



**REPUBLIC OF TURKEY
ADANA ALPARSLAN TÜRKER SCIENCE AND TECHNOLOGY
UNIVERSITY**

**INSTITUTE OF GRADUATE SCHOOL
DEPARTMENT OF BUSINESS ADMINISTRATION**

**THE RELATIONSHIP BETWEEN BUSINESS R&D EXPENDITURES
AND FINANCIAL DEVELOPMENT: PANEL DATA ANALYSIS FOR
OECD COUNTRIES**

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ADANA 2023



I hereby declare that all information in this thesis has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all information that is not original to this work.

[Signature]

Zümay ALSAN

ABSTRACT

THE RELATIONSHIP BETWEEN BUSINESS R&D EXPENDITURES AND FINANCIAL DEVELOPMENT: PANEL DATA ANALYSIS FOR OECD COUNTRIES

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Countries are giving importance to research and development (R&D) activities to produce and develop new products or technologies. For this reason, it is noticed that R&D expenditures have increased in recent years in countries that want to gain a competitive advantage. Also, financial development in countries increases the level of development and supports R&D activities. This thesis aims to investigate the relationship between business R&D expenditures and financial development. 15 OECD member countries are analyzed with the Dumitrescu-Hurlin Panel Granger Causality Test based on panel data analysis using data between 2009 and 2019. Also, it was analyzed using the data from total business enterprises, agriculture, forestry and fishing, manufacturing, and total services sectors. The results of the analysis indicate that there is a positive relationship.

Keywords: Research and development, financial development, innovation, panel data analysis

ÖZET

İŞLETME AR-GE HARCAMALARI VE FİNANSAL GELİŞME İLİŞKİSİ: OECD ÜLKELERİ İÇİN PANEL VERİ ANALİZİ

Zümay ALSAN

İşletme Yönetimi Anabilim Dalı

Danışman: Doç. Dr. Ömer Tuğsal DORUK

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Ülkeler yeni ürün veya teknoloji üretmek ve geliştirmek amacıyla Araştırma ve Geliştirme (AR-GE) faaliyetlerine önem vermektedir. Bu nedenle rekabet avantajı elde etmek isteyen ülkelerde son yıllarda AR-GE harcamalarının arttığı görülmektedir. Ayrıca, ülkelerdeki finansal gelişme, gelişmişlik düzeylerini artırır ve AR-GE faaliyetlerini destekler. Bu tezin amacı AR-GE harcamaları ile finansal gelişme arasındaki ilişkiyi araştırmaktır. OECD üyesi 15 ülke için 2009 ve 2019 yılları arasındaki veriler kullanılarak panel veri analizine dayalı Dumitrescu-Hurlin Panel Granger Nedensellik Testi ile analiz edilmiştir. Ayrıca, toplam ticari işletmeler, tarım, ormancılık ve balıkçılık, imalat ve toplam hizmet sektörlerinden elde edilen veriler kullanılarak analiz edilmiştir. Analiz sonuçları pozitif bir ilişki olduğunu göstermektedir.

Anahtar Kelimeler: Araştırma ve geliştirme, finansal gelişme, inovasyon, panel veri analizi

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TABLE OF CONTENTS

TABLE OF CONTENTS	vii
LIST OF FIGURES.....	viii
LIST OF TABLES.....	ix
NOMENCLATURE	x
1. INTRODUCTION	1
1.1 Importance of R&D Activities and Expenditures for Countries.....	1
1.2. R&D Indicators.....	2
1.2.1 R&D Intensity	2
1.2.2 Number of Personnel Working in the R&D Department	3
1.2.3. Advanced Technology Exports	3
1.2.4. Scientific Publications	3
1.2.5. Number of Patents.....	3
1.3. Financial Incentives for R&D Activities	4
1.4. Importance of Financial Development on Economic Performance	4
1.5. R&D Expenditures in OECD Countries	5
1.6. The Relationship between Business R&D Expenditures and Financial Development and the Hypothesis of the Thesis	7
1.7. Organization of the Thesis.....	8
2. LITERATURE REVIEW	9
3. DATA SET AND METHODOLOGY.....	18
3.1. Data Set	18
3.2. Methodology.....	21
4. RESULTS AND DISCUSSIONS	22
5. CONCLUSIONS.....	24
REFERENCES	25
CURRICULUM VITAE.....	Error! Bookmark not defined.

LIST OF FIGURES

Figure 1.1. Gross domestic expenditures on R&D	6
Figure 1.2. R&D intensity in selected OECD economies, 2019.....	6



LIST OF TABLES

Table 2.1. Literature Review Summary Results.....	15
Table 3.1. Countries and observations in the sample.....	19
Table 3.2. Descriptive Statistics.....	19
Table 4.1. Pairwise correlations.....	22
Table 4.2. Dumitrescu & Hurlin (2012) Granger causality test results: Total Business.....	22
Table 4.3. Dumitrescu & Hurlin (2012) Granger causality test results: Agriculture, Forestry and Fishing.....	23
Table 4.4. Dumitrescu & Hurlin (2012) Granger causality test results: Total Services.....	23
Table 4.5. Dumitrescu & Hurlin (2012) Granger causality test results: Manufacturing.....	23

NOMENCLATURE

R&D	: Research and Development
OECD	: Organisation for Economic Co-operation and Development
ANBERD	: Analytical Business Enterprise Research and Development
GDP	: Gross Domestic Product
GERD	: Gross Domestic Expenditures on R&D
EU	: European Union
US	: United States
IMF	: International Monetary Fund
CEM	: Coarsened Exact Matching

1. INTRODUCTION

In recent years, Research and Development (R&D) has been considered an essential term in supporting the improvement of countries, at the same time increasing their welfare levels. With globalization, countries are focusing on science and technology to get a competitive advantage and survive. Therefore, they are giving importance to R&D activities. Also, R&D is becoming a determining element in the development levels of countries (Firat et al., 2016).

