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Assessment on the Fiscal Policy Incidence on Country Technological Progress under Specific Tax System Complexity and Accounting Regulation Set-up

Abstract. *The taxation of technological innovation has generated substantial debate in the academic literature, with prior evidence yielding mixed and context-dependent results. These inconsistencies largely reflect cross-country heterogeneity in economic, institutional, and social environments, which shape both complementarities and trade-offs in tax policy design. This study examines the role of national tax policies in shaping innovation outcomes, with a particular focus on the moderating effects of R&D tax incentives, the quality of accounting standards, and the complexity of the business environment. Using panel data for G20 countries over the period 2012-2021, multivariate regression analysis was employed to investigate the relationship between government-provided R&D incentives and the innovation index in important economies. The findings indicate that countries with higher levels of economic development and financial capacity are better positioned to translate fiscal support into sustained innovation performance, reflecting stronger absorptive capacity and more effective policy transmission mechanisms. In contrast, resource-constrained economies exhibit weaker innovation responses to similar policy measures. These results carry important policy implications, highlighting that the effectiveness of tax-based innovation policies depends not only on their design but also on the broader institutional and economic context. In particular, the findings support the view that targeted fiscal instruments*

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can enhance technological innovation, given the multiplier effects associated with R&D investment.

Keywords: *technological innovation, R&D credits, fiscal subsidies, economic complexity.*

JEL Classification: H20, M41, O11, O38.

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1. Introduction

The achievement of the SDGs has attracted increasing attention, particularly as progress remains uneven and appears to be slowing down. While advances have been observed in areas such as economic growth and responsible production, weaker outcomes persist in domains related to climate action, institutional quality, and international cooperation (Renaud et al., 2022; Leal et al., 2025).

Innovation plays a central role in advancing SDGs, acting as a key driver for productivity, structural transformation, and the diffusion of digital and green technologies. R&D investment supports these processes by fostering knowledge creation and generating spillovers across sectors, thereby enhancing long-term economic resilience and competitiveness (Aristodemou et al., 2025).

Governments have increasingly relied on fiscal instruments, particularly R&D tax incentives, to stimulate private innovation. However, their effectiveness depends critically on policy design, clarity, and alignment with broader national strategies (Appelt et al., 2020; Hall, 2019). Prior research highlights that poorly designed or weakly enforced policies may fail to translate into tangible innovation outcomes, and in some cases may even produce counterproductive effects (Dimos et al., 2022).

Importantly, the impact of R&D tax incentives is conditioned by structural and institutional factors, including the quality of accounting frameworks, tax system complexity, and broader governance conditions. These factors influence both the transparency of R&D reporting and firms' ability to access and utilize incentives effectively, while the presence of a shadow economy may further distort policy outcomes.

Against this backdrop, this study examines the role of public policies in shaping country-level innovation, focusing on the interaction between R&D tax incentives, accounting quality, and tax complexity. It contributes by (i) analyzing the moderating role of tax complexity, (ii) providing macro-level evidence on the importance of accounting and auditing quality, (iii) incorporating the effects of the shadow economy, and (iv) capturing the impact of the COVID-19 period, characterized by unprecedented fiscal intervention.

Therefore, we start from the research question below:

How do R&D tax incentives influence country-level innovation, and to what extent is this relationship conditioned by tax system attractiveness, tax complexity, and the quality of accounting and auditing standards?

Despite extensive research on the relationship between fiscal policy and innovation, several important gaps remain. First, prior studies predominantly examine the direct effects of R&D tax incentives, largely abstracting from the institutional context in which such policies operate, particularly the roles of accounting quality and tax system complexity. Second, the literature offers limited evidence on the interaction between tax attractiveness and tax complexity, despite their potentially offsetting effects on firms' innovation decisions. Third, existing research rarely integrates financial reporting quality as a moderating factor, even though accounting standards directly shape the measurement, transparency, and monitoring of R&D activities. Fourth, most studies focus on either firm-level or single-country evidence, with limited cross-country analyses capturing systemic heterogeneity across major economies. Finally, the dynamic nature of these relationships- distinguishing short-run adjustment effects from long-run structural outcomes- remains insufficiently explored in the empirical literature.

This study addresses these gaps by developing an integrated framework that jointly examines R&D tax incentives, tax attractiveness, tax complexity, and accounting quality, using multi-method estimators (RE, GMM, and DOLS) to capture dynamics across G20 economies.

2. Theoretical Framework

The study's theoretical framework integrates information asymmetry, innovation incentive, and endogenous growth theories to explain how fiscal instruments shape innovation outcomes. Information asymmetry theory emphasizes the role of accounting and auditing quality in reducing informational frictions, innovation incentive theory highlights how tax-based instruments stimulate R&D investment, and endogenous growth theory links these investments to long-term economic performance. Figure 1 illustrates the combined mechanisms, policy tools, and institutional factors underlying the relationship between innovation and R&D tax incentives.

Firms' pursuit of sustainable growth depends on their capacity to generate value through R&D, which drives technological progress and long-run performance (Romer, 1986). However, since private returns to R&D are typically below social returns due to knowledge spillovers, firms tend to underinvest, justifying government intervention through tax incentives and other fiscal instruments that enhance national innovation outcomes.

From an information asymmetry perspective (Akerlof, 1970), the effectiveness of such policies depends critically on the quality of accounting and auditing frameworks, which shape the transparency and reliability of R&D reporting. Weak reporting standards and managerial discretion may distort information on R&D activities, leading to inefficient allocation of public support and reducing the real effectiveness of tax incentives.

