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The Relationship Between R&D Tax Incentives and Innovation Performance: An Empirical Analysis of Oecd Countries

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Abstract

This study examines the relationship between R&D tax incentives and innovation performance in selected OECD countries. In an environment of increasingly intense global competition, innovation has become a key determinant of sustainable economic growth, leading governments to rely more heavily on tax-based policy instruments to support R&D. However, the existing literature has not reached a clear consensus on the impact of R&D incentives on innovation, and long-run cross-country analyses remain relatively limited. Using a panel dataset covering 2007-2022, innovation performance is proxied by the Global Innovation Index, while R&D policies are analyses in terms of tax incentives, public R&D expenditures, and firm-level R&D financing. The empirical findings indicate that R&D tax incentives generally exert a positive effect on innovation performance in OECD countries. The impact of firm-level R&D financing on innovation outputs grows over time, whereas the contribution of public R&D expenditures appears more limited and sensitive to implementation conditions. Overall, the results suggest that the effects of R&D policies on innovation materialise not in the short run but in the long run through cumulative mechanisms. Long-term and comparative empirical evidence highlights that tax-based R&D incentives should be considered a central instrument in the design of innovation policies.

Key words: R&D Expenditures, Tax Incentives, Innovation, Tax Incentives for R&D Expenditures

JEL Code: H25, O31, O32, O38

1. Introduction

The process of globalization has generated multidimensional effects on the economic, technological, and institutional structures of countries, and these effects vary according to their level of development. While some countries have achieved significant gains from global integration through high value-added production,

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technology transfer, and capital flows, others have faced adverse outcomes due to competitive pressures, external dependence, and structural vulnerabilities in their production systems. This heterogeneous impact structure has prompted countries particularly those more intensely exposed to the disadvantages of globalization to develop new instruments in economic and fiscal policies. In this context, research and development (R&D) activities have emerged as a strategic policy area for promoting sustainable growth and enhancing competitiveness (Seçilmiş & Konu, 2019, p. 686).

Research and development (R&D) activities are defined as a systematic set of efforts aimed at expanding societies' stock of knowledge and generating new technological processes that enable the production of this knowledge (OECD, 2002). R&D activities are a fundamental factor in enhancing firms' competitiveness by improving production efficiency, reducing costs, and increasing product quality. However, R&D investments may impose substantial costs on firms due to their high level of uncertainty and significant financing requirements (Kutbay & Öz, 2017, p. 332).

In today's global system shaped by the knowledge economy, R&D activities have become not merely a matter of choice but a fundamental prerequisite for economic development. Technological progress and innovation capacity rank among the most critical determinants of countries' long-term growth performance; accordingly, innovation indicators are widely used as key measures of economic development. The ability of firms and national economies to attain a strong position in the global competitive environment is directly linked to their capacity to generate new technologies and commercialise them rapidly. For this reason, governments extensively employ indirect policy instruments, such as tax incentives, alongside direct support measures targeted at the private sector, to stimulate innovation (Öz, 2024, p. 170).

In the contemporary economic environment, where global competition has evolved toward a knowledge- and technology-based structure, enhancing innovation capacity has become a fundamental determinant of countries' long-term growth performance and competitiveness (Acemoglu & Robinson, 2008). Within this framework, research and development (R&D) activities are regarded as a strategic domain of production that enables firms to expand the stock of knowledge and generate new technological processes, thereby increasing productivity, reducing costs, and improving product quality (Guellec & De La Potterie, 2003; Guan & Yam, 2015). However, R&D investments are inherently characterised by high uncertainty, long gestation periods, and substantial financing requirements. These features render R&D a costly undertaking for the private sector and provide a strong rationale for public authorities to design and implement fiscal policy instruments aimed at supporting R&D activities (Zee, Stotsky & Ley, 2002). In recent years, the marked increase in both the number of OECD countries adopting tax-based R&D incentives and the share of such incentives relative to GDP indicates that these instruments have assumed an increasingly central role in the financing of innovation (OECD, 2023; OECD, 2024; OECD, 2025).

Despite this growing policy relevance, the empirical literature has not reached a clear consensus regarding the impact of R&D tax incentives on

innovation performance. While some studies document that tax incentives significantly stimulate R&D investment and innovation-related outputs (Dechezleprêtre et al., 2016; Kennedy & Barry, 2020; Sein & Darfo-Oduro, 2024), others suggest that the effects may be limited in magnitude, non-linear in nature, or highly contingent upon country-specific conditions (Zhu, 2022; Feng, 2024; Shen & Dai, 2024). Moreover, the relative scarcity of long-term and cross-country comparative analyses, together with the fact that the effectiveness of R&D policy instruments is shaped by institutional structures, financing constraints, and the broader policy mix implemented simultaneously, underscores the need for more comprehensive empirical investigations. In this context, testing the hypothesis that the effects of R&D incentives on innovation are not merely short-term fluctuations but rather emerge through cumulative and time-dependent mechanisms is of particular importance. Employing long-term, multi-country panel data approaches provides a rigorous empirical framework to examine these dynamics and contributes meaningfully to the existing literature.

At the global level, the importance of innovation has become more pronounced within the framework of the United Nations Sustainable Development Goals. The ninth Sustainable Development Goal aims to promote inclusive and resilient economic structures by strengthening industry and infrastructure, while fostering innovation activities (SDG 9). In line with this objective, increasing R&D expenditures by both the public and private sectors is considered one of the key indicators of innovation performance (Fendoğlu & Polat, 2021). The ultimate goal of supporting R&D and innovation is to accelerate the economic growth processes of developing and least developed countries by enhancing productivity and to narrow the welfare gap with advanced economies.

In line with these policy objectives, many OECD countries employ a combination of direct public support and indirect policy instruments to promote R&D activities. Over time, policy preferences have increasingly shifted from direct financial assistance toward tax incentives for R&D (OECD, 2023). Tax incentives aim to reduce the economic burden associated with firms' R&D activities, thereby facilitating more effective participation of the private sector in innovation processes. The literature provides evidence suggesting that tax incentives distort market mechanisms less than direct subsidies and are more effective in reducing the marginal cost of R&D expenditures (Dechezleprêtre et al., 2016; Jia et al., 2017). Over the past two decades, the expansion in both the scope and generosity of R&D tax incentives across OECD countries has further underscored the importance of empirically examining the impact of this policy instrument on innovation performance.

This study investigates the relationship between R&D tax incentives and innovation performance in selected OECD countries using a country-level panel dataset covering the period 2007-2022. Innovation performance is proxied by the Global Innovation Index (GII), while indirect government support for R&D provided through tax incentives is employed as the principal explanatory variable representing R&D policy. In addition to R&D tax incentives, the empirical specification incorporates the share of public R&D expenditures in GDP and the ratio of R&D financing and tax-based subsidies provided to enterprises relative to GDP. Macroeconomic control variables (AGB, AGF) are also included in the model

to account for broader structural and cyclical factors. By jointly considering these components, the analyses evaluates the relationship between the overall R&D policy mix and innovation performance within a comprehensive empirical framework.

The contribution of this study to the literature and to ongoing policy debates can be summarized under three main headings. First, the relationship between R&D tax incentives and innovation performance in OECD countries is examined within a long-term, cross-country panel data framework. By employing a dataset that allows for both temporal and cross-sectional variation, the study contributes to the evaluation of heterogeneous findings in the literature from a longitudinal perspective and provides comparative evidence across countries. Second, the empirical analysis does not rely on a single estimator. Instead, the Fixed Effects approach, Fixed Effects with Driscoll–Kraay robust standard errors, the Common Correlated Effects Mean Group (CCEMG) estimator, and the dynamic Generalized Method of Moments (GMM) estimator are jointly employed. This multi-estimator strategy enables testing the robustness of the estimated coefficients with respect to cross-sectional dependence, unobserved common shocks, slope heterogeneity, and dynamic panel structure, thereby strengthening the methodological rigor of the analysis. Third, by jointly incorporating tax-based incentives, public R&D budget allocations, and firm-level R&D financing into the empirical model, the study advances a policy-mix perspective. Rather than evaluating innovation policies as isolated instruments, it provides an empirical framework suggesting that their effectiveness should be assessed within an integrated policy composition, thereby offering implications for the design and coordination of innovation policies.

The selection of the OECD sample is based on three main considerations. First, OECD countries exhibit substantial variation in the design and intensity of R&D incentive schemes, which provides an appropriate setting for the comparative assessment of policy effects. Second, the availability of long-term, comparable, and regularly updated indicators from sources such as the OECD, WIPO, and the World Bank enhances the reliability and consistency of the panel data analysis. Third, given that OECD countries offer a relatively comparable institutional framework and reporting standards, the relationship between policy instruments and innovation performance can be examined more consistently at the country level. The remainder of the study is organized as follows. The second section reviews the literature on the relationship between R&D tax incentives, public R&D budgets, firm-level R&D financing, and innovation performance, and develops the research hypotheses. The third section presents the dataset, variable definitions, econometric methodology, and estimation strategy. The fourth section reports the empirical findings and provides a sensitivity analysis across alternative estimators. The final section concludes by summarizing the main results and discussing the limitations of the study.

2. Literature Review and Hypothesis Development

2.1. Literature on R&D Tax Incentives (AGT) and Innovation

The empirical literature conceptualizes the impact of R&D tax-based incentives on innovation performance not as a single, universal coefficient, but rather as a multidimensional process shaped by policy design, institutional environment, firm characteristics, and financing conditions (Seligová, 2016; Kennedy & Barry, 2020; Sun, Yin & Liu, 2021; Labeaga et al., 2021; Walter et al., 2022; Yu, Zhou & Jia, 2022; Sein & Darfo-Oduro, 2024; Feng, 2024; Zhang, Deng & Wu, 2024; Hu, Zhou & Li, 2025). These studies indicate that tax incentives reduce firms' effective R&D costs, increase the expected marginal return on innovation investments, and thereby stimulate R&D expenditures and innovative activities.

At the macro level, multi-country analyses generally report a positive association between R&D tax incentives and innovation outputs. Focusing on a sample of OECD countries, Sein and Darfo-Oduro (2024) find that tax incentives significantly enhance firm-level innovation performance and play a functional role within the broader innovation policy toolkit. Empirical evidence from European countries supports these findings. Seligová (2016) and Kennedy and Barry (2020) show that R&D tax credits increase firms' R&D investments and competitiveness; however, they emphasize that the magnitude and effectiveness of these incentives are strongly contingent upon the quality of policy design, administrative simplicity, and regulatory predictability.

Nevertheless, the literature also demonstrates that the effects of tax incentives are not homogeneous and vary depending on country- and firm-characteristic properties. At the country level, the overall tax burden and macro-fiscal pressures (Zhu, 2022; Sein & Darfo-Oduro, 2024), corporate quality and governance capacity (Kennedy & Barry, 2020; Şahin, 2024), as well as the investment climate and regulatory uncertainty (Seligová, 2016), are identified as key determinants influencing both the magnitude and the direction of the impact of tax incentives on innovation performance. At the firm level, factors such as firm size, ownership structure, and the severity of financial constraints significantly differentiate the effects of tax incentives on innovation outputs (Sun, Yin & Liu, 2021; Zhang, Deng & Wu, 2024; Hu, Zhou & Li, 2025).

