科学学研究 STUDIES IN SCIENCE OF SCIENCE
中国科学学与科技政策研究会
中国科学院科技战略咨询研究院
清华大学科学技术与社会研究中心
ISSN 1003-2053 CN 11-1805/G3

R&D, Innovation, and Firm Outcomes: Market Value and Performance Evidence from the G7

七国集团研发与创新对企业绩效与市场价值的证据

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Abstract. This study provides the first empirical evidence on how innovation and firm growth influence performance across G7 economies, using a unique panel dataset of 252 firms observed from 2020 to 2024. Focusing on two key dimensions of firm performance labor productivity and asset turnover the analysis incorporates multiple innovation indicators, including R&D Intensity, R&D-to-Assets, and R&D Growth Rate. To mitigate potential endogeneity arising from reverse causality and omitted variable bias, the study employs a heteroskedasticity-based instrumental variable estimator that constructs internal instruments from the model's error structure. The empirical results consistently show that innovation exerts a positive and significant causal effect on labor productivity, reinforcing its role as a critical driver of firm-level efficiency. Conversely, innovation demonstrates a negative and significant relationship with asset turnover, indicating short-term operational efficiency trade-offs, particularly among firms pursuing aggressive R&D strategies. Further analysis reveals that these innovation effects are moderated by firm profitability and industry-specific conditions, underscoring the strategic and contextual determinants of innovation outcomes. Overall, the findings highlight the dual nature of innovation simultaneously enhancing productivity while imposing transitional efficiency costs and provide important implications for corporate innovation strategy and public policy within advanced economies.

Keywords: Innovation, Firm Growth, Labor Productivity, G7 Economies, Firm Performance, Economic Growth

摘要: 本研究首次提供关于创新与企业增长如何影响七国集团（G7）经济体中企业绩效的经验证据，使用涵盖 252 家企业、2020 至 2024 年期间的独特面板数据集。研究聚焦于企业绩效的两个关键维度 劳动生产率和资产周转率，并纳入多项创新指标，包括研发强度、研发占资产比率以及研发增长率。为减轻由反向因果关系和遗漏变量偏误引起的潜在内生性问题，本研究采用基于异方差的工具变量估计方法，从模型误差结构中构建内部工具变量。实证结果一致表明，创新对劳动生产率具有正向且显著的因果影响，强化了其作为企业效率关键驱动力的作用。相反，创新对资产周转率呈现负向且显著的关系，这反映出企业在实施积极研发策略时会面临短期运营效率的权衡。进一步分析显示，企业盈利能力与行业特征会调节创新的影响，凸显创新结果受到战略与情境因素共同决定。总体而言，研究结果强调了创新的双重性质 既提升生产率， 又带来过渡期效率成本 并为先进经济体中的企业创新战略与公共政策提供了重要启示

关键词： 关键词；关键词2；关键词3（请提供3至10个相关关键词，这些关键词应能代表文章内容，并在学科领域中较为常用

Received: 1 November 2025 **Revised:** 24 November 2025 **Accepted:** 11 December 2025 **Published:** 15 December 2025

Citation: Dewandaru, R. O & Anggara, A. A. (2025). R&D, Innovation, and Firm Outcomes: Market Value and Performance Evidence from the G7: 七国集团研发与创新对企业绩效与市场价值的证据. *Studies in Science of Science*, 43(12), 830-850.

1. Introduction

Innovation has emerged as a central pillar of firm strategy, competitiveness, and long-term value creation in today's knowledge-based global economy. From digital transformation and clean technologies to process redesign and product development, firms increasingly invest in research and development (R&D) as a strategic response to market volatility and rapid technological change, particularly within the G7 economies where competitive pressures and market maturity are high. A substantial body of theoretical and empirical literature highlights the role of innovation, especially R&D investment, in enhancing firm productivity, operational efficiency, and competitive advantage. Schumpeterian models emphasize innovation's disruptive capacity as a driver of economic growth, while the Resource-Based View (RBV) conceptualizes innovation as a strategic asset enabling the development of dynamic capabilities (Aghion et al., 2015; Danneels, 2002; Zawawi et al., 2016). Empirical evidence consistently shows that R&D Intensity correlates positively with productivity and technical efficiency (Grant et al., 2019; Song et al., 2024; Habtewold, 2021), though diminishing returns may appear beyond optimal investment thresholds (Song et al., 2024).

Firm growth captured through revenue, employment, or asset expansion has similarly been associated with scale economies, experiential learning, and improved resource utilization (Penrose, 1959), while recent work emphasizes the integration of innovation and growth capabilities such as managerial capacity and absorptive capability (Tan & Mahoney, 2005; Sousa et al., 2021). Despite these advances, the joint effects of innovation and firm growth on performance remain underexplored, particularly in cross-national contexts shaped by heterogeneous institutional environments and industrial structures, and empirical studies often face endogeneity challenges arising from reverse causality and omitted variable bias (Rosenbusch et al., 2011; Dillen & Vandekerkhof, 2021).

Addressing this gap, the present study analyzes a balanced panel of 252 publicly listed G7 firms from 2020 to 2024, a period marked by post-pandemic realignment and geopolitical instability that has disrupted innovation strategies and weakened ESG performance across markets (Saharti et al., 2024b). Performance is measured through labor productivity and asset turnover, while innovation is captured using R&D Intensity, R&D-to-Assets ratio, and R&D Growth Rate, alongside firm growth indicators based on output and employment. To mitigate endogeneity concerns, the study employs the heteroskedasticity-based instrumental variable estimator developed by Lewbel (2012), which constructs internal instruments from model error structures in situations where valid external instruments are unavailable making it particularly suitable for innovation research. Overall, this study provides robust empirical evidence on the causal impact of innovation and firm growth on performance, advances the innovation–performance framework by incorporating growth dynamics, addresses methodological limitations through an advanced IV estimation strategy, and offers strategic insights for managers, investors, and policymakers. By clarifying the dual nature of innovation enhancing labor productivity while imposing short-term efficiency trade-offs on asset turnover the findings provide a foundation for aligning innovation investments with profitability conditions, industry dynamism, and long-term performance goals in advanced economies.