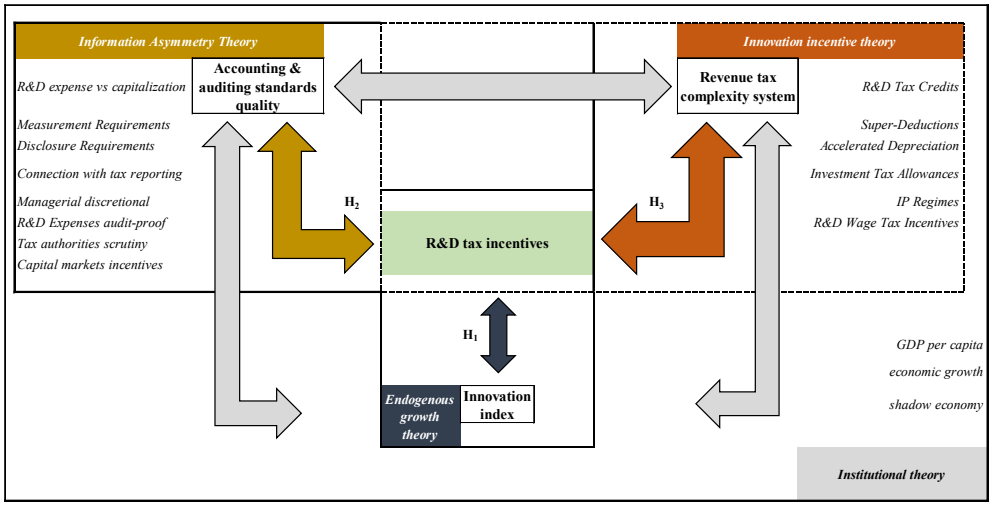

Figure 1. Theoretical framework
Source: Authors' processing.

Innovation incentive theory (Boadway & Keen, 2006) further highlights that tax policy design influences firms' R&D decisions by affecting expected returns and perceived risks. In this context, complex tax systems increase compliance costs and uncertainty, discouraging innovation or enabling opportunistic behavior, whereas clear and predictable frameworks enhance policy effectiveness.

Collectively, these perspectives suggest that the impact of R&D tax incentives on innovation depends on the broader fiscal and institutional environment. Specifically, tax attractiveness can strengthen incentive effects by improving investment conditions, while tax complexity introduces frictions that weaken their transmission. As such, innovation outcomes reflect the joint influence of tax design, administrative burden, and informational quality.

3. Literature Review

3.1 Technological innovation and fiscal policy

A substantial body of empirical literature examines the role of fiscal policy in shaping technological innovation through instruments such as tax incentives, public R&D expenditure, and demand-side policies. However, evidence on the relationship between R&D activities and tax incentives remains mixed, due to cross-country heterogeneity in economic and institutional environments.

Fiscal policy influences national innovation through multiple channels (Cabral et al., 2021; Sein & Darfo-Oduro, 2024). Given market failures in R&D investment, government intervention is essential to generate positive externalities across industries. Tax incentives reduce the cost of R&D at firm level and can be critical for sustaining innovation activities. While firms focus primarily on private returns, governments internalize broader macroeconomic effects, including spillovers and

complementarities. Accordingly, R&D incentive schemes may target either input-based mechanisms (e.g., stimulating R&D expenditure), output-based mechanisms (e.g., patent commercialization), or both. In addition, well-designed incentive programs can enhance investor confidence, attract foreign direct investment, and support the development of multinational R&D hubs (Melnik & Smith, 2024; Hu et. al., 2025; Anagnostopoulou et al., 2025).

Governments can support innovation through a wide range of fiscal instruments, including tax credits, super-deductions, accelerated depreciation, and payroll incentives. The effectiveness of these measures depends on policy clarity and predictability, which influence firms' willingness to undertake R&D investments of a higher risk and retain intellectual property domestically (Hoppe et al., 2023). Conversely, unclear or complex tax frameworks may deter firms from accessing incentives due to uncertainty and compliance risks. Moreover, inefficient allocation of R&D support may distort outcomes, potentially encouraging the relocation of innovation activities rather than strengthening domestic capabilities (Jin & Wang, 2024).

R&D tax incentives can either complement or substitute private investment. They are generally more effective for firms with limited technological capabilities, operating in highly competitive environments, or facing financial constraints (Lee, 2011; Castellacci & Lie, 2015). In contrast, more advanced firms may partially substitute private R&D spending with public support, increasing crowding-out effects (Dimos et al., 2022). As a result, the impact of tax incentives varies across firms and sectors, with stronger effects observed for incremental rather than radical innovation, and particularly for SMEs and firms in low-tech or service sectors (Xiao & Zhuang, 2022; Sein & Darfo-Oduro, 2024).

Importantly, the balance between complementarity and substitution is dynamic and depends on the broader policy mix. Effective innovation policies require coordinated and well-sequenced fiscal instruments that reinforce rather than distort private R&D investment (Lenihan et al., 2024).

Against this backdrop, the present study proposes the following hypothesis:

H_1*: There is positive marginal effect of the level of R&D tax incentives on country innovation index level.*

3.2 Technological innovation and accounting treatment

The effectiveness of R&D tax incentive schemes is shaped by the interplay between R&D accounting treatments and firms' tax planning strategies. Flexibility in accounting choices- such as discretionary expensing, accelerated deductions, and income shifting- enables firms to optimize their fiscal position. Moreover, transfer pricing of intellectual property and profit allocation across jurisdictions may moderate the link between fiscal incentives and actual innovation outcomes (Belz et al., 2016; Laplante et al., 2019; Cheng et al., 2021).

Additionally, the literature outlines that financial reporting standards could alter real corporate innovation decisions, as long as discretionary management decisions

on designing accounting policies and strategies on R&D capital and expenses, especially in case of R&D tax incentives, are not based on both accrual and cash flow incentives (Di Martino et. al., 2020; Williams & Williams, 2021). For instance, regulatory requirements and auditors' scrutiny can put additional pressure on firms investing in R&D because of uncertain tax positions generated, minimum disclosure requirements, weak internal controls on tax subsidies (Bauer, 2015), leading myopic managers to focus on short-term earnings and avoid investing in R&D projects that could generate significant added value on long-term.