Studies highlighting this heterogeneity suggest that although tax incentives constitute a policy instrument capable of supporting innovation, their effects do not materialize automatically or in a strictly linear manner. For instance, Feng (2024), in an analysis of multinational firms, finds that while generous tax incentives may increase R&D expenditures in the short run, they can exert a weakening effect on innovation quality in the long term. These findings indicate that the relationship between tax incentives and innovation should be conceptualized as a dynamic and time-sensitive process shaped by firm behavior and structural conditions rather than as a uniform and immediate policy outcome.

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2.2. Literature on Public R&D Budget (AGB), Firm R&D Financing (AGF), and Innovation

The impact of public R&D budgets on innovation is commonly explained by the public good characteristics of knowledge production. Since fundamental, long-term, and high-risk R&D activities are often underprovided by the private sector due to uncertainty and limited appropriability, public support plays a critical role in financing such activities and mitigating market failures (Guan & Yam, 2015). Within this framework, public R&D expenditures are expected to complement private sector investments by reducing risk, enhancing knowledge spillovers, and strengthening collaborative linkages within the innovation system. Accordingly, this approach posits that public R&D spending can enhance the overall capacity and resilience of the innovation ecosystem.

A substantial body of empirical research reports a positive association between public R&D budgets and innovation performance (Kutbay & Öz, 2017; Kennedy & Barry, 2020; Qian, 2023). Moreover, studies that jointly examine public R&D expenditures and tax-based incentives suggest that the simultaneous use of multiple policy instruments can enhance innovation effectiveness through complementarities within the policy mix (Guan & Yam, 2015; Qian, 2023; Zhao, Liu & Zhao, 2025). However, the literature also emphasizes that the impact of public R&D spending on innovation is highly context-dependent. Macro-level analyses indicate that public expenditures and the overall tax burden may support innovation within certain threshold levels; yet excessive fiscal pressure can deteriorate the investment climate and weaken innovation performance (Zhu, 2022; Shen & Dai, 2024). Furthermore, in countries with low institutional quality, public R&D support may generate limited or even adverse effects on innovative outputs. In contrast, in countries with strong institutional capacity, public R&D budgets tend to operate in a complementary manner with private sector R&D investments (Şahin, 2024).

Firm-level R&D financing is predominantly examined in the literature through the lens of alleviating financial constraints. Direct subsidies and firm-level R&D support mechanisms reduce liquidity pressures, facilitate firms' engagement in R&D activities, and establish a more direct linkage between innovation inputs and outputs (Qian, 2023; Zhang, Deng & Wu, 2024). Empirical evidence further suggests that the effectiveness of such support is more pronounced among firms facing severe financial constraints, and that both the intensity of support and the broader institutional environment significantly shape this relationship (Yu, Zhou & Jia, 2022; Sun, Li & Liu, 2023; Ni, 2025).

2.3. R&D Incentives Implemented Worldwide and Innovation Performance

Global R&D expenditures have exhibited a long-term upward trend. While worldwide R&D spending amounted to approximately USD 641 billion in 1999, this figure reached USD 1.4 trillion by 2012 (Göçer et al., 2014, p. 167). According to the most recent data, global R&D expenditures exceeded USD 2.8 trillion as of 2023, and it is estimated that this amount approached USD 3 trillion in 2024

(OECD, 2024a). This increase indicates that countries' competitiveness has become increasingly dependent on knowledge, technology, and innovation capacity.

Technological advancements accelerated by the globalization process necessitate the production of innovative and high value-added products, thereby becoming one of the fundamental determinants of international competitiveness. In particular, it is observed that the importance attributed to R&D tax incentives as a key component of innovation policies has increased in European Union (EU) countries (Göçer et al., 2014, p. 168). In supporting R&D and technological innovation, countries generally make use of three main policy instruments: (i) R&D activities conducted directly by public institutions, (ii) direct public support provided to private sector R&D activities in the form of grants and loans, and (iii) indirect financial support provided through tax incentives for R&D expenditures (Guellec & De La Potterie, 2003, p. 227).

Tax incentives encompass various mechanisms such as tax deductions, exemptions and allowances, accelerated depreciation schemes, tax credits, tax holidays, and the deductibility of R&D expenditures as expenses. By reducing the cost of R&D activities, these incentives encourage firms to engage in innovative investments and, in this respect, are considered one of the most widely used fiscal policy instruments affecting countries' R&D performance (Hodzic, 2013, p. 401). The literature frequently emphasises that tax incentives occupy an important place in the R&D and innovation policies of many countries. OECD data indicate that, as of 2023, several OECD countries provide particularly high levels of support in terms of the share of R&D tax incentives in GDP. For instance, the ratio of tax incentives to GDP is approximately 0.39% in Portugal, 0.38% in Iceland, 0.30% in the United Kingdom, 0.28% in France, and 0.24% in China (OECD, 2025a). These indicators reveal the economic significance of governments' efforts to encourage private sector R&D investments by foregoing a portion of total tax revenues.

OECD data further show that, as of 2024, 34 out of 38 OECD countries implement tax incentives for R&D expenditures, and that these incentives have assumed an increasingly widespread role within total support measures (OECD, 2025a). Tax incentives are generally implemented in two main forms: (i) expenditure-based incentives, which include practices such as tax deductions for R&D expenses or tax credits; and (ii) income-based incentives, which involve the application of lower tax rates to income derived from R&D or innovation activities (OECD, 2025b). Within this framework, tax incentives are regarded as an important policy instrument in strengthening innovation output and long-term competitiveness by increasing firms R&D investments.

Tax incentives for R&D activities are among the policy instruments aimed at enhancing firms' innovation capacity by reducing the financial burden associated with R&D expenditures undertaken within this scope. Rather than being strictly tied to specific project types or predefined conditions, these incentives provide firms with flexibility to develop and implement R&D projects in line with their own strategic priorities. Effectively and balancedly designed tax incentives contribute to the expansion of innovative activities and the acceleration of the knowledge production process by increasing private sector R&D investments (Çelebi and Kahriman, 2011). Countries utilise various policy instruments, such as direct support measures, tax incentives, and institutional collaborations, to strengthen

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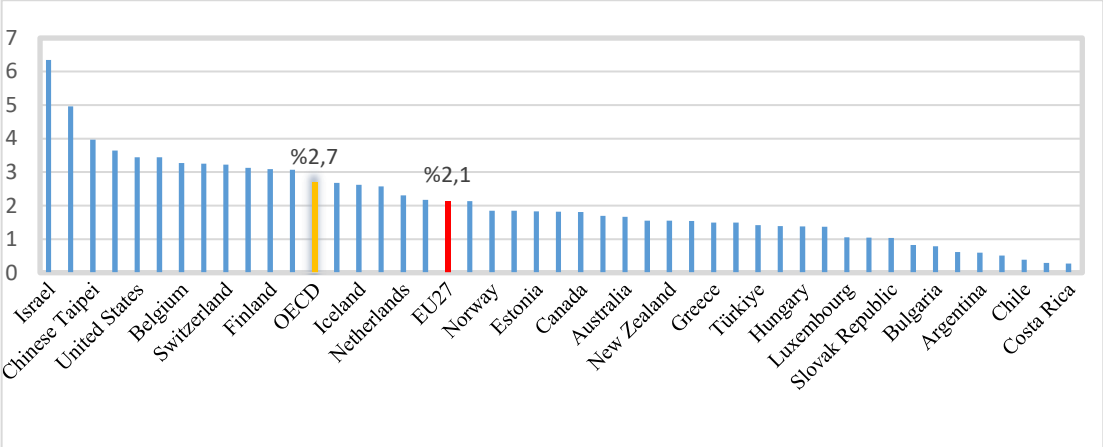
their R&D and innovation performance. These incentive mechanisms are not limited to enhancing firms research capacity; they also support economic growth by encouraging scientific knowledge production and play a significant role in increasing international competitiveness. In this context, R&D incentives are regarded as one of the fundamental components of innovation-driven development strategies.

Figure 1: Share of R&D Incentives in GDP (%) in OECD Countries



Source: OECD, Main Science and Technology Indicators, R&D Tax Incentives Database 2025

In the OECD region, the growth rate of public R&D budget allocations (GBARD) slowed markedly in 2023, declining to 0.6%. This represents a significant decrease compared to the 5.5% increase recorded in 2022. One of the main reasons for this decline is the expiration of temporary fiscal support and stimulus packages implemented in many OECD countries in response to the COVID-19 pandemic. However, since R&D funds allocated within public budgets can be utilized in subsequent years, it is considered that the budgetary slowdown observed in 2023 may not yet have had a direct impact on R&D performance in the same year, particularly in sectors that are more heavily dependent on public funding. The budget outlook for 2024 remains uncertain, as many countries have not yet reported data for this year. In addition, existing GBARD statistics do not include R&D funding provided through the European Union budget. Available data indicate that public R&D budget allocations in 2024 followed a largely flat trajectory and, with a limited increase of approximately 0.5%, remained well below economic growth rates.

2.4. Conceptual Framework

One of the key determinants shaping national competitiveness in today's economy is a highly skilled workforce, and research and development (R&D) activities constitute one of the domains in which such human capital is most intensively utilised. Investments undertaken within the scope of R&D activities are reported to generate multidimensional and significant contributions to the national

economy (Gökmenoğlu et al., 2012, p. 7). In the contemporary economic structure characterised by increasingly intense global competition, firms' ability to sustain their existence has become a strategic necessity. Accordingly, firms are required to develop new products and services in order to adapt to rapid changes in consumer preferences or to adopt alternative production techniques that enable existing production processes to be carried out at lower costs. The primary driving force behind this transformation is technological progress. Technological advancements emerge as a result of R&D activities conducted on a scientific basis and, by occupying a central position in the innovation process, make significant contributions to the commercialisation of new products and the improvement of the quality of existing products (Cenikli, 2021, p. 233).

The literature provides various definitions of R&D activities. Some studies conceptualise R&D as a structure that enables firms to achieve normal or above-average profitability and to gain a competitive advantage over existing or potential rivals (Ghaffar & Khan, 2014, p. 354). Others define R&D activities as a process based on the intensive use of human capital and requiring substantial long-term investment (Doruk & Söylemezoğlu, 2014, pp. 2–3). When these definitions are considered jointly, it becomes evident that R&D activities should be regarded as one of the fundamental driving forces of economic growth and development through the creation and advancement of new technologies.

An examination of differences in economic growth and per capita income across countries reveals that human capital, natural resources, technological infrastructure, labour productivity, and political and economic stability constitute key determining factors. For this reason, particularly for developing countries, it is crucial to promote technology transfer, increase educational expenditures, and formulate policies that support R&D activities in order to attain the level of competitiveness achieved by developed economies (Göçer, 2013, p. 237). R&D activities provide a wide range of contributions to national economies and are widely recognised as one of the key indicators used to assess countries' level of development. Moreover, by supporting technological progress, R&D activities contribute to attracting foreign direct investment, thereby increasing technological investment and reducing external dependency (Taş, Taşar, & Açcı, 2017, p. 200). In addition, R&D activities facilitate the expansion of high-value-added production. However, it is also noted that when R&D expenditures fail to yield successful outcomes, they may generate adverse effects on firms financial performance in the long run (Taşıyan & Çadırcı, 2024, p. 45).

