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R&D and Innovation and Its Impact on Firm Performance and Market Value: Panel Evidence from G7 Economies

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Abstract

This study provides the first empirical evidence on the impact of innovation and firm growth on performance across G7 economies, using a unique panel dataset of 252 firms from 2020 to 2024. This study examines two core dimensions of firm performance—labor productivity and asset turnover—and employs multiple innovation proxies, including R&D Intensity, R&D-to-Assets, and R&D Growth Rate. To address potential endogeneity arising from reverse causality and omitted variable bias, the author implements the heteroskedasticity-based instrumental variable estimator, which constructs internal instruments from the model's error structure. The study's results reveal a consistent and significant positive causal effect of innovation on labor productivity, confirming its role as a driver of firm-level efficiency. However, innovation exhibits a negative and significant association with asset turnover, highlighting short-term trade-offs in operational efficiency, particularly in firms with aggressive R&D strategies. This study further finds that these effects are moderated by firm profitability and industry conditions, suggesting the importance of strategic and contextual alignment in innovation outcomes. Taken together, the findings offer new insights into the dual nature of innovation, enhancing productivity while imposing transitional efficiency costs and carrying significant implications for corporate innovation strategy and public policy in advanced economies.

Keywords: innovation; firm growth; labor productivity; G7 economies; firm performance; economic growth

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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 are increasingly compelled to invest in research and development (R&D) as a strategic response to market volatility and rapid technological change. This imperative is particularly salient within the G7 economies, where firms operate in mature markets under intense innovation pressures and heightened global competition. As such, understanding how innovation and firm growth jointly shape performance outcomes represents a question of both scholarly significance and strategic urgency.

A large body of theoretical and empirical literature highlights the critical role of innovation, particularly R&D investment, in enhancing firm productivity, operational efficiency, and competitive advantage. Schumpeterian models emphasize innovation's disruptive potential as a driver of economic growth, while the Resource-Based View (RBV) conceptualizes innovation as a firm-specific strategic asset that enables the development of dynamic

capabilities (Aghion et al., 2015; Danneels, 2002; Zawawi et al., 2016). Empirical research provides consistent evidence that R&D Intensity correlates positively with productivity and technical efficiency (Grant et al., 2019; Song et al., 2024; Habtewold, 2021), although diminishing returns may emerge beyond optimal levels of investment (Song et al., 2024).

Similarly, firm growth—measured through revenue, employment, or asset expansion—has been linked to scale economies, experiential learning, and enhanced resource utilization (Penrose, 1959). The integration of innovation and growth perspectives has drawn attention to internal capabilities such as managerial capacity and absorptive capability (Tan & Mahoney, 2005; Sousa et al., 2021), yet the joint impact of innovation and firm growth on performance remains underexamined, particularly in cross-national contexts where firms are embedded in diverse institutional environments and industrial structures.

Existing research has often relied on single-country or industry-specific samples, which limits the generalizability of findings. Furthermore, concerns about endogeneity, such as reverse causality and omitted variable bias, are pervasive in this domain. High-performing firms may self-select into higher innovation investment, while unobserved firm-level heterogeneity, such as managerial skill or intangible resources, can simultaneously influence growth, innovation, and performance (Rosenbusch et al., 2011; Dillen & Vandekerkhof, 2021). This study offers an empirical contribution by examining the causal relationship between innovation, firm growth, and performance using a cross-country firm-level panel from the G7 economies. This study assembles a balanced dataset of 252 publicly listed firms from 2020 to 2024, characterized by post-pandemic realignment and strategic adaptation. Performance outcomes are captured through labor productivity and asset turnover. At the same time, innovation is measured using multiple proxies—R&D Intensity, R&D-to-Assets ratio, and R&D Growth Rate—and firm growth is assessed via output and employment indicators. Geopolitical instability has further complicated firm-level innovation strategies, particularly through its adverse impacts on ESG performance across international markets (Saharti et al., 2024b).

To address endogeneity concerns, the author applies the Lewbel (2012) heteroskedasticity-based instrumental variable estimator, which exploits internal variation to construct instruments when external instruments are unavailable. This econometric approach is particularly suitable in innovation research, where identifying valid external instruments is difficult.

In sum, this paper provides robust empirical evidence on the performance effects of innovation and growth in a cross-national setting. It contributes to existing literature by integrating firm growth dynamics into the innovation–performance framework, addressing methodological limitations through an advanced IV approach and offering practical insights for firms and policymakers on aligning innovation investments with strategic and contextual factors.

