

Enhancing Private Sector R&D Investment in OECD Countries: The Role of Government Funding

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Abstract

This study examines the effect of government funding on private-sector research and development (R&D) expenditure across 33 OECD countries from 2005 to 2019. Additionally, the analysis extends to subgroups of countries, including the EU-15, newly joined EU members, other European non-EU countries, and non-European OECD countries. To empirically assess this relationship, we employ both pooled ordinary least squares (OLS) regression and instrumental variable two-stage least squares (IV-2SLS) models. The findings indicate that government support fosters a complementary relationship with private-sector R&D expenditure, rather than a crowding-out effect. This suggests that both direct government funding and R&D tax incentives play a crucial role in boosting private-sector R&D investment, with the effects varying across different

economic and institutional contexts. By offering a comprehensive cross-country perspective, this research highlights the differential effectiveness of R&D support mechanisms in OECD countries and contributes to a deeper understanding of how government funding can enhance private-sector R&D investment.

Keywords: R&D policies, OECD, economic development, knowledge-based economy

JEL classification: H50, O3, O10

1 Introduction

In today's dynamic global landscape, research and development (R&D) is a cornerstone of economic progress and competitiveness (Mowery & Rosenberg, 1998; Alexander, 2000). Nations worldwide acknowledge its key role in fostering innovation, propelling economic development, and ensuring long-term sustainability (Sarpong et al., 2023; Wang et al., 2023). R&D catalyzes scientific and technological advancements, generating novel products and services that address evolving societal needs while supporting enterprise competitiveness (Freeman, 1987; Fagerberg et al., 2011). Furthermore, it fuels knowledge creation across diverse fields, contributing to societies' intellectual and academic capital (Kolomytseva & Pavlovska, 2020; Owen et al., 2023). Therefore, R&D represents a strategic investment for nations seeking to maintain a competitive edge and achieve sustainable development (Edquist, 2009).

The distinct yet interconnected roles of the public and private sectors shape the R&D landscape. Traditionally, public entities invest in fundamental research, pushing the frontiers of knowledge, while private companies focus on applied R&D activities aimed at commercializing new technologies (Cohen & Levinthal, 1989; Li & Deng, 2025). However, these roles are not mutually exclusive; collaboration between the sectors can yield significant breakthroughs and accelerate innovation (Etzkowitz & Leydesdorff, 2000). Understanding these interactions is crucial for fostering a thriving innovation and economic development environment.

The relationship between public and private R&D is multifaceted, characterized by intricate collaboration, competition, and co-existence dynamics. One key aspect is complementarity, where public investments stimulate and enhance private-sector innovation (Griliches, 1994; Jalles et al., 2024). Governments provide grants, subsidies, and research partnerships, fostering a collaborative environment that drives innovation forward (Bae & Lee, 2020).

However, the public-private R&D relationship faces challenges. The concept of “crowding-out” raises concerns about excessive public funding potentially discouraging private investment (Guellec & Van Pottelsberghe De La Potterie, 2003). Effective policymaking requires striking a balance between promoting public good and supporting the independence of the private sector. This requires ensuring that public funding complements and supports private initiatives while avoiding stifling private investment (European Commission, 2006).

Further, the European Policy Analysis Group report argues that the EU is falling behind the US in innovation despite similar levels of public R&D spending (Fuest et al., 2024). The reason lies in the private sector, where US businesses invest nearly twice as much in R&D compared to the EU. US R&D is concentrated in high-tech industries, while the EU focuses on mid-tech sectors like automotive. This “middle technology trap” hinders growth and geopolitical influence.

The report proposes institutional reforms to address this gap. The proposed reforms could be a step in the right direction. However, some potential challenges remain. Decentralizing decision-making might increase efficiency but could also lead to inconsistencies. Similarly, attracting top scientists to the European Innovation Council (EIC) Board could be difficult. Additionally, the effectiveness of the proposed budget-neutral approach depends on the efficiency gains achieved by redirecting funds and streamlining bureaucracy.

In addition, while numerous studies have explored the relationship between government funding and private R&D expenditure (European Commission, 2008; Guellec & Van Pottelsberghe De La Potterie, 2003; Rehman et al., 2020;

Soete et al., 2022), a crucial question remains largely unanswered: How does the effectiveness of this funding vary across countries or country groups with different economic structures? This study delves into this complex relationship by examining government funding and R&D expenditure across the 33 OECD member countries between 2005 and 2019. To better understand the interplay between public and private R&D investments in diverse economic structures, we will classify the 33 OECD countries into different groups.

This study focuses on the issue of whether government R&D funding affects private R&D expenditure. Based on our research objectives, we have formulated the following hypothesis:

H₀: Increased government funding for R&D positively affects private R&D expenditure.