Tax incentives are regarded as one of the fundamental policy instruments that enable governments to assume a guiding role over the economy. In general, these incentives comprise regulatory arrangements that reduce the tax burden borne by entrepreneurs. In both developed and developing countries, the economic effects of tax incentives are highly pronounced. The ability of governments to allocate their limited resources among sectors or regions in line with economic priorities is made possible through fiscal instruments, which renders incentive mechanisms an important policy tool. Through tax incentives, it is aimed to achieve a more balanced and efficient distribution of resources within the national economy. The concept of tax incentives is addressed from different perspectives in the literature. Zee et al. (2002: 1948) define tax incentives as specific and applicable legal tax

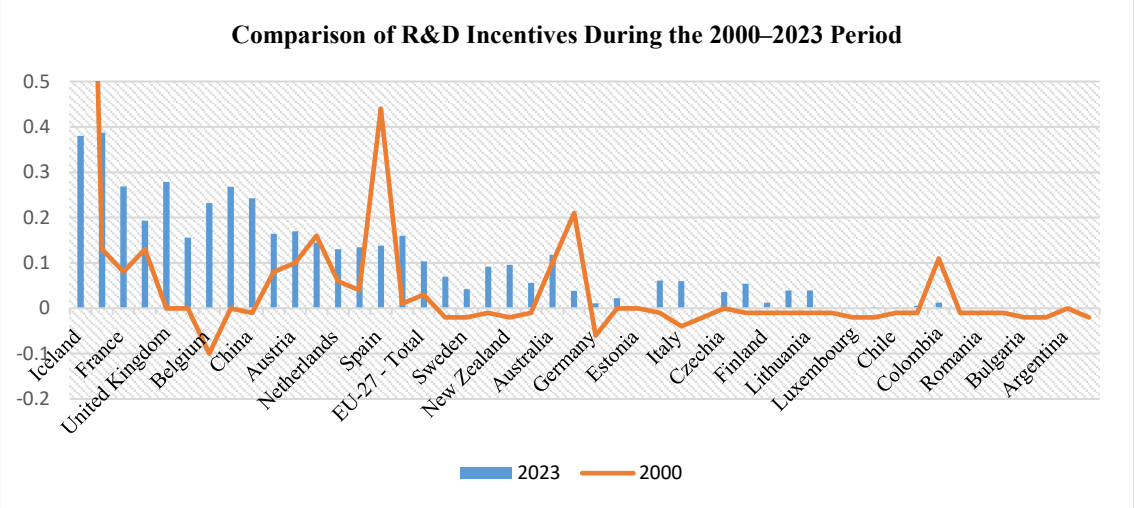
provisions that are implemented for certain and qualified investment projects without expecting a direct return, and that differ from general tax regulations. Similarly, tax incentives are distinguished from general tax rules and described as preferential tax arrangements that target only specific sectors or areas of activity. Within this framework, tax incentives may also be considered as a set of fiscal measures that reduce or entirely eliminate the tax burden for selected sectors within the economy (Zolt, 2013: 11).

The objectives sought through tax incentives are not confined solely to economic growth; they also encompass social dimensions. In this context, in addition to goals that support economic growth, social objectives such as the formalization of the labor market from the perspective of individuals and households, the promotion of savings behavior and philanthropic activities, the encouragement of fertility rates, the improvement of health conditions, and the reduction of poverty levels come to the fore (Oluklulu & Çakır, 2025, p. 571). The fundamental purpose of tax incentives is to direct economic resources toward areas that are assumed to be more beneficial for the national economy. In other words, tax incentives aim to increase efficiency in the allocation of resources.

Tax incentives are also addressed within the scope of the concept of "tax expenditures." Tax expenditures refer to the loss of public revenue that arises as a result of the government's deliberate relinquishment of its right and potential to generate revenue on behalf of the public. In this respect, tax incentives perform a function similar to public expenditures, as they lead to a reduction in budget revenues. Indeed, tax incentives represent costs arising from the forgoing of public revenues and are therefore considered expenditure items from the perspective of the public budget (Öz, R., 2024, pp. 170-171).

Over the past century, technological advances and investments in capital goods have played a decisive role in the transformation of economic structures on a global scale. In this process, innovation and technological change have become one of the main driving forces of economic growth (Bernanke, 2011, p. 2). As the effects of innovation on economic performance have become increasingly well understood, countries have reoriented their production processes toward R&D-based structures and placed the support of innovation activities at the centre of their development strategies. Accordingly, the adoption of R&D-intensive production models has become an important component of countries' objectives to enhance competitiveness and achieve sustainable growth. The reflections of this globally observed trend over time can also be clearly traced through the data presented in Figure 1.

Figure 2: Changes in R&D Tax Incentives in OECD Countries Between 2000 and 2023



Source: Prepared using data from the OECD R&D Tax Incentives Database

Figure 2 illustrates the changes over time in tax incentives for R&D expenditures in OECD member countries as well as in selected non-OECD countries for the period 2000-2023. Overall, the 2023 data indicate a higher and more widespread level of tax incentives in many countries compared to 2000. In particular, countries such as Portugal, France, the United Kingdom, and Ireland exhibit significant increases in R&D tax incentives, indicating that these countries have strengthened their support for R&D activities through tax policy instruments. A positive trend is also evident in the OECD and G20 country averages from 2000 to 2023, suggesting that tax incentives have become an increasingly important policy tool in the financing of R&D. By contrast, in some countries the level of incentives has remained limited or the increase has been relatively modest, while in a few cases incentives appear to have stagnated or declined marginally in 2023. An examination of non-OECD countries shows that although periodic increases are observed in countries such as South Africa and Brazil, their overall incentive levels remain below the OECD average. These findings reveal that tax incentives for R&D vary considerably across countries and have exhibited heterogeneous development over time in terms of both scope and intensity.

Tax incentives for R&D activities constitute one of the principal policy instruments widely employed to support innovation across a large share of OECD member countries and many leading economies worldwide. As of 2000, the number

of OECD countries implementing tax credits or tax exemptions for R&D expenditures was limited to 19. Focusing on the European Union, by 2022, 22 out of 27 member states were providing tax support for R&D activities. This indicates that, compared to 2000, the number of EU countries applying R&D tax incentives nearly doubled (OECD, 2022). According to the most recent OECD data, as of 2024, 34 of the 38 OECD member countries employ tax relief mechanisms to encourage R&D expenditures (OECD, 2025).

Tax incentives for R&D activities stand out as an important support instrument that reduces project costs and thereby increases net present value and investment feasibility. These incentives play a particularly encouraging role for small and medium-sized enterprises that face limitations in accessing direct public support, and they function as a broad-based support mechanism covering a wide range of firms. Nevertheless, tax incentives make it more difficult for public authorities to directly channel resources toward specific R&D areas with high social returns and carry the potential to steer firms toward shorter-term activities rather than long-term, high-risk projects (Laporšek et al., 2025, p. 2).

This study is grounded in a multi-channel framework in which innovation performance is shaped by different components of R&D policy. Conceptually, innovation performance is not reduced to the aggregate level of R&D expenditures alone; rather, it is treated as an outcome determined by the specific policy instruments through which R&D activities are supported, the financing structure of these instruments, and the institutional environment in which they are implemented (Guellec & De La Potterie, 2003; Acemoglu & Robinson, 2008; Walter et al., 2022). Accordingly, innovation performance is operationalized as the dependent variable and measured by the Global Innovation Index (GII), while the three core components of R&D policy are incorporated into the empirical model as explanatory variables.

R&D tax-based incentives (AGT) are defined as an indirect policy instrument that stimulates private sector R&D investment by reducing the marginal cost of firms' R&D activities. The theoretical framework posits that tax incentives increase the expected marginal return from R&D investments, thereby encouraging firms to engage more intensively in innovative activities (Zee, Stotsky & Ley, 2002). Empirical evidence generally suggests that this mechanism can exert a positive effect on both innovation inputs and outputs; however, the magnitude and direction of the effect are sensitive to country-specific factors such as fiscal pressures, institutional quality, and regulatory predictability (Seligová, 2016; Kennedy & Barry, 2020; Sein & Darfo-Oduro, 2024). Within this framework, the AGT variable is measured by the rate of tax-based R&D incentives, and its direct and long-run impact on innovation performance is examined in the empirical analysis.

Public R&D budget allocations (AGB) are conceptualized as a policy component that strengthens the knowledge production capacity of the innovation ecosystem by supporting fundamental, long-term, and high-risk R&D activities that the private sector is often reluctant to undertake due to the public good nature of knowledge (Guellec & De La Potterie, 2003; Bernanke, 2011). The literature emphasizes that public R&D expenditures can establish a complementary

relationship with private sector R&D investments; however, the strength and direction of this relationship depend on factors such as institutional capacity, fiscal sustainability, and the quality of policy implementation (Guan & Yam, 2015; Qian, 2023; Şahin, 2024). Accordingly, the AGB variable is measured as the share of public R&D budget allocations in GDP, and its conditional effect on innovation performance is empirically tested within the model.

Firm-level R&D financing (AGF) is considered a policy instrument that directly supports private sector R&D activities by alleviating financial constraints and reducing liquidity pressures. The financial constraints literature indicates that direct monetary support can exert strong effects on firms' innovation decisions, particularly in environments where access to external finance is limited (Guan & Yam, 2015; Zhang, Deng & Wu, 2024). Empirical findings further suggest that the impact of firm-level R&D financing on innovation outputs is sensitive to the intensity of support, firm size, and the institutional framework within which firms operate (Yu, Zhou & Jia, 2022; Sun, Li & Liu, 2023). Accordingly, the AGF variable is measured as the ratio of R&D financing provided to firms relative to GDP, and its effect on innovation performance is examined within the empirical model.

Assuming that the relationship between innovation performance and R&D policies is not independent of macroeconomic conditions, control variables such as income per capita, overall R&D intensity, and economic scale are incorporated into the model (Kutbay & Öz, 2017; Tingbani et al., 2023). Within this framework, the study aims to evaluate the effects of R&D tax incentives, public R&D budgets, and firm-level R&D financing on innovation performance through a policy-mix perspective, using a long-term and comparative OECD panel dataset.

2.5. Hypothesis Development

The empirical literature conceptualizes the impact of R&D tax-based incentives on innovation performance not as a single and universal coefficient, but as a multi-channel process shaped by policy design, institutional environment, firm characteristics, and financing conditions (Seligová, 2016; Kennedy & Barry, 2020; Sun, Yin & Liu, 2021; Labeaga et al., 2021; Walter et al., 2022; Yu, Zhou & Jia, 2022; Sein & Darfo-Oduro, 2024; Feng, 2024; Zhang, Deng & Wu, 2024; Hu, Zhou & Li, 2025). Within this framework, although most studies report a positive association between tax incentives and innovation performance, the magnitude and in some cases even the direction of this effect varies significantly across contexts. At the country level, total tax burden and macro-fiscal pressures (Sein & Darfo-Oduro, 2024; Zhu, 2022), institutional quality and governance capacity (Kennedy & Barry, 2020; Şahin, 2024), as well as the investment climate and regulatory predictability (Seligová, 2016) are identified as key determinants. At the firm level, factors such as firm size and ownership structure (Sun, Yin & Liu, 2021; Hu, Zhou & Li, 2025), along with the severity of financial constraints and access to external finance (Zhang, Deng & Wu, 2024), significantly differentiate the observed effects.