Beyond its academic contributions, this study provides actionable insights for investors and corporate decision-makers. By disentangling the dual impact of innovation on labor productivity and asset efficiency, the analysis informs investment strategies that weigh long-term gains against short-term trade-offs. The findings give investors a more nuanced understanding of how innovation intensity and firm growth dynamics signal future performance potential, particularly within mature economies, such as the G7. In doing so, the study offers an evidence-based framework for integrating innovation indicators into firm valuation and capital allocation decisions.

Building on the identified gap in understanding how innovation affects multiple facets of firm performance, we pose the following research questions: RQ1. Does innovation investment enhance labor productivity in G7 firms? RQ2. Does innovation impose short-term costs by reducing asset turnover? RQ3. Do firm profitability and industry dynamism condition the innovation–performance relationship?

From these questions, we derive five hypotheses: H1a. Greater R&D Intensity is positively associated with labor productivity. H1b. Greater R&D Intensity is negatively associated with asset turnover. H2a. The positive effect of R&D Intensity on productivity is stronger for highly profitable firms. H2b. The negative effect of R&D Intensity on asset turnover is weaker in dynamic industries. H3. The moderating effects in H2a and H2b persist after controlling for endogeneity via instrumental variable estimation.

The rest of the paper is structured as follows. Section 2 reviews theoretical and empirical literature, establishing the conceptual foundations of the study. Section 3 outlines the dataset, variable construction, and econometric methodology, including strategies to address endogeneity. Section 4 presents the empirical findings, supported by robustness checks and interaction analyses to uncover contextual nuances. Section 5 critically discusses the results, highlighting their managerial and policy relevance. Finally, Section 6 synthesizes key insights, literature contributions, and future research directions.

2. Literature Review

Research consistently shows that R&D investment boosts firm productivity and efficiency, but the magnitude of these gains depends on industry context, firm capabilities, and institutional quality (Peters et al., 2017; Song et al., 2024). While R&D generally yields positive returns, diminishing marginal gains may emerge in capital-intensive or technologically saturated settings (Song et al., 2024). Sector-specific evidence—from biotechnology and pharmaceuticals (Grant et al., 2019) to Ethiopian manufacturing (Habtewold, 2021)—confirms that innovation-driven efficiency improvements arise in both developed and emerging markets when supportive ecosystems exist. Institutional strength (Yoo et al., 2019) and firm life-cycle stage further moderate R&D payoffs, with mature firms typically translating knowledge stocks into performance more effectively than young firms.

In emerging economies, R&D also underpins growth and market positioning; Indian food-processing firms, for example, leverage innovation spillovers to reinforce productivity and expansion (Manogna & Mishra, 2021). Collectively, these studies emphasize that strategic alignment, absorptive capacity, and institutional support are prerequisites for realizing R&D benefits.

Two theoretical lenses dominate the innovation–performance debate. Schumpeterian theory posits that "creative destruction" yields temporary monopolistic advantages (Schumpeter, 1934/1983), a dynamic confirmed by Aghion et al. (2015, 2009), Aghion (2016), and Yay and Yay (2022). Resource-Based View (RBV) traditions argue that sustainable advantage stems from VRIN resources (Zawawi et al., 2016); dynamic capabilities (Danneels, 2002) and eco-innovation (Clarissa et al., 2024) illustrate how R&D competencies become competitively valuable when aligned with environmental and strategic goals. Empirical evidence shows that absorptive-capacity mechanisms convert external knowledge into returns (Tran et al., 2022), while weak alignment or institutional voids curtail benefits (Bloom & Van Reenen, 2002; Hall, 2002; Artz et al., 2010). Innovation is typically measured via 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). Combining these indicators yields richer insight and mitigates single-measure limitations. Recent work also highlights syndicated loan structures as an emerging proxy for innovation financing (Saharti et al., 2024a). R&D Intensity is positively linked to labor productivity (Hintzmann et al., 2021; Woo et al., 2013) and asset turnover (Chung & Choi, 2017; Ubaldo & Siedschlag, 2020), especially when complemented by intellectual property investments (Ubaldo & Siedschlag, 2020). Profitability gains are documented across contexts—from Korean manufacturing (Chung & Choi, 2017) to Nigerian insurance (Tamunomiebi & Okorie, 2019)—and reinforced through process innovation (Piening & Salge, 2014) and persistent

R&D engagement (Cefis & Ciccarelli, 2005). Meta-analytic evidence confirms that returns vary with environmental munificence and resource availability (Rosenbusch et al., 2011); high-profit industries and financially healthy firms exploit R&D more effectively (Ren et al., 2023), whereas financially constrained firms often withdraw from ambitious innovation (Dillen & Vandekerkhof, 2021). Capital market perspectives indicate that innovative firms command valuation premiums (Rubera & Kirca, 2012; Handriani, 2020), with intellectual capital intensifying the innovation–value link (Ren et al., 2023). The advent of Fourth Industrial Revolution (4IR) technologies further amplifies productivity and efficiency gains (Benassi et al., 2020).