Nonetheless, we remind that this practice makes even harder for government tax authorities to identify non-compliance cases or to ensure optimal R&D resources allocation at country level. This refers to firms that do not disclose all relevant information on R&D investment and related expenses, with various reasons, such as protecting proprietary information from competitors, avoidance of drawing investor attention to risky long-term R&D, or having decentralized R&D programs that are harder to track (Koh & Reeb, 2015; Kou et. al., 2023). On those circumstances, it is extremely difficult to measure R&D tax incentive programs' efficiency, as governments cannot accurately assess firms' real R&D needs, and investors do not have all internal information on potential R&D projects and their potential multiplication effect on long-term, leading to misallocation of subsidies. Consequently, in the absence of high transparency, limited R&D-related resources may be inefficiently allocated. Firms may overinvest due to artificially low financing costs associated with subsidies, compete for public support rather than improving innovation efficiency, or substitute private R&D spending with subsidized funding. Moreover, firms may strategically overinvest in projects misaligned with their core innovation needs to secure future subsidies, while smaller firms with genuine R&D requirements may remain underfunded.

Therefore, a complementary research hypothesis is related to the relevance of financial reporting and auditing framework and the level of tax regulation complexity, as core elements influencing the way tax incentives are granted by the state and how the accounting treatment is polluted by tax-related aspects, respectively:

H_2*: There is positive moderating marginal effect of the quality of accounting and auditing standards on the effect determined by R&D tax incentives on country innovation level.*

3.3 Technological innovation and fiscal system complexity

A key aspect of R&D tax incentive design lies in its interaction with accounting treatments, which can significantly affect policy effectiveness. Firms may use R&D activity for tax planning through discretionary accounting choices, including immediate expensing, accelerated deductions, income shifting, and transfer pricing of intellectual property, thereby exploiting jurisdictional tax differences (Belz et al., 2016; Laplante et al., 2019; Cheng et al., 2021).

Financial reporting standards further shape innovation decisions, as managerial discretion in recognizing and measuring R&D expenditures, especially in the

absence of aligned accrual and cash-flow incentives, may distort real investment behavior (Di Martino et al., 2020; Williams & Williams, 2021). Increased regulatory scrutiny and disclosure of requirements can also induce managerial myopia, discouraging long-term R&D investment in favor of short-term earnings targets (Bauer, 2015).

At the same time, limited transparency in R&D reporting complicates the ability of tax authorities and investors to assess the effectiveness of incentive programs. Firms may withhold information due to proprietary concerns or risk signaling, resulting in incomplete data on R&D activities (Koh & Reeb, 2015; Kou et al., 2023). This opacity can lead to inefficient allocation of public resources, including subsidy misallocation, crowding-out of private investment, and biased access favoring larger or more sophisticated firms.

Accordingly, the effectiveness of R&D tax incentives is closely tied to the quality of financial reporting and the complexity of tax regulation, which jointly shape how incentives are implemented, monitored, and translated into innovation outcomes.

H_3*: There is a negative moderating marginal effect of the quality (effectiveness) of tax policy framework on the effect determined by R&D tax incentives on country innovation level.*

A complementary hypothesis examines the role of financial reporting quality and tax system design (through both attractiveness and complexity) in shaping the effectiveness of tax incentives and their interaction with accounting treatment (H_3).

4. Methodology Research

The study examines the role of public policies in shaping country-level innovation, with a focus on the impact of R&D tax incentives and the moderating effect of accounting quality. **Table 1** summarizes the variables included. The dependent variable is the country-level innovation index, while the main independent variable captures R&D tax allowances and preferential treatments. The analysis focuses on G20 countries, given their economic and political influence on global tax policy and innovation dynamics.

Table 1. Variable and source of data

Variables	Symbol	Description	Data source	Expected sign
Dependent variable				
Country innovation index	INN	Composite country index reflecting the level of innovation through various dimensions institutional, market and technological driven outputs.	WIPO database	
Independent variable				
R&D fiscal incentives	R&D	Country-level measure of government tax incentives for R&D, expressed as the implied marginal tax subsidy rate.	OECD R&D Tax Incentives database	+

Variables	Symbol	Description	Data source	Expected sign
Accounting and auditing regulation quality	SARS	Investors' perceived trust on the quality of accounting and auditing standards, on national level.	WEF Global Competitiveness Report	+
Tax attractiveness index	TAI	Country composite index measuring the overall attractiveness of the corporate tax system based on rates, incentives, and planning opportunities.	Keller & Schanz (2013)	+
Tax complexity index	TCI	Country-level composite index measuring corporate tax system complexity, including both tax rules and administrative procedures.	Hoppe et al. (2023)	-
Control variable				
GDP capita	GDP	Gross domestic product per capita.	OECD database	+
Growth GPD	GDP growth	Economic growth on country level.	OECD database	+
Shadow GDP	GDP shadow	Country level of shadow economy, as per MIMIC method proposed by Elgin et. al. (2021).	World Bank database	-

Source: Authors' processing.

The analysis covers the period 2012-2021, characterized by multiple overlapping crises, providing a relevant setting to examine the relationship between R&D tax incentives and innovation. During such periods, governments often tighten fiscal policy by reducing tax incentives, increasing pressure on firms and potentially dampening long-term innovation and economic growth. The empirical strategy relies on a set of linear regression models, as specified below.

The interaction between tax regulation, accounting frameworks, and the costs of implementing innovative activities is central to assessing the effectiveness of public policies, as financial statements represent the primary source of information on R&D activity. Accordingly, we estimate the impact of R&D tax incentives on the innovation index while controlling for the interaction between R&D-specific policies and the broader tax environment (1).

$$INN_{i,t} = \alpha_0 + \alpha_1 \cdot R\&D_{i,t} + \alpha_2 \cdot R\&D_{i,t}^2 + \varepsilon_{i,t} \quad (1)$$

In the first model incorporating an interaction term, we include an interaction term between R&D tax incentives and the tax attractiveness index (TAI) to examine whether the effectiveness of innovation-related fiscal measures depends on the overall favorability of the tax environment. While baseline models implicitly assume that the impact of R&D incentives is homogeneous across countries, this specification allows for heterogeneous effects, recognizing that incentives are likely to be more effective when embedded in a broader tax system that enhances investment conditions and reduces distortions. Consequently, the interaction model

provides a more nuanced assessment by capturing complementarity effects between targeted innovation policies and the general tax framework, offering insights that cannot be derived from models that consider these factors independently.