As defined by The Organisation for Economic Co-operation and Development (OECD), R&D covers activities implemented to raise the stock of information and to develop new methods of available information. R&D consists of three processes. First, Basic research is an empirical investigation to obtain new information about the principles of basic facts and characteristics with no implementation. Second, applied research is an original examination to obtain new information. However, it is mostly conducted for a typical applied purpose. Third, experimental development is the systematic effort to create new goods or instruments, to develop new systems, and processes, or to considerably develop the available information obtained from research or applied experience (OECD Frascati Manual, 2015).

1.1 Importance of R&D Activities and Expenditures for Countries

'New' is the first term that comes to mind when discussing R&D and innovation. R&D is the collection of components that include a new concept, product, approach, process, or any other distinguishing activity. R&D expenditures are a major factor in innovations that successfully enhance countries' growth rates. Increased R&D spending in essential industries such as software and technology leads to the establishment of high-value-added goods, ideas, or brands (Yücel and Ahmetoğulları, 2015).

Additionally, R&D is a prerequisite for innovation. Innovation exists when new ideas are generated and commercialized through R&D. R&D and innovation are essential for development and sustainable improvement. It is strategically important for countries to promote the work produced for this purpose. The goal of developing countries is to produce high quality

products with high added value through R&D and innovation. In this way, companies in the country will increase their competitiveness by differentiating from the others (Müsiad, 2012).

The essential objectives of R&D activities are listed as follows:

- Helping countries and businesses to grow
- Developing new products and processes
- Increasing efficiency in the organization
- Reducing production costs
- Finding new applications for existing products and materials
- Maintaining competitiveness by keeping pace with the developments of other businesses
- Contributing to the management information system (Zerenler et al., 2007).

R&D expenditures support exports of advanced technology. One of the indicators showing the level of development is that countries can produce and export their own technologies. Therefore, the goals of both developed and emerging nations are to raise the share and productivity of high-tech products. Countries have to use technology effectively to experience an effective productivity process in the market and to make an important advance for growth (Durgun and Çapik, 2018).

1.2. R&D Indicators

R&D indicators are fundamental indicators that enable us to obtain information and measure countries' development levels. A country is considered developed to the extent that it develops the technological requirements of the industrial and information society. R&D indicators include R&D intensity, the number of personnel employed in R&D, advanced technology exports, scientific publications, and number of patents (Ünal and Seçilmiş, 2013).

1.2.1 R&D Intensity

R&D intensity is calculated by dividing corporation's R&D expenditure by its revenue. R&D is the primary source of innovation, at the same time R&D spending and intensity are two of

the primary measures implemented for evaluating scientific and technological resources (Eurostat, 2022).

1.2.2 Number of Personnel Working in the R&D Department

The sharing of personnel involved in R&D activities in overall employment is an indication of the significance and support provided to scientific research in a nation (Adaçay, 2007).

1.2.3. Advanced Technology Exports

A country's technology-intensive exports are the main indicator of how advanced that country is in technology production and therefore of its level of development. At the same time, the competitiveness of countries, which is one of the criteria of globalization, is related to the technology-intensive export structure (Adaçay, 2007).

1.2.4. Scientific Publications

Scientific publications are used as a criterion for comparing the scientific qualifications of countries or institutions and for evaluating the academic performance of scientists. The criterias for identifying scientific publications from others in their field are as follows:

- Number of publications in international scientific journals,
- Publication of publications in journals reviewed in scientific indexes,
- Number of citations to publications (Ak and Gülmez, 2006).

1.2.5. Number of Patents

Patents are indicators of R&D activities in protecting the copyright and usage rights of findings created or improved by researchers. The development, production, and marketing of an invention needs entrepreneurial endeavor. Also, patent-related indicators have been used extensively to analyze the rate and direction of technological change (OECD, 1994).

The number of patents in a country indicates the innovation power in that country and is evidence of how many new inventions are made. Therefore, a high amount of patents is also a

measure of the country's R&D system's performance. Patents, which are an indicator of R&D output, empower the producer by enabling innovations to turn into commercial products (Ünal and Seçilmiş, 2013).

1.3. Financial Incentives for R&D Activities

R&D incentives are based on supports that encourage firms to engage in R&D activities. R&D activities are incentivized under four different policy frameworks. Firstly, Government support for R&D differs by country. The government can directly finance enterprises to conduct research, either via purchasing programs or grants. Secondly, the government supports R&D through tax incentives, in particular R&D tax credits, which are used in some OECD countries. Thirdly, the government itself engages in R&D at public labs. Such studies often benefit the government's particular requirements, for instance in the fields of security, energy, or public health. Lastly, the government finances academic institutions' research, often to generate fundamental information (Guellec and Van Pottelsberghe, 2003).

Incentives are a tool for achieving the required economic and social goals. Nowadays, countries attach significance to R&D activities and encourage these activities to improve their science and technology capacities, which are considered the key to progress and development. Therefore, it is a requirement for the state to support and promote R&D activities, which are not allocated sufficient resources in the market, to raise them to the required level. Particularly in countries that are backward in terms of science and technology, promoting R&D activities is even more significant (Çelebi and Kahrıman, 2011).