Accordingly, the hypotheses developed in this study are not formulated solely on the basis of average positive effects reported in the literature. Rather, they are structured by jointly considering the direct impact of tax incentives on

innovation, the indirect mechanisms operating through financial and institutional channels, and the potential non-linear effects that are sensitive to country and firm specific contexts. In this framework, the hypotheses and the empirical literature underpinning them are presented as follows.

Tax-based R&D incentives are conceptualized as a policy instrument that stimulates innovation by reducing firms' R&D costs and increasing the expected marginal returns from R&D activities. This mechanism enables firms, under existing budget constraints, to allocate greater resources to R&D investment and to engage more intensively in innovative activities. Macro-level and multi-country studies generally report a positive association between R&D tax incentives and innovation outputs. Focusing on a sample of OECD countries, Sein and Darfo-Oduro (2024) demonstrate that tax incentives significantly enhance firm-level innovation performance and play a functional role within the broader innovation policy toolkit. Empirical evidence from European countries corroborates these findings. Seligová (2016) and Kennedy and Barry (2020) show that R&D tax credits strengthen firms' R&D investments and competitiveness; however, they emphasize that the effectiveness of these incentives is strongly contingent upon the quality of policy design, administrative simplicity, and regulatory predictability. In comparative analyses that include Türkiye, Kutbay and Öz (2017) find that increases in R&D tax incentives support both R&D expenditures and economic growth, suggesting that tax incentives can play a positive role in the innovation–growth nexus. This relationship has been examined in greater detail at the firm level and within emerging economy samples. In particular, a substantial body of research focusing on China shows that R&D tax credits and related incentives generally exert positive effects on R&D investments, innovation inputs, and patent outputs. However, these effects are found to vary significantly depending on firm age, firm size, ownership structure, and the institutional characteristics of the region in which firms operate (Sun, Yin & Liu, 2021; Xiao & Zhuang, 2022; Yang, Yang & Guan, 2024; Hu, Zhou & Li, 2025; Wu & He, 2021). These findings suggest that although tax incentives constitute an instrument capable of supporting innovation, their impact is neither homogeneous nor automatic. Furthermore, Feng (2024) demonstrates that international tax incentives increase the R&D expenditures of multinational firms; however, this increase does not necessarily translate into higher innovation quality or a greater volume of innovative outputs. The study indicates that firms' tendency to relocate R&D activities to jurisdictions offering more generous incentives may generate short-term increases in R&D spending, yet potentially weaken innovation performance in the long run.

As evidenced by the empirical literature, the effects of tax incentives on innovation constitute a context-dependent process that is sensitive to temporal dynamics and firm behavior. Within this framework, Hypothesis H1 is formulated in light of the prevailing tendency in the literature regarding the relationship between tax-based R&D incentives and innovation performance. However, the hypothesis does not rest on the assumption that the magnitude of this effect is uniform across countries or constant over time. Rather, it is grounded in the premise that the impact operates through a mechanism that becomes more pronounced in the medium and long term and is contingent upon institutional characteristics and

firm-level heterogeneity. Accordingly, testing this hypothesis requires methodological approaches capable of jointly evaluating long-run relationships and dynamic structures. In this context, the following hypothesis is proposed and empirically tested:

H1. An increase in tax-based R&D incentives is associated with a positive and statistically significant long-run relationship with innovation performance in OECD countries.

The impact of public R&D budgets on innovation is primarily explained by the public good nature of knowledge production. Since fundamental, long-term, and high-risk R&D activities are often underprovided by the private sector due to uncertainty and limited appropriability, public support plays a crucial role in financing such activities. Through this mechanism, public R&D expenditures can complement private sector R&D investments and enhance the overall capacity of the innovation ecosystem (Guan & Yam, 2015). Empirical studies conducted within this framework frequently report positive associations between public R&D spending and innovation outputs as well as broader economic performance indicators (Kutbay & Öz, 2017; Kennedy & Barry, 2020; Qian, 2023). Similarly, sector-specific analyses and studies adopting a policy-mix perspective indicate that the simultaneous implementation of public R&D budgets and tax-based incentives can generate reinforcing effects on innovation efficiency and productivity (Guan & Yam, 2015; Qian, 2023; Zhao, Liu & Zhao, 2025).

These findings empirically substantiate the theoretical expectation that increases in public R&D budgets may support innovation performance. However, the literature also indicates that the effect of the public R&D budget channel does not operate automatically, linearly, or uniformly positively under all conditions. In particular, macro-level studies demonstrate that the impact of public expenditures and the overall tax burden on innovation varies depending on threshold levels and prevailing macroeconomic conditions. In this context, Shen and Dai (2024), in an analysis jointly examining public spending and the macro tax burden, find that the tax burden supports innovation efficiency up to a certain level; beyond this threshold, however, the investment climate deteriorates, and innovation is indirectly weakened, particularly through a decline in foreign direct investment inflows. This evidence suggests that the contribution of public resources to innovation depends critically on the extent to which fiscal pressures influence investment decisions. Similarly, Zhu (2022), examining the relationship between the corporate tax rate and firm-level innovation performance, identifies an inverted U-shaped effect, indicating that moderate taxation may stimulate innovation, whereas excessive tax burdens can exert a detrimental impact.

The findings indicate that both very low and very high levels of taxation and public burden are unfavorable for innovation, whereas innovation performance tends to peak under a moderate fiscal burden. Taken together, these studies suggest that the impact of public R&D budgets on innovation depends not only on the level of spending itself, but also on institutional capacity, fiscal sustainability, and the overall tax–expenditure composition. The empirical evidence further clarifies the positive yet conditional nature of Hypothesis H2. Seçilmiş and Konu (2019), in their analysis of OECD countries, show that the relationship between R&D

incentives and innovation performance is not statistically significant in certain periods and samples, highlighting the decisive role of institutional and structural context. Similarly, Şahin (2024) finds that the effect of government R&D support on innovative outputs varies with the level of institutional quality: in environments characterized by weak institutional capacity, public support may exert constraining effects, whereas in countries with strong institutional frameworks, public R&D budgets operate complementarily with private sector R&D activities and enhance innovation performance.

These findings imply that the impact of public R&D budgets on innovation is not homogeneous across OECD countries and is highly sensitive to implementation capacity and institutional conditions. Accordingly, Hypothesis H2 is formulated in light of the mixed evidence in the literature regarding the effect of public R&D budgets on innovation performance. The hypothesis does not assume that the magnitude of the effect is uniform across countries or constant over time. Rather, it is tested under the premise that the impact operates through a context-dependent mechanism shaped by institutional quality, investment climate, and the broader policy mix. Thus, while H2 examines the innovation-enhancing potential of public R&D budgets, it simultaneously acknowledges that this effect may weaken or materialize with a lag depending on prevailing structural and macroeconomic conditions. Within this framework, the following hypothesis is proposed and empirically tested:

H2. An increase in public R&D budget allocations positively affects innovation performance in OECD countries, conditional upon institutional capacity and the broader policy mix.

Firm-level R&D financing is primarily grounded in the empirical literature through the mechanisms of alleviating financial constraints and accelerating private sector R&D activities. Unlike tax incentives, firm-level R&D financing directly affects firms' R&D budgets and project scale, thereby establishing a more immediate linkage with innovation inputs and outputs. In this respect, compared to general tax reductions or aggregate public budget allocations, firm-level financial support is expected to translate more rapidly and visibly into firms' innovation decisions. A number of studies support this expectation. Sectoral and firm-level analyses demonstrate that fiscal subsidies and direct R&D financing can increase R&D intensity, enhance innovation efficiency, and improve total factor productivity. Qian (2023), focusing on the new energy sector, finds that firm-level R&D support exerts a statistically significant and positive effect on innovation outputs. Similarly, Guan and Yam (2015) and Zhao, Liu, and Zhao (2025) show that fiscal subsidies stimulate private sector R&D investment and strengthen innovation capacity. Collectively, these findings suggest that when firm-level R&D financing is implemented alongside tax incentives, it can form a coherent policy bundle that more effectively supports innovation performance.

The indirect mechanisms through which firm-level R&D financing affects innovation are also clearly articulated in the literature. Studies centered on financial constraints demonstrate that fiscal support strengthens innovation particularly by easing access to external finance and reducing liquidity pressures. Zhang, Deng,

and Wu (2024) and Qian (2023) show that R&D support not only directly enhances innovation performance but also indirectly accelerates innovative activities by alleviating the financial constraints faced by firms. These findings indicate that firm-level R&D financing functions not merely as an expenditure-increasing instrument, but also as a policy tool operating through a financial relief channel. Similarly, Gong et al. (2025) find that tax integrity expands access to external financing and thereby increases innovation output, while Ni (2025) demonstrates that public budget management and governance quality act as regulatory factors shaping the effectiveness of this financing channel.

However, the literature also emphasizes that the effect of firm-level R&D financing is neither strictly linear nor automatic. Studies focusing on incentive intensity and threshold effects reveal that increases in financial support below certain levels generate limited impact, whereas exceeding specific thresholds can lead to more pronounced improvements in innovation outputs. Yu, Zhou, and Jia (2022) and Sun, Li, and Liu (2023) show that the impact of subsidies and firm-level R&D support on innovation performance is non-linear, and that the effect strengthens under appropriate levels of support intensity and favorable institutional conditions. These findings suggest that the effect of firm-level R&D financing on innovation is inherently conditional and context-sensitive. Accordingly, Hypothesis H3 is formulated on the premise that increases in R&D financing provided to firms positively affect innovation performance. However, the hypothesis does not assume that the magnitude of this effect is uniform across countries or time periods. Rather, it is empirically tested under the assumption that the relationship operates through a mechanism sensitive to financial constraints, incentive intensity, and institutional framework. Within this context, the following hypothesis is proposed and empirically examined:

H3. An increase in firm-level R&D financing exerts a more direct and stronger positive effect on innovation performance in OECD countries.

3. Sample and Research Design

This study examines the relationship between R&D tax incentives and innovation performance in selected OECD countries using panel data analysis. The dependent variable, innovation performance, is proxied by the Global Innovation Index. The main independent variable represents R&D policy through indirect government support in the form of R&D tax incentives. To enhance the robustness of the empirical results, several control variables are incorporated into the model, including the ratio of government R&D budget allocations to GDP, the ratio of indirect tax subsidies for business R&D expenditures to GDP, GDP per capita, and the ratio of total R&D expenditures to GDP. For the panel dataset covering the period 2007–2022, panel unit root and cointegration tests are conducted to examine the time-series properties of the variables and the existence of a long-run

equilibrium relationship. Dynamic panel models are subsequently employed to estimate both the long-run and short-run effects.