Endogenous growth models (Romer, 1994; Aghion & Howitt, 1990) complement Schumpeterian views by showing how policy, education, and institutional quality foster knowledge spillovers and sustained economic expansion. Competitive entry threats stimulate incumbent innovation, raising industry productivity (Aghion et al., 2009). Thus, firm-level innovation both shapes and responds to macro-level dynamics. Penrose's (1959) theory underscores managerial capacity as a growth constraint; empirical studies confirm that resource coordination limits the pace and effectiveness of expansion (Lockett et al., 2009; Goerzen & Beamish, 2007). These ideas integrate with RBV to show how internal resource orchestration—particularly of innovation capabilities—enables sustained competitive advantage (Lockett & Thompson, 2003; Sousa et al., 2021; Kor et al., 2016; Tan & Mahoney, 2005). Across theoretical streams and empirical contexts, innovation—operationalized mainly through R&D—drives productivity, profitability, and valuation when (i) strategically aligned with firm resources, (ii) supported by robust institutions, and (iii) complemented by absorptive capability and intellectual property assets. These contingencies explain heterogeneity in innovation outcomes and guide both policy and managerial efforts to maximize R&D returns.

3. Theoretical and Empirical Foundations of the Model

This section reviews the theoretical and empirical foundations linking innovation and firm performance, focusing on the constructs operationalized in the empirical model: labor productivity, asset turnover, R&D Intensity, and firm growth. The review is structured to mirror the model design and highlight the theoretical justifications for the included control variables, ensuring a coherent alignment between theory and empirical specification.

3.1. Innovation and Firm Performance

A robust body of literature underscores the positive influence of R&D investment on firm productivity. Innovation enhances performance through knowledge accumulation, process optimization, and capability development. Peters et al. (2017) conceptualized R&D as a complementary input to capital and labor, augmenting firm productivity. Empirical evidence from Song et al. (2024) and Grant et al. (2019) confirms this relationship across various industries, although excessive R&D may lead to diminishing returns, particularly in capital-intensive sectors. Technological efficiency gains attributed to innovation have been documented in high-tech, pharmaceutical, and emerging markets (Habtewold, 2021). However, the institutional environment and firm maturity modulate R&D effectiveness. For instance, Yoo et al. (2019) showed that early-stage firms often lack absorptive capacity, whereas mature firms integrate R&D more effectively into operational processes.

3.2. Firm Growth and Performance

Firm growth is an essential determinant of performance, influencing economies of scale and resource deployment efficiency. Penrose's theory emphasizes the internal use of underutilized managerial resources as a driver of firm expansion (Tan & Mahoney, 2005).

Accordingly, this study includes output (log of revenue) and employment size (NMP) to capture the growth scale and organizational complexity. The theoretical rationale supports their role as mediators in the innovation–performance relationship.

3.3. Control Variables and Theoretical Justifications

Each control variable in the model has a well-established theoretical foundation: Capital intensity (log of fixed assets) reflects the firm's reliance on physical capital; high capital intensity may influence productivity and asset utilization (Grant et al., 2019). Firm size (log of total assets): Larger firms may benefit from economies of scale but face bureaucratic inefficiencies, influencing innovation implementation (Penrose, 1959). Total debt and leverage ratio: Capital structure affects risk tolerance and investment capacity; financial constraints can hinder or discipline innovation strategies (Dillen & Vandekerkhof, 2021). Profitability metrics (ROA and ROE) indicate financial health, which conditions a firm's ability to absorb innovation costs and sustain R&D over time (Ren et al., 2023).

3.4. Moderating Effects and Strategic Context

Contextual moderators shape the relationship between innovation and performance. This study includes interaction terms to explore these dynamics: R&D × Industry Performance. This section captures sector-specific heterogeneity, acknowledging that innovation returns differ by industry profitability (Rosenbusch et al., 2011). R&D × Profitability tests whether internal financial strength amplifies or moderates the effectiveness of R&D investment. High R&D dummy represents firms with top-quartile R&D growth, assessing whether aggressive innovation yields diminishing returns.