This paper begins with a comprehensive literature review, highlighting the relationship between R&D funding and economic development, with a particular focus on the nuances of government interventions. Following the review, we present our detailed findings, analyzing the relationship between government funding and R&D expenditure in the OECD countries between 2005 and 2019. Subsequent sections delve into the empirical evidence, revealing patterns, trends, and disparities in R&D expenditure among different country groups classified based on economic structures. We analyze the effectiveness of R&D investments, identifying key drivers of economic development. Drawing on our analysis, we conclude this study by presenting a summary of our findings, which might offer policymakers valuable approaches to maximize the effectiveness of government funding in driving R&D investments and fostering sustainable economic development.

2 Literature Review

In today's knowledge-based economy (KBE), R&D expenditure is critical to economic growth, innovation, and global competitiveness. However, private firms may underinvest in R&D due to high upfront costs, long-term returns, and knowledge spillovers. Therefore, government funding plays a crucial role in stimulating R&D activities.

With limited public resources, governments are constantly striving to optimize the allocation of funds for maximum impact. This scrutiny extends to R&D expenditures – a critical engine for long-term economic development, competitiveness, and job creation (OECD, 2014). However, navigating the relationship between public and private R&D funding presents a complex challenge.

Public and private R&D serve distinct purposes. Public R&D aims to accelerate technological advancements and national productivity, often focusing on areas of long-term benefit or high risk that might not be attractive to private investors (Arrow, 1962; Nast et al., 2024; Uhlbach et al., 2022). Conversely, private R&D is driven by profit and market dominance, leading to a focus on innovations with clear commercial applications (Coccia, 2010).

The relationship between public and private R&D is complex. Empirical studies suggest the following effects:

- **Complementary effect:** Publicly funded R&D programs can act as a catalyst, stimulating private sector investment. By providing crucial research infrastructure and de-risking early-stage research, these programs can encourage private firms to take the leap and invest in further development efforts (David et al., 2000; Wang et al., 2021).
- **Crowding-out effect:** In some cases, however, excessive public R&D funding might have the unintended consequence of discouraging private investment. This is known as the “crowding-out effect.” Studies by Guellec and Van

Pottelsberghe De La Potterie (2003) suggest that large, established firms with strong R&D track records might disproportionately benefit from government grants or subsidies, potentially stifling innovation among smaller players.

While the crowding-out effect is a concern, some argue that it may be mitigated by the knowledge spillovers from publicly funded research. These spillovers can benefit smaller firms that may not have the resources to conduct their fundamental research (Damrich et al., 2022). Additionally, government funding can play a role in levelling the playing field by providing smaller firms with access to research infrastructure and expertise they may otherwise lack.

To optimize the effectiveness of public R&D funding and foster a thriving innovation ecosystem, governments consider several key strategies:

- Targeted allocation: Focusing on R&D investments with the highest potential return on investment for economic and social development is crucial (OECD, 2015b).
- Impact evaluation: Developing robust methods to measure the effectiveness of R&D programs ensures public resources are used efficiently (Mazzucato, 2021).
- Fostering collaboration: Encouraging collaboration between government, research institutions, and private companies can accelerate innovation and knowledge transfer (Cunningham & Link, 2014).

Additionally, governments employ various funding mechanisms, such as direct grants, tax initiatives, and public-private partnerships (PPPs), to stimulate R&D, each with its advantages and limitations (OECD, 2011; Sikombe et al., 2024).

Competitive research grants awarded through independent review processes can support specific research projects aligned with national priorities (OECD, 2015b). However, concerns exist regarding the efficiency and fairness of the grant selection process.

By offering tax breaks for R&D activities, governments can encourage broader participation from private firms and reduce the financial burden of research investments (Crespi et al., 2016). However, the effectiveness can be limited if firms are already likely to undertake the R&D regardless of the tax incentive, leading to a potential deadweight loss.

Collaborations between government and private entities enable the pooling of resources and expertise for large-scale R&D projects that may be too risky or expensive for individual actors (Mazzucato, 2021; Vivona et al., 2023). However, ensuring fair risk-sharing, managing intellectual property rights, and maintaining project focus can be complex.

The optimal mix of funding mechanisms will depend on each KBE's specific objectives and context. However, a well-designed government R&D funding strategy can stimulate innovation, drive economic development, and foster long-term societal well-being within a knowledge-based economy.

Among policy instruments, R&D tax incentives have become increasingly important as an alternative to direct subsidies, reducing innovation costs by allowing firms to deduct R&D expenses or receive tax credits (OECD, 2018). These incentives provide greater flexibility in research funding and are widely adopted across OECD and EU countries (Appelt et al., 2016). Empirical evidence shows they can boost private R&D, especially for small and medium-sized enterprises (SMEs) (Lokshin & Mohnen, 2013). Their effectiveness, however, depends on factors such as firm size, sector, and national tax systems, as well as broader institutional conditions like policy stability and administrative complexity (González Cabral et al., 2021; OECD, 2023b).

