155	2.756
EXPO	-0.0807	0.083	-0.971	0.332	-0.244	0.082
CSIZE	0.2544	0.046	5.567	0.000	0.165	0.344
SUBS	0.3737	0.192	1.942	0.052	-0.003	0.751
AGE	-0.0008	0.001	-0.556	0.578	-0.004	0.002
EMPX	-0.0003	0.000	-1.677	0.094	-0.001	5.27e-05

(b)

Marginal Effects of Hungary:

Logit Marginal Effects

Dep. Variable:	INOV
Method:	dydx
At:	mean

	dy/dx	std err	z	P>|z|	[0.025	0.975]
RD/TSALE	4.4644	1.244	3.589	0.000	2.026	6.903
EXPO	0.0401	0.053	0.760	0.447	-0.063	0.143
CSIZE	0.0366	0.026	1.407	0.159	-0.014	0.087
SUBS	0.0639	0.057	1.128	0.259	-0.047	0.175
AGE	-0.0017	0.002	-0.912	0.362	-0.005	0.002
EMPX	-3.407e-05	0.000	-0.308	0.758	-0.000	0.000

(c)

Figure D.1 : Marginal effects results of selected countries by survey year 2019: (a)Slovenia. (b)Czech Republic. (c)Hungary.

```
Marginal Effects of Italy:
        Logit Marginal Effects
=====================================
Dep. Variable:                   INOV
Method:                          dydx
At:                              mean
==============================================================================
                dy/dx    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
RD/TSALE      -0.8749      1.211     -0.723      0.470      -3.248       1.498
EXPO           0.3072      0.052      5.930      0.000       0.206       0.409
CSIZE         -0.0478      0.021     -2.248      0.025      -0.090      -0.006
SUBS           0.2503      0.134      1.862      0.063      -0.013       0.514
AGE            0.0010      0.001      1.832      0.067   -6.75e-05       0.002
EMPX           0.0001   8.45e-05      1.288      0.198   -5.68e-05       0.000
==============================================================================
```

(a)

```
Marginal Effects of Portugal:
        Logit Marginal Effects
=====================================
Dep. Variable:                   INOV
Method:                          dydx
At:                              mean
==============================================================================
                dy/dx    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
RD/TSALE       1.7981      1.091      1.649      0.099      -0.340       3.936
EXPO          -0.0319      0.046     -0.694      0.487      -0.122       0.058
CSIZE          0.0615      0.024      2.577      0.010       0.015       0.108
SUBS          -0.0430      0.095     -0.455      0.649      -0.228       0.142
AGE            0.0010      0.001      1.458      0.145      -0.000       0.002
EMPX        5.409e-05      0.000      0.528      0.598      -0.000       0.000
==============================================================================
```

(b)

```
Marginal Effects of Poland:
        Logit Marginal Effects
=====================================
Dep. Variable:                   INOV
Method:                          dydx
At:                              mean
==============================================================================
                dy/dx    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
RD/TSALE      14.2543      6.119      2.330      0.020       2.261      26.247
EXPO           0.3316      0.079      4.186      0.000       0.176       0.487
CSIZE         -0.0397      0.029     -1.383      0.167      -0.096       0.017
SUBS           0.2876      0.087      3.296      0.001       0.117       0.459
AGE            0.0013      0.001      1.030      0.303      -0.001       0.004
EMPX       -5.389e-05      0.000     -0.481      0.630      -0.000       0.000
==============================================================================
```

(c)

Figure D.2 : Marginal effects results of selected countries by survey year 2019: (a)Italy. (b)Portugal. (c)Poland.

```
Marginal Effects of Greece:
        Logit Marginal Effects
=====================================
Dep. Variable:                   INOV
Method:                          dydx
At:                              mean
==============================================================================
                dy/dx    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
RD/TSALE      -0.0104      0.079     -0.132      0.895      -0.166       0.145
EXPO           0.0415      0.068      0.614      0.539      -0.091       0.174
CSIZE          0.0321      0.032      1.004      0.315      -0.031       0.095
SUBS           0.2378      0.100      2.387      0.017       0.043       0.433
AGE           -0.0006      0.001     -0.547      0.584      -0.003       0.002
EMPX           0.0002      0.000      0.773      0.439      -0.000       0.001
==============================================================================
```