2. Theoritical Framework

Research consistently shows that R&D investment enhances firm productivity and efficiency, yet the scale of these improvements is shaped by industry characteristics, firm-specific capabilities, and institutional quality (Peters et al., 2017; Song et al., 2024). Although R&D generally generates positive returns, diminishing marginal gains may occur in capital-intensive or technologically saturated environments (Song et al., 2024). Evidence across sectors from biotechnology and pharmaceuticals (Grant et al., 2019) to manufacturing industries in emerging markets such as Ethiopia (Habtewold, 2021) demonstrates that innovation-driven efficiency gains materialize when supportive ecosystems are present. These outcomes are further moderated by institutional strength (Yoo et al., 2019) and firm life-cycle stages, where mature firms tend to convert accumulated knowledge into performance advantages more effectively than younger firms. In emerging economies, R&D similarly plays a pivotal role in driving growth and strengthening competitive positioning; for instance, innovation spillovers in Indian food-processing firms have reinforced productivity and market expansion (Manogna & Mishra, 2021). Overall, these studies underline that strategic alignment, absorptive capacity, and robust institutional support are essential prerequisites for fully realizing the performance benefits of R&D investment.

Two dominant theoretical lenses frame the innovation–performance relationship. Schumpeterian theory argues that innovation-driven "creative destruction" generates temporary monopolistic advantages (Schumpeter, 1934/1983), a dynamic empirically supported by Aghion et al. (2015, 2009), Aghion (2016), and Yay and Yay (2022). Complementing this, the Resource-Based View (RBV) posits that sustainable performance advantages arise from VRIN resources (Zawawi et al., 2016), with dynamic capabilities (Danneels, 2002) and eco-innovation (Clarissa et al., 2024) demonstrating how R&D competencies become strategically valuable when aligned with environmental and organizational goals. Empirical evidence shows that absorptive capacity enables firms to convert external knowledge into performance gains (Tran et al., 2022), whereas weak strategic alignment or institutional voids reduce R&D effectiveness (Bloom & Van Reenen, 2002; Hall, 2002; Artz et al., 2010). Innovation is commonly operationalized using R&D intensity (Daizadeh, 2009), patent counts and citations (Daizadeh, 2009), and perception-based surveys (Mairesse & Mohnen, 2004; Jaumotte & Pain, 2005; Keiningham et al., 2023), with multi-measure approaches mitigating the limitations of single proxies. Recent studies introduce syndicated loan structures as a novel indicator of innovation financing (Saharti et al., 2024a). Empirically, R&D Intensity is positively associated with labor productivity (Hintzmann et al., 2021; Woo et al., 2013) and asset turnover (Chung & Choi, 2017; Ubaldo & Siedschlag, 2020), particularly when supported by intellectual property investment (Ubaldo & Siedschlag, 2020). Profitability gains from innovation are documented in diverse contexts from manufacturing firms in Korea (Chung & Choi, 2017) to the Nigerian insurance sector (Tamunomiebi & Okorie, 2019) and reinforced by process innovation (Piening & Salge, 2014) and persistent R&D engagement (Cefis & Ciccarelli, 2005). Meta-analytic evidence indicates that innovation returns vary with environmental munificence and resource availability (Rosenbusch et al., 2011); firms in high-profit industries or with strong financial health leverage R&D more effectively (Ren et al., 2023), while financially constrained firms tend to scale back innovation efforts (Dillen & Vandekerkhof, 2021). From a capital market perspective, innovative firms receive valuation premiums (Rubera & Kirca, 2012; Handriani, 2020), with intellectual capital amplifying this effect (Ren et al., 2023). The rise of Fourth Industrial Revolution (4IR) technologies further strengthens innovation's positive influence on productivity and efficiency (Benassi et al., 2020).

Endogenous growth theory (Romer, 1994; Aghion & Howitt, 1990) complements Schumpeterian perspectives by showing how policy, education, and institutional quality facilitate knowledge spillovers and sustained economic expansion, while competitive entry pressures stimulate incumbent innovation and raise industry-wide productivity (Aghion et al., 2009). At the firm level, Penrose's (1959) growth theory highlights managerial capacity as a constraint on expansion, with empirical evidence indicating that resource coordination challenges shape growth outcomes (Lockett et al., 2009; Goerzen & Beamish, 2007). Integrated with RBV, these insights affirm that internal resource orchestration especially the management of innovation capabilities supports sustained competitive advantage (Lockett & Thompson, 2003; Sousa et al., 2021; Kor et al., 2016; Tan & Mahoney, 2005). Across theoretical perspectives and empirical settings, innovation primarily reflected in R&D activity enhances productivity, profitability, and firm valuation when strategically aligned with internal resources, supported by strong institutional environments, and complemented by absorptive capacity and intellectual property assets. These contingencies explain the heterogeneity in innovation outcomes and offer guidance for policymakers and managers seeking to maximize returns to R&D investment.

2.1 Innovation and Firm Performance

A robust body of literature establishes that R&D investment exerts a positive and substantial influence on firm productivity and performance by enhancing knowledge accumulation, process efficiency, and organizational capabilities. Peters et al. (2017) conceptualize R&D as a complementary input to capital and labor, thereby augmenting productivity through innovation-driven improvements. Empirical evidence across diverse sectors ranging from high-tech and pharmaceutical industries to emerging market manufacturing confirms this positive association (Song et al., 2024; Grant et al., 2019; Habtewold, 2021). Nonetheless, the benefits of innovation are not uniform, as excessive or misaligned R&D may lead to diminishing marginal returns, particularly in capital-intensive settings (Song et al., 2024). The effectiveness of innovation is also shaped by contextual factors such as institutional environments and firm maturity. Early-stage firms often lack adequate absorptive capacity to internalize R&D outcomes, whereas mature firms integrate innovative activities more effectively into operational routines (Yoo et al., 2019).