4. Data and Empirical Strategy

4.1. Data

The dataset employed in this study consists of 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 five years from 2020 to 2024. The data were extracted from Refinitiv Eikon, a widely recognized financial and corporate database that offers comprehensive and standardized firm-level information, including R&D expenditures, financial statements, and employment data. This period was purposefully selected to capture the post-pandemic phase of strategic adaptation, during which firms across advanced economies re-evaluated their innovation strategies in response to disrupted global supply chains, digital acceleration, and changing market conditions. The sample spans ten major industry sectors based on the Global Industry Classification Standard (GICS)—namely, information technology, healthcare, industrials, financials, consumer discretionary, consumer staples, energy, materials, utilities, and communication services—ensuring cross-sectoral representation and generalizability. To provide a richer understanding of firm heterogeneity, we report descriptive statistics for core firm attributes, including firm size (total assets), capital intensity, leverage ratio, R&D intensity, employment levels, return on assets (ROA), and return on equity (ROE). These attributes reflect variations in firm scale, innovation capacity, and financial health. The panel is fully balanced, with all firms observed across all five years, which enhances the internal validity of the fixed effects and instrumental variable estimations by reducing concerns related to sample attrition, survivor bias, or unobserved heterogeneity. The study's analysis focuses on two primary dependent variables that reflect firm-level performance: labor productivity, measured as operating revenue per employee, and asset turnover, computed as the ratio of revenue to total assets. These metrics provide complementary insights into operational efficiency and asset utilization.

The core independent variables capture various dimensions of innovation and firm growth. Innovation is operationalized through multiple proxies, including R&D Intensity (R&D expenditure as a share of sales), R&D-to-Assets, R&D Growth Rate, and three interaction terms designed to assess contextual effects: R&D × Industry Performance, R&D × Profitability, and a high-innovation dummy (High R&D). Firm growth is captured through output (log of revenue) and NMP (number of employees), both of which reflect scale and expansion over time. The author includes a comprehensive set of control variables grounded in empirical literature to mitigate omitted variable bias and control for firm-specific heterogeneity. These include capital intensity (log of total fixed assets), firm size (log of total assets), total debt, leverage ratio (total debt to total assets), and profitability metrics, such as return on assets (ROA) and return on equity (ROE). These controls account for firm-level capital structure, scale economies, and financial health.

This study's primary variable of interest is R&D Intensity, with particular attention given to its marginal and interactive effects on performance metrics under different contextual conditions. The interaction terms are designed to uncover whether R&D-driven innovation yields differential effects depending on profitability levels and industry performance.

Table 1 provides detailed definitions and data sources for all variables used in the empirical models. The analysis begins by estimating a baseline model to evaluate the impact of R&D Intensity and output on labor productivity while examining the effects of capital intensity and firm growth on asset turnover. Subsequent specifications incorporate alternative measures of innovation and interaction terms to assess the robustness of these relationships. The consistency of results across these various model formulations enhances the credibility of the findings. To evaluate potential multicollinearity, we also examine the correlation structure among key variables, which generally reveals low intercorrelations, aside from a notably strong association between capital intensity and output, as expected in capital-intensive sectors.

Nevertheless, all control variables are retained to preserve theoretical completeness and mitigate 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

4.2. Summary Statistics

Descriptive statistics are presented for all key variables in the analysis to provide an overview of the data characteristics. Table 1 contains the detailed definitions and data sources, while the summary statistics are reported in the subsequent section. These statistics serve as an initial diagnostic tool, offering insight into the distributional properties and potential variability across firms in the G7 economies during the 2020–2024 period. Labor productivity, the primary performance outcome in this study, exhibits substantial dispersion, with a mean of approximately 416,554 and a standard deviation exceeding 11 million. This wide variability reflects significant heterogeneity in revenue generation relative to workforce size across firms, which is consistent with the sample's diversity of industries and operational scales. Asset turnover, another dependent variable, has a mean of 0.77, indicating that, on average, firms generate less than one unit of revenue per unit of assets annually. However, the maximum value exceeds 115, suggesting notable outliers with exceptionally high asset efficiency.

Given the skewed distributions and presence of outliers in variables such as revenue, total assets, and fixed assets, we apply natural log transformations to output, capital intensity, and firm size. This improves model fit, mitigates heteroskedasticity, and facilitates elasticity-based interpretation of coefficients. Log transformations are standard in firm-level analysis, particularly when addressing scale effects and nonlinear relationships in performance modeling.