3.1 Model Specification

The study employs an annual panel dataset for OECD countries covering the period 2007-2022, subject to data availability. The dataset has an unbalanced panel structure at the country level. The dependent variable is the Global Innovation Index (GII). GII data were compiled from the World Intellectual Property Organization (WIPO) IP Statistics Data Center. The main independent variables include the R&D tax incentive rate (AGT) and the government budget allocated to R&D (AGB), both obtained from the OECD Data Explorer. As control variables, the share of government financing for business R&D in GDP (AGF) was also sourced from the OECD Data Explorer, while GDP per capita (GDP) and gross domestic expenditure on R&D as a percentage of GDP (RD) were retrieved from the World Bank database. Due to data constraints, the sample comprises 31 of the 38 OECD member countries. Chile, Colombia, Costa Rica, Norway, Slovenia, Spain, and Switzerland were excluded from the analysis owing to incomplete data availability.

In this study, the variables are conceptually distinguished to represent different R&D policy channels. AGT refers to tax-based R&D incentives and captures indirect government support provided through the tax system, including mechanisms such as tax deductions, tax credits, and similar instruments aimed at stimulating private sector R&D activities. AGB represents direct government budget allocations to R&D and is measured as the share of public R&D expenditures in Gross Domestic Product (GDP). AGF, on the other hand, refers to firm-level R&D financial support and captures direct government support provided to enterprises through subsidies and financial assistance mechanisms designed to increase private sector R&D investment. This distinction ensures that tax incentives, public R&D expenditures, and firm-level financial support are treated as separate policy channels within the analysis.

Table 1. Data Set

Variable Type	Abbreviation	Description	Unit of Measurement	Data Source
Dependent Variable	GII	Global Innovation Index	Index	WIPO (World Intellectuall Property Office) IP Statistical Data Center
Independent Variables	AGT	R&D Tax Incentive Rate	%	OECD- Data Explorer
Control Variables	AGB	Budget Allocated to R&D	%	OECD- Data Explorer
	AGF	Ratio of R&D Financing Provided to	%	OECD- Data Explorer

	Enterprises to Gross Domestic Product		
GDP	Gross Domestic Product (GDP) per Capita	United States Dollar ($)	World Bank- World Development Indicators
RD	Ratio of Research and Development (R&D) Expenditures to Gross Domestic Product	%	World Bank- World Development Indicators

* The variables marked in the table were constructed by the author.

Based on the specified variables, the research model developed for the study is presented as follows:

$$\ln(GII_{it}) = \alpha + \beta_1(AGT_{it}) + \gamma_1 ln(AGB_{it}) + \gamma_2(AGF_{it}) + \gamma_3(GPD_{it}) + \gamma_4(RD_{it}) + \mu_{it}$$

Definitions (i= country, t=year):

- GII_{it}: Global Innovation Index (log).
- AGT_{it}: Indirect government support through R&D tax incentives.
- AGB_{it}: Research and Development Expenditure as a Percentage of GDP.
- AGF_{it}: The Ratio of Indirect Tax Subsidies on Business R&D Expenditures to GDP.
- GDP_{it}: Per Capita Gross Domestic Product (log).
- RD_{it}: Research and Development Expenditure as a Percentage of GDP.
- μ_{it} : Constant term.

3.2. Econometric Strategy, Endogeneity, and Robustness

In this study, the estimation of the relationship between R&D policy instruments and innovation performance was conducted using a set of multiple estimators, taking into account structural differences observed among OECD countries, common shocks, and potential endogeneity issues. The main objective is to assess the effects of policies not solely based on a single model assumption, but through a robustness check under alternative error structures, heterogeneous slopes, and dynamic specifications.

3.2.1. Baseline Specification and Estimator

In the baseline specification, LN_GII, representing innovation performance, was used as the dependent variable, while AGT (tax-based R&D incentives), AGB

(public R&D budget), and AGF (firm-level R&D financing/incentives) were included as explanatory variables. To control for differences in macroeconomic capacity and R&D intensity, LN_GDP and RD were incorporated into the model. The model was estimated with country and year fixed effects. This framework aims to exploit within-country variation in policy variables while accounting for time-invariant country characteristics (e.g., geographic features, cultural factors, relatively persistent institutional arrangements). In this context, the Fixed Effects (FE) approach was first applied. Subsequently, to ensure the robustness of the results against potential cross-sectional dependence and autocorrelation affecting standard errors, Driscoll–Kraay standard errors (DKFE) were employed.

In this study, the Fixed Effects (FE) approach is employed as the baseline model. The main reason for selecting the FE model is that it allows controlling for unobserved, time-invariant country-specific characteristics across OECD countries, thereby enabling a more reliable examination of the relationship between R&D policies and innovation performance based solely on within-country variations over time. In addition, in order to test the robustness of the findings under different econometric assumptions, the DKFE, CCEMG, and GMM methods are included as complementary estimators. The DKFE model is used to obtain standard errors that are robust to cross-sectional dependence and autocorrelation, while the CCEMG approach provides a more flexible framework by accounting for common shocks across countries and heterogeneous slope coefficients. The GMM method, in turn, is applied to address potential endogeneity issues and to account for the dynamic nature of the innovation process.

3.2.2. Potential Endogeneity Channels

The relationship between R&D incentives and innovation performance carries a risk of biased estimation in the context of observational data due to various endogeneity channels. This study specifically considers three main channels:

I. **Reverse causality.** Countries with higher innovation performance are more likely to design more comprehensive R&D incentives or increase incentive rates. In this case, the relationship between **AGT/AGB/AGF** and **LN_GII** may be bidirectional.
II. **Omitted variable bias.** Unobserved or excluded factors such as institutional quality, human capital, intellectual property regimes, sectoral composition, or the maturity of the innovation ecosystem may simultaneously influence both the design of incentives and innovation outcomes.
III. **Policy mix simultaneity.** Tax incentives are often implemented as part of a broader set of policies together with public R&D budgets and firm-level financing. This simultaneity can complicate the identification of the marginal effect of a single policy instrument.

Therefore, causal interpretations based solely on the FE results are deemed inappropriate; additional estimators capturing common shocks and heterogeneity were employed to mitigate endogeneity risks.

3.2.3. Addressing Endogeneity and Common Shocks

The set of methods employed to address endogeneity and common factor issues is structured as follows:

FE with year effects: Provides the baseline comparison framework by controlling for country-specific time-invariant heterogeneity and common year shocks.

DKFE: Tests the statistical robustness of the FE findings by making standard errors robust to cross-sectional dependence and autocorrelation.

CCEMG (Common Correlated Effects Mean Group): In the OECD sample, this approach provides a more flexible framework by modeling unobserved common factors and allowing for country-specific heterogeneous slopes, addressing the possibility that common shocks (e.g., global technology waves, financial conditions, supply chain disruptions) affect innovation alongside policy variables. This method serves to test whether the average relationships observed in FE/DKFE persist once common factors are controlled for.

Dynamic GMM: Due to the path-dependent nature of innovation performance, the lagged dependent variable is included in the model, and a set of lagged instruments is employed to address potential endogeneity issues. Within this framework, Arellano Bond autocorrelation tests (AR(1), AR(2)) and Hansen/Sargan tests for instrument validity are reported.

4. Empirical Results

The descriptive statistics of the series, which allow us to observe their scale and dispersion, identify potential outliers or data errors, assess the proximity of the distribution to normality, and detect the need for possible transformations, are presented in Table 2.

Table 2. Descriptive Statistics of the Variables for OECD Countries

Statistics	LN_GII	AGT	AGB	AGF	LN_GDP	RD
Mean	3.313653	0.0802	0.6163	0.1522	10.4092	2.0011
Median	3.877432	0.0515	0.6207	0.15	10.61850	1.769110
Maximum	4.171306	0.3871	1.6928	0.55	11.81278	6.019240
Minimum	0.928219	0	0.1476	-0.03	9.038789	0.257820

Standard Deviation	1.0983	0.0871	0.2522	0.1377	0.6096	1.0706
Skewness	-1.2095	1.123	0.5514	0.3437	-0.3376	0.7274
Kurtosis	2.5825	3.70365	3.7201	2.0668	2.3318	3.3221
Jarque-Bera	132.3231	121.7203	38.0955	29.50076	18.64965	45.88904
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sum	1746.295	42.3157	24.8231	80.21	5162.981	992.5621
Sum of Squares	634.5928	3.993398	33.4691	9.981047	183.9549	567.4417
Number of Observations	496	496	496	496	496	496

LN_GII: The Natural Logarithm of the Global Innovation Index

LN_GDP: The Natural Logarithm of Gross Domestic Product per Capita

GII_{it}: Global Innovation Index (log)

AGT_{it}: Indirect government support through R&D tax incentives.

AGB_{it}: R&D Budget Allocation as a Percentage of GDP.

AGF_{it}: The Ratio of Indirect Tax Subsidies on Business R&D Expenditures to GDP

GDP_{it}: Gross Domestic Product per Capita (log).

RD_{it}: R&D Expenditures as a Percentage of GDP

An examination of the mean values reported in Table 2 indicates that innovation performance generally remains at a medium-to-high level, while the wide range between minimum and maximum values points to substantial cross-country heterogeneity in terms of policy intensity and resource allocation. The pronounced skewness and high kurtosis observed in the distributions of the variables suggest deviations from the normality assumption, a finding further confirmed by the results of the Jarque–Bera test.

The descriptive statistics presented in Table 2 provide important insights for examining the relationship between R&D tax incentives and innovation performance in the selected OECD countries. The mean and median values of the logarithmic Global Innovation Index indicate that innovation performance across OECD countries generally remains within a medium-to-high range. However, the substantial gap between minimum and maximum values points to pronounced cross-country heterogeneity in innovation capacity and policy implementation. Although the average level of the variables representing R&D tax incentives is relatively low, the observed standard deviation and right-skewed distribution

suggest that such incentives are implemented more intensively in certain countries. This finding implies that R&D tax incentives do not constitute a homogeneous policy instrument across OECD countries; rather, their intensity varies depending on national innovation strategies.

Meanwhile, the dispersion observed in **LN_GDP**, representing income per capita, and **RD**, denoting R&D expenditures as a share of GDP, indicates that the macroeconomic and technological infrastructure underlying innovation capacity differs across countries. The statistical significance of the Jarque–Bera test statistics for all variables suggests deviations from normality and implies that the relationship between innovation and R&D incentives may involve more complex dynamics rather than a purely linear and symmetric structure. Within this framework, the findings underscore the necessity of evaluating the impact of R&D tax incentives on innovation through dynamic analyses that control for macroeconomic conditions and R&D intensity.

The correlation matrix, which indicates the direction and strength of the relationships between the variables, is presented in Table 3.

Table 1. Correlation Matrix

	LN_GII	AGT	AGB	AGF	LN_GDP	RD
LN_GII	1.000000					
AGT	0.173629	1.000000				
AGB	0.108772	0.104164	1.000000			
AGF	0.129762	0.662814	-0.037033	1.000000		
LN_GDP	0.174159	0.262578	0.512817	0.007791	1.000000	
RD	0.159996	0.174023	0.687965	-0.104479	0.511463	1.000000

According to the correlation results presented in Table 3, positive relationships are observed between the Global Innovation Index and R&D support indicators. The fact that the Global Innovation Index moves in the same direction as the R&D tax incentives rate, the public budget allocated to R&D, and R&D incentives provided to firms generally indicates that these support mechanisms contribute to enhancing innovation performance. In particular, the strong relationship between R&D tax incentives and R&D incentives provided to firms suggests that tax-based incentives support private sector R&D activities and encourage firms to increase their innovative investments. In contrast, the weak relationship between the public budget allocated to R&D and the incentives provided to firms indicates that public support does not always directly translate into private sector investment behavior.