2.2 Control Variables and Theoretical Justifications

The inclusion of control variables in the empirical model is grounded in well-established theoretical rationales. Capital intensity, measured through the log of fixed assets, captures a firm’s reliance on physical capital, which can shape productivity and asset utilization patterns (Grant et al., 2019). Firm size, proxied by the log of total assets, reflects economies of scale while also accounting for potential bureaucratic rigidities that influence innovation implementation (Penrose, 1959). Total debt and leverage ratios represent financial constraints that affect risk-taking capacity and investment flexibility; such constraints may either restrict or discipline innovation strategies (Dillen & Vandekerkhof, 2021). Profitability indicators such as ROA and ROE function as measures of financial strength, conditioning a firm's ability to sustain long-term R&D investment and absorb innovation-related costs (Ren et al., 2023).

2.3 Moderating Effects and Strategic Context

Contextual moderators play a critical role in shaping how innovation translates into performance outcomes. To capture these dynamics, the study incorporates several interaction terms. The interaction between R&D and industry performance acknowledges sectoral heterogeneity, as prior research demonstrates that innovation returns vary across industries depending on levels of profitability and environmental munificence (Rosenbusch et al., 2011). The interaction between R&D and profitability examines whether financially stronger firms can more effectively leverage innovation investments, consistent with the argument that resource-rich firms generate higher R&D productivity. Additionally, a high-R&D dummy is included to identify firms with top-quartile R&D growth, enabling assessment of whether aggressive innovation strategies generate diminishing marginal returns or distinct performance trajectories.

3. Research Methods

3.1 Data

The dataset used in this study comprises a balanced panel of 252 publicly listed firms from the G7 economies Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States observed over the five-year period from 2020 to 2024. Firm-level financial and operational data were obtained from Refinitiv Eikon, a widely recognized database that provides standardized and comprehensive information on R&D expenditures, financial statements, and employment indicators. The selected period captures the post-pandemic phase of corporate realignment, during which firms in advanced economies reassessed their innovation strategies in response to global supply chain disruptions, accelerated digitalization, and shifting competitive landscapes.

The sample spans ten major Global Industry Classification Standard (GICS) sectors information technology, healthcare, industrials, financials, consumer discretionary, consumer staples, energy, materials, utilities, and communication services ensuring cross-sectoral variation and enhancing the generalizability of the findings. Descriptive statistics are reported for key firm attributes, including firm size (total assets), capital intensity, leverage ratio, R&D intensity, employment scale, return on assets (ROA), and return on equity (ROE), reflecting heterogeneity in firm scale, innovation capacity, and financial health. The fully balanced structure of the panel strengthens internal validity by eliminating concerns related to attrition, survivor bias, or inconsistent time-series representation.

Firm performance is captured through two dependent variables: labor productivity, measured as operating revenue per employee, and asset turnover, computed as revenue relative to total assets. These measures jointly reflect operational efficiency and asset utilization. The core independent variables represent multiple dimensions of innovation and firm growth. Innovation is proxied through R&D Intensity (R&D expenditure relative to sales), R&D-to-Assets, R&D Growth Rate, and three interaction terms R&D × Industry Performance, R&D × Profitability, and a High-R&D dummy designed to assess contextual moderating effects. Firm growth is represented by output (log of revenue) and NMP (number of employees), capturing scale expansion and organizational complexity.

To mitigate omitted-variable bias and control for firm-specific heterogeneity, the empirical specifications include a comprehensive set of theoretically grounded control variables: capital intensity (log of fixed assets), firm size (log of total assets), total debt, leverage ratio, and profitability indicators such as ROA and ROE. These controls account for variation in capital structure, scale economies, and financial resilience. The primary variable of interest is R&D Intensity, with emphasis on its marginal and interactive effects on performance under different strategic and industry conditions.

Table 1 provides detailed definitions and data sources for all variables employed in the analysis. The empirical strategy begins with baseline models assessing the effects of R&D Intensity and output on labor productivity and examining how capital intensity and firm growth shape asset turnover. Subsequent specifications incorporate alternative innovation measures and interaction terms to test the robustness of the results. Correlation diagnostics reveal generally low intercorrelations among key variables, aside from an expected strong relationship between capital intensity and output in capital-intensive sectors. Despite this, all control variables are retained to preserve theoretical completeness and address potential endogeneity concerns.

Table 1. Variable definitions.

Category	Variable Name	Definition
Performance Variables	Labor Productivity	Operating revenue divided by number of employees
	Asset Turnover	Revenue divided by total assets
Innovation and Contextual Variables	R&D Intensity	R&D expenditure divided by sales
	R&D-to-Assets	R&D expenditure divided by total assets
	R&D Growth Rate	Year-over-year percentage change in R&D expenditure
	R&D × Industry Performance	R&D Growth Rate multiplied by industry ROA
	R&D × Profitability	Interaction based on R&D Growth Rate quartiles and firm ROA
	High R&D	Dummy variable for top quartile of R&D Growth Rate × R&D Growth Rate
Control Variables	NMP	Total number of employees (full-time or part-time)
	Capital Intensity	Natural logarithm of total fixed assets
	Output	Natural logarithm of revenue
	Firm Size	Natural logarithm of total assets
	Total Debt	Aggregate debt outstanding on the balance sheet
	Leverage Ratio	Total debt divided by total assets
	Return on Assets (ROA)	Net income divided by total assets
	Return on Equity (ROE)	Net income divided by shareholder equity

3.2 Summary Statistics

Descriptive statistics for all key variables are presented to provide an overview of the dataset's characteristics and distributional properties. Table 1 reports the definitions and data sources, while the summary statistics appear in the following section. These descriptive measures serve as an initial diagnostic tool, offering insight into variability across firms in the G7 economies during the 2020–2024 period.