Among the innovation variables, R&D Intensity has a mean of 0.25 but a significant standard deviation (5.61), highlighting the skewed distribution of R&D spending relative to sales. This aligns with empirical expectations, as a subset of firms, particularly in high-tech or pharmaceutical sectors, invest disproportionately in R&D. The R&D-to-Assets measure also shows extreme values, with a maximum of over USD 1.7 billion and a considerable range, reinforcing the notion of firm-level asymmetry in innovation strategies. The R&D Growth Rate, measured year-over-year, averages over 1000%, though the standard deviation exceeds 32,000%, suggesting that some firms experience exponential growth in R&D investment during the sample period. Regarding growth controls, output (measured as the log of revenue) and capital intensity (log of total fixed assets) have stable distributions, with means around 22.5 and 21.9, respectively. NMP, capturing the number of employees, varies moderately across firms, with a mean of 9.65. Financial control variables such as leverage (mean = 0.22), ROA (mean = 7.47%), and ROE (mean = 12.94%) display expected patterns for developed-market firms, though the standard deviations signal the presence of firms with harmful or highly volatile profitability, which could influence sensitivity to innovation and growth strategies.

The empirical strategy incorporates multiple regression specifications to rigorously test the stability and explanatory power of R&D-related variables on firm performance. Across all model variants, R&D Intensity consistently demonstrates a positive and statistically significant association with labor productivity, reinforcing its role as a key driver of performance outcomes. Interaction effects between R&D and contextual factors, such as industry characteristics and profitability, uncover significant heterogeneities, suggesting that innovation returns are not uniform but contingent on firm-specific and environmental conditions. Complementary correlation analysis further validates these assumptions by revealing expected patterns: capital-intensive firms tend to exhibit larger output and size metrics. In contrast, firms with stronger R&D profiles often align with higher productivity but lower non-manufacturing presence. The overall low correlation coefficients reduce concerns about multicollinearity, ensuring that the estimated relationships in the regression models are stable and interpretable.

Collectively, these summary statistics confirm the sample's heterogeneity in terms of innovation, firm scale, financial health, and performance outcomes. This variation is essential for capturing differential effects in the subsequent econometric analysis.

4.3. Empirical Strategy and Estimation Methodology

A series of regression models, including linear panel regression models with firm-level fixed effects, is estimated to assess the relationship between innovation, firm growth, and performance across G7 economies. This approach allows us to control for unobserved time-invariant heterogeneity at the firm level that may simultaneously influence innovation inputs and performance outcomes. In addition, we include industry and time-fixed effects to capture standard shocks within sectors and macroeconomic dynamics over the sample period.

The primary econometric specification is as follows:

$$\text{Performance}_{ti} = \beta_0 + \beta_1 \times \text{Innovation}_{ti} + \beta_2 \times \text{Growth}_{ti} + \theta \times Z_{ti} + \gamma_i + \delta_t + \eta_j + \varepsilon_{ti}$$

where performance_{ti} refers to the firm-level performance measures—labor productivity and asset turnover—for firm i in year t.

Innovation_{ti} includes key explanatory variables such as R&D Intensity, R&D-to-Assets, R&D Growth Rate, and interaction terms (e.g., R&D × Industry Performance, R&D × Profitability, and High R&D).

Growth_{ti} represents firm growth indicators, notably output and NMP (number of employees).

Z_{ti} is a vector of control variables: capital intensity, firm size, total debt, leverage ratio, return on assets (ROA), and return on equity (ROE).

γ_i, δ_t, and η_j denote firm, year, and industry-fixed effects, respectively.

ε_{ti} is the idiosyncratic error term, assumed to be independently and identically distributed (i.i.d.) across firms and time.

All models are estimated using robust standard errors to ensure heteroscedasticity-consistent inference.

Models are further estimated with interaction terms to investigate the robustness of innovation effects and potential nonlinearity. These include interactions between R&D growth and profitability and between R&D growth and industry performance to test for conditional effects and strategic complementarities.

Given the possibility of reverse causality—whereby higher-performing firms may be more likely to invest in R&D—we implement a two-stage least squares (2SLS) instrumental variables approach. In this framework, R&D Intensity is treated as an endogenous regressor. Instrumental validity is verified using the Kleibergen–Paap LM statistic for under-identification and the Hansen J-statistic for over-identification. The 2SLS model is specified as follows:

$$\text{Performance}_{ti} = \alpha_0 + \alpha_1 \times \text{R\&D Intensity}_{ti} + \alpha_2 \times \text{Growth}_{ti} + \theta \times Z_{ti} + \gamma_i + \delta_t + \eta_j + \varepsilon_{ti}$$

where $\text{R\&D Intensity}_{ti}$ is the predicted value from the first-stage regression.