$$INN_{i,t} = \alpha_0 + \alpha_1 \cdot R\&D_{i,t} + \alpha_2 \cdot R\&D_{i,t}^2 + \\ + \alpha_3 \cdot TAI_{i,t} \cdot R\&D_{i,t} + \varepsilon_{i,t} \quad (2)$$

In the second model with interaction, we include an interaction between tax complexity (TCI) and R&D tax incentives to assess whether the effectiveness of innovation-related tax measures depends on the administrative burden of the tax system. Unlike baseline models that assume uniform effects, this specification allows the impact of incentives to vary across different levels of tax complexity, capturing potential frictions or inefficiencies that may hinder their effectiveness and providing a more refined understanding of how tax system design shapes innovation outcomes.

$$INN_{i,t} = \alpha_0 + \alpha_1 \cdot R\&D_{i,t} + \alpha_2 \cdot R\&D_{i,t}^2 + \\ + \alpha_4 \cdot TAI_{i,t} \cdot R\&D_{i,t} + \varepsilon_{i,t} \quad (3)$$

We include an interaction between the accounting and auditing standards quality proxy and R&D tax incentives to examine whether the effectiveness of fiscal support for innovation depends on the informational and institutional environment. Unlike models based on tax attractiveness or tax complexity, this specification focuses on the role of financial reporting quality in shaping how firms access, interpret, and exploit tax incentives. In particular, it captures key mechanisms such as (i) transparency effects, whereby higher reporting quality reduces information asymmetry and enhances the allocation of R&D resources; (ii) credibility effects, as stronger auditing and accounting standards increase the reliability of financial information used by investors and policymakers; and (iii) efficiency channels, where well-functioning reporting environments improve monitoring and reduce opportunistic behavior. This approach provides a complementary perspective by linking innovation outcomes not only to tax design, but also to the broader informational infrastructure within which tax incentives operate.

$$INN_{i,t} = \alpha_0 + \alpha_1 \cdot R\&D_{i,t} + \alpha_2 \cdot R\&D_{i,t}^2 + \alpha_3 \cdot SARS_{i,t} \cdot R\&D_{i,t} \\ + \alpha_4 \cdot TCI_{i,t} \cdot R\&D_{i,t} + \varepsilon_{i,t} \quad (4)$$

We extend the specification by controlling the previous model with key macroeconomic variables, such as GDP per capita, economic growth, and the size of the shadow economy, to capture structural conditions that directly shape innovation performance and indirectly influence the effectiveness of tax incentives. Higher GDP per capita reflects greater development, human capital, and absorptive capacity, directly supporting innovation while enhancing firms' ability to utilize R&D incentives. Economic growth captures demand dynamics and investment cycles, which can stimulate innovation activity but also affect the timing and responsiveness to fiscal incentives. In contrast, a larger shadow economy signals institutional

weaknesses and informality, which can constrain formal innovation, reduce the uptake of tax incentives, and weaken policy transmission. By accounting for these channels, the model provides a more robust assessment of how institutional quality and macroeconomic conditions jointly condition both innovation outcomes and the effectiveness of tax-based policy instruments.

$$\begin{aligned} INN_{i,t} &= \alpha_0 + \alpha_1 \cdot R\&D_{i,t} + \alpha_2 \cdot R\&D_{i,t}^2 + \alpha_3 \cdot SARS_{i,t} \cdot R\&D_{i,t} \\ &+\alpha_4 \cdot TAI_{i,t} \cdot R\&D_{i,t} + \alpha_5 \cdot GDP_{i,t} + \alpha_5 \cdot GDPgrowth_{i,t} \\ &+GDP\ shadow_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (5)$$

Additional models are estimated, by incorporating a three-way interaction between R&D tax incentives, the tax attractiveness index, and the tax complexity index to capture the joint and conditional effects of tax policy design on innovation. This specification allows us to test whether the effectiveness of R&D incentives depends simultaneously on the overall favorability of the tax environment and the administrative frictions embedded in the system. In particular, it captures multiple mechanisms, including (i) complementarity, whereby incentives are more effective in highly attractive tax systems; (ii) attenuation effects, where high tax complexity reduces the accessibility and impact of incentives; and (iii) offsetting dynamics, where the benefits of tax attractiveness may be weakened by administrative burdens. Compared to lower-order models, this approach provides a more comprehensive and realistic assessment of how policy design and implementation jointly shape innovation outcomes.

Therefore, the baseline empirical specification relies on linear and quadratic regression models to test both the direct and non-linear effects of R&D tax incentives on innovation. The inclusion of a quadratic term allows the identification of potential threshold effects, capturing whether excessive fiscal support may reduce innovation efficiency. The inflection changes the behavior of taxation burden in relation to the level of the innovation score, as expressed by $Optimal\ threshold = -\frac{\alpha_1}{2 \cdot \alpha_2}$. However, the purpose of this paper is not to establish an optimal threshold of R&D projects taxation, but rather to outline the way tax related public policies can influence the innovation.

$$\begin{aligned} INN_{i,t} &= \alpha_0 + \alpha_1 \cdot R\&D_{i,t} + \alpha_2 \cdot R\&D_{i,t}^2 + \alpha_3 \cdot SARS_{i,t} \cdot R\&D_{i,t} \\ &+\alpha_4 \cdot TCI_{i,t} \cdot TAI_{i,t} \cdot R\&D_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (6)$$

In addition, the study estimates multiple interaction models to assess how the effectiveness of R&D incentives varies with tax system characteristics and accounting frameworks, thereby explicitly modelling heterogeneous policy effects. A challenge for the current research effort is to have a better understanding on the trade-off effects on the public choice between more attractive national taxation frameworks - maybe with more customized solutions on the R&D activities area – and less complex taxation ecosystems. This interaction term analysis is expected to bring insights on integrating the tax innovation incentives theory and the institutional theory, which places the taxation channels in relation with related enforcement

mechanisms, suggesting some empirical evidences in terms of R&D governments tax incentive programs efficiency.