Labor productivity the primary performance variable exhibits substantial dispersion, with a mean of approximately 416,554 and a standard deviation exceeding 11 million. This wide range reflects strong heterogeneity in revenue generation relative to workforce size, consistent with the diverse industrial composition and scale differences across firms in the sample. Asset turnover has a mean value of 0.77, indicating that firms, on average, generate less than one unit of revenue for every unit of assets annually. However, the maximum value above 115 illustrates the presence of extreme outliers with exceptionally high asset efficiency.

Given the highly skewed distributions observed in revenue, total assets, and fixed assets, natural log transformations are applied to output, capital intensity, and firm size. This procedure improves model fit, mitigates heteroskedasticity, and facilitates elasticity-based interpretation of coefficients an approach widely adopted in firm-level empirical research to address scale effects and nonlinearities.

Innovation-related variables also display notable variability. R&D Intensity has a mean of 0.25 and a relatively large standard deviation of 5.61, indicating that only a subset of firms typically in technology-intensive industries allocate disproportionately high expenditure to R&D relative to sales. The R&D-to-Assets measure further highlights this asymmetry, with a maximum exceeding USD 1.7 billion. The R&D Growth Rate shows extreme volatility, with an average above 1000% and a standard deviation surpassing 32,000%, suggesting that some firms experienced rapid expansions in R&D investment during the sample window.

Growth-related controls, including output (log of revenue) and capital intensity (log of fixed assets), appear stable, with respective means of around 22.5 and 21.9. Employee count (NMP) shows moderate variation, averaging about 9.65. Financial indicators demonstrate expected patterns for developed-market firms: leverage averages 0.22, ROA averages 7.47%, and ROE averages 12.94%. Nonetheless, the wide standard deviations indicate the presence of firms with negative or highly volatile profitability, which may shape their sensitivity to innovation and growth strategies.

The empirical analysis incorporates several regression specifications to evaluate the robustness of R&D effects on firm performance. Across all models, R&D Intensity consistently displays a positive and statistically significant association with labor productivity, underscoring innovation's central role in driving efficiency outcomes. Interaction terms with contextual variables such as industry performance and profitability reveal significant heterogeneity, indicating that returns to innovation vary depending on external conditions and firm-specific characteristics.

Complementary correlation diagnostics reveal expected relationships: capital-intensive firms exhibit larger output and size measures, whereas firms with strong R&D profiles typically align with higher productivity but lower non-manufacturing presence. The generally low correlation coefficients help mitigate concerns regarding multicollinearity, ensuring that regression estimates remain stable and interpretable.

Collectively, these summary statistics highlight pronounced heterogeneity across firms in innovation strategies, scale, financial conditions, and performance outcomes variation that is essential for capturing differential effects in the subsequent econometric analysis.

3.3 Empirical Strategy and Estimation Methodology

The empirical analysis employs a series of regression models primarily linear panel regressions with firm-level fixed effects to examine the relationship between innovation, firm growth, and performance across G7 economies. The fixed-effects specification allows control for unobserved time-invariant firm characteristics that may simultaneously influence innovation inputs and performance outcomes. In addition, industry and year fixed effects are included to capture sector-specific shocks and common macroeconomic dynamics over the study period.

The baseline econometric specification is expressed as:

$$Performance_{it}=\beta_0+\beta_1 Innovation_{it}+\beta_2 Growth_{it}+\theta Z_{it}+\gamma_i+\delta_t+\eta_j+\varepsilon_{it}$$

where:

- Performanceit denotes the performance measures for firm *i* in year *t*: labor productivity and asset turnover.
- Innovationitit includes the core explanatory variables: *R&D Intensity, R&D-to-Assets, R&D Growth Rate*, and interaction terms such as *R&D × Industry Performance*, *R&D × Profitability*, and *High R&D*.
- Growthit captures firm growth indicators, including *output* and *NMP* (number of employees).
- Zit is a vector of controls: capital intensity, firm size, total debt, leverage ratio, ROA, and ROE.
- γiδti and ηj represent firm, year, and industry fixed effects.
- εit\varepsilon_{it}εit is the idiosyncratic error term, assumed to be independently and identically distributed.

All estimations employ heteroskedasticity-robust standard errors to ensure consistent inference. To assess robustness and explore conditional relationships, additional specifications incorporate interaction terms capturing strategic complementarities and contextual dependencies such as interactions between R&D growth and profitability, and between R&D growth and industry performance.

Because reverse causality poses a key methodological concern where more productive firms may choose to invest more in R&D the study further applies a two-stage least squares (2SLS) instrumental variables estimator. In this framework, *R&D Intensity* is treated as endogenous. Instrument relevance and validity are assessed using the Kleibergen–Paap LM test (under-identification) and the Hansen J-test (over-identification).

The 2SLS structural equation is:

$$Performance_{it}=\alpha_0+\alpha_1 \widehat{R\&D\ Intensity}_{it}+\alpha_2 Growth_{it}+\theta Z_{it}+\gamma_i+\delta_t+\eta_j+\varepsilon_{it}$$

where R&D Intensity is the predicted value from the first-stage regression.

4. Result

Results from the fixed-effects models and instrumental variable estimations are reported in Tables 2–9, covering baseline specifications, interaction models, and robustness checks. The consistent statistical significance of innovation and growth variables across these models reinforces the robustness of the identified relationship between R&D activities and firm performance in the G7 economies.

Table 2. Summary statistics.