1.4. Importance of Financial Development on Economic Performance

Financial development is the process of evolution in the efficiency quantity, and quality of financial services. It is a process in which many activities and institutions connect. Therefore, it would not be defined in a single measure. Additionally, it is essential for long-term economic development due to its influence on technological innovation through financial sector services (Abu-bader and Abu-qarn, 2008). According to the findings, the growth of the financial industry significantly affects economic development by improving saving rates, promoting foreign

capital inflows, generating information on investment, and advancing technological progress (World Bank, 2023).

Additionally, financial development is characterized in the literature as a growth in the range of instruments utilized in a country's financial market and the more widespread usage of these products. Financial development could also refer to the growth of financial markets. The degree of mobilization of national and international savings is seen as a key measure in determining the growth of financial markets (Erim and Türk, 2005).

The development and appropriate management of the financial sector contribute to quicker and more sustainable economic development. These can be listed as follows:

- Easy accessibility to financial assets encourages investment, which immediately raises the income of low-income populations through expanding opportunities for labor.
- Easy accessibility to financial assets allows low-income groups of the population to gain access to human capital that supports economic growth, such as health care and education.
- Financial growth decreases income and wealth disparity, which in turn lessens comparable problems caused by income inequality.
- Financial development could maintain the income of the wealthy by providing Easy accessibility to financial assets during periods of excessive inflation (Shahbaz et al., 2015).

1.5. R&D Expenditures in OECD Countries

In today's economy, sustainable growth is related to a country's technological development within the framework of incentives and investments in R&D activities. Technological development promotes production and efficiency, which enhances the country's competitiveness. Therefore, countries are increasingly focusing on R&D activities to improve their competitiveness and level of development (Ülger and Durgun, 2017).

Gross domestic expenditures on R&D (GERD) is the primary statistic for identifying a country's R&D activities. Also, it includes all R&D expenditures in the economy. GERD is calculated by summing up all relevant expenditures made in the sectors performing R&D: Sectors of higher education, businesses, and private non-profit organizations (OECD, 2020)

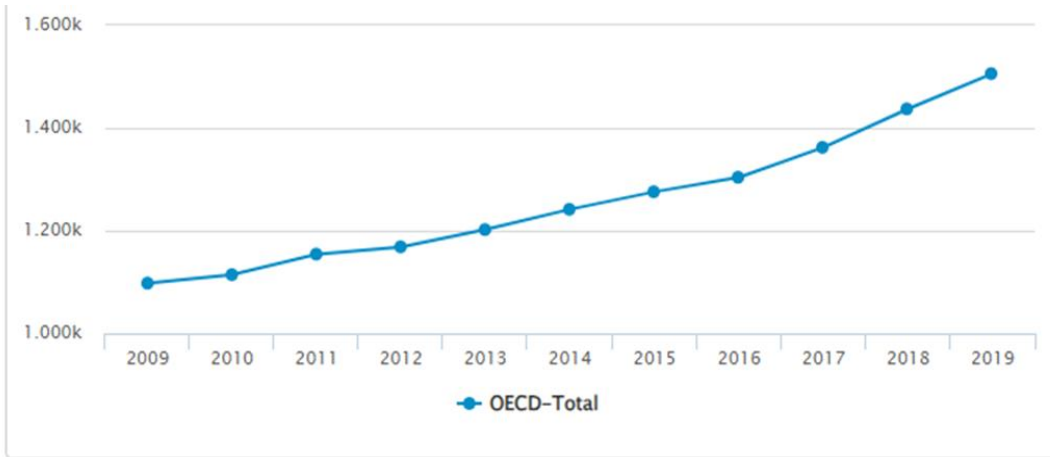


Figure 1.1. Gross domestic expenditures on R&D

Source: OECD

Annual gross domestic R&D expenditures of OECD countries for the period 2009-2019 are presented in Figure 1.1. According to the figure, R&D expenditures have increased over the years in OECD countries. It is recognized that more importance has been given to R&D expenditures in recent years.