The positive relationships observed in the correlation matrix between the Global Innovation Index and the three R&D policy indicators are consistent with the main findings of the empirical literature. Numerous studies conducted in the

OECD and EU contexts demonstrate that tax incentives and firm-level R&D support generally move positively with innovation indicators. For instance, the findings of Sein and Darfo-Oduro (2024) for OECD countries indicate that R&D tax incentives significantly enhance firm-level innovation, while Kutbay and Öz (2017) and Seligová (2016) also highlight the positive effects of tax incentives and R&D expenditures on both growth and firm performance. Firm-level studies in China (Sun, Yin, & Liu, 2021; Sun, Li, & Liu, 2023; Yang, Yang, & Guan, 2024; Hu, Zhou, & Li, 2025; Xiao & Zhuang, 2022; Wang & Kesan, 2022; Wu & He, 2021) similarly report generally positive relationships among tax incentives, public support, and innovation outputs, reinforcing the pattern of correlations observed in the table.

The relatively high correlation coefficient between R&D Tax Incentives (AGT) and R&D Financial Support to Firms (AGF) (0.662814) appears consistent with literature findings indicating that tax-based incentives and other firm-level R&D support measures are often implemented together in practice and function as complementary instruments. Qian (2023) on new energy vehicle manufacturers, Zhao, Liu, and Zhao (2025) on SMEs, and Guan and Yam (2015) on Chinese manufacturing firms, all demonstrate that tax incentives and financial subsidies jointly enhance R&D investments and innovation effectiveness, with subsidies in some cases reinforcing the impact of tax incentives. Similarly, Yu, Zhou, and Jia (2022) and Sun, Li, and Liu (2023) report a non-linear but generally complementary relationship between subsidies and tax incentives, indicating that innovation performance increases more markedly when certain threshold levels are exceeded. Within this framework, the strong AGT-AGF relationship observed in the table can be interpreted as suggesting that tax-based incentives support private sector R&D activities more effectively when implemented alongside other firm-level R&D financing instruments, forming a more intensive policy package.

In contrast, the weak and even negatively signed correlation between the Public R&D Budget (AGB) and R&D Financial Support to Firms (AGF) indicates that public R&D expenditures do not always translate directly into firm-level tax incentives or R&D financing. This finding supports studies emphasizing that the transmission channels of public spending to innovation can be indirect and delayed. Guan and Yam (2015) show that direct grants in China during the 1990s had weak and occasionally negative effects on innovative performance, while analyses by Feng (2024) and Shen and Dai (2024) suggest that tax subsidies and increases in macro-level tax burdens can produce divergent outcomes through capital flows and investment composition once certain thresholds are exceeded. Therefore, the pattern observed in the correlation matrix reinforces a distinction frequently highlighted in the literature: tax credits and firm-level incentives are more directly linked to private sector R&D decisions, whereas the general public R&D budget often affects innovation indirectly, gradually, and through channels sensitive to institutional context.

It should be noted that correlation coefficients indicate only the co-movement of variables and do not, by themselves, provide evidence of causality. Indeed, some studies (Feng, 2024; Sun, Yin, & Liu, 2021) report that while incentives may increase R&D expenditures, they do not necessarily lead to

proportional improvements in innovation performance, and in certain contexts, tax credits can even overshadow R&D intensity through a 'crowding-out' effect. Therefore, despite the positive relationships observed in the table, the cointegration and dynamic panel models applied in the subsequent analysis serve as a critical complementary step for testing these potential variations and long-term impact channels emphasized in the literature.

The correlation matrix presented in Table 3 shows a positive relationship between R&D tax incentives and innovation performance. The positive correlation between the Global Innovation Index and R&D tax incentives suggests that tax-based incentives encourage firms' R&D activities, thereby supporting innovation performance. In particular, the high correlation coefficient (0.655684) between R&D tax incentives and firm-level R&D financing indicates that these policy instruments are often implemented as complementary mechanisms in practice. In contrast, the weak relationship between public R&D expenditures and firm-level R&D support suggests that the effects of public spending on innovation are more indirect and context-dependent. Overall, the findings indicate that tax-based R&D incentives are more directly associated with innovation performance, while also highlighting the necessity of testing the causal structure of these relationships through long-term analyses.

Table 4 presents the panel unit root tests applied to examine the stationarity of the series.

Table 4. LLC and IPS Unit Root Tests

Variable	LLC-t statistic	p-value	IPS-t statistic	p-value
LN_GII	-7.0028	0.000***	3.1866	0.999
ΔLN_GII	-13.223	0.000***	-5.9716	0.000***
AGT	-27.912	0.000***	-10.072	0.000***
AGB	-4.4867	0.000***	-1.7673	0.038**
AGF	-29.943	0.000***	-8.1622	0.000***
LN_GDP	0.272	0.607	1.1228	0.869
ΔLN_GDP	-14.261	0.000***	-12.383	0.000***
RD	-2.084	0.018***	0.285	0.609
ΔRD	-7.760	0.000***	-6.510	0.000***

Note: The symbol Δ represents the first difference. Significance levels are indicated as * 0.1; **0.05; *0.01

The LLC (Levin–Lin–Chu) and IPS (Im–Pesaran–Shin) panel unit root test results reported in Table 4 indicate that the stationarity properties of the variables differ. Accordingly, the LN_GII variable contains a unit root at level according to the IPS test, but becomes strongly stationary after first differencing. Similarly, the LN_GDP variable is non-stationary at level and becomes stationary in both tests after first differencing. Examining the R&D policy variables, AGT, AGB, and AGF are stationary at level according to both LLC and IPS tests. For the RD variable, the

results differ across tests: while the LLC test indicates stationarity at level, the IPS test does not confirm level stationarity; however, both tests support stationarity at the first difference. These findings suggest that, with respect to innovation performance and macroeconomic indicators, long-term dynamics should be taken into account, whereas R&D policy instruments exhibit a more stable structure at level. Therefore, the relationship between R&D incentives and innovation performance may not be limited to short-term fluctuations, but rather may accumulate over time and manifest in the long run. Within this framework, the Kao cointegration test results, which examine the long-term relationships among the variables, are presented in Table 5.

Table 5. Kao Cointegration Test

Statistic	t statistic	p-value
Modified Dickey–Fuller t	-3.4571	0.000***
Dickey–Fuller t	-6.5133	0.000***
Augmented Dickey–Fuller t	-8.1523	0.000***
Unadjusted modified Dickey–Fuller t	-3.6738	0.000***
Unadjusted Dickey–Fuller t	-6.5987	0.000***

*0,1; **0,05; ***0,01 indicates significance at the level

Note: Modified Dickey–Fuller t: Modified Dickey–Fuller t test; Dickey–Fuller t: Dickey–Fuller t test; Augmented Dickey–Fuller t: Augmented Dickey–Fuller t test; Unadjusted Modified Dickey–Fuller t: Unadjusted modified Dickey–Fuller t test; Unadjusted Dickey–Fuller t: Unadjusted Dickey–Fuller t test.

The Kao cointegration test results presented in Table 5 indicate that the p-values for all test statistics are extremely close to zero at the 1% significance level. These findings provide strong evidence against the null hypothesis of ‘no cointegration’ and suggest the existence of a long-term cointegration relationship among the variables considered. Accordingly, it can be concluded that the Global Innovation Index and the R&D incentive variables move together in the long run, forming a stable equilibrium relationship.

Specifically, the Kao test results in Table 5 demonstrate the presence of a long-term equilibrium relationship between the Global Innovation Index and R&D tax incentives, public R&D expenditures, and firm-level R&D support. This outcome indicates that the effect of R&D tax incentives on innovation performance is not temporary but exhibits a persistent structure over time. These findings imply that tax-based R&D incentives should be regarded as long-term components of innovation policy.

Table 6. Model Results

Not: Significance levels are indicated as * 0.1; **0.05; * **0.01**

	Model 1	**Model 2**	**Model 3**	**Model 5**
	(FE)	**(DKFE)**	**(CCEMG)**	**(GMM)**
LN_GII			**0.9953*** **	**1.0264*** **
AGT	**1.3022*** **	**1.2207***	-1.4762	0.044
AGB	0.0501	-0.0655	0.2615	-0.009
AGF	**0.8753*** **	**0.7480*** **	-1.1831	-0.067
LN_GDP	**0.8570*** **	**0.8902** **	0.4200	-0.009
RD	**0.2009** **	**0.5246** **	0.1223	-0.001
_cons	**0.4698*** **	**0.6164*** **	1.3700	0.087
R2	0.1874	0.1878		
Adj-R2	0.1255	0.1137		
AR (1)				0.145
AR (2)				0.138
Hansen				0.188
Sargan				0.973

Note: FE: Fixed Effects model; DKFE: Fixed Effects regression with Driscoll-Kraay standard errors; CCEMG: Common Correlated Effects Mean Group method; GMM: Generalized Method of Moments. R^2: coefficient of determination; Adj-R^2: adjusted coefficient of determination; AR(1) and AR(2): significance levels of first- and second-order autocorrelation test statistics. Hansen: p-value of the overidentification test assessing the validity of the instruments; Sargan: p-value of the overidentification test evaluating the validity of the instrument set.

Indicates significance at the 1% ($p < 0.01$), 5% ($p < 0.05$), and 10% ($p < 0.10$) levels

The model results presented in Table 6 indicate that the relationship between R&D policies and innovation performance varies substantially depending on the estimator employed. This variation suggests that both the magnitude and statistical significance of the coefficients can differ when unobserved common shocks across countries, heterogeneous slopes, and potential endogeneity issues are taken into account.

Examining the Fixed Effects (FE) model results, R&D tax incentives (AGT) exhibit a positive and statistically significant effect on innovation performance at

the 1% level. Similarly, R&D support provided to firms (AGF) also shows a positive and substantial coefficient, indicating that private sector–oriented support mechanisms are associated with innovation outputs. In contrast, public R&D expenditures (AGB) do not display a statistically significant effect within the FE model, suggesting that the translation of public resources into innovation may occur through more indirect channels or with a lag. Additionally, the positive and significant coefficients for LN_GDP, representing per capita income, and RD, representing R&D expenditures as a share of GDP, indicate that innovation performance moves in conjunction with macroeconomic capacity and R&D intensity.

The Driscoll–Kraay Fixed Effects (DKFE) results largely preserve the general direction of the FE findings, while demonstrating that under standard errors more robust to cross-sectional dependence and autocorrelation, the significance levels of some coefficients may change. In this context, the positive effect of AGT is retained at a more limited significance level, whereas the positive and statistically significant coefficient of AGF remains under the DKFE specification. The sustained significance of LN_GDP and RD suggests that the relationship between macroeconomic conditions, R&D intensity, and innovation performance can be observed even under alternative error structures.

The Common Correlated Effects Mean Group (CCEMG) results, which account more comprehensively for cross-country heterogeneity and unobserved common factors, indicate that the coefficients of R&D policy variables are no longer statistically significant. In contrast, the coefficient of the lagged dependent variable is high and significant, highlighting the strong persistence of innovation performance and the substantial influence of past innovation levels on the current period. This finding suggests that part of the positive relationships observed in the FE and DKFE models may weaken once common shocks and heterogeneous structures are taken into account.