Beyond public funding and tax incentives, foreign direct investment (FDI) and human capital, particularly R&D personnel, are widely recognized as key drivers of innovation performance. Economic research highlights the role of FDI in enhancing technological capabilities and facilitating knowledge diffusion (Borensztein et al., 1998). Its impact depends on the host economy's absorptive

capacity, shaped by the existing knowledge base and institutional environment (Cohen & Levinthal, 1990; Ahn et al., 2024). Human capital quality is also critical, as a skilled workforce maximizes foreign knowledge spillovers (Xu & Wang, 2000; Sadeghi et al., 2020; Emako et al., 2023). Additionally, institutional quality, intellectual property rights, and the sectoral composition of FDI influence technological diffusion (Castellani & Zanfei, 2006; Crespo & Fontoura, 2007). Marin and Bell (2006) posit that the impact of FDI on R&D intensity is stronger when supported by high levels of human capital, highlighting the importance of considering FDI and R&D personnel together in the assessment of innovation performance.

The role of R&D personnel in fostering innovation is well established, particularly within endogenous growth theory. Romer (1990) and Aghion and Howitt (1992) emphasize that skilled human capital, especially researchers and engineers, drives technological progress and productivity. Empirical evidence shows that R&D personnel enhance innovation at both firm and national levels through knowledge spillovers and improved R&D efficiency (Griliches & Lichtenberg, 1982; Guellec & Van Pottelsberghe de la Potterie, 2001; Masso & Tiwari, 2024). Innovation complementarities highlight human capital's role in leveraging external knowledge sources, such as FDI and public funding (Belderbos et al., 2004; Park et al., 2022). Archibugi and Filippetti (2018) emphasize the crucial role of public research in sustaining national innovation capacity and warn that a decline in public sector R&D may undermine long-term innovation performance.

The literature suggests that government funding is crucial in stimulating R&D expenditure in a KBE. While market failures justify government intervention, the potential for crowding-out effects, market distortions, and rent-seeking behavior necessitates careful design and implementation of funding programs. Optimizing the effectiveness of government R&D funding requires a focus on targeted allocation, robust impact evaluation, and fostering collaboration between public and private actors.

3 Data and Methodology

The study strives to investigate the relationship between government funding and private sector R&D investment in 33 OECD countries over the period from 2005 to 2019. This timeframe was chosen to ensure data comparability across nations, as economic policies and global factors can evolve. It provides a suitable window to analyze the connection between government policies and business R&D expenditure. To strengthen our analysis and explore potential variations, we also compare different country groups. In addition to all OECD countries in the sample, the analysis includes the following groups: EU-15 countries, newly joined EU countries, other European countries outside the EU, and non-European OECD countries (Appendix, Table A1).

The decision to analyze all OECD countries alongside subgroup models reflects key heterogeneities in economic structures, innovation systems, and policy orientations. EU-15 countries benefit from long-standing, coordinated R&D strategies under EU frameworks, supporting a stable and integrated innovation landscape. In contrast, newer EU members face structural challenges shaped by transitional economies and uneven convergence. Other European countries not in the EU and OECD countries operate within distinct institutional and policy environments, warranting separate analysis to capture the full spectrum of innovation dynamics across the OECD.

To ensure methodological consistency and enhance cross-country comparability, all variables are measured in per capita terms. Data for all variables, including the corresponding population figures, were obtained from OECD databases (OECD, 2023a), with a detailed description provided in Table 1.

Table 1: Research Variables

Variable descriptions		
Variable	Dependent variable	Source
Business enterprise R&D expenditure (BERD) (per capita)	BERD measures the total expenditure on R&D activities carried out within the business sector over a given period. When identifying sources of BERD funding, five primary sectors are recognized: the business enterprise sector itself, government, higher education institutions, private non-profit organizations, and rest of the world (OECD, 2015a).	OECD (2023a), https://www.oecd.org/en/data.html
	Independent variable	
Government budget allocations for R&D (GBARD) (per capita)	GBARD is a quantitative measure of a government's commitment to R&D activities within a nation. It reflects the financial resources, expressed as a per capita value, that a government dedicates to support R&D endeavors.	OECD (2023a), https://www.oecd.org/en/data.html
	Control variables	
Indirect government support through R&D tax incentives (per capita)	This variable reflects indirect government support through R&D tax incentives, where governments encourage businesses to invest in R&D by offering tax benefits instead of direct funding.	OECD (2023a), https://www.oecd.org/en/data.html
Foreign direct investment (FDI) (per capita)	FDI refers to investment made by a resident of one economy into a business enterprise in another economy, establishing a lasting interest and exerting significant influence over the foreign business.	OECD (2023a), https://www.oecd.org/en/data.html
R&D personnel (per capita)	R&D personnel are the people employed in research and development activities. They can encompass a wide range of roles depending on the specific industry and research focus.	OECD (2023a), https://www.oecd.org/en/data.html

Source: Authors' compilation.