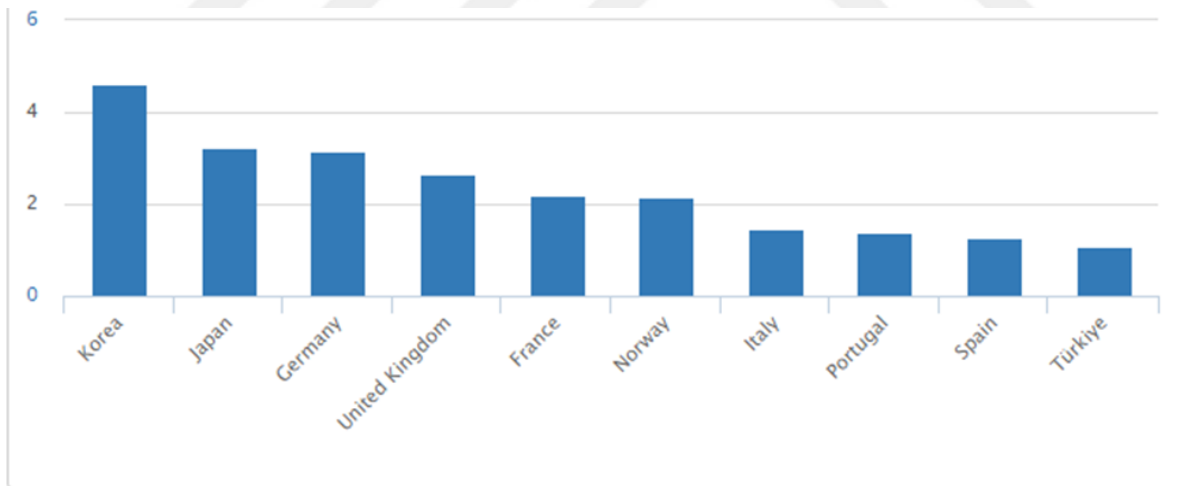


Figure 1.2. R&D intensity in selected OECD economies, 2019

Source: OECD

R&D intensity of selected OECD economies in 2019 is presented in Figure 1.2. Based on the data from OECD countries, it was observed that Korea, Japan, Germany, The United Kingdom, and France made the highest R&D performers in 2019 (OECD Database, 2021).

1.6. The Relationship between Business R&D Expenditures and Financial Development and the Hypothesis of the Thesis

According to Schumpeter's hypothesis in 1911, financial growth and R&D expenditures are favorably correlated. Financial development in countries leads to a high level of knowledge accumulation, increases their level of development, and supports R&D activities for the implementation of new products and production processes by providing the necessary resources and funds (Akıncı et al., 2014).

R&D expenditures contributed to financial development when it was invested in sufficient amounts and also used efficiently (Polat and Elmas, 2016). Countries carry out R&D activities to manufacture new goods in the long term and to improve the sales and profitability of the firm. To survive, firms need to develop their knowledge and technology, discover new ideas and methods, gain an advantage faster than the firms competing with them, and thus improve their financial performance (Turhan, 2021).

Financial growth is linked to the country's innovativeness. Besides, the low rate of R&D investment is recognized as significant evidence of the loss of growth capacity. Yet, for R&D investments to be profitable, participants' entrepreneurship and tolerance of risk must be improved. It is observed that R&D is affected by macro-financial quality (Hwang et al., 2010).

A well-developed financial system reduces the risks of asymmetric information problems and transaction costs related to R&D projects. It also facilitates the financing of R&D projects and increases R&D spending by directing funds to the most innovative companies (Demirci, 2017). Larger enterprises generally have stronger financial capabilities and adequate financing for R&D investment than smaller enterprises. For this reason, it is considered that larger enterprises can be more efficient in conducting R&D operations (Xu et al., 2019). Since easier access to financial resources enables firms to invest more in R&D activities (Özaytürk, 2022).

In recent years countries' transition from labor-intensive to technology-intensive capital increased by R&D investments. It is recognized that this strategy is particularly implemented by developed countries (Ergün and Ergün, 2021). R&D expenditures contribute to the sustainable growth of companies while also having an essential role in increasing the profitability of companies with global competitive advantage (Dağlı and Ergün, 2017).

It has become the fundamental principle to provide maximum benefit by using limited resources. For this reason, enterprises are experiencing a process centered on R&D and innovation to use limited resources in the least amount, to obtain the maximum added value, and to transform them into products at the lowest cost (Tezcan, 2018). The current paradigm of innovation management is not limited to improvements in products and technology, but also involves improvements in methods, processes, and services, and comprises the management of innovation activities with strategies based on R&D integration (Ventura and Soyuer, 2016).

Consequently, factors that increase financial development are expected to contribute positively to R&D expenditures. R&D expenditures support the sustainable growth of firms and gain a global competitive advantage. Also, the hypothesis of the thesis is that financial development positively impacts R&D expenditures. Thus, the link between these two variables was investigated and analyzed in this thesis.

1.7. Organization of the Thesis

This thesis aims to describe the relationship between R&D expenditures and financial development for the 15 OECD member countries. It provides a contribution to the literature by making a sectoral analysis at the macro level using Analytical Business Enterprise R&D (ANBERD) data which includes manufacturing and service sectors.

The thesis is organized as follows: In the second part, the literature is investigated to understand the relationship between R&D spending with financial development and performance. In the third and fourth parts, the dataset and methodology are defined. The methodology is the Dumitrescu-Hurlin Panel Granger Causality Test for examining the main argument of the thesis for the 15 OECD member countries. In the fifth part, conclusions and findings are explained in the analysis.

2. LITERATURE REVIEW

This chapter first examined some researches that investigated the link between R&D spending, countries' growth, and financial development. A positive effect was observed from these studies. Also, it was emphasized that countries should enhance the importance given to R&D. Some of the related studies in the literature are as follows:

Chang et al. (2005) researched the connection between R&D expenditures, trade, and financial development. In the theoretical model, the data covering the years 1991 and 1999 for 16 countries are analyzed. The share of R&D spending in the manufacturing industry has been recognized to bring greater gains than in the agricultural sector. According to research country's financial development is connected to R&D spending. Besides, it is emphasized that the growth in R&D spending favorably impacts exports and the manufacturing sector. It is suggested that the importance given to R&D expenditures should increase in nations for a greater share of total exports.

Pienknagura (2010) examined a more elaborate examination of the link between financial development, R&D spending, and aggregate growth. Infinite-horizon general equilibrium model was used in the research. Also, it consisted of companies from 98 several countries in the period 1987-2006. It has been observed that firms that spend greater amounts on R&D increase long-term financial growth and affect financial dependency as well. In addition, firms with greater R&D capability raised the optimal subsidy depending on size and have better financial development.