To ensure robustness and address methodological limitations, the study employs multiple estimation techniques. Random effects (RE) panel regressions are used to exploit both within- and between-country variation while accounting for unobserved heterogeneity. Generalized Method of Moments (GMM) estimators are applied to control for endogeneity, reverse causality, and dynamic adjustment effects, capturing short-run relationships. Finally, Dynamic Ordinary Least Squares (DOLS) models are used to estimate long-run equilibrium relationships in a cointegration framework, allowing for a comprehensive distinction between short-run dynamics and long-run structural effects.

5. Results and discussion

5.1 Analysis of financial premises for innovation

Table 2 presents the descriptive statistics of the variables. The analysis focuses on the role of tax policy in promoting innovation as part of the broader sustainability transformation agenda. The results suggest that significant gaps remain in innovation policy design and institutional support mechanisms, including those fostering technological development, knowledge management, and collaborative innovation (Howoldt, 2024). Overall, the innovation index remains relatively low, with moderate cross-country variation, largely driven by differences in multinational activity and the strength of institutional frameworks supporting innovation (Cabral et al., 2021; Sein & Darfo-Oduro, 2023; Cowx, 2025).

Table 2. Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max	VIF	IPS W-stat.		Pesaran CD
INN	45,23	10,63	26,5	62,4	-	-1,822*	I(1)	5,211*
R&D	0,078	0,086	0	0,312	2,095	-5,139*	I(0)	-
SARS	5,092	0,734	3,763	6,727	3,474	-3,393*	I(0)	-0,489*
TAI	0,346	0,098	0,15	0,54	1,539	-4,386*	I(0)	1,381*
GDP	10,22	0,64	8,423	11,06	3,623			
Growth GDP	2,098	3,508	-11,03	11,35	1,102	-		-
Shadow GDP	21,36	9,418	8,07	43,07	2,682			

Note: * 0.01 significance level, **0.05 significance level, ***0.10 significance level.
Source: Authors' processing.

The results on government involvement through R&D tax incentives indicate substantial cross-country variation, reflected in the high dispersion of the incentive measure, suggesting heterogeneous policy approaches and levels of fiscal support (Balsalobre-Lorente et al., 2021; Fernández-Rodríguez et al., 2023).

The results highlight as well that the independent variables are stationary [I(0)], showing a stable evolution along the period analyzed. Instead, the innovation index shows a I(1) non-stationary evolution, which could suggest that that shocks to innovation performance have permanent effects, reflecting the cumulative and path-dependent nature of innovation processes across countries. In macro-panel settings, such non-stationarity is expected, as innovation is driven by structural factors, which include measures related to tax policy that evolve gradually over time.

Rather than reflecting independent dynamics, national economies exhibit a high degree of interdependence, characterized by substantial cross-border capital mobility driven, in part, by country-specific tax incentives. This pattern is consistent with the presence of cross-sectional dependence, indicating that common shocks and shared structural factors systematically affect multiple economies simultaneously.

5.2 Impact of accounting and taxation regulation on innovation

The next stage of the analysis evaluates the marginal effects of R&D tax incentives, with Table 3 reporting results for both linear and quadratic specifications. All models are statistically significant, confirming the relevance of tax incentives in shaping innovation outcomes. Consistent with prior literature, tax policy emerges as a key instrument for supporting private R&D activity (Belz et al., 2016).

The results further reveal a non-linear (quadratic) relationship, indicating the existence of an inflection point beyond which additional tax incentives reduce innovation performance. This finding underscores the importance of policy design and targeting, suggesting that incentives should be directed toward productive R&D projects aligned with national innovation strategies (Hall et al., 2019; Kou et al., 2023), otherwise limited and, generally, small positive effects could be generated.

Table 3. Tax and accounting regulation marginal effects on innovation

Dependent variable: INN	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Intercept	40.75*	38.24*	38.82*	39.58*	39.96*
	(1.04)	(1.16)	(1.10)	(1.10)	(1.06)
R&D	60.04*	136.9*	-60.74	351.1*	159.1*
	(8.06)	(21.56)	(49.65)	(46.01)	(64.70)
$R\&D^2$	-	-251.3*	-325.6*	-142.0***	-216.8*
		(82.19)	(79.67)	(79.08)	(77.70)
*Accounting and taxation framework **moderating** effect*					
SARS x R&D	-	-	38.24*	-	33.29*
			(8.75)		(8.24)
TAI x R&D	-	-	-	-649.6*	-589.4*

Dependent variable: INN	(1)	(2)	(3)	(4)	(5)
				(125.8)	(120.9)
Model validation					
Adjusted R^2	0.333	0.393	0.455	0.478	0.525
F stat.	69.26*	52.37*	45.30*	49.52*	44.87*
Durbin-Watson	0.053	0.000	0.000	0.000	0.000

Note: * 0.01 significance level, **0.05 significance level, ***0.10 significance level.
Source: Authors' processing.

While the direct effect of tax incentives appears limited in isolation, both the tax environment and the quality of accounting and auditing frameworks exert statistically significant influence on innovation. These findings support the view that tax policy effectiveness is conditional on broader institutional settings.

Overall, the results highlight the moderating role of both the tax system (attractiveness of taxation framework) and corporate reporting (perceived quality of accounting and auditing framework) in shaping innovation outcomes at the country level (Belz et al., 2017; Laplante et al., 2019).

Higher corporate transparency and the disclosure of high-quality financial information enhance stakeholder understanding of R&D opportunities, supporting more efficient investment decisions. The positive effect of the accounting regulation quality on innovation index, when controlling for R&D tax incentives, suggests that high-quality accounting frameworks enhance the effectiveness of innovation at the country level. Strong accounting regulation improves transparency, comparability, and the reliability of financial information, thereby reducing information asymmetries and facilitating more efficient capital allocation toward R&D activities. As a result, firms operating in such environments are better able to identify, fund, and manage innovative projects, amplifying the impact of R&D tax incentives on innovation outcomes, whereas governments are able to design efficient tax incentives programs. However, this effect is conditioned by the interaction between tax regulation and accounting policy, which varies across G20 countries. Evidence from PwC (2015) indicates that only a small number of countries maintain a clear separation between tax and accounting systems, while most exhibit a quasi-dependent relationship. As a result, even high-quality reporting and auditing frameworks may be constrained by their linkage to tax regulation, limiting their effectiveness in supporting innovation, which is generally reflected in the level of tax framework complexity and effectiveness of enforcement mechanism.

