DRIVERS OF FIRM GROWTH: AN EMPIRICAL STUDY OF PRODUCT, PROCESS, AND R&D INNOVATION

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Drivers of Firm Growth: An Empirical Study of Product, Process, and R&D Innovation

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DECLARATION

We have written this master’s thesis independently. Any ideas and data taken from other authors have been fully referenced.

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ABSTRACT

This study examines how product innovation, process innovation, and investing in R&D are related to firm growth using cross-sectional data from 7,319 firms across 14 European countries based on the World Bank Enterprise Survey. Employing Ordinary Least Squares, Instrumental Variable method, and quantile regression methods, the analysis accounts for potential endogeneity by using industry-level averages of innovation as instruments. The results show that product innovation is not consistently linked to higher growth and, under the IV approach, is associated with notably lower growth, suggesting that investment in new products may involve delays in realizing commercial outcomes. In contrast, process innovation shows a more stable and positive relationship with firm growth, particularly among firms in the upper part of the growth distribution. Investing in R&D, including its associated costs in the short term, does not show a clear pattern in relation to firm growth, with estimated differences close to zero in most cases. Firm characteristics such as age and size remain relevant: younger and medium-sized firms tend to grow more quickly than older or smaller ones. Overall, the study highlights the diverse ways through which product innovation, process innovation and investing in R&D are associated with firm growth, varying according to firm profile and national context.

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1. INTRODUCTION

Innovation, when approached strategically, remains a central pillar in how firms navigate competitive markets and pursue long-term growth. Rather than being a stand-alone activity, innovation is increasingly seen as a deliberate choice shaped by firm-specific goals, resource capabilities, and broader economic conditions. This perspective is well-rooted in the literature, with early theoretical contributions highlighting innovation's role in reshaping industries and driving productivity (Schumpeter, 1934, 1942; Romer, 1990; Grossman and Helpman, 1994). More recent studies have emphasized that it is not innovation *per se*, but the strategy behind it - be it product, process, or R&D, hat determines how firms respond to shifting market dynamics (Geroski et al., 1993; Laursen and Salter, 2006).

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In this study, we examine how product and process innovations individually and in combination affect firm growth and whether these effects are conditioned by contemporaneous R&D investment. Drawing on harmonized firm-level data collected between 2023 and 2024 from fourteen European countries, the analysis captures a diverse range of economic contexts. By focusing on the interaction between different innovation types and real-time R&D activity, the study provides new insights into how firms adapt their innovation strategies in response to changing economic conditions. This cross-national perspective is particularly relevant in the wake of the COVID-19 pandemic, as firms across Europe continue to recover and reposition themselves within evolving industrial landscapes.[1]

The significance of innovation strategies became particularly evident during the COVID-19 pandemic. In the face of abrupt disruptions, firms that acted proactively by adapting their operations, rethinking production lines, or exploring digital tools demonstrated a level of resilience that reactive firms often lacked (OECD, 2021; Archibugi et al., 2021). This underscores the idea that innovation, when embedded within a firm's broader strategic approach, can be a powerful buffer against uncertainty.

Europe offers an ideal setting to examine these dynamics. Its mix of advanced and emerging economies creates a rich empirical ground for understanding how different institutional contexts and levels of development shape the outcomes of innovation strategies (Castellacci and Natera, 2013). This diversity helps illuminate not only whether innovation supports firm growth but also under what conditions and through which strategic channels growth is realized.

Although considerable scholarly attention has been dedicated to understanding innovation's positive economic implications, notable ambiguities persist; particularly regarding the distinct and joint effects of product and process innovation on firm growth (Cassiman and Golovko, 2011; Peters, 2004). Product innovation, often defined by the development of new or significantly improved goods or services, is typically linked to direct growth channels such as increased market share and enhanced customer value. In contrast, process innovation

[1] The dataset includes firms from Austria, Belgium, Croatia, Czech Republic, Estonia, Finland, France, Germany, Hungary, Italy, Poland, Portugal, Spain, and Sweden.

improvements in production techniques or internal operations tend to drive growth indirectly, mainly through efficiency gains and cost reductions (Evangelista and Savona, 2003; Dachs and Peters, 2014).

However, what remains underexplored are the interaction effects between these two innovation types - specifically, how their simultaneous implementation may reinforce or dampen each other's impact on firm performance. For instance, process innovation might enable firms to scale up or deliver new products more efficiently, amplifying the returns from product innovation. Conversely, if process improvements are geared towards standardization, they may limit the flexibility needed to support innovative product development.