		Mean	Std dev	Min				
		0.77355	3.085	0.00344				
Labor Productivity	USD (thousands)				416.5538	11,000.00000	−615.02410	353,000.00000
R&D Intensity	%				0.24566	5.60552	1.54345	182.1248
R&D-to-Assets	USD (billions)				0.0451	0.115	0.00001	1.7
NMP	Interaction term (unitless)				9.64899	1.54661	4.18966	12.861
Capital Intensity	Interaction term (unitless)				21.89286	1.69368	15.17392	26.31035

Output	Interaction term (unitless)	22.47406	1.58597	12.26552	26.70806
Firm Size	USD (billions)	30.5	65.2	0.0274	596
Debt	USD (billions)	7.97	21.5	0.00146	242
Leverage	Ratio	0.21666	0.17024	1.57844	1.51307
ROA	%	0.07468	0.10798	−0.39900	1.508
ROE	%	0.12945	0.38302	−5.26139	5.2985
R&D growth	%	1012.48100	32,850.63000	-2.45320	1,066,002.00000

Table 3. Correlation matrix of key variables

	R&D Intensity	NMP	Capital Intensity	Output	Firm Size	Debt	Leverage	ROA	ROE
R&D Intensity	1	−0.0209	0.0057	−0.0601	−0.0129	−0.0106	−0.0369	−0.0378	−0.0451
NMP		1	0.2086*	0.6890*	0.6633*	0.5989*	0.0945*	−0.1144	−0.0070
Capital Intensity			1	0.3294*	0.1848*	0.1239*	0.1301*	−0.0759	−0.0108
Output				1	0.6262*	0.5133*	0.1814*	−0.0311	0.0725*
Firm Size					1	0.8445*	0.1035*	−0.0300	0.0394
Debt						1	0.2819*	−0.0024	0.0243
Leverage							1	−0.1839	0.0348
Return on Assets								1	0.2821*
Return on Equity									1

Note: * indicates significance at the 5% level ($p < 0.05$). All coefficients are based on pairwise Pearson correlations.

Table 4. Baseline regression impact of R&D Intensity on firm performance.

	(1)	(2)
Variables	**Labor Productivity**	**Asset Turnover**
R&D Intensity	233.947 ***	−0.778 ***
	−76.534	−0.0765
NMP	−89.096 ***	−0.00128
	−7805	−0.0099
Capital Intensity	7644	−0.261 ***
	−9214	−0.0106
Output	89.080 ***	0.299 ***
	−11.490	−0.0144
Leverage	−45.573	0.114 ***

	(1)	(2)
Variables	Labor Productivity	Asset Turnover
	−35.666	−0.0436
Return on Assets (ROA)	638,960 ***	−0.0978
	−50.524	−0.069
Return on Equity (ROE)	53,807 ***	−0.0103
	−12.137	−0.0142
Constant	-1.298×10^{6} ***	0.396 **
	−177,895	−0.198
Observations	741	741
R-squared	0.454	0.617
Firm Size	YES	YES
Total Debt	YES	YES
Time FE	YES	YES
Industry FE	YES	YES
Country FE	YES	YES

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5. Robustness check using R&D-to-Assets as an alternative innovation measure.

	(1)	(2)
Variables	Labor Productivity	Asset Turnover
R&D-to-Assets	0.000455 ***	-1.47×10^{-10} *
	-9.71×10^{-5}	-8.62×10^{-11}
NMP	−93,232 ***	0.0127
	−7685	−0.0103
Capital Intensity	8653	−0.269 ***
	−8980	−0.0111
Output	83,360 ***	0.298 ***
	−11,356	−0.015
Leverage	−39,960	0.187 ***
	−35,443	−0.0453
Return on Assets (ROA)	625,425 ***	−0.0098
	−50,386	−0.0722
Return on Equity (ROE)	45,582 ***	0.000866

Variables	(1) Labor Productivity	(2) Asset Turnover
	−11,763	−0.0148
Constant	-1.136×10^{6} ***	0.361 *
	−180,270	−0.207
Observations	741	741
R-squared	0.448	0.493
Firm Size	YES	YES
Total Debt	YES	YES
Time FE	YES	YES
Industry FE	YES	YES
Country FE	YES	YES

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6. Dynamic innovation effect of R&D Growth Rate on firm performance.

Variables	Labor Productivity	Asset Turnover
R&D Growth Rate	−0.0521 ***	-1.13×10^{-7} ***
	(0.0151)	(3.37×10^{-8})
NMP	−98,541 ***	0.0401 ***
	(16,009)	(0.0136)
Capital Intensity	10,160	−0.274 ***
	(15,477)	(0.0173)
Output	95,013 ***	0.273 ***
	(26,126)	(0.0238)
Leverage	−9877	0.0727
	(51,212)	(0.0588)
Return on Assets (ROA)	642,355 **	4.47×10^{-5}
	(325,130)	(0.0857)
Return on Equity (ROE)	47,983 **	−0.0137
	(21,103)	(0.0346)
Constant	-1.344×10^{6} ***	0.210
	(243,325)	(0.225)
Observations	741	741
R-squared	0.431	0.489
Firm Size	YES	YES
Total Debt	YES	YES

Variables	Labor Productivity	Asset Turnover
Time FE	YES	YES
Industry FE	YES	YES

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7. Interaction effect R&D Growth Rate × Industry Performance.

Variables	Labor Productivity	Asset Turnover
R&D × Industry Performance	−13.22 ***	-2.95×10^{-5} ***
	(3.882)	(8.64×10^{-6})
NMP	−98,544 ***	0.0401 ***
	(16,010)	(0.0136)
Capital Intensity	10,158	−0.274 ***
	(15,477)	(0.0173)
Output	95,016 ***	0.273 ***
	(26,126)	(0.0238)
Leverage	−9839	0.0728
	(51,211)	(0.0588)
Return on Assets (ROA)	642,338 **	-8.85×10^{-6}
	(325,133)	(0.0857)
Return on Equity (ROE)	47,981 **	−0.0137
	(21,104)	(0.0346)
Constant	-1.344×10^{6} ***	0.210
	(243,325)	(0.224)
Observations	741	741
R-squared	0.431	0.489
Firm Size	YES	YES
Total Debt	YES	YES
Time FE	YES	YES
Industry FE	YES	YES

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8. Interaction effect R&D Growth Rate × firm profitability.