The GMM model results, which account for the dynamic structure and potential endogeneity issues, also confirm the strong persistence of innovation performance, with the lagged dependent variable being positive and statistically significant at the 1% level. In contrast, the R&D policy variables (AGT, AGB, and AGF) are not statistically significant in the GMM specification, indicating that when endogeneity and dynamics are controlled for, there is no strong evidence of short-term effects of R&D policy instruments. Evaluating the model diagnostic tests, the insignificance of the Arellano–Bond AR(2) test suggests the absence of second-order autocorrelation, while the Hansen test remaining above the significance threshold generally supports the validity of the instrument set. Within this framework, the GMM findings imply that the effects of R&D policy instruments on innovation are likely to operate primarily through long-term mechanisms, and that short-term coefficient estimates may be sensitive to the choice of estimator.

Table 7. Hypothesis Table

Hypothesis	Expected Effect	Overall Assessment
H1: Increases in R&D tax incentives exhibit a positive and statistically significant long-term relationship with innovation performance in OECD countries.	(+)	The long-term relationship is supported; however, it is sensitive to short-term fluctuations and common shocks.
H2: Increases in public R&D expenditures positively affect innovation performance in OECD countries, depending on institutional capacity and the composition of policy measures.	(+)	Conditional and context-dependent effect; overall support is limited.
H3: The increase in R&D financing provided to firms exerts a more direct and stronger positive effect on innovation performance in OECD countries.	(+)	The hypothesis receives qualified support, as the positive effect becomes weaker under estimators controlling for heterogeneity and cross-sectional dependence.

The hypothesis test results presented in Table 7 indicate that the relationship between R&D policies and innovation performance may vary depending on the estimator employed. The effects of R&D tax incentives (H1) and R&D support provided to firms (H3) on innovation performance exhibit a positive association in the expected direction under the FE and DKFE estimators. However, this relationship cannot be statistically confirmed with comparable strength under the CCEMG estimator, which more comprehensively accounts for common factors and heterogeneity, nor under the GMM estimator, which incorporates a dynamic structure.

In contrast, the H2 hypothesis concerning public budget allocations to R&D is not consistently supported across different estimators.

These findings suggest that the relationship between R&D-oriented fiscal policy instruments and innovation performance should be interpreted with greater caution when country-specific structures, common shocks, and potential endogeneity are taken into account. In particular, the attenuation of the positive associations observed under the FE and DKFE estimators when more robust approaches such as CCEMG and GMM, which incorporate stronger control mechanisms are employed, implies that the effects of these policy instruments may be heterogeneous across countries or may materialise primarily through long-run dynamic processes.

Therefore, while the findings remain broadly consistent with H3, the empirical support should be interpreted with caution due to sensitivity to estimator choice and cross-sectional heterogeneity.

5. Conclusions

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In the contemporary economic environment, where global competition has evolved into a knowledge- and technology-driven structure, enhancing innovation capacity has become a decisive factor for countries' long-term growth and competitiveness. In this context, supporting research and development (R&D) activities particularly through tax-based incentive mechanisms designed to steer the private sector toward innovative endeavors has emerged as a prominent policy instrument widely employed across OECD member states. Data from the Organisation for Economic Co-operation and Development (OECD) indicate that over the period 2000-2022, R&D tax incentives exhibited a marked upward trend, both in terms of the number of countries adopting such measures and their relative visibility as a share of GDP. As of 2022, the ratio of R&D tax incentives to GDP reached comparatively high levels in countries such as Portugal, Iceland, United Kingdom, and France, underscoring the significant role of these instruments in the financing of innovation. Nevertheless, it should be acknowledged that the effectiveness of such policy instruments may vary depending on countries' institutional frameworks, the specific design features of the incentives, and prevailing economic conditions.

This study examines the relationship between R&D tax incentives, public budget allocations to R&D, firm-level R&D financing, and innovation performance in selected OECD countries within a panel data framework. The dataset covering the period 2007–2022 was subjected to panel unit root and cointegration analyses, which reveal heterogeneity in the stationarity properties of the variables and indicate a structure that necessitates the consideration of long-run relationships. Accordingly, multiple estimation strategies were employed to assess the robustness of the findings across alternative methodological specifications. These include the Fixed Effects approach, which controls for unobserved country-specific heterogeneity; the Driscoll Kraay corrected Fixed Effects estimator, which provides robustness against cross-sectional dependence and heteroskedasticity in the error structure; the Common Correlated Effects Mean Group (CCEMG) estimator, which accounts for common shocks and slope heterogeneity; and the Generalized Method of Moments (GMM) estimator, which addresses potential endogeneity and dynamic panel characteristics. Through the joint application of these methods, the sensitivity of the empirical results to different econometric techniques was systematically evaluated.

Frequent changes in tax incentives or the presence of design features that create policy uncertainty may weaken firms' R&D investment decisions, thereby reducing the overall effectiveness of such policy instruments. The findings indicate that the impact of public R&D budgets is not direct or automatic, but rather closely linked to institutional capacity and implementation quality. In this regard, the effectiveness of public R&D expenditures is expected to be higher when supported by transparent project selection mechanisms, robust monitoring and evaluation systems, and institutional structures that enhance efficiency in resource allocation. Firm-level R&D financing constitutes a more direct transmission channel; however, it generates stronger outcomes particularly when financial constraints are alleviated and when it is designed in a complementary manner with tax incentives. Finally, the observed model sensitivity across estimators and the presence of cross-country

heterogeneity suggest that R&D policy instruments do not generate uniform effects across countries, highlighting the need for policy design to be tailored to differences in institutional and technological capacity.

The empirical findings indicate that the relationship between R&D policy instruments and innovation performance varies depending on the estimator employed. In both the Fixed Effects and the Driscoll Kraay corrected Fixed Effects models, R&D tax incentives and firm-level R&D support exhibit a positive and statistically significant association with innovation performance. These results provide supportive evidence that such policy instruments move in tandem with innovation outputs. By contrast, the effect of public budget allocations to R&D does not consistently attain statistical significance across model specifications. This finding suggests that the transformation of public R&D expenditures into measurable innovation outcomes may often occur through indirect channels and materialize over a longer time horizon. Within this framework, the effectiveness of public support mechanisms can be considered sensitive to factors such as institutional capacity, project selection processes, resource allocation efficiency, and the quality of policy implementation.

In the CCEMG estimations, which more comprehensively account for common factors and cross-country heterogeneity, the weakening of the statistical significance of the policy variables suggests that a portion of the observed positive associations may be driven by common shocks and structural country-specific characteristics. This finding implies that failing to control adequately for cross-sectional dependence and heterogeneity may lead to an overestimation of the direct impact of policy instruments on innovation performance. Similarly, in the GMM specification designed to address dynamic structure and potential endogeneity the lagged dependent variable emerges as strong and statistically significant. This result indicates that innovation performance exhibits substantial persistence, with past innovation levels exerting a pronounced influence on current outcomes. The absence of statistically robust short-run effects of policy variables in the GMM framework further suggests that R&D-oriented fiscal instruments may be highly sensitive to contextual and implementation conditions, and that their impact is more likely to materialize through cumulative mechanisms unfolding over time rather than through immediate effects. Taken together, these findings underscore that the effects of R&D policies on innovation performance should not be inferred from a single estimator in isolation. Instead, a cautious and methodologically pluralistic interpretation integrating results obtained from alternative econometric approaches is required to derive more reliable and nuanced conclusions.

The study employs multiple econometric approaches jointly and demonstrates that the results are model-dependent. In particular, while tax incentives and firm-level support appear strong and statistically significant in some baseline models, their effects weaken under more advanced estimators that account for heterogeneity and common shocks. This finding indicates that the effects of R&D policy instruments are not fixed or homogeneous, but rather exhibit a conditional structure shaped by country heterogeneity, common shocks, and dynamic adjustment processes. Accordingly, the study provides both empirical and methodological evidence against the commonly assumed unidirectional and uniform policy effect in the existing literature.

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Overall, the empirical evidence suggests that R&D tax incentives and firm-level R&D financing tend to move positively in tandem with innovation performance across OECD countries. However, the magnitude and statistical significance of this relationship are sensitive to the choice of estimator and the time horizon under consideration. This sensitivity underscores the importance of adopting a policy mix approach in the design of innovation strategies, rather than relying on a single policy instrument. In particular, the implementation of tax incentives within a stable and predictable framework may reduce uncertainty surrounding firms R&D investment decisions, thereby fostering innovation capacity. By contrast, the impact of public R&D budget allocations appears to depend more critically on complementary factors such as effective project selection mechanisms, systematic performance monitoring, and the strengthening of interaction channels between the public sector and private firms. Enhancing these institutional and governance dimensions may enable public R&D expenditures to translate more effectively into improved innovation outcomes.

The findings further suggest that the effects of R&D tax incentives on innovation performance are likely to operate through cumulative channels that accumulate over time, rather than through short-term fiscal stimuli. The widespread adoption of tax incentives for R&D expenditures across OECD countries indicates that this policy instrument has become a structural preference in the financing of innovation. At the same time, the periodic slowdown in the growth of public R&D budgets highlights the complementary role of tax-based incentives in ensuring the sustainability of innovation policies. Within this context, the design of R&D tax incentives should take into account institutional capacity, sectoral structure, and the maturity of the innovation ecosystem. Moreover, public and private support mechanisms should be structured in a complementary rather than mutually exclusive manner to maximize their effectiveness.

In conclusion, R&D oriented fiscal policies function as complementary instruments within the innovation ecosystem. To sustainably enhance innovation, both tax incentives and public R&D expenditures need to be designed within a holistic framework that considers institutional capacities and market dynamics. This study contributes empirically to the literature by examining the relationship between innovation performance and fiscal policy instruments in OECD countries using panel data methods. It also underscores the importance of future research adopting comparative analyses that account for country groupings, sectoral differences, and variations in policy design.

Limitations and Recommendations For Future Studies

The findings of this study should be interpreted within certain limitations. First, the analysis is confined to OECD countries due to data availability and comparability considerations. Consequently, caution is warranted when attempting to generalize the results to non-OECD countries with different institutional structures and innovation ecosystems. Second, the use of the Global Innovation Index as the measure of innovation performance provides the advantage of

capturing the multidimensional nature of innovation; however, it may limit the ability to disentangle mechanisms operating through more specific indicators, such as patent counts, citation-weighted patents, or firm-level innovation outputs. Third, although the FE, DKFE, CCEMG, and dynamic GMM estimators employed in this study account substantially for endogeneity, common shocks, and heterogeneity, fully establishing the causal effects of policy instruments would require natural experiments, difference-in-differences designs based on policy changes, or analyses using strong external instrumental variables. Within this framework, the results provide robust empirical evidence on the direction and long-term nature of the relationship between R&D policies and innovation performance, while necessitating a cautious interpretation regarding causality. Future research could make significant contributions to the literature by focusing on heterogeneity analyses that disentangle the effects of R&D tax incentives and public support across country groups, sectors, or firm sizes. Additionally, adopting mechanism-based approaches that investigate the channels through which policy instruments affect innovation such as R&D intensity or private-sector financing would further deepen the understanding of how fiscal innovation policies translate into measurable innovation outcomes.