While prior studies have often examined product and process innovation in isolation or controlled for one while estimating the other's effect, comparative and integrative approaches remain limited especially in cross-country contexts. This study addresses that gap by jointly analyzing the effects of product and process innovation on firm growth using recent data from a diverse set of European countries. By doing so, it offers new insights into whether firms benefit more from pursuing these strategies independently or in tandem, and how this relationship may vary across different institutional and market settings.

An additional critical yet relatively underexplored dimension within the innovationgrowth relationship concerns the role of contemporaneous research and development (R&D) investment as a moderating factor. Building on the absorptive capacity framework, existing literature highlights R&D's importance in equipping firms to absorb, integrate, and apply external knowledge and technologies effectively (Cohen and Levinthal, 1989, 1990; Zahra and
George, 2002). However, much of the empirical focus has remained on cumulative or historical R&D investments, often overlooking the more immediate value of current R&D decisions; particularly in shaping firms' ability to respond to emerging opportunities or adapt quickly during periods of disruption (Fabrizio, 2009; Leiponen and Helfat, 2010). In this context, current R&D intensity reflects not just financial commitment but also a firm's operational readiness and strategic flexibility in deploying innovation-related resources when they are most needed.

At the same time, it is increasingly recognized that not all innovation stems directly from formal R&D activities. The *doing, using, and interacting (DUI)* mode of innovation emphasizes experiential learning, practical problem-solving, and informal networks as equally important drivers of innovation, particularly among small and medium-sized enterprises or firms in traditional industries (Jensen et al., 2007). Incorporating this broader view allows for a more nuanced understanding of how innovation occurs in practice and the extent to which R&D-based and non-R&D-based pathways interact in influencing firm growth.

The urgency of examining these dynamics becomes clearer when considering how firms' innovation behaviours have evolved in response to recent economic disruptions. Traditionally, R&D activities were often framed in terms of long-term technological development or fundamental research. However, in the aftermath of the COVID-19 crisis and amid growing global uncertainties, firms are increasingly shifting their focus toward more immediate, strategic R&D allocations - particularly in areas like digitalization, operational resilience, and process optimization (European Innovation Scoreboard, 2022; Kancs and Siliverstovs, 2021). These shifts reflect a broader move toward adaptive innovation practices, where firms aim to stay agile and responsive to fast-changing environments.

In contributing to the existing innovation literature, this research makes two substantial advances. First, by explicitly distinguishing and empirically comparing the individual and joint effects of product and process innovations, it offers greater analytical clarity on how each type contributes to firm growth both in isolation and through interaction. Second, and more critically, the study advances prior research by shifting the focus from lagged or cumulative R&D expenditures to **contemporaneous R&D investment**. While earlier studies have predominantly examined how past R&D influences future outcomes, this research emphasizes the immediate role of R&D as a real-time strategic lever, particularly in volatile economic environments where timely allocation decisions can significantly influence innovation performance and firm resilience (Griliches, 1998; Cockburn and Henderson, 1998). This more current lens responds to growing calls for dynamic, context-sensitive analyses of innovation behavior under conditions of uncertainty.

From a policy perspective, the insights derived from this study can be particularly valuable for European policymakers engaged in designing and implementing targeted innovation strategies aimed at fostering economic recovery and sustained growth. Enhanced empirical understanding of differential innovation impacts and the strategic significance of contemporaneous R&D spending can guide more precise policy interventions, enabling policymakers to effectively leverage innovation ecosystems to maximize economic resilience and competitiveness (Pianta, 2005; Evangelista and Vezzani, 2012).

Lastly, by adopting a comprehensive cross-country comparative approach, this study addresses a notable limitation in prior research, which has often concentrated on single-country analyses or relatively homogeneous regions(Altuzarra, 2024), (Anwar & Sun, 2024). In contrast, the dataset used here encompasses fourteen European countries spanning both advanced industrial economies and emerging markets, including Germany, Sweden, Portugal, Poland, and Croatia. This diversity enables the analysis to capture variation in institutional settings, innovation policy environments, and firm capabilities - factors known to influence how innovation strategies translate into growth.

Such heterogeneity is essential for moving beyond generalizations and understanding how innovation functions under different national innovation systems. Previous cross-country studies (e.g., Mohnen and Röller, 2005; Crespi and Zuniga, 2012) have highlighted the importance of institutional context but have typically focused on broader innovation inputs or patent activity. By focusing on the interaction between innovation types and contemporaneous R&D investment, this study contributes a more fine-grained understanding of how firm-level outcomes vary across firms. It thereby adds to the evolving literature on comparative innovation performance of firms in Europe, particularly in light of recent structural changes.