Although theoretically counterintuitive, the negative moderating effect of tax attractiveness suggests that favorable tax environments do not necessarily enhance innovation. Conditional on R&D tax incentives, highly attractive tax regimes may instead encourage tax planning activities, such as profit shifting, intellectual property relocation, and strategic income allocation, rather than productive R&D investment.

Table 4. Panel regression results considering random effects

Dependent variable: INN	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Intercept	44,66*	44,08*	43,63*	44,07*	43,58*
	(2,816)	(2,768)	(2,727)	(2,823)	(2,763)
R&D	7,285**	27,54**	45,19*	30,74	-37,47
	(3,544)	(11,18)	(21,45)	(20,56)	(27,36)
$R\&D^2$	-	-75,48**	-107,7**	-70,70**	-96,89**
		(35,11)	(39,79)	(36,42)	(41,90)
*Accounting and taxation framework **moderating** effects*					
SARS x R&D	-	-	15,79*	-	15,93*
			(4,419)		(4,375)
TAI x R&D	-	-	-	-10,23	-25,37
				(45,01)	(42,65)
Model validation					
Adjusted R^2	0,393	0,444	0,502	0,451	0,515
F stat.	2,234	2,746	5,145	1,801	1,801
Breusch-Pagan test	629,6*	617,3*	633,1*	611,3*	627,6*
Rho statistic	0,941	0,939	0,939	0,941	0,940
Hausman p-value	1,000	1,000	1,000	1,000	1,000
Durbin-Watson	0,512	0,536	0,618	0,539	0,625

Note: * 0.01 significance level, **0.05 significance level, ***0.10 significance level.
Source: Authors' processing.

5.3 Assessment of the nexus between innovation and tax policies

Table 4 reports the results of the random effects (RE) specifications. The RE panel model is appropriate for analysing cross-country variation in tax policy, as it accounts for unobserved country-specific heterogeneity while exploiting both within- and between-country variation. Unlike fixed effects models, which rely solely on within-country dynamics, the RE approach incorporates cross-sectional differences that are essential for explaining structural policy variation across countries.

Based on the Hausman test ($p > 0.05$) and the Breusch–Pagan test ($p < 0.05$), we employ random effects (RE) panel regression models. This specification confirms the importance of country-specific characteristics in shaping tax policy, reflecting the discretion national governments retain in policy design. Compared to fixed effects models, the RE approach allows for the inclusion of time-invariant institutional and structural factors, which are central in tax policy analysis.

The results are broadly consistent with previous findings, indicating a positive association between R&D tax incentives and the innovation index, as well as a significant positive effect of accounting and auditing quality. In contrast, the tax

attractiveness index does not exhibit a statistically significant marginal effect when included separately.

Relative to the baseline results, these findings underscore the strategic role of tax policy as a country-specific instrument, often tailored to national economic models and used as a tool of competitive differentiation. While full harmonization of tax systems appears unlikely, partial convergence, such as through OECD BEPS initiatives or EU frameworks like BEFIT, illustrates ongoing efforts to balance national autonomy with international coordination.

5.4 Impact of tax-related economic development premises on innovation

Table 5 reports the estimation results, highlighting the complementary role of tax incentives in supporting innovation, consistent with expectations. Beyond fiscal incentives, governments influence innovation through additional channels, including public R&D programs, academic research, education systems, and the digitalization of public services.

The results remain robust across model specifications and confirm the presence of an inflection point in the relationship between tax incentives and innovation. This suggests that, irrespective of economic development, growth, or shadow economy levels, the effectiveness of R&D support depends critically on policy design and targeting adequate research projects, based on firms' and governments' strategies. In particular, increased funding alone does not guarantee improved innovation outcomes, as it may not necessarily translate into commercially viable outputs such as patents, services, or technological solutions.

The results further indicate that the level of economic development is a key determinant of innovation performance, reflecting the availability of financial resources to support R&D activities. This helps explain persistent cross-country disparities, with advanced economies exhibiting higher innovation levels, compared to less developed G20 members. These differences largely stem from the robustness of institutional frameworks and their alignment with business environments and global economic conditions (Zou et al., 2025).

The findings also reveal a negative effect of the shadow economy, suggesting that informality reduces the pool of resources available for funding R&D and weakens innovation capacity. From a policy perspective, this underscores the need for governments to prioritize efficient allocation of public funds, establish transparent selection criteria, and strengthen monitoring mechanisms to ensure that R&D support targets high-impact, economically viable projects.

5.5 Tax framework complexity and innovation nexus dynamics across time

The last step of our research consists of robustness analysis to check for the consistency of the results concerning the nexus between the innovation index and the R&D tax incentives, as reflected in **Table 6**.

For this purpose, the empirical analysis relies on OLS with random effects, GMM, and DOLS estimators to capture different dimensions of the relationship between the innovation index, R&D tax incentives, tax complexity, and SARS.

The random effects model provides a baseline assessment of the overall association across countries and time, while the GMM estimator corrects for potential endogeneity, reverse causality, and dynamic persistence, thereby capturing short-run causal effects. In contrast, the DOLS approach is designed to identify the long-run equilibrium relationship among the variables in a cointegration framework. Differences in the magnitude and sign of the coefficients suggest that their impact on innovation index may vary across time horizons, with short-run adjustment dynamics potentially diverging from long-run structural effects, and highlight the importance of addressing both endogeneity and non-stationarity in the analysis.