Maskus et al. (2012) analyzed the effects of financial market development on R&D intensity in 22 manufacturing sectors. Also, 18 OECD countries were considered with data for the years 1990-2003. The study determined that the development of alternative types of financing can incentivize R&D expenditures to different degrees. Besides, it is observed that there are economic and statistically significant influences on financial market development for many local indicators.

Işık and Kılınç (2011) emphasized the essential role of innovation and R&D spending in regional growth. It has been analyzed comparatively in country groups like the European Union (EU) and the OECD. For this purpose, some innovation indicators such as the rate of R&D spending in Gross domestic product (GDP), high technology exports, number of patent registrations, and applications were examined. Accordingly, when innovation indicators are considered, Japan and the US are the leading countries. It is also argued that innovation activities are carried out more effectively in developed countries. According to the research, it should be more emphasize innovation and R&D activities as they provide inputs to the financial system.

Koç and Koç (2017) researched the influence of R&D spending on financial development. G8 countries tested with the Panel Causality Test for 1996 and 2013. According to the analysis, there is causality from R&D spending to financial development only in Italy and financial development to R&D spending only in France. The findings indicate that R&D spending has a substantial influence on the financial development of countries.

Pala et al. (2018) examined the impact of R&D and innovation on the financial growth of BRICS countries. Annual data for the years 2000 - 2015 were used in the panel data analysis. Consequently, a long-term and positive connection has been determined for R&D, innovation investments, and financial growth. Besides, in developed and developing countries, R&D and innovation investments have a great impact on economic and financial growth has been observed.

Helhel (2018) analyzed E-7 countries for examining the impact of financial growth on R&D spending. In the research, the indicator was GDP and it included annual data from 2001-2013 for panel data analysis. Therefore, a long-term co-integration relationship was observed between the variables. In conclusion, the level of financial development showed improvement positively to R&D expenditures. Additionally, it emphasized the significance of the banking industry and the importance of its development for countries.

Yıldırım and Göze Kaya (2019) researched Development of R&D Expenditures for EU nations and Türkiye. Therefore some indicators are investigated such as the R&D expenditures rate within GDP, distributed across financial funding, and the number of manpower employed in

R&D activities. Also, the rates of R&D expenditures between 2003 and 2016 are considered. In this process, it is analyzed that monetary resources for R&D activities have increased in Türkiye. However, comparing Türkiye statistics to the average of EU countries reveals that it is at a low rate. Consequently, it is argued that R&D activities should be given importance for the growth of countries.

Bulut (2020) aimed to investigate the influence of R&D and innovation activities on both growth and development. In the study, the ratio of R&D expenditures to GDP in BRICS_T countries is analyzed to investigate its effect on the global innovation index. The data covered the years 2007-2019. As a result, a positive impact was found in the analysis. Moreover, the largest impact was observed in China and Russia.

Ergün and Ergün (2021) investigated the connection between financial growth and R&D expenditures for 11 emerging nations. In the panel data analysis, the period of 2000-2016 was used. In the study, R&D spending and financial growth were shown to be meaningfully and favorably connected. Therefore, it has been analyzed that the rise in the level of financial growth affects the rise in the resources allocated to R&D expenditures for developing countries.

Dağlı and Ezanoğlu (2021) reviewed the macroeconomic factors affecting R&D expenditures, technology export variables, and patent figures on economic development. An econometric analysis was conducted for the period 2007-2017 with the autoregressive panel data model for the OECD countries. The analysis reveals that R&D spending has a larger influence on growth than the number of patents, and both have a statistically positive effect. However, the effect of advanced technology exports on growth was not found to be statistically meaningful. Consequently, it was determined that countries that increase their technological capabilities by investing in R&D contribute to economic growth.

Özaytürk (2022) analyzed how financial development influences R&D investments. The research argues that financial growth improves economic development and therefore it would increase R&D expenditures. A panel data regression analysis was made by using annual data for the years 2001-2018. Also, 16 Developing countries were analyzed and it was emphasized that the rate of use of innovative technologies and R&D investments should be improved in this

group of countries. The investigation's conclusions imply that financial growth has a favorable and significant role in R&D investments.

Oğul (2022) investigated the relationship between R&D expenditures and financial development in the Turkish economy. The financial development index data utilized in the research are derived from the International Monetary Fund (IMF) database, while R&D expenditure data are derived from the OECD database. For the cointegration relationship between the variables, the ARDL bounds test is utilized for the period 1990-2019. It is concluded that financial growth contributes positively to R&D spending. Since higher financial growth increases R&D spending in the long run.

Karakaya Kırmızı et al. (2022) evaluated the influence of R&D and health expenditures on financial development. Therefore, annual data covering the period 2000-2017 were used and panel data analysis was conducted for 14 developing IMF countries. R&D and health spending as a share of GDP is used as a measure, and the share of domestic loans extended by banks to the private sector in GDP is used as a measure of financial growth. According to the findings, financial growth positively impacts R&D and health expenditures.

Karyağdi et al. (2022) evaluated the influence of R&D spending on the financial growth and economic development of some European countries in the Developing Economies group. In the analysis, the Westerlund cointegration test was used for the 2003-2020 period. The analysis reveals that R&D spending has a great influence on financial growth. At the same time, a long-run cointegrated relationship was found.

Also, some studies research the impact of R&D expenditures on the performance of firms. In general, the influence of R&D on a firm's efficiency and profitability has been examined. These studies are as follows:

Zhu and Huangn (2012) aimed to investigate the Chinese Information Technology industry to find the relationship between firms' R&D investment and financial performance. Thus, the analysis was made using the annual data of Chinese IT companies from 2007-2009. It has been examined that R&D expenditures have a positive impact on the firm's performance. In addition, it has been observed that some companies prefer not to take risks so their R&D expenditures

are low. However, it was emphasized that the significance of R&D expenditures should increase for firms' better performance.