The remainder of the paper is structured as follows: Section 2 provides a detailed literature review highlighting theoretical frameworks and empirical evidence, thereby establishing the scholarly context for this study. Section 3 outlines data sources, key variables, and the methodological framework. Section 4 presents empirical results and robustness checks. Section 5 discusses implications for managerial practice and innovation policy, and Section 6 concludes by summarizing key insights and proposing directions for future research.

2. LITERATURE REVIEW

2.1. Theoretical Perspectives on Innovation and Firm Growth

Innovation has long been recognized as a central mechanism in shaping firm performance and long-run economic growth. While its conceptual roots can be traced to Joseph Schumpeter's theory of *creative destruction* which emphasized the role of innovation in displacing outdated industries and creating new economic structures (Schumpeter, 1934, 1942), contemporary research has shifted toward empirically evaluating how different types of innovation influence firm-level outcomes such as firm performance, competitiveness and market expansion in dynamic market environments. Within this broad literature, product and process innovations have received particular attention due to their distinct channels of impact: product innovation often drives revenue growth through differentiation and market expansion, while process innovation tends to improve operational efficiency and cost competitiveness (Cohen and Klepper, 1996; Hall, 2011). Hall (2011), drawing on evidence mainly from manufacturing and services in OECD countries, particularly Europe and the US, shows how the effects of these innovation types can vary depending on industry and firm-level conditions. Similarly, Cohen and Klepper (1996), using data from US manufacturing firms engaged in R&D, find that larger firms are more inclined toward process innovation because of scale advantages, whereas product innovation holds greater potential for revenue growth, especially in dynamic or competitive markets.

Several empirical studies have reinforced these distinctions, emphasizing that firms leveraging product innovation are more likely to access new markets or command price premiums (Mairesse and Mohnen, 2010; Cassiman and Golovko, 2011), whereas process innovation may provide more incremental performance improvements, especially in mature industries (Peters, 2004; Doms, Dunne, and Troske, 1997). Moreover, these effects are not uniform across contexts. Evidence from Crespi and Zuniga (2012), using data from Latin America, and Piva and Vivarelli (2009) in a European setting, suggests that institutional quality, firm size, and sectoral characteristics can significantly moderate the innovation-growth relationship.

Meta-analytical work also highlights the importance of disaggregating innovation effects to avoid masking heterogeneity across firm types and country contexts (De Jong and Marsili, 2006; Rosenbusch, Brinckmann, and Bausch, 2011). Against this backdrop, the present study contributes by not only examining product and process innovations in isolation but also exploring how their *interaction* shapes firm growth; a perspective that remains relatively underexplored in cross-country settings. This approach enables a more nuanced understanding of how innovation strategies operate under diverse institutional configurations and economic structures.

Building extensively upon Schumpeter’s foundational insights, subsequent theoretical advancements have clarified how innovation serves as a key driver of firm growth and competitive advantage. Endogenous growth theory is particularly influential, placing innovation and knowledge accumulation at the center of sustained firm-level expansion. Seminal contributions by Romer (1990) and Grossman and Helpman (1994) emphasize that ongoing investment in research and development (R&D) generates new knowledge that directly boosts a firm's productivity and market position. Beyond these internal gains, the spillover of knowledge to other firms further enhances growth opportunities across industries by enabling firms to improve their products and processes without shouldering the entire cost of innovation. This continuous flow of knowledge is critical for firm growth, as it fosters innovation capacity, expands market reach, and strengthens a firm's long-term performance.The channels through which these spillovers operate include labor mobility, supplier-customer relationships, imitation, and informal knowledge networks (Griliches, 1992; Jaffe, Trajtenberg, and Henderson, 1993). Particularly in high-tech and science-based sectors, such spillovers have been shown to drive regional innovation clusters and national competitiveness (Audretsch and Feldman, 1996; Furman, Porter, and Stern, 2002). At the firm level, Cohen and Levinthal's (1990) concept of absorptive capacity underscores that the benefits firms derive from external knowledge depend heavily on their own investment in R&D, which enables them to recognize, assimilate, and apply new ideas effectively.

More recent extensions of endogenous growth models have attempted to differentiate between the types of innovation that generate these effects. For instance, Aghion and Howitt (1998) model innovation as both a driver of creative destruction and a cumulative, learningbased process, where each generation of innovation builds on prior technological advances. This has important implications for firm strategy: product innovation may offer more visible market returns, but process innovation; particularly when diffused across an industry, can enhance overall productivity growth through shared learning and efficiency improvements (Griffith, Redding, and Van Reenen, 2004).