REFERENCES

Acemoglu, D. & J. Robinson (2008), "The Role of Institutions in Growth and Development", Working Paper No. 10, Washington, DC: World Bank.

Bernanke, Ben Shalom (2011), "Promoting Research and Development: The Government's Role", New Building Blocks for Jobs and Economic Growth Conferance, Georgtown University.

Çelebi, A.K. ve Kahriman, H. (2011), "Avrupa Birliği Ülkeleri ve Türkiye'de Ar-Ge Faaliyetlerine Yönelik Vergi Teşvikleri ve Bunların Karşılaştırmalı Analizi", Maliye Dergisi, 161, 33-63.

Cenikli, V. S. (2021). Türkiye ve Avrupa Birliği üyesi ülkelerin göreli araştırma ve geliştirme (Ar-Ge) etkinliğinin analizi, İnsan ve Toplum Bilimleri Araştırmaları Dergisi, 10 (1), 231-246.

Dechezleprêtre, A. vd. (2016), "Do tax incentives for research increase firm innovation? An RD design for R&D", NBER Working Paper, No. w22405.

Doruk, Ö. T. ve Söylemezoğlu, E. (2014). Gelişmekte olan ülkelerde ar-ge'ye dayalı büyümenin varlığının sınanması (testing of the existence of r&d based growth in developing countries), 1.Ulusal Üretim Ekonomisi Kongresi, 1-12.

Fendoğlu, E. & M.A. Polat (2021), "The Relationship Between R&D Expenditures and Economic Growth: Panel Data Analysis in Selected New Industrializing Countries", Kent Akademisi, 14(3), 728-747.

Feng, C. (2024). International tax incentives, cross-border research and development, and corporate innovation performance. Finance Research Letters, 66, 105646. https://doi.org/10.1016/j.frl.2024.105646

Ghaffar, A. ve Khan, W. A. (2014). Impact of research and development on firm performance. International Journal of Accounting and Financial Reporting, 4 (1), 357-367.

Gong, X., Chen, W., & Gong, X. (2025). Tax integrity and innovation output: Evidence from China. Accounting Forum. Advance online publication. https://doi.org/10.1080/01559982.2025.2529074

Göçer, İ. (2013). Ar-Ge Harcamalarının yüksek teknolojili ürün ihracatı, dış ticaret dengesi ve ekonomik büyüme üzerindeki etkileri. Maliye Dergisi, (165), 215-240.

Guan, J., & Yam, R. C. M. (2015). Effects of government financial incentives on firms' innovation performance in China: Evidences from Beijing in the 1990s. Research Policy, 44(1), 273-282. https://doi.org/10.1016/j.respol.2014.09.001

Gökmenoğlu, S. M., Akal, M., & Altunışık, R. (2012). Ulusal Rekabet Gücünü Belirleyen Faktörler Üzerine Değerlendirmeler. Rekabet Dergisi(52), 3-43.

Guellec, D. ve De La Potterie, B.V.P. (2003), "The Impact of Public R&D Expenditure on Business R&D", Economics of Innovation and New Technology, 12(3), 225-243.

Hu, S., Zhou, X., & Li, P. (2025). Tax incentives, market competition, and corporate innovation. Finance Research Letters, 77, 107067. https://doi.org/10.1016/j.frl.2025.107067

Hodzic, S. (2013), "Tax Incentives for Research and Development in Austria and Croatia: B-Index", Ekon. Misao Praksa Dbk. God XXII. 397-419.

Kennedy, J., & Barry, F. (2020). An assessment of R&D tax credits and their role towards innovation within Irish industry. Irish Journal of Management, 39(1), 34–46. https://doi.org/10.2478/ijm-2010-0003

Kutbay, H., & Öz, E. (2017). Effects of R&D expenditures on economic growth: An econometric analysis in terms of tax incentives for Turkey and selected countries. Maliye Dergisi, 173, 331–361.

Labeaga, J. M., Martínez-Ros, E., Sanchis, A., & Sanchis, J. A. (2021). Does persistence in using R&D tax credits help to achieve product innovations? Technological Forecasting and Social Change, 173, 121065. https://doi.org/10.1016/j.techfore.2021.121065

Laporšek, S., Stubelj, I., & Vodopivec, M. (2025). The effects of tax reliefs on the R&D activity in Slovenia. Ekonomska Misao i Praksa, 1-20.

Li, N., Feng, J., & Zhang, C. (2023). Macro tax incentives and corporate sustainable innovation: Evidence from Chinese enterprises. Environmental Science and

Pollution Research, 30(45), 101546–101564. https://doi.org/10.1007/s11356-023-29268-0

Liu, J. (2025). The impact of environmental protection tax law on corporate innovation. Finance Research Letters, 86, 108534. https://doi.org/10.1016/j.frl.2025.108534

Ni, Q. (2025). Government budget management, tax incentives, and corporate performance. Finance Research Letters, 86, 108768. https://doi.org/10.1016/j.frl.2025.108768

OECD (2023), "Tax incentives for research and development", in: Corporate Tax Statistics 2023, Paris: OECD Publishing.

OECD. (2024). R&D tax incentives and direct government support for R&D: OECD indicators. Organisation for Economic Co-operation and Development.

OECD. (2025). Tax incentives for research and development: Corporate Tax Statistics 2025.

OECD. (2025a). R&D tax incentives continue to outpace other forms of government support for R&D in most countries.

OECD. (2025b). Tax incentives for research and development: Corporate Tax Statistics 2025.

Oluklulu, S. & T. Çakır (2025), "Ar-Ge Vergi Teşviklerinin Ekonomik Büyüme Üzerindeki Etkisinin Bootstrap Panel Nedensellik Testiyle Analizi", Sosyoekonomi, 33(65), 569-586.

Öz, R. (2024). Ar-Ge Vergi Teşviklerinin Makroekonomik Performans Üzerindeki Etkisi: AB ve Türkiye Örneği. Maliye Dergisi, 186, 169-193.

Qian, B. (2023). Financial subsidies, tax incentives, and new energy vehicle enterprises' innovation efficiency: Evidence from Chinese listed enterprises. PLOS ONE, 18(10), e0293117. https://doi.org/10.1371/journal.pone.0293117

Seçilmiş, N. ve Konu, A. (2019). OECD Ülkelerinde Ar-Ge Teşvikleri ve İnovasyon İlişkisi Üzerine Ampirik Bir İnceleme. Kahramanmaraş Sütçü İmam Üniversitesi Sosyal Bilimler Dergisi, 16 (2), 686-702. DOI: 10.33437/ksusbd.533175

Sein, Y. Y., & Darfo-Oduro, R. (2024). Analyzing the impact of R&D tax incentive policy on firm innovations in OECD countries. Scientific Papers of the University of Pardubice-Series D: Faculty of Economics and Administration, 32(1), 1939. https://doi.org/10.46585/sp32011939

Seligová, M. (2016). The influence of R&D expenditures and tax incentives on firms' growth in selected countries of European Union. In Proceedings of 14th International Scientific Conference: Economic Policy in the European Union Member Countries (pp. 736–745).

Shen, X., & Dai, P. (2024). Macro tax burden, FDI, and national innovation efficiency: A study on the impact of macro tax burden on national innovation efficiency. PLOS ONE, 19(10), e0312451. https://doi.org/10.1371/journal.pone.0312451

Sun, Q., Li, L., & Liu, L. (2023). Impact of tax incentives on technological innovation inputs and outputs of manufacturing firms: The moderating effect of regional marketization. Transformations in Business & Economics, 22(1), 149–164.

Sun, W., Yin, K., & Liu, Z. (2021). Tax incentives, R&D manipulation, and corporate innovation performance: Evidence from listed companies in China. Sustainability, 13(21), 11819. https://doi.org/10.3390/su132111819

Taş, Ş., Taşar, İ. ve Açcı, Y. (2017). Ar-Ge harcamaları ve ekonomik büyüme arasındaki ilişki: Türkiye örneği. Ömer Halisdemir Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 10(2), 197-206.

Tingbani, I., Salia, S., Hussain, J. G., & Alhassan, Y. (2023). Environmental tax, SME financing constraint, and innovation: Evidence from OECD countries. IEEE Transactions on Engineering Management, 70(3), 1006–1025. https://doi.org/10.1109/TEM.2021.3110812

Walter, C. E., Au-Yong-Oliveira, M., Veloso, C. M., & Polonia, D. F. (2022). R&D tax incentives and innovation: Unveiling the mechanisms behind innovation capacity. Journal of Advances in Management Research, 19(3), 367–388. https://doi.org/10.1108/JAMR-06-2021-0194

Wang, K. T., Walpola, S., Zhu, N. Z., & Ulima, I. (2025). R&D tax incentive reforms around the world: The impact on firm value. European Accounting Review, 34(5), 1799–1827. https://doi.org/10.1080/09638180.2024.2433231

Wang, R., & Kesan, J. P. (2022). Do tax policies drive innovation by SMEs in China? Journal of Small Business Management, 60(2), 309–346. https://doi.org/10.1080/00472778.2019.1709381

Wu, L., & He, Y. (2021). Impact of tax incentives on the efficiency of corporate technological innovation. In 2021 7th International Conference on Information Management (ICIM 2021) (pp. 6–12). https://doi.org/10.1109/ICIM52229.2021.9417145

Xiao, C., & Zhuang, Z. (2022). Do R&D tax credits incentivize radical or incremental innovation? Evidence from China. Sustainability, 14(14), 8238. https://doi.org/10.3390/su14148238

Yang, P., Yang, H., & Guan, C. (2024). Impact of R&D tax credit policy adjustment on enterprise innovation: Evidence from China. Applied Economics Letters, 31(20), 2124–2133. https://doi.org/10.1080/13504851.2023.2211326

Yu, Y., Zhou, Z., & Jia, J. (2022). Threshold effect of government support on enterprise innovation performance and its regional differences. Transformations in Business & Economics, 21(3C), 549-567.

Zee, H.H., Stotsky, J.G. ve Ley, E. (2002), "Tax Incentives for Business Investment: A Primer for Policy Makers in Developing Countries", World Development, Pergamon, 30(9), 1497-1516.

Zeng, J., Ling, W., Hua, M., & Chan, K. C. (2024). Impact of an increase in tax deductibility of R&D expenditure on firms' ESG: Evidence from China. International Review of Financial Analysis, 96, 103567. https://doi.org/10.1016/j.irfa.2024.103567

Zhang, X., Deng, Y., & Wu, X. (2024). Exploring fiscal incentives, financial constraints, and firm innovation performance: A multidimensional correlation analysis and mechanism exploration. International Review of Financial Analysis, 96, 103534. https://doi.org/10.1016/j.irfa.2024.103534

Zhao, X., Liu, G., & Zhao, X. (2025). Tax incentives, financial subsidies and high-quality development of enterprises. Finance Research Letters, 86, 108350. https://doi.org/10.1016/j.frl.2025.108350

Zhu, X. (2022). Corporate tax competition and innovation: An inverted-U relationship. Economics Bulletin, 42(2).

Zolt, E.M. (2013), "Tax incentives and tax base protection issues", Papers on Selected Topics in Protecting the Tax Base of Developing Countries. Draft Paper.