The analysis employed a multi-stage approach to investigate the relationships between the selected dependent and independent variables. The initial stage involved descriptive statistics (Appendix, Table A2), providing insights into data distribution and variability (Leon, 1998). Before conducting correlation and regression analyses, we addressed negative and missing (NA) values in several variables, which are incompatible with log transformation. To ensure methodological consistency and retain as much data as possible, we applied established transformation techniques or excluded observations with invalid or missing values as appropriate. Subsequently, a Pearson correlation analysis was

conducted to examine the strength and direction of linear relationships among the independent variables.

Next, we employed a pooled ordinary least squares (OLS) regression model in a log-log form, which allows us to interpret the estimated regression coefficients as elasticities. The general equation is presented below.

Pooled OLS:

$$\ln y_{it} = \beta_0 + \beta_i \ln x_{it} + \sum_{j=1}^m \gamma_j c_{jit} + \varepsilon_{it} \quad (1)$$

Fixed effect / random effect:

$$\ln y_{it} = \beta_0 + \beta_i \ln x_{it} + \sum_j^m \gamma_j c_{jit} + \gamma_j + \varepsilon_{it} \quad (2)$$

where y_i = dependent variable; x_i = independent variable; y_j = entities (countries) fixed or random effects; c_{ji} = control variables; m = number of entities (countries); β_0 = constant; β_i = regression coefficients; ε_i = error term.

Initially, we estimated both fixed-effects (FE) and random-effects (RE) models depending on the nature of the data and research question. To determine the most appropriate model, we applied the Hausman test, which consistently indicated that the FE “within” specification was preferable. To further ensure the robustness and reliability of our findings, we assessed potential multicollinearity among the independent and control variables through variance inflation factor (VIF) analysis. The resulting VIF values for all variables were below the generally accepted threshold, indicating that multicollinearity was not severe enough to pose concerns. However, the possibility of endogeneity in the main independent variable warranted further investigation.

To address potential endogeneity, we investigated the instrumental variables (IV) approach, which leverages exogenous variables to obtain consistent coefficients in regression models. This approach involves estimating a two-stage least squares (2SLS) technique, a widely used IV estimation method. Per this approach, we estimated two models:

$$\ln x_{it} = \theta_0 + \sum_{j=1}^n \theta_j \ln z_{jt} + v_{it} \quad (3)$$

$$\ln y_{it} = \beta_0 + \beta_1 \widehat{x}_{1it} + \varepsilon_{it} \quad (4)$$

where z_j = instrumental variables; θ_j = regression coefficients; v_i = error term. Equation (4) contains fitted values of the dependent variable from Equation (3). Equation (3) is the first-stage, and Equation (4) is the second-stage regression.

In the first stage, the endogenous regressor was instrumented using a set of theoretically relevant and exogenous variables. The validity and strength of the instruments were assessed using first-stage F -statistics and overidentification tests. Additionally, the Wu-Hausman test was performed to detect and confirm the presence of endogeneity in our primary independent variable. While the Wu-Hausman test justified the IV approach by confirming endogeneity, the Sargan test confirmed the validity of instruments (FDI and R&D personnel).

Although multiple linear regression provides a balance of simplicity and robustness, the validity of the IV-2SLS model has been confirmed. By implementing this multi-stage approach, we aimed first to understand the data, identify potential issues like multicollinearity, and then employ appropriate techniques to obtain reliable estimates of the relationships between the variables of interest.

4 Results and Discussion

The results of the Pearson correlation analysis are presented in Table A3 (in the Appendix). The correlation matrix shows a strong positive relationship between BERD and both GBARD and R&D personnel, indicating that public funding and human capital are key drivers of private R&D investment. Indirect tax incentives show a moderate correlation with BERD, suggesting partial effectiveness. FDI, however, has a weak correlation with BERD, implying limited direct correlation with private R&D across the observed countries.

Following the correlation matrix analysis, we conducted multicollinearity diagnostics to evaluate the potential for linear dependencies among the selected variables (Appendix, Table A4). The results, as indicated by the VIF values, confirm that multicollinearity is not a concern in our regression model. Specifically, all VIF values are significantly below the widely accepted threshold, indicating that each predictor contributes distinct explanatory power to the regression. Thus, we can conclude that multicollinearity does not pose a threat to the validity or reliability of our regression estimates.