By situating this study within these theoretical frameworks, we highlight the relevance of examining not just *whether* innovation affects growth, but *how* the timing, type, and interaction of product and process innovation particularly in relation to real-time R&D investment; shape firm-level outcomes in heterogeneous economic environments.

Further elaboration of innovation theory has emphasized distinct classifications of innovation, notably distinguishing between product and process innovations, each exerting unique impacts on firm growth dynamics. Product innovation encompasses the development and introduction of new or significantly improved goods or services, directly enhancing firms' market positions by stimulating consumer demand, creating differentiated competitive advantages, and increasing sales and market shares (Cassiman and Golovko, 2011; Hall et al., 2008). These innovations enable firms to not only establish leadership in existing markets but also facilitate entry into entirely new market segments, thereby directly influencing revenue trajectories and growth potential.

Conversely, process innovations refer to enhancements in production techniques, organizational structures, or operational procedures, primarily targeting efficiency improvements, cost reductions, and productivity gains. Such innovations indirectly drive firm growth through improved profit margins, resource allocation efficiency, and enhanced competitiveness (Lachenmaier and Rottmann, 2011; Evangelista and Savona, 2003). Although process innovations may not yield immediate increases in sales or market share, they play a crucial role in ensuring firm sustainability by enhancing resource efficiency, reducing production costs, and improving internal workflows and adaptability. These improvements support a firm's capacity to scale operations, respond to external shocks, and maintain longterm competitiveness especially in industries where margins are tight and operational resilience is key (Peters, 2004; Dachs and Peters, 2014). By contrast, product innovation is more directly associated with top-line growth through the introduction of novel or significantly improved goods and services that create differentiation, satisfy emerging consumer needs, and open new market segments (Mairesse and Mohnen, 2010; Piva and Vivarelli, 2009).

This study builds on these theoretical expectations by hypothesizing that product innovation will exert a more immediate and visible impact on firm growth, particularly in terms of revenue expansion. Meanwhile, process innovation is anticipated to deliver more gradual benefits by strengthening the efficiency and cost structure of firms, which may not reflect as directly in short-term growth indicators but are critical for long-term performance. Moreover, the study considers the potential interactive effect of these innovation types, recognizing that firms engaging in both may realize complementary benefits. For instance, when enhanced production processes enable the scalable and cost-effective delivery of new products (Cassiman and Veugelers, 2006; Triguero, Córcoles, and Cuerva, 2014).

By empirically distinguishing these effects using harmonized multi-country firm-level data, the analysis provides a clearer understanding of how firms' innovation strategies shape their growth trajectories under different institutional and economic conditions.

2.2. **Empirical Studies on Innovation Types and Firm Growth**

A review of empirical approaches in the innovation-growth literature reveals a variety of methods, reflecting differences in data availability, research focus, and country context. Many early studies relied on survey-based cross-sectional data, often using innovation indicators from the Community Innovation Survey (CIS) to examine the effects of product and process innovations on firm performance (e.g., Crépon, Duguet, and Mairesse, 1998; Mairesse and Mohnen, 2010). These studies frequently employed probit or logit models for innovation inputs and outputs and extended into structural equation modeling to account for simultaneity and endogeneity.

Panel data approaches have gained traction more recently, enabling scholars to control for unobserved heterogeneity and track innovation outcomes over time. For instance, Peters et al. (2018) used longitudinal firm-level datasets from Germany to distinguish between short- and long-term effects of R&D and innovation activities. Dynamic panel models, including system GMM, have also been used to address reverse causality between innovation and firm growth (Coad and Rao, 2008; Hall et al., 2009).

In terms of moderating effects, particularly regarding R&D, some studies rely on interaction terms in regression models, while others adopt quantile regressions or matching techniques to explore heterogeneity across firm types (Bianchini, Pellegrino, and Tamagni, 2019; Leiponen and Helfat, 2010). Despite these methodological advances, many studies continue to focus on cumulative or lagged R&D, with fewer capturing contemporaneous R&D activity. Moreover, most cross-country analyses have been descriptive or limited to countrylevel indicators, lacking firm-level granularity across diverse institutional environments.

This methodological landscape informs the present study's design, which combines recent harmonized cross-sectional data with interaction modeling and fixed effects estimation to better isolate the effects of contemporaneous innovation indicators under heterogeneous conditions.