The results from both the fixed-effects and instrumental variable approaches are presented in Tables 2–9, covering multiple specifications and robustness checks. The consistent significance of innovation and growth variables across these models underscores the robustness of the relationship between R&D efforts and firm-level performance within the G7 context.

Table 2. Summary statistics.

Variable	Unit	Mean	Std dev	Min	Max
Asset Turnover	Ratio	0.77355	3.085	0.00344	115.6248
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 ***
	−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

Table 4. *Cont.*

	(1)	(2)
Variables	**Labor Productivity**	**Asset Turnover**
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
	−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.

	(1)	(2)
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)

Table 6. *Cont.*

Variables	(1) Labor Productivity	(2) Asset Turnover
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
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	(1) Labor Productivity	(2) 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	(1) Labor Productivity	(2) 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.

Variables	(1) Labor Productivity	(2) 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 ***
	(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; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5. Estimated Results

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	Asset Turnover
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	1963.956 (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 ** (23,343.000)	−0.022 (0.036)
Constant	−1,298,716.000 *** (231,751.500)	0.110 (0.203)
Observations	741	741
R-squared	0.4418	0.5533
Kleibergen–Paap rk LM stat	50.884 ***	45.530 ***

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

5.1. 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. The outcome variables are labor productivity and asset turnover, reflecting firm-level resource utilization and operational effectiveness efficiency. Across all specifications, standard errors are robust and clustered at the firm level to address potential serial correlation. The analysis

begins with Table 4, which reports the baseline estimates using R&D Intensity—defined as R&D expenditure scaled by sales—as the primary proxy for innovation. The results indicate a strong and statistically significant positive relationship between R&D Intensity and labor productivity (coefficient: 278,795; $p < 0.01$), confirming the role of innovation as a productivity-enhancing input. This aligns closely with prior studies demonstrating that R&D contributes to developing intangible assets and technological capabilities that raise worker productivity (Hintzmann et al., 2021; Peters et al., 2017).

Furthermore, this result supports the broader literature asserting that innovation efforts, especially when sustained, generate meaningful gains in operational efficiency (Song et al., 2024; Habtewold, 2021). However, the effect on asset turnover is negative and significant (coefficient: -0.934; $p < 0.01$), suggesting that firms with higher innovation spending may experience a short-run decline in asset efficiency, potentially due to increased capital absorption or delayed innovation returns. Similar concerns have been noted by Ubaldo and Siedschlag (2020), who emphasized that the complementarity between R&D and intellectual capital may take time to translate into efficient asset use, especially during periods of innovation build-up.

Table 5 tests the robustness of these results by employing R&D-to-Assets as an alternative innovation measure. This specification continues to show a significant positive association with labor productivity ($p < 0.05$), while its negative effect on asset turnover remains consistent ($p < 0.05$). These findings underscore the robustness of the innovation–productivity link, regardless of the denominator used in scaling R&D expenditure, and reinforce the empirical observation that innovation can exert asymmetric effects on different dimensions of firm performance (Woo et al., 2013).

Next, Table 6 examines the effect of the R&D Growth Rate, capturing the year-on-year percentage change in R&D spending. Interestingly, this dynamic measure of innovation effort reveals 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 while innovation spending contributes positively to productivity when considered in levels, rapid accelerations in R&D investment may introduce adjustment costs or managerial inefficiencies that temporarily depress firm performance. This insight echoes findings by Yoo et al. (2019), who demonstrated that the benefits of R&D are moderated by a firm's life cycle and internal capacity to absorb and integrate innovation, emphasizing the potential downside of overly aggressive innovation strategies.

To probe the contextual effects of innovation, Tables 5–7 introduce a set of interaction terms designed to capture conditional heterogeneity in the innovation–performance relationship. In Table 7, R&D interacts with Growth Rate and Industry Performance, proxied by ROA. The interaction term (R&D $\times$ Industry Performance) is negatively associated with both labor productivity (coefficient: -13.22; $p < 0.01$) and asset turnover (coefficient: -2.95×10^{-5}; $p < 0.01$). This implies that, counterintuitively, additional innovation investment in industries with high profitability does not translate into immediate performance gains, potentially due to market saturation, strategic slack, or crowding-out effects. This finding is consistent with the argument advanced by Rosenbusch et al. (2011), who found that the innovation–performance relationship varies significantly with industry context and competitive intensity. It also resonates with Ren et al. (2023), who showed that innovation effectiveness is conditioned by external profitability and intellectual capital and is not uniformly positive across sectors.