(a)

```
Marginal Effects of Croatia:
        Logit Marginal Effects
=====================================
Dep. Variable:                   INOV
Method:                          dydx
At:                              mean
==============================================================================
                dy/dx    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
RD/TSALE      35.6708     24.182      1.475      0.140     -11.726      83.067
EXPO           0.1872      0.085      2.190      0.029       0.020       0.355
CSIZE          0.0770      0.040      1.921      0.055      -0.002       0.156
SUBS           0.1978      0.227      0.873      0.383      -0.246       0.642
AGE           -0.0003      0.002     -0.185      0.853      -0.003       0.003
EMPX           0.0002      0.000      1.099      0.272      -0.000       0.000
==============================================================================
```

(b)

```
Marginal Effects of Russia:
        Logit Marginal Effects
=====================================
Dep. Variable:                   INOV
Method:                          dydx
At:                              mean
==============================================================================
                dy/dx    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
RD/TSALE       3.9501      1.141      3.462      0.001       1.714       6.186
EXPO           0.1051      0.070      1.504      0.132      -0.032       0.242
CSIZE          0.0109      0.015      0.752      0.452      -0.018       0.039
SUBS           0.1820      0.062      2.927      0.003       0.060       0.304
AGE            0.0047      0.001      4.602      0.000       0.003       0.007
EMPX        6.265e-07   1.45e-05      0.043      0.966   -2.78e-05     2.9e-05
==============================================================================
```

(c)

Figure D.3 : Marginal effects results of selected countries by survey year 2019: (a)Greece. (b)Croatia. (c)Russia.

```
Marginal Effects of Lithuania:
       Logit Marginal Effects
=====================================
Dep. Variable:                   INOV
Method:                          dydx
At:                              mean
==============================================================================
                dy/dx    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
RD/TSALE     100.3262     69.981      1.434      0.152     -36.833     237.486
EXPO          -0.1467      0.091     -1.609      0.108      -0.325       0.032
CSIZE          0.1391      0.049      2.820      0.005       0.042       0.236
SUBS          -0.2345      0.235     -0.998      0.318      -0.695       0.226
AGE           -0.0026      0.002     -1.130      0.259      -0.007       0.002
EMPX       -6.601e-05      0.000     -0.180      0.857      -0.001       0.001
==============================================================================
```

(a)

```
Marginal Effects of Malaysia:
       Logit Marginal Effects
=====================================
Dep. Variable:                   INOV
Method:                          dydx
At:                              mean
==============================================================================
                dy/dx    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
RD/TSALE      16.9416      3.663      4.626      0.000       9.763      24.120
EXPO           0.0341      0.049      0.693      0.489      -0.062       0.130
CSIZE          0.0683      0.023      3.023      0.003       0.024       0.113
SUBS           0.1551      0.085      1.822      0.068      -0.012       0.322
AGE           -0.0007      0.001     -0.539      0.590      -0.003       0.002
EMPX        2.998e-06   3.77e-05      0.079      0.937    -7.1e-05     7.7e-05
==============================================================================
```

(b)

```
Marginal Effects of Serbia:
       Logit Marginal Effects
=====================================
Dep. Variable:                   INOV
Method:                          dydx
At:                              mean
==============================================================================
                dy/dx    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
RD/TSALE      -0.1494      2.467     -0.061      0.952      -4.984       4.685
EXPO           0.1394      0.106      1.313      0.189      -0.069       0.348
CSIZE          0.1172      0.040      2.943      0.003       0.039       0.195
SUBS          -0.1489      0.143     -1.039      0.299      -0.430       0.132
AGE            0.0002      0.002      0.116      0.908      -0.003       0.004
EMPX       -1.333e-05      0.000     -0.090      0.928      -0.000       0.000
==============================================================================
```

(c)

Figure D.4 : Marginal effects results of selected countries by survey year 2019: (a)Lithuania. (b)Malaysia. (c)Serbia.

```
Marginal Effects of Bulgaria:
        Logit Marginal Effects
=====================================
Dep. Variable:                   INOV
Method:                          dydx
At:                              mean
==============================================================================
                dy/dx    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
RD/TSALE      18.6176      5.069      3.673      0.000       8.683      28.552
EXPO           0.1912      0.051      3.739      0.000       0.091       0.291
CSIZE          0.0645      0.026      2.510      0.012       0.014       0.115
SUBS           0.2313      0.164      1.415      0.157      -0.089       0.552
AGE            0.0034      0.001      2.500      0.012       0.001       0.006
EMPX        -7.82e-05      0.000     -0.706      0.480      -0.000       0.000
==============================================================================
```

Figure D.5 : Marginal effects results of Bulgaria by survey year 2019.

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