Empirical research has extensively examined the relationship between innovation and firm growth, consistently revealing that outcomes vary depending on the type of innovation, firm characteristics, and the surrounding industry and institutional context. Product innovations, defined as the introduction of new or significantly improved goods and services, have been shown to drive firm performance by expanding customer bases, enhancing brand visibility, and fostering competitive advantage across a range of sectors (Hall et al., 2008; Benavente and Lauterbach, 2008). Firms that engage in product innovation often report increased demand, improved pricing power, and stronger market positions, which collectively contribute to accelerated growth (Cassiman and Golovko, 2011; Peters, 2004; Raymond and St-Pierre, 2010).

While a number of prior studies focus on firms with a sustained or repeated history of innovation activity, such patterns typically require long-term panel data or innovation histories that are difficult to observe in cross-country firm-level surveys. In contrast, this study emphasizes the timing and configuration of innovation indicators particularly the interaction between product and process innovation.. By shifting the focus from innovation frequency to strategic combinations observable within a specific time frame, the analysis captures a more immediate snapshot of how firms deploy innovation under current economic conditions. This approach is particularly relevant for assessing short- to medium-term performance effects in periods of recovery and structural transition, where firm decisions tend to be more reactive and context-dependent

However, the empirical evidence of the relationship between product innovation and firm growth remains inconsistent. It is highly context-dependent and influenced by a range of internal and external constraints that shape a firm's ability to translate innovation into tangible growth. Firm size is a frequently cited determinant. Smaller firms often face more acute financial, organizational, and market-related barriers that limit their capacity to scale innovative outputs (Triguero and Córcoles, 2013; Baldwin and Lin, 2002). These constraints can include limited access to finance, a narrower customer base, lower brand recognition, and insufficient infrastructure to support product commercialization. In contrast, larger firms typically benefit from economies of scale, existing distribution networks, and more robust financial reserves, which make it easier to absorb innovation-related risks and reap performance gains.

Beyond firm size, managerial capabilities and strategic vision play a critical role in shaping innovation outcomes. Freel and Robson (2004) and Garcia and Calantone (2002) emphasize that firms with strong leadership, clearer innovation goals, and better decisionmaking frameworks are more likely to allocate resources efficiently and adapt innovation strategies to market needs. These factors are particularly important in dynamic or uncertain environments, where innovation success often hinges on how effectively firms can pivot or leverage internal knowledge.

Importantly, these constraints do not only affect the *outcomes* of innovation but also the firm's ability to engage in innovation in the first place, particularly through formal R&D. Financial limitations, managerial inexperience, and risk aversion may prevent firms from initiating or sustaining R&D investment, thereby limiting their capacity to build innovation pipelines or absorb external knowledge (Savignac, 2008; Czarnitzki and Hottenrott, 2011). For this reason, even though R&D intensity is not the central focus of this study, understanding these barriers is crucial when interpreting firm-level differences in innovation performance.

Where data allow, variables reflecting managerial experience or firm governance can serve as useful control variables to account for these internal differences in innovation capacity. While our dataset does not offer detailed managerial profiles, it does allow us to proxy for structural constraints through firm size, sector classification, and innovation expenditure intensity. Together these factors shape a firm's innovation potential and its likelihood of translating that potential into measurable growth.

In contrast to product innovation, empirical evidence on process innovation reveals a more complex and indirect relationship with firm growth. Process innovations targeting enhancements in internal production techniques, logistics systems, or quality control procedures are primarily designed to improve operational efficiency and reduce costs. Their contribution to firm performance has been well documented in terms of productivity gains (Crepon, Duguet, & Mairesse, 1998; Hall, Mairesse, & Mohnen, 2010), though the link to topline growth is more ambiguous (Huergo & Jaumandreu, 2004). Piva and Vivarelli (2005), analyzing data from Italian manufacturing firms, found that while process innovation improved labor productivity, its effect on employment and sales growth was statistically insignificant unless complemented by product innovation. Similarly, Hall et al. (2009) used a multi-country European sample and reported that process innovation positively impacted cost efficiency and firm survival, but had no strong direct effect on revenue expansion.

Crespi, Criscuolo, and Haskel (2008), using UK innovation survey data, found that process innovation contributed to firm growth primarily by driving productivity improvements, especially among medium-sized firms in capital-intensive industries. However, these gains led to measurable firm growth only in competitive markets where firms could effectively leverage efficiency improvements. Similarly, in a Latin American context, Crespi et al. (2019) showed that process innovations supported firm growth when combined with complementary strategies such as external partnerships or product innovation, highlighting the importance of these factors for translating operational gains into growth outcomes.