After estimating both fixed-effects (FE) and random-effects (RE) models, the Hausman test consistently supported the FE specification, confirming its appropriateness. The FE results (Appendix, Table A5) provide valuable insights across OECD country groups. GBARD exhibits a positive and significant impact on BERD in the full sample, with an even stronger effect in the EU-15, underscoring the critical role of government funding in fostering innovation. However, this relationship is not significant in newer EU members or non-European OECD countries, potentially reflecting institutional differences or differences in funding capacity.

R&D tax incentives are significant in most groups, particularly in the EU-15 and other European non-EU and non-European OECD countries, suggesting that well-designed tax policies can support innovation. Their insignificance in newer EU states points to policy context as a key factor. FDI shows no consistent

relationship with BERD, while R&D personnel per capita are consistently significant across all groups, emphasizing the central role of human capital in innovation. These results suggest that the effectiveness of policy instruments varies across contexts and may depend on factors such as industry structure or the skill level of the R&D workforce.

Table 2 presents the results of a multiple linear regression analysis assessing the relationship between the dependent variable, business enterprise R&D expenditure (per capita), and a set of independent and control variables across different country groups.

Table 2: Multiple Linear Regression Model

		All OECD countries in the sample	EU-15	Newly joined EU countries	Other European countries not in the EU and non-European OECD countries
(Intercept)	Estimate	5.32376	3.60968	9.31257	7.62165
	Pr(> t)	1.89e-12	0.000326	1.60e-05	0.000104
GBARD	Estimate	0.70625	0.95897	0.33277	0.57206
	Pr(> t)	< 2e-16	< 2e-16	0.00771	0.001991
Indirect government support through R&D tax incentives	Estimate	0.18019	0.12296	0.22204	0.11901
	Pr(> t)	< 2e-16	8.43e-12	8.48e-06	0.095437
FDI	Estimate	-0.04207	0.04337	0.22204	-0.16939
	Pr(> t)	0.0146	0.009569	8.48e-06	1.78e-07
R&D personnel	Estimate	0.65835	0.67208	1.15988	0.75242
	Pr(> t)	5.33e-15	1.67e-08	1.79e-06	7.32e-06
Residual standard error		0.3331 on 233 degrees of freedom	0.228 on 110 degrees of freedom	0.3845 on 59 degrees of freedom	0.187 on 42 degrees of freedom
Multiple R-squared		0.8534	0.8954	0.763	0.9682
Adjusted R-squared		0.8509	0.8916	0.7469	0.9651
F-statistic		339.1 on 4 and 233 DF	235.5 on 4 and 110 DF	47.49 on 4 and 59 DF	319.4 on 4 and 42 DF
p-value		< 2.2e-16	< 2.2e-16	< 2.2e-16	< 2.2e-16

Source: Authors' own calculation.

The coefficient for government budget allocations for R&D (per capita) has a statistically significant positive relationship with business R&D expenditure in all given groups of countries. This indicates that higher government budgetary allocations for R&D are generally associated with increased BERD.

The coefficient values for government budget allocations range from approximately 0.33 to 0.96. They are much stronger in the economically integrated regions (EU-15) with a solid economic history, compared to the newly accepted EU countries or OECD countries. This suggests that the EU-15 might effectively leverage private R&D. One of the reasons can be that in the case of multinational corporations (MNCs), it is primarily the parent company operating in the old member countries that focuses on R&D, not the subsidiaries in the new member countries (Uzunidis & Boutillier, 2012; Hamida & Piscitello, 2013). For this reason, public R&D expenditure cannot play a more significant role in the complementary effect of supporting BERD.

Another factor to consider is the current structure of EU R&D funding. While national governments contribute the majority of funds, the EU's Horizon Europe program offers limited support for breakthrough innovation. The recently established European Innovation Council (EIC) (European Commission, 2024) faces criticism for its bureaucratic processes and limited focus on high-risk, high-reward research. These limitations may hinder the effectiveness of public funding in driving BERD.

In its Annual Activity Report, the EIC highlights the importance of private sector involvement in driving innovation. While government funding plays a role, a strong ecosystem with high levels of BERD is crucial for technological advancement. The report offers a compelling critique of the current EU approach, particularly the focus on mid-tech industries and the limitations of the EIC.

This finding is consistent with previous studies that have found a positive relationship between government R&D funding and private-sector R&D investment (Levy & Terleckyj, 1983; Archibald & Pereira, 2003). The following

factor might explain the positive and statistically significant relationship between government R&D funding and BERD: government funding acts as a catalyst, reducing the financial risks associated with R&D for businesses. This can be achieved through direct grants, research project co-funding, or shared research infrastructure funding. By lowering the upfront costs, government investment “crowds in” private sector resources, encouraging businesses to invest in their R&D activities.