VanderPal (2015) analyzed the impact of R&D expenditures on companies' financial performance. In the research, some indicators such as operational performance and market value were examined and panel data analysis was used. It consists of 103 firms with various sectors and the period includes 1979 and 2013. The result showed that there is a positive linkage between R&D expenditures and companies' financial performance.

Rafiq et al. (2016) researched the effect of R&D expenditures on companies' financial performance in the United States (US) and China. Research was analyzed by using Coarsened Exact Matching (CEM) for 168 US and Chinese mining companies and the period of 2009 and 2013. According to the research, it was emphasized that it is an advantage for mining companies to invest more in R&D for greater profit growth. The results show that US firms have greater financial performance than Chinese firms.

Demir and Alpaslan (2016) investigated 20 companies that spend the most on R&D and innovation in the world. They aimed to determine the influence of R&D spending and innovation on company performance and employment. In the research, the data of Net Profit, Equity Size, Number of Employees, and R&D expenditure of the companies between 2008 and 2012 were used. According to the results, the opposite of the expectation, no relationship exists between the increase in R&D expenditure and innovation, company performance, and employment.

Polat and Elmas (2016) analyzed the influence of R&D investments on the financial performance of firms in the Turkish manufacturing sector. In the research, the data of 13 firms for the period 2007-2015 were analyzed by panel data analysis. The influence of R&D spending on business performance was shown to be negative. Furthermore, the individual impacts of the companies were investigated and it was identified that some companies were positively influenced, and some companies were negatively influenced, by R&D investments. It is argued that the level of R&D investment made depends on its adequacy and efficient use.

Çıtak and İltaş (2017) aimed to define the impact of R&D investments on financial performance. The data of 7 technology firms in the Borsa İstanbul Technology Index between the years 2013-2015 were examined to evaluate the performance efficiencies of R&D expenditures. Inputs and outputs were analyzed with data envelopment analysis by making use of the financial statements on the website of the Public Disclosure Platform. According to the results obtained from the analysis, it was seen that five companies have full pure technical efficiency.

Demirci (2017) explored the intimate relationship between private sector R&D intensity and financial growth. Also, it has been argued that R&D spending is linked to the financial systems of countries. In the research, cointegration analysis was used and the data for 1990-2014 were analyzed in Türkiye. Eventually, it showed that there is a positive cointegrated relation between the ratio of private sector R&D expenditures to GDP and financial development in the long run. Besides policies that increase financial development also increase private sector R&D intensity.

Yıldırım and Sakarya (2018) evaluated the influence of R&D spending on the financial performance of 5 firms operating in the BIST Technology sector. Panel data analysis was made using return on equity (ROE) and return on assets (ROA) for 2009 and 2016. According to analysis, ROA and ROE are significantly and favorably impacted by R&D spending. It has been emphasized that the effective use of investments in R&D activities will increase the profitability of enterprises.

Ravšelj and Aristovnik (2020) investigated the relationship between R&D expenditures and business efficiency. The research used the period of 2012–2016 and 2015–2017 for Slovenian and world R&D firms. Thus, it was analyzed with multiple regression analysis. It has been demonstrated that investing in R&D would improve operating results in the future. In the result, it emphasized that R&D spending in the current period has more efficient market performance in the long term.

Table 2.1. Literature Review Summary Results

Author	period	country	Method	Findings
Chang et al. (2005)	1991-1999	16 selected countries	Panel Regression Analysis	A positive relationship was determined.
Pienknagura (2010)	1987-2006	98 several countries	General Equilibrium Model	A positive relationship was determined.
Maskus et al. (2012)	1990-2003	18 OECD countries	Comparative analysis	A positive relationship was determined.
Işık and Kılınç (2011)	1998-2008	EU and the OECD countries	Evaluating the innovation and R&D indicators	A positive relationship was determined.
Koç and Koç (2017)	1996-2013	G8 countries	Dumitrescu & Hurlin (2012) Panel Causality Test	A positive relationship was determined.
Pala et al. (2018)	2000-2015	BRICS nations	Panel Data Analysis	A positive relationship was determined.
Helhel (2018)	2001-2013	E-7 countries	Panel Data Analysis	A positive relationship was determined.
Yıldırım and Göze Kaya (2019)	2003-2016	EU countries and Türkiye	Evaluating the R&D indicators	Turkey had a low R&D rate among EU nations.
Bulut (2020)	2007-2019	BRICS_T countries	Panel Cointegration And Causality Analyses	A positive relationship was determined.
Ergün and Ergün (2021)	2000-2016	11 emerging nations	Panel Data Analysis	A positive relationship was determined.
Dağlı and Ezanoğlu (2021)	2007-2017	OECD countries	Panel Data Analysis	A positive relationship was determined.