Evangelista and Vezzani (2012), using a panel dataset from the Community Innovation Survey covering several EU countries, emphasized that process innovations often work through intermediate channels such as waste reduction, improved delivery times, and enhanced compliance with quality standards. These factors support long-term profitability and market positioning but may not immediately reflect in sales growth metrics.

These studies collectively underscore that the growth effects of process innovation are context-dependent and frequently conditional on internal capabilities and external complements. This highlights the importance of investigating not only process innovation in isolation but also its interplay with other innovation types and investment strategies. In this study, we extend these insights by examining the joint effects of product and process innovation on firm growth, and whether contemporaneous R&D investment enables firms to more effectively convert operational improvements into measurable performance gains.

The role of research and development (R&D) investment as a moderating factor in the innovation-growth relationship has emerged as an increasingly significant research focus within innovation studies. The theoretical underpinning of this moderating relationship is grounded primarily in the concept of absorptive capacity, as initially proposed by Cohen and Levinthal (1989, 1990). Absorptive capacity refers to a firm's ability to recognize, assimilate, and apply external knowledge to commercial ends, an ability which is critically enhanced through sustained R&D investment. Firms with higher absorptive capacities, cultivated through ongoing R&D activities, are more adept at integrating external innovations, responding effectively to market dynamics, and consequently achieving superior growth outcomes (Leiponen and Helfat, 2010).

Historically, empirical research has placed strong emphasis on cumulative R&D efforts, often operationalized through the concept of *R&D capital* - the accumulated stock of past R&D expenditures that continue to contribute to a firm’s innovation potential over time (Griliches, 1998; Hall and Sena, 2017). This approach, grounded in the idea that knowledge and technological competencies build progressively, has been widely adopted in empirical growth models. R&D capital is typically constructed using perpetual inventory methods, where current-period R&D investment adds to the existing stock, and depreciation captures the obsolescence of older knowledge (Czarnitzki and Lopes-Bento, 2014; Hall and Mairesse, 1995). Numerous studies have demonstrated that firms with high R&D capital are more likely to introduce significant innovations, benefit from knowledge spillovers, and enjoy sustained competitive advantages (Coad and Rao, 2008; Griffith, Redding, and Van Reenen, 2004).

However, more recent scholarship has called attention to the limitations of focusing solely on cumulative measures. In fast-changing and uncertain environments such as those triggered by economic shocks, technological disruptions, or geopolitical instability, contemporaneous R&D investment is increasingly viewed as a more accurate reflection of firms' immediate strategic responses (Archibugi et al., 2021; Kancs and Siliverstovs, 2021). Current R&D spending often signals real-time reallocation of resources, rapid experimentation, and responsiveness to emerging market conditions - factors that may exert a stronger and more dynamic influence on short-term innovation outcomes and growth paths.

By focusing on contemporaneous R&D, this study departs from the traditional emphasis on long-term R&D accumulation and instead examines how contemporaneous investment decisions affects firm growth (Romer, 1990; Grossman & Helpman, 1994). This perspective is particularly relevant in periods marked by volatility and transformation, where firms must adapt quickly and cannot rely solely on previously accumulated knowledge capital. In doing so, the analysis offers a timely contribution to the growing body of research that treats R&D not only as a long-run input but as a strategic lever for navigating immediate economic challenges (Cohen & Klepper, 1996).Empirical studies conducted during and following significant economic disruptions; most notably the COVID-19 pandemic; offer growing support for this shift toward a more dynamic view of R&D investment. Recent analyses underscore how firms strategically reallocated R&D expenditures in response to crisis-induced uncertainty, with a notable emphasis on digital transformation, supply chain resilience, and agile process reconfiguration. For instance, Archibugi, Coad, and Sommariva (2021) highlight how firms across Europe adapted their innovation strategies during the pandemic to prioritize short-term operational flexibility and technological responsiveness. Similarly, the European Innovation Scoreboard (2022) documents an uptick in innovation intensity among firms that responded proactively to the crisis, particularly through real-time investment in digital tools and data-driven processes.

These shifts demonstrate that timely, strategically aligned R&D expenditures can amplify firms' ability to innovate under pressure, enhancing adaptability, preserving market competitiveness, and accelerating recovery trajectories. Unlike cumulative R&D capital, which reflects past investment commitments, contemporaneous R&D captures firms' real-time strategic intent and responsiveness - an increasingly crucial dimension in today's unpredictable economic landscape (OECD, 2021; Zahra, 2021). This evolving understanding further motivates the present study's focus on contemporaneous R&D a factor for firm growth..