Indirect government support through R&D tax incentives is a significant driver of BERD in most country groups analyzed. However, in other European non-EU and non-European OECD countries, the effect is not significant. This suggests that the effectiveness of R&D tax incentives in stimulating business R&D expenditure may vary across different economic contexts, possibly due to tax policies and business environments. One possible explanation for this result could be differences in the design and implementation of R&D tax incentive schemes across countries. The generosity of tax credits may influence the effectiveness of such incentives, the ease of access to incentives, and the overall business climate.

The coefficient for FDI (per capita) shows a mixed relationship with BERD across country groups. In the EU-15 and newly joined EU countries, the effect is positive and significant, suggesting that foreign firms may actively engage in R&D or foster collaboration with local firms. This supports the view that in countries with growing or integrating innovation systems, FDI can complement domestic R&D.

However, in the overall OECD sample and especially in other European non-EU and non-European OECD countries, the FDI coefficient is negative and statistically significant, challenging the assumption of a positive link between FDI and BERD. This may suggest that foreign firms in these contexts prioritize market access or cost-efficiency over innovation (Sultana & Turkina, 2020). Furthermore, the positive effects of FDI in emerging economies may indicate reliance on foreign investment for technology transfer and R&D stimulation

(Erdal & Göçer, 2015), underscoring the role of institutional context and absorptive capacity in influencing FDI's impact on private R&D.

The coefficient for R&D personnel (per capita) is positive and statistically significant across all country groups, suggesting that the availability of human capital is a robust and universal determinant of business R&D expenditure. However, the magnitude of the effect varies, with the strongest impact observed in the newly joined EU countries, indicating that R&D personnel may play a particularly crucial role in emerging or transitioning innovation systems.

While the presence of R&D personnel appears consistently important, the underlying mechanisms may differ by context. For instance, the concept of sectoral innovation systems (Malerba, 2009) suggests that the relationship between R&D personnel and BERD may depend on industry composition. Countries with a higher concentration of R&D-intensive sectors are likely to derive greater benefit from the presence of researchers whose skills align with industry needs. Thus, the quality and specialization of human capital may be as important as the quantity.

Furthermore, the model's inability to differentiate between skill levels is a limitation. Countries with a significant effect for R&D personnel might have a higher engagement of highly skilled researchers. This builds on human capital theory, which emphasizes the importance of skilled labor for innovation and economic development (Frese & Rauch, 2001). Further research employing data that capture researcher qualifications, functional roles, and alignment with sector-specific demands could provide more nuanced insights into how human capital influences private R&D investment.

Initially, we employed OLS regression as the primary estimation approach to establish a baseline model. However, recognizing the potential endogeneity of BERD, we conducted various IV-2SLS tests to address this issue (Table 3). Through a series of diagnostic tests, including the Wu-Hausman test for endogeneity, the weak instruments test, and the Sargan test for overidentification, we evaluated the validity and strength of various instrument specifications.

The results indicated that excluding indirect government support through R&D tax incentives as an instrument led to an improvement in model performance, as evidenced by a higher instrument strength, improved efficiency, and a better overall fit. Consequently, we adopted the refined IV specification, utilizing FDI and R&D personnel as instruments, as it provided the most robust and reliable estimation results while effectively addressing endogeneity concerns.

Table 3: IV-2SLS Model

		All OECD countries in the sample	EU-15	Newly joined EU countries	Other European countries not in the EU and non-European OECD countries
(Intercept)	Estimate	-2.45841	-3.17842	-4.2343	-2.30114
	Pr(> t)	1.05e-10	2.14e-09	2.18e-07	1.52e-06
GBARD	Estimate	1.56991	1.67371	1.9516	1.55696
	Pr(> t)	< 2e-16	< 2e-16	< 2e-16	< 2e-16
Instrumental variables	FDI and R&D personnel				
Weak instruments	<i>p</i> -value	< 2e-16	< 2e-16	< 2e-16	< 2e-16
Wu-Hausman	<i>p</i> -value	2.86e-14	2.59e-14	5.94e-13	9.13e-05
Sargan	<i>p</i> -value	0.603	0.684	0.542	0.5365
Residual standard error		0.4742 on 236 degrees of freedom	0.416 on 154 degrees of freedom	0.6301 on 108 degrees of freedom	0.3231 on 51 degrees of freedom
<i>R</i> -squared		0.6993	0.6765	0.4773	0.8861
Adjusted <i>R</i> -squared		0.698	0.6744	0.4725	0.8839
Wald test		534.2 on 1 and 236 DF	355.9 on 1 and 154 DF	142.9 on 1 and 108 DF	408.1 on 1 and 51 DF
<i>p</i> -value		< 2.2e-16	< 2.2e-16	< 2e-16	< 2.2e-16

Source: Authors' own calculation.