Özaytürk (2022)	2001-2018	16 Developing countries	Panel Data Analysis	A positive relationship was determined.
Oğul (2022)	1990-2019	Türkiye	ARDL Bounds Test	A positive relationship was determined.
Karakaya Kırmızı et al. (2022)	2000-2017	14 Developing IMF countries	Econometric Analysis	A positive relationship was determined.
Karyağdi et al. (2022)	2003-2020	Some Emerging European countries	Westerlund Cointegration Test	A positive relationship was determined.
Zhu and Huangn (2012)	2007-2009	China	Multiple Regression Analysis	A positive relationship was determined.
VanderPal (2015)	1979- 2013	Several countries	Panel Data Analysis	A positive relationship was determined.
Rafiq et al. (2016)	2009-2013	United States (US) and China	Coarsened Exact Matching (CEM)	A positive relationship was determined.
Demir and Alpaslan (2016)	2008-2012	Several countries	Comparative Analysis	No significant relationship was determined.
Polat and Elmas (2016)	2007-2015	Türkiye	Panel Data Analysis	Some firms were positively affected while others were negatively affected.
Çıtak and İltaş (2017)	2013-2015	Türkiye	Data Envelopment Analysis	Only five firms are considered to have full pure technical efficiency.

Demirci (2017)	1990-2014	Türkiye	Cointegration, Causality, impulse-response analyses	A positive relationship was determined.
Yıldırım and Sakarya (2018)	2009-2016	Türkiye	Panel Data Analysis	A positive relationship was determined.
Ravšelj and Aristovnik (2020)	2012-2016	Some selected countries	Multiple Regression Analysis	A positive relationship was determined.

The literature reveals that many studies have been conducted to investigate the link between R&D spending and economic development. However, it is realized that fewer studies are researching the link between R&D spending and financial development on a country basis. This thesis aims to provide a contribution to the literature by analyzing the relationship between business R&D expenditures and financial development sectorally at the macro level for 15 OECD member countries.

3. DATA SET AND METHODOLOGY

3.1. Data Set

In this thesis, the data set includes the period between 2009, and 2019 for ANBERD, 2009, and 2019 for Domestic credit to the private sector (% of GDP). The database of ANBERD benefited from the oecd.org site and domestic credit to the private sector (% of GDP) benefited from the databank.worldbank.org site. The data set exists the following 15 OECD member countries: Belgium, Czech Republic, Denmark, Finland, Germany, Italy, Japan, Korea, Norway, Poland, Portugal, Slovenia, Spain, Türkiye, and the United Kingdom.

The data set of ANBERD contains extensive data on annual R&D expenditures of OECD countries, which are categorized into manufacturing and service sector groups. Besides, it benefits from National currency - 2015 prices (OECD Database, 2020). Since some of the countries in the data consisted of a series of predicted values, these countries were excluded and 15 OECD member countries were selected.

Domestic credit to the private sector consists of financial funds extended to the private sector by financial institutions, as borrowings, trade loans, and purchases of non-equity instruments, which generate a demand for refunds. Financial institutions cover monetary authorities and deposit banks, as well as other financial organizations for which data are available (World Bank, 2022).

The main sectors used in the data set of the thesis are total business enterprises, agriculture, forestry and fishing, manufacturing, and total services sectors. Also, it covers all sub-sectors. Thus, it is aimed to make a detailed analysis.

Table 3.1. Countries and observations in the sample

Country	Freq.	Percent	Cum.
Belgium	11	7.69	7.69
Czech Republic	11	7.69	15.38
Denmark	11	7.69	23.08
Finland	11	7.69	30.77
Germany	11	7.69	38.46
Italy	11	7.69	46.15
Japan	11	7.69	53.85
Korea	11	7.69	61.54
Norway	11	7.69	69.23
Portugal	11	7.69	76.92
Spain	11	7.69	84.62
Türkiye	11	7.69	92.31
United Kingdom	11	7.69	100.00
Total	143	100.00	

Source: The table was created by the author with database from OECD, ANBERD (2021)

There are 15 countries in the analysis and the data was obtained from the OECD dataset.

Table 3.2. Descriptive Statistics

Variable		Mean	Std. dev.	Min	Max	Observations
DC	overall	104.3328	44.42848	37.08022	201.2587	N = 165 n = 15 T = 11
TB	overall	4.24e+12	1.31e+13	4.40e+08	6.88e+13	N = 165 n = 15 T = 11
AF	overall	2.85e+09	1.05e+10	0	7.97e+10	N = 162 n = 15 T bar = 10.8

MF	overall	3.73e+12	1.16e+13	3.46e+08	6.02e+13	N = 165 n = 15 T = 11
TS	overall	4.04e+11	1.19e+12	8.62e+07	7.30e+12	N = 165 n = 15 T = 11
Log(AF)	overall	23.5018	3.119107	19.66322	31.72903	N = 165 n = 15 T = 11
Log(MF)	overall	17.77657	2.814104	9.11493	25.1011	N = 161 n = 15 T bar = 10.7333
Log(TS)	overall	22.94673	2.562139	18.27265	29.6188	N = 165 n = 15 T = 11

Source: The table was created by the author using the information from World Bank and OECD, ANBERD (2021)

Note: Explanations of abbreviations in table 3.3 are as follows: DC: domestic credit to the private sector TB: total business enterprises, AF: agriculture, forestry and fishing, MF: manufacturing TS: total services sector.

According to the descriptive statistics, there are 165 observations, 15 countries, and 11 average time horizons. Also, it includes means, standard deviation, min and max values and we take the logarithm of the values because R&D expenditures vary a lot across countries. So the big difference has become smaller and minimizing the varying variance. In addition according to the domestic credit to the private sector ratios, it can be observed that the mean is 104.33%, which is more than the national income, the standard deviation is 44.42%, the min value is 37.08% and the max value is 201.25%. According to the agriculture ratios, the min value is 0 which means that there are countries that do not spend on R&D in agriculture.