A key consideration in cross-country analyses of innovation is the inherent diversity of national contexts, particularly within Europe. Differences in institutional quality, innovation policy frameworks, R&D intensity, and market maturity can significantly shape how firms implement and benefit from innovation strategies (Edquist, 2005; Lundvall, 2007). National innovation systems influence not only the extent of public and private support for R&D, but also firms' access to skilled labor, technological infrastructure, and collaborative networks. As noted by Veugelers and Schneider (2010), cross-country comparisons within Europe reveal stark contrasts in innovation capacity and performance, which cannot be ignored in empirical analysis. Mohnen and Röller (2005) further demonstrate that the productivity of innovation inputs depends heavily on the interplay between firm-level characteristics such as age and size

To adequately reflect this heterogeneity, the present study incorporates country fixed effects into its empirical framework, allowing for the control of unobserved national factors that may systematically influence innovation outcomes. In addition, the richness of the dataset enables exploratory subgroup analyses that compare innovation-growth the dynamics bwtween innovation and growth across different segments of the firm growth distribution. These analytical choices ensure that the role of contemporaneous R&D is not interpreted in isolation but within the broader institutional and economic landscapes that shape firm behaviour across countries.

Despite extensive exploration, a notable gap remains in explicitly analyzing the moderating role of contemporaneous R&D investments in cross-country contexts, especially across diverse European economic environments. This study aims to address this gap by empirically assessing how current R&D investments interact with product and process innovations to influence firm growth trajectories, providing nuanced insights into strategic innovation management within Europe's post-pandemic recovery landscape.

3. DATA AND DESCRIPTIVE ANALYSIS

3.1. **Data**

This study relies on a pooled cross-sectional dataset of 14 European countries constructed from one main source. The primary source is the World Bank Enterprise Surveys (WBES) for the years 2023 and 2024, which collects firm-level data through structured interviews using Computer-Assisted Personal Interviewing (CAPI). The WBES adopts a stratified random sampling methodology, ensuring that firms are representative across size, sector, and geographical location. The survey targets formal, private sector firms with five or more employees and captures detailed information on business performance, product and process innovation, management practices, infrastructure, and various operational constraints. Interviews are conducted directly with top managers or business owners, using standardized questionnaires that ensure comparability across countries and time.

We construct our working dataset from an initial sample of firm-level observations drawn from the World Bank Enterprise Surveys (2023–2024) covering 14 European countries. We remove firms that provided “Don’t know (spontaneous)” responses to either product or process innovation questions and investing in R&D, as these responses do not offer usable information. Second, we exclude firms with implausible age values, specifically, those younger than three years or older than 300 years. We exclude firms younger than three years because we want to focus on those that were actively involved in product or process innovation at least three years before the survey was conducted. Finally, we eliminate all observations with missing values in any of the variables used in the empirical analysis. The original sample consisted of 7,790 firms; however, after elimination, we remained with 7319 firms.

Tabel 1: Number of firms in each country.

Country	Count	Percentage
Bulgaria	672	9.2
Croatia	419	5.7
Cyprus	245	3.4
Estonia	335	4.6

Greece	573	7.8
Hungary	772	10.6
Ireland	575	7.9
Italy	1110	15.2
Moldova	143	2.0
Portugal	143	2.0
Romania	910	12.4
Serbia	464	6.3
Slovenia	393	5.4
Sweden	595	7.7
Total	7319	100.0

Source: Computed using our sample data from the World Bank Enterprise Survey.

3.2. **Main Variables**

Our key variable of interest, firm growth (denoted as *gri*), is measured in terms of sales. In particular, the growth rate is calculated as the change in annual sales from t-3 to t, divided by the average of annual sales at t and t-3. This growth measurement is symmetric about zero and lies in the closed interval [-2,2] (Davis & Haltiwanger, 1990).

$$\text{gri} = \frac{S_{it} - S_{it-3}}{0.5(S_{it} + S_{it-3})}$$

Tabel 2: Description of variables.

Variable	Description
Firm growth (Dependent variable)	We determine growth using annual sales *Total annual sales:* the value of all annual sales of manufactured goods, goods the establishment has bought for re-sale, and services provided. *Total sales three complete fiscal years ago:* the value of all annual sales of manufactured goods, goods the establishment has bought for re-sale, and services provided. We calculate the firm growth rate in terms of annual sales.