On long-run, the positive association between innovation index and R&D tax incentives is confirmed as well within the DOLS model, which suggest the essential role of the governments on ensuring sustainable economic development via innovation mechanism, using various tax instruments to reduce firms' initial investment cost burden in R&D project. Afterall, those R&D projects are run along multiple years, suggesting that the benefits should be excepted on a long-run perspective. This observation is supported as well by the cumulative effect of innovation index.

In the short run, the GMM models reveal a negative association between the innovation index and R&D tax incentives. This pattern further suggests that R&D tax incentive programs are not sufficiently attractive and therefore, countries with a lower innovation index tend to gradually increase these tax incentives in order to identify the optimal scheme. The inefficiency of the R&D tax incentives could be related as well to the results obtained by changing the innovation index with the level of R&D expenses in GPD, which suggests that the higher the R&D tax incentives index, the lower the R&D expense % in GDP.

Table 5. Economic development marginal effects on innovation

Dependent variable: INN	**(11)**	**(12)**	**(13)**	**(14)**	**(15)**
Intercept	10,60*	29,34*	-44,29*	-12,10**	-44,20*
	(2,282)	(5,896)	(14,83)	(5,720)	(15,03)
R&D	146,0*	23,24**	18,33***	152,95*	-13,26
	(10,26)	(11,04)	(9,388)	(35,76)	(20,07)
$R\&D^2$	-340,5*	-63,96***	-55,31***	-208,80*	-53,65
	(35,81)	(34,26)	(29,25)	(42,51)	(33,93)
Accounting and taxation framework ***moderating*** effects					
SARS	5,066*	1,998*	-	-	-
	(0,487)	(0,643)			
TAI	-5,716*	13,70	-	-	-
	(1,899)	(8,473)			

Dependent variable: INN	(11)	(12)	(13)	(14)	(15)
SARS x R&D	-	-	-	-9,14***	10,54*
				(5,420)	(3,542)
TAI x R&D	-	-	-	-25,21	-51,56
				(29,31)	(35,96)
Economic development ***moderating*** effects					
GDP growth	-	-	0,068	0,067	0,069
			(0,067)	(0,098)	(0,067)
GDP	-	-	9,793*	6,188*	9,675*
			(1,398)	(0,518)	(1,395)
GDP shadow	-	-	-0,535*	-0,500*	-0,501*
			(0,101)	(0,040)	(0,112)
Model validation					
Adjusted R^2	0,572	0,563	0,766	0,775	0,766
F stat.	61,88	241,4	124,7	89,62	281,5
Breusch-Pagan test		581,9*	568,4*		541,0*
Rho statistic	-	0,932	0,909	-	0,917
Hausman p-value		1,000	1,000		1,000
Durbin-Watson	0,138	0,576	0,604	0,133	0,659

Note: * 0.01 significance level, **0.05 significance level, ***0.10 significance level.
Source: Authors' processing.

The difference between the innovation index and R&D expenses % in GDP is that the innovation index reflects already confirmed research results through patents number, whereas the R&D expenses % in GDP shows just firms' and governments' efforts to support the research activities. However, based on the quadratic model estimated, the discriminant coefficient is lower than the linear coefficient, which indicates that an inflexion point determines the optimal scheme for government support via R&D subsidies or other tax instruments.

Table 6. Analysis of the nexus between innovation and R&D tax framework

Robustness level	INN			D(INN)		R&D %
Model	*GMM*	*DOLS*	*GMM*	*OLS*	*OLS*	*OLS*
	(16)	*(17)*	*(18)*	*(19)*	*(20)*	*(21)*
Intercept	-	-	-	-0,221	-0,234	0,165*
				(0,217)	(0,199)	(0,013)
INN [-1]	0,568*	-	0,336*	-	-	-
	(0,027)		(0,078)			
R&D	-15,26*	10,95*	-50,66*	30,56**	28,78**	-0,478*
	(2,982)	(5,903)	(12,22)	(15,59)	(11,40)	(0,126)

Robustness level	**INN**			**D(INN)**		**R&D %**
R&D²	-	-	-	4,771 (16,52)	37,42 (25,20)	-0,242** (0,127)
Accounting and taxation framework moderating effects						
SARS x R&D	-	-	-	-3,423*** (1,955)	-4,124** (1,909)	0,033*** (0,018)
TCI x R&D	-	-	119,4* (87,73)	-32,89 (24,98)	-	-
TCI x TAI x R&D	-	-	-	-	-84,03*** (41,90)	0,740* (0,231)
Model validation						
Adj. R^2	-	0,992	-	0,232	0,052	0,320
F stat.	-	-	-	0,718	1,219	21,79
AB stat.	-2,383*	-	-2,821*	-	-	-
PP-stat.	-	-	1,932	-	-	-
BP stat.	-	-	-	116,9*	126,1*	726,6*
Rho stat.				0,072	0,045	0,979
DW stat.	-	-	-	2,366	2,428	0,767

Note: * 0.01 significance level, **0.05 significance level, ***0.10 significance level.
Source: Authors' processing.

Additionally, we observe that the level of complexity of the taxation environment generates a positive effect on the innovation index on short-run, therefore the higher the ambiguity within the taxation environment, the higher the innovation index. This counterintuitive result may reflect the fact that more innovative economies tend to have more sophisticated and intricate tax frameworks, particularly in relation to R&D incentives and specialized fiscal instruments. Additionally, it may indicate that firms operating in highly innovative environments possess the capabilities to navigate complex tax systems more effectively.

Furthermore, the results suggest on short-run a negative impact of the trade-off between the complexity and the attractiveness of the taxation system on the efficiency of R&D tax incentives. The negative moderating effect captured by the interaction between tax complexity and tax attractiveness indicates that the institutional configuration of the tax system plays a critical role in shaping the transmission of R&D incentives. Although attractive tax frameworks are designed to stimulate innovation, their effectiveness is weakened in the presence of high tax complexity. This can be explained by the fact that complex tax systems increase administrative burdens, reduce transparency, and create uncertainty regarding eligibility and expected benefits, thereby constraining firms' ability to efficiently respond to fiscal incentives. As a result, the marginal effect of R&D tax incentives

on innovation decreases when both tax attractiveness and complexity are jointly high.