The results of the IV-2SLS regression analysis confirm a strong and statistically significant impact of government R&D expenditure on the dependent variable across all country groups. The coefficient estimates indicate that government budget allocations for R&D consistently promote higher levels of BERD, with the strongest effects observed in the newly joined EU countries, followed by the EU-15, other European countries not in the EU, and non-European OECD

countries. The weak instruments test strongly rejects the null hypothesis across all country groups, confirming that the selected instrumental variables FDI and R&D personnel are highly relevant predictors of the endogenous regressor. Additionally, the Wu-Hausman test provides robust evidence that OLS estimation would have produced biased and inconsistent results, further justifying the application of IV estimation.

Additionally, the Sargan test results consistently show p -values well above the conventional significance threshold, indicating that the null hypothesis of instrument validity cannot be rejected. This suggests that the chosen instrumental variables do not introduce bias into the estimation and are appropriate for use in the model.

The findings confirm that the instrumental variables effectively address potential endogeneity concerns, strengthening the reliability of the estimated relationship between government budget allocations for R&D and economic or innovation-related outcomes.

In conclusion, this analysis highlights the crucial role of government R&D funding in stimulating BERD across different country contexts. While the effectiveness of R&D tax incentives appears to vary, a focus on strengthening institutional frameworks and technological capabilities alongside human capital development could further enhance the impact of government policies. This knowledge can inform the design of effective policy measures that foster innovation and drive economic growth.

5 Conclusion

Our findings support the hypothesis that increased government funding for R&D positively influences BERD across all country groups. Specifically, the multiple linear regression results indicate that a 1 percent increase in government R&D funding is associated with an increase in BERD per capita ranging from approximately 0.33 percent to 0.96 percent, depending on the country group. Moreover, the IV-2SLS model revealed an even stronger relationship, suggesting that a 1 percent rise in government funding corresponds to an increase in BERD between 1.56 percent and 1.95 percent, further reinforcing the critical role of public investment in stimulating private R&D activity across different groups. These results align with prior research emphasizing the significance of governmental investment in fostering private-sector innovation and technological advancement.

The impact of indirect government support through R&D tax incentives appears more nuanced. While statistically significant in the full OECD sample, the EU-15, other European non-EU, and non-European OECD country groups, it lacked significance in the newly joined EU countries. This suggests that the effectiveness of tax incentives may depend on institutional and economic context. R&D tax policies should therefore be tailored to reflect national tax structures, administrative capacity, and firm characteristics.

The relationship between FDI and BERD showed variation in both direction and magnitude. FDI was statistically significant across all groups, but with differing signs—positive in some, negative in others. This indicates that the effect of FDI on domestic R&D is conditional and may depend on absorptive capacity, innovation infrastructure, and the sectoral focus of foreign investment.

The findings regarding R&D personnel were consistent across all groups. The coefficient was statistically significant in every country group, emphasizing the importance of human capital in shaping private R&D investment. These results highlight the need for policies that strengthen the R&D workforce through

education, training, and mobility initiatives aligned with national innovation priorities. Further research could explore how industry structure and skill specialization influence this relationship.

Although this study does not provide evidence of a crowding-out effect, where public R&D spending displaces private investment, the results suggest a complementary relationship. Government funding may act as a catalyst, encouraging firms to invest in R&D by reducing risk and supporting early-stage research that may otherwise be underfunded.

Several implications emerge from these findings. Expanding public R&D funding can increase private-sector investment, especially in countries with underdeveloped innovation systems. The effectiveness of tax incentives depends on institutional conditions and should not be assumed to be uniform. Strengthening the R&D workforce remains essential to sustaining innovation. In addition, realizing the benefits of FDI for domestic R&D requires appropriate frameworks and alignment with national research capabilities.

Furthermore, tailoring R&D support mechanisms to the specific economic and institutional contexts of countries and promoting public–private partnerships can enhance the overall effectiveness of R&D policies.

Limitations of this study include potential data gaps and variation in data quality across countries. The complexity of factors influencing R&D investment also suggests that future research could benefit from more advanced econometric techniques or qualitative approaches to explore the underlying mechanisms more thoroughly.

This study provides insights into how government R&D policies interact with private-sector innovation dynamics. The findings offer empirical evidence to support more effective and context-sensitive design of public support instruments aimed at advancing KBEs.