Variables	Labor Productivity	Asset Turnover
R&D × Profitability	−427.6 **	−0.00118 ***
	(197.2)	(0.000356)
NMP	−98,544 ***	0.0401 ***
	(16,010)	(0.0136)
Capital Intensity	10,157	−0.274 ***
	(15,478)	(0.0173)
Output	95,016 ***	0.273 ***
	(26,128)	(0.0238)
Leverage	−9776	0.0727
	(51,230)	(0.0588)
Return on Assets (ROA)	642,339 **	-1.81×10^{-5}
	(325,192)	(0.0857)
Return on Equity (ROE)	47,989 **	−0.0137
	(21,105)	(0.0346)
Constant	-1.344×10^{6} ***	0.210
	(243,319)	(0.224)
Observations	741	741
R-squared	0.431	0.489
Firm Size	YES	YES
Total Debt	YES	YES
Time FE	YES	YES
Industry FE	YES	YES

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 9. High innovation strategy effect of top-quartile R&D growth firms.

	(1)	(2)
Variables	**Labor Productivity**	**Asset Turnover**
High R&D	−53.27 ***	−0.000114 ***
	(15.44)	(3.45×10^{-5})
NMP	−98,542 ***	0.0401 ***
	(16,009)	(0.0136)
Capital Intensity	10,157	−0.274 ***

Variables	(1) Labor Productivity	(2) Asset Turnover
	(15,478)	(0.0173)
Output	95,015 ***	0.273 ***
	(26,126)	(0.0238)
Leverage	-7.28×10^{-8}	−0
	(4.91×10^{-7})	(0)
Return on Assets (ROA)	642,349 **	2.45×10^{-5}
	(325,131)	(0.0857)
Return on Equity (ROE)	47,981 **	−0.0137
	(21,103)	(0.0346)
Constant	-1.344×10^{6} ***	0.210
	(243,324)	(0.225)
Observations	741	741
R-squared	0.431	0.489
Firm Size	YES	YES
Total Debt	YES	YES
Time FE	YES	YES
Industry FE	YES	YES

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

To improve thematic clarity and facilitate interpretation, the estimation results are organized into four analytically coherent groups, each aligned with a distinct dimension of the research framework. First, the core relationship between innovation and firm performance is established in Table 4, which presents baseline fixed-effects regressions using R&D Intensity as the primary explanatory variable. Second, the robustness of these results is examined through alternative innovation measures: R&D-to-Assets and R&D Growth Rate, reported in Tables 5 and 6, respectively. These specifications test whether the observed performance effects are sensitive to how innovation inputs are defined and scaled. Third, the analysis incorporates contextual moderators to capture the heterogeneous nature of innovation outcomes. Specifically, Tables 7–9 explore interaction effects between innovation and industry profitability, firm-level profitability, and high-intensity R&D strategies, respectively, highlighting how innovation returns vary across strategic and sectoral contexts. Fourth, potential endogeneity and cross-country heterogeneity are addressed in Table 10, which implements the Lewbel (2012) heteroskedasticity-based instrumental variable approach. This structured presentation reflects the empirical strategy's sequential logic and ensures the reader can differentiate between baseline effects, robustness checks, contextual interactions, and identification strategies.

Table 10. Instrumental variable estimation 2SLS results using the Lewbel (2012) estimator.

Variables	Labor Productivity	Std. Error	Asset Turnover	Std. Error
R&D Intensity	307,914.600 ***	(82,095.260)	–1.118 ***	(0.126)
NMP	–92,540.390 ***	(14,819.290)	0.009	(0.011)
Capital Intensity	1,963.956	(15,903.820)	–0.259 ***	(0.015)
Output	97,878.100 ***	(25,856.480)	0.282 ***	(0.022)
Leverage	–12,715.020	(49,927.110)	0.035	(0.058)
Return on Assets (ROA)	634,989.900 *	(311,173.900)	–0.090	(0.087)
Return on Equity (ROE)	57,377.640 **	(23,343.400)	–0.022	(0.036)
Constant	–1,298,716.000 ***	(231,751.500)	0.110	(0.203)

Observations: 741

R-squared: Labor Productivity = 0.4418, Asset Turnover = 0.5533

Kleibergen–Paap rk LM stat: Labor Productivity = 50.884 ***, Asset Turnover = 45.530 ***

Note: Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4.1 Baseline Estimates

This section presents the baseline empirical findings on the relationship between innovation, firm growth, and performance among G7 firms over the 2020–2024 period. The analysis employs panel data regressions with firm-, year-, and industry-fixed effects, using labor productivity and asset turnover as the primary outcome variables that reflect firm-level resource utilization and operational efficiency. Across all specifications, standard errors are clustered at the firm level to address potential serial correlation.

Table 4 provides the baseline estimates using R&D Intensity measured as R&D expenditure scaled by sales as the core innovation proxy. The results reveal a strong and statistically significant positive association between R&D Intensity and labor productivity (coefficient: 278,795; $p < 0.01$), indicating that innovation serves as a productivity-enhancing input. This finding is consistent with prior evidence showing that R&D fosters intangible asset formation and technological capability development that elevates worker productivity (Hintzmann et al., 2021; Peters et al., 2017). Supporting broader conclusions in the innovation literature (Song et al., 2024; Habtewold, 2021), the estimates confirm that sustained innovation investment contributes meaningfully to operational efficiency.

However, R&D Intensity exhibits a negative and significant effect on asset turnover (coefficient: -0.934; $p < 0.01$), suggesting short-term declines in asset-use efficiency among firms with higher innovation spending. This pattern may reflect capital absorption, increased intangible investment, or time lags in realizing innovation returns. Ubaldo and Siedschlag (2020) documented similar dynamics, emphasizing that complementarities between R&D and intellectual capital require time to translate into improvements in asset utilization, especially during periods of innovation build-up.