Instead, on long-run the results show a really low, but positive effect of this interaction term incorporating both tax complexity and tax attractiveness proxies, on the innovation level. This result suggests that firms gradually internalize complex tax rules and adapt their strategies accordingly, reducing compliance costs and uncertainty over time. Although tax complexity may initially introduce administrative frictions, in the long run it may reflect institutional maturity, regulatory depth, and effective enforcement mechanisms. These features can improve the alignment between fiscal incentives and genuine R&D activities, ensuring that tax benefits are more effectively translated into innovation outcomes.

Nonetheless, the results show a negative association between the SARS score and the change in the innovation index in the case of the random effects model estimates, reflecting short-run dynamics rather than long-run structural relationships. While higher-quality financial reporting frameworks are theoretically expected to foster innovation by reducing information asymmetries and improving capital allocation, including in R&D projects, their effects are unlikely to materialize instantaneously. Instead, improvements in accounting and auditing standards may initially impose compliance costs, increase reporting rigidity, or redirect managerial attention toward governance and transparency, thereby temporarily constraining incremental innovation outcomes. Moreover, because the random effects estimator relies heavily on cross-sectional variation and does not adequately address endogeneity, the estimated negative coefficient may also capture transitional adjustments and unobserved country-specific factors that simultaneously influence changes in innovation and perceived reporting quality.

6. Conclusions

This study examines the role of public policies in shaping country-level innovation, focusing on the impact of R&D tax incentives and the moderating effect of accounting quality, using G20 data for the period 2012–2021. The results indicate that, despite policy efforts, innovation levels remain relatively low, highlighting gaps in institutional mechanisms supporting technological development, knowledge management, and collaborative innovation.

The empirical results provide consistent evidence that R&D tax incentives exert a positive but non-linear effect on country-level innovation. While fiscal support stimulates innovation activity, an inflection point emerges beyond which additional incentives yield diminishing or even negative returns, highlighting the importance of optimal policy calibration. The findings further show that the effectiveness of R&D incentives is strongly conditioned by the broader institutional environment. In particular, higher-quality accounting and auditing standards enhance policy effectiveness by improving transparency and resource allocation, whereas tax system complexity introduces administrative frictions that weaken the transmission of fiscal measures.

The analysis also reveals substantial cross-country heterogeneity, with more developed economies better able to translate fiscal support into sustained innovation outcomes, reflecting stronger institutional capacity and absorptive capabilities. Conversely, the presence of a large shadow economy negatively affects innovation by reducing the effectiveness of policy transmission and limiting the formal uptake of incentives.

Importantly, the results distinguish between short-run and long-run dynamics. While long-run estimates confirm a positive structural relationship between R&D incentives and innovation, short-run estimates suggest the presence of adjustment effects and potential inefficiencies in policy implementation. Overall, the findings indicate that the impact of R&D tax incentives depends not only on their magnitude, but also on the design of the tax system, the quality of financial reporting, and the broader economic and institutional context.

The empirical findings broadly support the three proposed hypotheses, albeit with important nuances. Hypothesis H1 is validated, as R&D tax incentives exhibit a positive non-linear effect on the innovation index, confirming their relevance while highlighting diminishing returns beyond an optimal threshold. Hypothesis H2 is also supported, as the quality of accounting and auditing standards significantly strengthens the effectiveness of R&D incentives, consistent with enhanced transparency and resource allocation mechanisms. In contrast, Hypothesis H3 is only partially supported: while tax system characteristics matter, the results indicate that tax complexity and overall tax attractiveness do not uniformly weaken the impact of incentives, but instead generate heterogeneous and context-dependent effects, reflecting both frictions and structural features of more advanced economies.

This study contributes to the literature by extending existing theoretical frameworks in several important ways. First, it integrates endogenous growth theory, innovation incentive theory, and information asymmetry theory into a unified empirical setting, demonstrating that the impact of R&D tax incentives cannot be understood in isolation but must be interpreted within a broader institutional context. Second, the findings highlight that tax attractiveness and tax complexity represent distinct yet interdependent dimensions of tax systems, generating complementarity and friction effects that shape innovation outcomes. Third, the results provide novel evidence that financial reporting quality acts as a key transmission mechanism, linking fiscal policy to real economic outcomes through transparency, monitoring, and capital allocation channels. Finally, the study contributes to the literature on policy evaluation by showing that fiscal interventions may generate temporally heterogeneous effects, thereby reconciling previously mixed empirical findings.

The findings have important implications for policymakers and practitioners. First, they suggest that R&D tax incentives alone are insufficient to stimulate innovation, unless supported by coherent tax system design and strong institutional frameworks. Second, the presence of a non-linear relationship indicates that excessive fiscal support may reduce efficiency, highlighting the need for optimal calibration of incentive schemes. Third, the results underscore the importance of simplifying tax systems while maintaining attractiveness, as excessive complexity

may undermine the effectiveness of otherwise favorable policies. Fourth, the evidence on accounting quality suggests that strengthening financial reporting and auditing standards enhances the efficiency of public R&D spending by improving transparency and reducing misallocation risks. Finally, the role of economic development and the shadow economy highlights that policy effectiveness is contingent on broader structural conditions, implying that innovation strategies should be tailored to country-specific institutional capacities rather than relying on uniform policy prescriptions.

This study is subject to several limitations related to the scope of the sample. Future research should extend the analysis to a broader set of countries and incorporate additional institutional factors, such as capital market incentives and public enforcement mechanisms, to enable a more comprehensive assessment of the effectiveness of R&D-related fiscal policies.

A further limitation arises from the paper's focus on a unidirectional causality framework, examining only the effect of R&D tax incentives on innovation. Future research could extend this approach by also exploring the reverse causality, thereby providing a more complete understanding of the dynamic relationship between innovation and R&D tax incentives.

In sum, this study contributes to the literature by providing a multi-dimensional and institutionally grounded analysis of the innovation effects of R&D tax incentives, integrating fiscal policy design, accounting quality, and tax system complexity within a unified empirical framework.

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