Table 8 incorporates the interaction between R&D Growth Rate and firm-level profitability, creating a variable (R&D $\times$ Profitability) that captures the internal capacity of firms to absorb and leverage innovation. The negative and significant coefficients across both performance measures ($p < 0.05$ and $p < 0.01$) suggest that even profitable firms may experi-

ence diminishing marginal returns to innovation when R&D growth accelerates beyond a sustainable threshold. This reinforces the importance of pacing innovation by internal absorptive capacity—an insight supported by Tran et al. (2022), who emphasized that R&D expenditures must be complemented by managerial and organizational capabilities to yield performance benefits.

Finally, Table 9 introduces a binary High R&D variable, defined as the top quartile of firms by R&D growth, and interacts it with R&D Growth Rate. The interaction term is again significantly negative for both performance indicators (labor productivity: −53.27, asset turnover: −0.000114; $p < 0.01$), providing further evidence that aggressive innovation strategies, though potentially beneficial in the long term, can adversely impact short-term efficiency. This empirical pattern supports the notion of a non-linear or inverted U-shaped relationship between R&D and performance, as Song et al. (2024) previously documented in their study of high-tech manufacturing firms. Such findings suggest that additional R&D investments may yield diminishing or even negative returns beyond a certain threshold in the short term. Control variables across all specifications exhibit expected signs. Output is consistently and positively related to both dependent variables, reaffirming the scale–performance relationship. NMP is negatively associated with labor productivity, suggesting diminishing returns to labor absent productivity-aligned growth. Capital intensity consistently exhibits a negative relationship with asset turnover, reflecting the trade-off between physical investment and immediate efficiency. Profitability metrics (ROA and ROE) are positively associated with productivity in several models, though their effects on asset turnover are less pronounced. These relationships mirror findings from existing literature on the moderating role of firm financial health in shaping innovation returns (Dillen & Vandekerkhof, 2021; Ren et al., 2023).

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

5.2. Addressing Endogeneity

While the baseline fixed-effects estimations presented in Section 4.1 offer robust evidence of the relationship between innovation and firm performance, they may still suffer from potential endogeneity concerns. Specifically, the direction of causality between innovation and performance may be bidirectional: while innovation can drive productivity, firms with higher performance levels may also be more inclined to invest in R&D. Moreover, unobserved time-varying factors such as managerial quality or strategic orientation could simultaneously influence both innovation and performance, leading to biased coefficient estimates.

To mitigate these concerns, a two-stage least squares (2SLS) estimation strategy is employed, treating R&D Intensity as an endogenous variable. The first-stage regression generates predicted values for R&D Intensity using internal instruments derived from the data structure, consistent with Lewbel-type heteroskedasticity-based identification. The second stage then uses these expected values to estimate their impact on labor productivity and asset turnover.

The 2SLS results are presented in Table 10. The coefficient on instrumented R&D Intensity remains positive and highly significant in the labor productivity regression (coef-

ficient: 307,914.60; $p < 0.01$), closely aligned with the fixed-effects baseline in Table 4. This consistency reinforces the causal interpretation that increased R&D spending enhances firm-level productivity. Notably, the magnitude of the coefficient is slightly more significant in the 2SLS specification, suggesting that baseline OLS estimates may have been downward-biased due to attenuation from measurement error or omitted variable bias. In contrast, the 2SLS estimate for asset turnover again yields a negative and statistically significant coefficient on R&D Intensity (1.118; $p < 0.01$). This finding confirms the earlier insight that innovation, particularly in increased R&D outlays, may temporarily reduce asset efficiency, likely due to delays between investment and commercialization or the capital-absorbing nature of R&D infrastructure.

Control variables retain their expected signs and significance levels. Output continues to exhibit a strong positive association with both performance metrics ($p < 0.01$), reaffirming the productivity advantages of firm scale. NMP is negatively associated with labor productivity and remains insignificant in the asset turnover regression. Capital intensity is negatively and significantly related to asset turnover, while the effects of leverage, ROA, and ROE mirror earlier results and provide additional robustness. Crucially, diagnostic tests validate the strength and appropriateness of the instruments used. The Kleibergen–Paap rk LM statistic yields values of 50.88 and 45.53 for the labor productivity and asset turnover models, respectively. Both are significant at the 1% level, thereby rejecting the null hypothesis of under-identification.