3.2. Methodology

In this thesis, Panel Granger causality analysis is used to evaluate the heterogeneous structure which was developed by Dumitrescu and Hurlin (2012). Dumitrescu-Hurlin Panel Granger Causality Test equation is as follows:

$$\gamma_{i,t} = \alpha_i + \sum_{k=1}^K \gamma_i^{(k)} \gamma_{i,t-k} + \sum_{k=1}^K \beta_i^{(k)} x_{i,t-k} + \varepsilon_{i,t} \quad (1)$$

Where γ is the business R&D expenditures / GDP, x is the financial development, i is the countries, t is the time period, and k is the lag level determined in Dumitrescu-Hurlin Panel Granger Causality Test.

The main argument in the Dumitrescu-Hurlin Panel Heterogeneous Granger Causality Test is that the panel is balanced and the lag level k of the horizontal cross-sectional units is specific to each unit. At the same time, unit-specific effects are assumed to be fixed (Doruk, 2021).

The main hypothesis and alternative hypotheses of this methodology are as follows.

H_0 : Granger Causality relationship does not exist

H_1 : Granger Causality exists for at least one horizontal cross-section.

Additionally, the descriptive statistics show that R&D expenditures are heterogeneous. Therefore Dumitrescu-Hurlin Panel Heterogeneous Granger Causality Test is appropriate to examine such a causal relationship.

4. RESULTS AND DISCUSSIONS

This part of the thesis shows the results of the analysis. It includes Pairwise correlations and Dumitrescu & Hurlin (2012) Granger causality test results by sectors. It is aimed to provide the interpretation of these values.

Table 4.1. Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)
(1) DC	1.000				
(2) TB	0.274*	1.000			
(3) AF	0.203*	0.942*	1.000		
(4) MF	0.272*	1.000*	0.942*	1.000	
(5) TS	0.296*	0.993*	0.935*	0.992*	1.000

Note:*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source: The table was created by the author using the information from World Bank and OECD, ANBERD (2021)

According to Pairwise correlations, the result obtained is statistically significant in 0.1. Also, there is a 27% correlation between total business enterprises' R&D expenditure and financial development, while agriculture has a %20 correlation, manufacturing has a 27% correlation, and total services have a %29 correlation with financial development. In addition, Agriculture, manufacturing, and total services sectors have ratios that support each other. The correlation analysis findings reveal a linearly positive link between the variables.

Table 4.2. Dumitrescu & Hurlin (2012) Granger causality test results: Total Business

Lag order: 1
W-bar = 5.4591
Z-bar = 12.2118 (p-value = 0.0000)
Z-bar tilde = 5.6146 (p-value = 0.0000)
H0: DC does not Granger-cause logrd.
H1: DC does Granger-cause logrd for
> at least one panel

Table 4.3. Dumitrescu & Hurlin (2012) Granger causality test results: Agriculture, Forestry, and Fishing

Lag order: 1
W-bar = 2.2928
Z-bar = 3.2961 (p-value = 0.0010)
Z-bar tilde = 1.1497 (p-value = 0.2503)
H0: DC does not Granger-cause logrd_agri.
H1: DC does Granger-cause logrd_agri for at least one panel

Table 4.4. Dumitrescu & Hurlin (2012) Granger causality test results: Total Services

Lag order: 1
W-bar = 3.6020
Z-bar = 7.1259 (p-value = 0.0000)
Z-bar tilde = 3.0458 (p-value = 0.0023)
H0: DC does not Granger-cause logrd_services.
H1: DC does Granger-cause logrd_services for at least one panel

Table 4.5. Dumitrescu & Hurlin (2012) Granger causality test results: Manufacturing

Lag order: 1
W-bar = 3.1869
Z-bar = 5.9891 (p-value = 0.0000)
Z-bar tilde = 2.4717 (p-value = 0.0134)
H0: DC does not Granger-cause logrd_manuf.
H1: DC does Granger-cause logrd_manuf for at least one panel

Source: The table was created by the author using the information from World Bank and OECD, ANBERD (2021)

According to the results, a causal relationship exists between financial development and business R&D expenditures in at least one country for 15 OECD member countries. As financial development increases, the R&D expenditure of the enterprise is expected to increase.

5. CONCLUSIONS

The significance of R&D expenditures has increased in recent years since it affects global competition and development of the country.

The main purpose of the thesis is to examine the relationship between business R&D expenditures and financial development. Dumitrescu-Hurlin Panel Granger Causality Test was conducted using the data of ANBERD and Domestic credit to the private sector (% of GDP) between 2009 and 2019. 15 OECD member countries are included in the analysis. Dumitrescu-Hurlin (2012) heterogeneous panel Granger causality test was chosen because it is a very convenient causality test in terms of modeling differences between countries such as level of development and technical progress.

OECD countries consist of developed and developing countries, so it is observed that they attach more emphasis to R&D activities. In the analysis, OECD countries with missing data were excluded and 15 OECD member countries were selected to ensure a balanced panel data set. For this reason, including 15 countries in the analysis is a limitation of the thesis.

Dumitrescu & Hurlin (2012) Granger causality test results indicate that a causal relationship exists between financial development and R&D expenditures of enterprises. Consequently, financial development positively affects the increase in business R&D expenditures. Thus, the main hypothesis of the thesis is confirmed. It is concluded that financial development is a significant determinant of R&D spending.

According to the results, it can be recommended that policymakers should pay attention to the factors that increase financial development for increasing R&D expenditures and focus on R&D activities for the growth of businesses. Therefore, they can implement methods to increase incentives to invest in R&D activities.

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