Appendix

Table A1: Classification of Selected Countries by Group

All OECD countries in the sample	EU-15	Newly joined EU countries	Other European countries not in the EU and non-European OECD countries
Australia	Austria	Czech Republic	Australia
Austria	Belgium	Estonia	Canada
Belgium	Denmark	Hungary	Iceland
Canada	Finland	Latvia	Japan
Czech Republic	France	Lithuania	Korea
Denmark	Germany	Poland	New Zealand
Estonia	Greece	Slovak Republic	Norway
Finland	Ireland	Slovenia	Switzerland
France	Italy		Türkiye
Germany	Luxembourg		United States
Greece	Netherlands		
Hungary	Portugal		
Iceland	Spain		
Ireland	Sweden		
Italy	United Kingdom		
Japan			
Korea			
Latvia			
Lithuania			
Luxembourg			
Netherlands			
New Zealand			
Norway			
Poland			
Portugal			
Slovak Republic			
Slovenia			
Spain			
Sweden			
Switzerland			
Türkiye			
United Kingdom			
United States			

Source: Authors' compilation.

Table A2: Descriptive Statistics

	BERD	GBARD	Indirect government support through R&D tax incentives	FDI	R&D personnel
All OECD countries					
Observations	428	480	338	431	434
Min.	3.35	3.47	0.14	0.93	0.54
Max.	7.35	6.52	5.23	13.20	2.50
Mean	5.88	5.41	3.26	6.59	1.85
Std. deviation	1.01	0.64	1.16	1.44	0.39
EU-15					
Observations	188	225	153	195	219
Min.	4.09	4.53	0.23	0.93	1.24
Max.	7.16	6.52	5.23	13.20	2.49
Mean	6.27	5.65	3.32	6.92	1.99
Std. deviation	0.70	0.44	1.34	1.62	0.29
Newly joined EU countries					
Observations	120	120	70	110	120
Min.	3.35	3.47	0.14	2.39	1.07
Max.	6.39	5.47	3.83	7.79	2.14
Mean	4.88	4.68	2.51	6.13	1.56
Std. deviation	0.86	0.50	0.98	0.84	0.27
Other European countries not in the EU and non-European OECD countries					
Observations	105	120	100	114	80
Min.	3.56	3.97	1.07	1.89	0.54
Max.	7.35	6.49	4.54	9.99	2.50
Mean	6.27	5.59	3.63	6.35	1.87
Std. deviation	0.92	0.51	0.75	1.42	0.54

Source: Authors' own calculation.

Table A3: *Pearson Correlation Matrix for All OECD Countries*

	BERD	GBARD	Indirect government support through R&D tax incentives	FDI	R&D personnel
BERD	1	0.783	0.423	0.094	0.831
GBARD	0.783	1	0.263	0.0709	0.808
Indirect government support through R&D tax incentives	0.423	0.263	1	0.448	0.374
FDI	0.094	0.071	0.448	1	0.158
R&D personnel	0.831	0.808	0.374	0.158	1

Source: Authors' own calculation.

Table A4: *Multicollinearity Statistics for All OECD Countries*

	GBARD	Indirect government support through R&D tax incentives	FDI	R&D personnel
Tolerance	0.3619211	0.7483095	0.8708233	0.3599687
VIF	2.763033	1.336346	1.148339	2.778019

Source: Authors' own calculation.

Table A5: Fixed Effects (Within) Model Estimates and Hausman Test Results

		All OECD countries in the sample	EU-15	Newly joined EU countries	Other European countries not in the EU and non-European OECD countries
		n = 27, T = 1-15, N = 238	n = 13, T = 1-14, N = 115	n = 7, T = 4-15, N = 64	n = 6, T = 2-13, N = 47
GBARD	Estimate	0.251687	0.4052903	-0.0044778	0.078759
	Pr(> t)	0.001147	0.0006627	0.9790	0.4711074
Indirect government support through R&D tax incentives	Estimate	0.039214	0.0778697	0.0422809	0.146319
	Pr(> t)	0.033316	0.0002672	0.3713	0.0003727
FDI	Estimate	0.011490	0.0012037	0.0311079	0.035328
	Pr(> t)	0.397640	0.9371149	0.3695	0.0610424
R&D personnel	Estimate	1.068639	0.6110738	1.5707523	1.090056
	Pr(> t)	< 2.2e-16	3.382e-07	7.639e-14	2.567e-13
R-squared		0.6397	0.53508	0.69954	0.9513
Adjusted R-squared		0.58748	0.45918	0.64285	0.93946
F-statistic		91.8786 on 4 and 207 DF	28.1976 on 4 and 98 DF	30.8496 on 4 and 53 DF	180.695 on 4 and 37 DF
p-value		< 2.22e-16	1.3685e-15	2.8319e-13	< 2.22e-16
Hausman test					
		$\chi^2 = 15.265$	$\chi^2 = 18.409$	$\chi^2 = 11.99$	$\chi^2 = 11.254$
		df = 4	df = 4	df = 4	df = 4
		p = 0.004182	p = 0.001026	p = 0.0174	p = 0.02386

Source: Authors' own calculation.

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