Overall, the 2SLS results corroborate the main conclusions drawn from the fixed-effects models. The causal impact of R&D Intensity on firm performance is robust to endogeneity correction: innovation efforts significantly improve labor productivity while temporarily reducing asset turnover. These findings emphasize the importance of understanding the timing and efficiency trade-offs associated with innovation-driven strategies, particularly in the context of high-investment, high-return R&D environments typical of advanced economies like the G7.

5.3. Discussion

This study confirms a nuanced, context-dependent link between innovation and firm performance, in line with both Schumpeterian and Resource-Based View (RBV) logics. Consistent with Schumpeterian theory, sustained R&D Intensity catalyzes technological progress that lifts labor productivity (Aghion & Howitt, 1990; Peters et al., 2017; Hintzmann et al., 2021). However, the same innovation spending lowers asset turnover, illustrating the classic trade-off predicted by endogenous growth models: resources tied up in intangible assets and knowledge spillovers delay operational pay-offs (Romer, 1994). When R&D expansion is exceptionally aggressive, the strain on managerial coordination and internal capacity—the "Penrose effect"—further depresses near-term efficiency (Penrose, 1959; Kor et al., 2016).

Interaction tests show that innovation returns are contingent rather than universal. Negative coefficients on R&D × Industry Performance and R&D × Profitability indicate that even firms in attractive environments see muted short-run gains when innovation outpaces absorptive capacity or strategic fit, echoing RBV arguments about resource orchestration (Danneels, 2002; Tran et al., 2022). At very high R&D Growth Rates, firms face the "innovation paradox": significant inputs do not translate into proportional outputs because execution bottlenecks, misalignment, or strategic crowding erode differentiation (Chesbrough, 2003). By employing Lewbel's heteroskedasticity-based IV estimator, the analysis corrects endogeneity and extends prior single-country or single-industry evidence (e.g., Chung & Choi, 2017). R&D Intensity remains a robust predictor of labor productivity, even after instrumentation, underscoring causal credibility. The cross-country setting also

reveals performance asymmetries that earlier studies could not detect. The post-pandemic window (2020–2024) heightens the strategic relevance of these findings. Supply chain shocks and demand volatility magnify the cost of mistimed innovation. Incremental, digitally enabled projects and agile governance can balance long-term transformation with near-term liquidity.

For policymakers, counter-cyclical R&D subsidies, targeted tax credits, and risk-sharing mechanisms can encourage private innovation while buffering efficiency losses, especially in capital-intensive sectors. Integrating Schumpeterian and RBV perspectives yields concrete guidance: policymakers should identify industries ripe for disruptive innovation and craft supportive regulation, while managers must build human capital, technological competencies, and processes that allow the firm to absorb and exploit innovation. Lending relationships can further steer firms toward sustainability-linked innovation pathways (Saharti et al., 2024c). In sum, innovation is a double-edged sword. It strengthens labor productivity and long-run competitiveness but can hinder short-term asset utilization when intensity is excessive, poorly timed, or misaligned with internal capabilities and industry context. Strategic pacing, capability development, and well-designed policy instruments are therefore essential to unlock innovation's full value while mitigating its temporary efficiency costs.

6. Conclusions

This study investigates the impact of innovation and firm growth on firm-level performance across G7 economies over the period 2020–2024. Using a comprehensive panel dataset of 252 firms and employing a range of innovation proxies—including R&D Intensity, R&D-to-Assets, and R&D Growth Rate—we provide robust empirical evidence on the dual role of innovation as a performance driver and a source of operational trade-offs.

This study's fixed effects and instrumental variable regressions consistently show that innovation positively and significantly enhances labor productivity, confirming the productivity-enhancing role of R&D investments. This relationship holds across alternative specifications and remains robust after addressing endogeneity using two-stage least squares estimation. These findings reaffirm innovation's central role in driving firm-level efficiency and sustaining competitive advantage in advanced economies.

The findings of this study contribute to literature by offering a nuanced understanding of innovation's performance implications, accounting for its long-term productivity gains and short-term operational costs. The results have important implications for corporate decision-makers, who must weigh innovation strategies' timing, intensity, and contextual fit, and policymakers aiming to foster innovation-led growth. Future research could build on this work by exploring sector-specific dynamics in more detail, examining cross-country institutional differences within the G7, or incorporating measures of innovation quality (e.g., patent citations or product innovations) to further refine the understanding of how innovation translates into firm performance.

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