Table 5 strengthens these insights by substituting R&D-to-Assets as an alternative innovation measure. The positive association with labor productivity remains statistically significant ($p < 0.05$), and the negative association with asset turnover also persists ($p < 0.05$). These findings reinforce the robustness of the innovation–productivity link and highlight that innovation exerts differentiated effects across performance dimensions, consistent with earlier research (Woo et al., 2013).

Table 6 explores the effects of R&D Growth Rate, capturing the year-over-year percentage change in innovation spending. Unlike the level-based measures, this dynamic indicator exhibits a statistically significant negative relationship with both labor productivity (coefficient: -0.052; $p < 0.01$) and asset turnover (coefficient: -1.13×10^{-7}; $p < 0.01$). These results suggest that rapid accelerations in R&D

investment may introduce adjustment costs, managerial strain, or absorption challenges that temporarily depress firm performance. Yoo et al. (2019) similarly emphasized that the benefits of R&D depend on firm life cycle and absorptive capacity, pointing to potential downsides of overly aggressive innovation strategies.

To examine conditional and contextual effects, Tables 5–7 introduce interaction terms. In Table 7, the interaction between R&D and Industry Performance (proxied by ROA) is negatively associated with both labor productivity (coefficient: -13.22; $p < 0.01$) and asset turnover (coefficient: -2.95×10^{-5}; $p < 0.01$). These results indicate that increased innovation investment in highly profitable industries may not yield immediate performance gains, possibly due to strategic complacency, market saturation, or diminishing marginal returns. This aligns with Rosenbusch et al. (2011) and Ren et al. (2023), who found that the effectiveness of innovation is contingent on industry conditions, competitive dynamics, and complementary intellectual capital.

Table 8 incorporates an interaction term between R&D Growth Rate and firm-level profitability (R&D × Profitability). The negative and significant coefficients for both performance measures ($p < 0.05$ and $p < 0.01$) imply that even profitable firms may face diminishing marginal returns when expanding R&D too rapidly. This underscores the relevance of absorptive capacity and internal resource alignment, consistent with Tran et al. (2022), who argued that innovation spending must be paired with managerial and organizational capabilities to generate performance benefits.

Table 9 introduces a dummy variable identifying firms in the top quartile of R&D growth (High R&D) and interacts it with R&D Growth Rate. The interaction remains significantly negative for labor productivity (-53.27; $p < 0.01$) and asset turnover (-0.000114; $p < 0.01$), providing additional evidence that aggressive innovation expansion can impose short-term performance costs. These findings correspond with the inverted U-shaped innovation–performance relationship documented by Song et al. (2024), suggesting diminishing or negative returns when R&D investment exceeds an optimal threshold.

Control variables across all models behave as expected. Output consistently shows a positive relationship with both labor productivity and asset turnover, reinforcing scale–performance effects. NMP displays a negative association with labor productivity, implying diminishing marginal returns to labor. Capital intensity is negatively associated with asset turnover, reflecting trade-offs between fixed-asset accumulation and immediate efficiency. Profitability indicators (ROA and ROE) positively influence productivity in several models, though their effects on asset turnover are weaker, consistent with prior research on the moderating role of financial health (Dillen & Vandekerkhof, 2021; Ren et al., 2023).

Taken together, the results in Tables 2–7 offer strong and internally consistent evidence that sustained innovation enhances labor productivity among G7 firms. However, the observed trade-offs in asset efficiency and the contextual sensitivity of innovation returns highlight the need for strategic alignment between R&D investment, firm capabilities, and industry conditions. These findings contribute to a deeper understanding of the complex, conditional nature of the innovation–performance relationship (Clarissa et al., 2024; Ubaldo & Siedschlag, 2020; Yoo et al., 2019).

4.2 Addressing Endogeneity

Although the baseline fixed-effects estimations presented in Section 4.1 provide robust evidence of the relationship between innovation and firm performance, they may still be subject to endogeneity concerns. In particular, the causality between innovation and performance is potentially bidirectional: while innovation can enhance productivity, firms exhibiting higher levels of performance may also be more inclined to invest in R&D. Additionally, unobserved time-varying characteristics such as managerial quality, strategic orientation, or organizational culture may jointly influence both innovation investment and performance outcomes, thereby introducing bias into coefficient estimates.

To address these concerns, the study employs a two-stage least squares (2SLS) estimation strategy, treating R&D Intensity as an endogenous regressor. The first-stage regression generates predicted values for R&D Intensity using internal instruments derived from heteroskedasticity-based identification consistent with the Lewbel approach. These predicted values are then used in the second stage to estimate their causal impact on labor productivity and asset turnover.

The 2SLS results, presented in Table 10, show that the instrumented R&D Intensity variable remains positive and highly significant in the labor productivity regression (coefficient: 307,914.60; $p < 0.01$), closely mirroring the baseline fixed-effects estimate in Table 4. This consistency strengthens the causal interpretation that increased R&D spending enhances firm-level productivity. The slightly larger magnitude of the 2SLS coefficient suggests that the baseline OLS estimates may have been downward-biased, potentially due to measurement error or omitted variable bias.

By contrast, the 2SLS estimate for asset turnover again reveals a negative and statistically significant coefficient on R&D Intensity (1.118; $p < 0.01$). This confirms earlier findings that innovation particularly through increased R&D expenditures may temporarily reduce asset efficiency. Such effects likely reflect the inherent lag between R&D investment and commercialization outcomes, along with the capital-absorbing nature of innovation processes.

The control variables maintain expected signs and statistical significance. Output continues to display a strong positive association with both performance measures ($p < 0.01$), reaffirming the productivity advantages associated with firm scale. NMP remains negatively associated with labor productivity and statistically insignificant in the asset turnover model. Capital intensity is negatively and significantly related to asset turnover, while the effects of leverage, ROA, and ROE replicate previous patterns and add further robustness to the findings.

Importantly, diagnostic tests confirm the relevance and validity of the instruments employed. The Kleibergen–Paap rk LM statistics yield values of 50.88 and 45.53 for the labor productivity and asset turnover models, respectively both significant at the 1% level thereby rejecting the null hypothesis of under-identification.

Overall, the 2SLS estimations corroborate the principal conclusions derived from the fixed-effects models. The causal impact of R&D Intensity on firm performance remains robust after correcting for endogeneity: innovation exerted a significant positive effect on labor productivity while temporarily reducing asset turnover. These findings highlight that innovation-driven strategies involve both long-term performance gains and short-term efficiency trade-offs, particularly within the high-investment R&D environments characteristic of advanced G7 economies.

5. Discussion

This study confirms a nuanced, context-dependent relationship between innovation and firm performance, consistent with both Schumpeterian and Resource-Based View (RBV) perspectives. In line with Schumpeterian theory, sustained R&D Intensity acts as a catalyst for technological progress, thereby improving labor productivity (Aghion & Howitt, 1990; Peters et al., 2017; Hintzmann et al., 2021). At the same time, however, innovation investment is associated with reduced asset turnover, illustrating the classic trade-off highlighted in endogenous growth models: resources allocated to intangible assets and knowledge accumulation often produce delayed operational payoffs (Romer, 1994). When R&D expansion becomes especially aggressive, managerial coordination burdens and internal capacity constraints the “Penrose effect” further suppress short-run efficiency (Penrose, 1959; Kor et al., 2016).

The interaction analyses reinforce that the returns to innovation are contingent rather than universal. The negative coefficients on R&D × Industry Performance and R&D × Profitability show that even firms operating in favorable environments experience muted short-term gains when innovation intensity exceeds absorptive capacity or misaligns with strategic needs, consistent with RBV arguments regarding resource orchestration (Danneels, 2002; Tran et al., 2022). At very high R&D Growth Rates, firms encounter an "innovation paradox," wherein substantial innovation inputs fail to generate proportional performance outputs due to execution bottlenecks, misalignment, or strategic crowding that undermines differentiation (Chesbrough, 2003).

By applying Lewbel's heteroskedasticity-based IV estimator, this study addresses endogeneity concerns and extends prior single-country or single-industry evidence (e.g., Chung & Choi, 2017). Instrumented regressions show that R&D Intensity remains a strong and significant predictor of labor productivity, strengthening the causal interpretation. The cross-country design also uncovers performance asymmetries that earlier studies could not detect, particularly within the strategically turbulent post-pandemic period (2020–2024). Heightened supply chain uncertainty and demand volatility amplify the cost of mistimed or overly aggressive innovation efforts. In this context, incremental, digitally driven innovation projects and agile governance structures can help firms balance long-term transformation with short-term liquidity needs.

The findings also offer important implications for economic policy. Counter-cyclical R&D subsidies, targeted tax incentives, and public–private risk-sharing mechanisms can stimulate private innovation while mitigating temporary efficiency losses, especially in capital-intensive industries. Integrating Schumpeterian and RBV insights provides actionable guidance: policymakers must identify sectors with strong potential for disruptive innovation and craft appropriate regulatory environments, while firms should build human capital, technological capabilities, and organizational processes that strengthen absorptive capacity and ensure innovation can be effectively deployed. Lending relationships may additionally channel firms toward sustainability-oriented innovation pathways, resulting in long-term value creation (Saharti et al., 2024c).

In sum, innovation operates as a double-edged sword. While it strengthens labor productivity and enhances long-run competitiveness, it can temporarily depress asset utilization when undertaken too intensively, poorly timed, or out of alignment with internal capabilities and industry conditions. Strategic pacing, capability development, and supportive policy frameworks are therefore essential to unlock the full benefits of innovation while minimizing its short-term efficiency costs.

6. Conclusions and Implications

This study investigates the impact of innovation and firm growth on firm-level performance across G7 economies during the 2020–2024 period. Drawing on a comprehensive panel of 252 publicly listed firms and employing multiple innovation proxies including R&D Intensity, R&D-to-Assets, and R&D Growth Rate the analysis provides robust empirical evidence on the dual nature of innovation as both a driver of firm performance and a source of operational trade-offs. Across all specifications, the fixed-effects and instrumental variable estimations reveal that innovation exerts a consistently positive and significant effect on labor productivity, reinforcing the productivity-enhancing role of R&D investments. This conclusion remains stable when alternative innovation measures are applied and persists after controlling for endogeneity through two-stage least squares estimation, underscoring the causal link between innovation and firm-level efficiency in advanced economies.

At the same time, the findings highlight the complex performance implications of innovation. While innovation supports long-term productivity gains and competitive advantage, it may also generate short-term efficiency costs particularly for firms intensifying R&D investments or undergoing rapid innovation expansion. These operational trade-offs underscore the importance of strategic alignment between innovation timing, investment intensity, and firm-specific or industry-specific conditions. The study therefore extends existing literature by offering a more nuanced understanding of how innovation simultaneously strengthens and challenges firm performance, emphasizing the role of contextual and organizational factors in shaping innovation outcomes.

The implications of this study are relevant for both managerial practice and public policy. Corporate decision-makers must evaluate innovation strategies not only in terms of expected long-term gains but also with regard to their potential short-run impacts on operational efficiency. Policymakers seeking to promote innovation-led growth should consider designing supportive environments such as targeted subsidies, R&D tax incentives, or innovation-friendly regulatory frameworks that help firms manage transitional costs while advancing technological capabilities. Future research could further enrich these findings by examining sector-specific dynamics, comparing institutional environments across G7 countries, or incorporating measures of innovation quality such as patent citations or new product introductions to deepen understanding of how innovation translates into firm performance.

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