Product innovation	*New or improved products and services (product innovation):* Introduction to the market during the reference period of a) products or services that are new to the establishment; and b) products or services that have significant improvements in capabilities, user friendliness, components or sub-systems. We consider the introduction of new products in the last three years from when the survey was carried out. (yes/no)
Process Innovation	*New or improved processes* include the introduction by the establishment during the reference period of; a) methods of manufacturing products or offering services; b) logistics, delivery, or distribution methods for inputs, products, or services; c) supporting activities. We consider introduction of new processes in the last three years from when the survey was carried out. (yes/no)
Expenditure on R&D	*Spending on R&D:* R&D or research and development refers to a specific group of activities that a business chooses to conduct with the intention of making a discovery that can either lead to the development of new products or service or procedures, or to improvement of existing products or service or procedures. For example, laboratory research for a new chemical compound of paint would be research and development while market research surveys or internet surfing are not considered to be R&D. R&D spending either in-house or by contracting other companies is considered here.
Age of firm	(Current Year- The year establishment began operation. *The year the establishment began operation* refers to the year in which the establishment started producing (or providing services), not to the year in which it was registered for the first time.
Firm size	Number of permanent, full-time workers three complete fiscal years ago: workers that are contracted for one or more fiscal years and/or have a guaranteed renewal of employment or an openended contract. These workers work a full shift, though this definition may vary by country and by industry. Include paid and unpaid workers (for ex. family members if any). All workers and managers (including respondent) should be counted. The firm can be small, medium or large. Size categories are based on employment. Small (5- 19 employees), medium (20-99 employees), large (100 or more employees).
Cost of R&D	*Cost of R&D* refers to how much money was spent on R&D either in-house or contracted to other companies. R&D as defined in Expenditure on R&D. Includes all spending related to R&D (personnel costs, materials,

Tabel 3: Descriptive Statistics of the variables

Country	firms in product innovation		firms in process innovation		firms investing in R&D		Firms involved in all		Firms not involved in any	
	Count	Share	Count	Share	Count	Share	Count	Share	Count	Share
Bulgaria	55	8.18	33	4.91	15	2.23	2	0.3	580	86.31
Croatia	27	6.44	20	4.77	33	7.88	5	1.19	358	85.44
Cyprus	17	6.94	6	2.45	63	25.71	0	0	172	70.2
Estonia	51	15.22	26	7.76	63	18.81	0	0	216	64.48
Greece	30	5.24	13	2.27	89	15.53	1	0.17	468	81.68
Hungary	104	13.47	99	12.82	112	14.51	6	0.78	517	66.97
Ireland	390	67.83	303	52.7	132	22.96	85	14.78	112	19.48
Italy	379	34.14	272	24.5	231	20.81	64	5.77	519	46.76
Moldova	39	27.27	33	23.08	29	20.28	9	6.29	77	53.85
Portugal	39	27.27	33	23.08	29	20.28	9	6.29	77	53.85
Romania	47	5.16	32	3.52	36	3.96	2	0.22	812	89.23
Serbia	102	21.98	59	12.72	28	6.03	10	2.16	329	70.91
Slovenia	214	54.45	153	38.93	122	31.04	76	19.34	133	33.84
Sweden	364	64.42	295	52.21	126	22.3	72	12.74	102	18.05
Total	1858		1377		1108		341		4472	

Source: Computed using our sample data from the World Bank Enterprise Survey. Share is in (%),

From the table above, Ireland has the largest share of firms that introduced new or improved products (67.8%), showing that more businesses in Ireland are focusing on product innovation compared to the other countries in the study. On the other hand, Romania had the least share of firms that introduced new products (5.2%). Sweden and Ireland had the largest share of firms that introduced a new or improved process (52.2% and 52.7%, respectively). More than half of the firms in Sweden and Ireland are engaged in process innovation, indicating that improving production methods is a common strategy among businesses across these countries. Greece and Cyprus have the least share of firms that introduced a new or improved process (2.3% and 2.5%). Slovenia has the highest share of firms investing in R&D at 31.0%, while Bulgaria has the lowest, with only 2.2% of firms reporting R&D activity. Overall, it is uncommon for firms to engage in product innovation, process innovation, and invest in R&D simultaneously. In both Estonia and Cyprus, no firms reported involvement in all three indicators at the same time. Conversely, a substantial proportion of firms did not engage in any of the three. This was particularly evident in Bulgaria and Romania, where 86.3% and 89.2% of firms, respectively, reported no engagement in product innovation, process innovation and investment in R&D.

Comparing these statistics with the CIS13 data from Eurostat for the year 2022 shows some clear differences in how much firms are involved in product and process innovation. Both datasets agree that countries like Ireland and Sweden have a high number of firms in process and product innovation. However, the data used in this study generally show lower levels of innovation, especially in countries such as Bulgaria, Romania, and Greece.

Tabel 4: Innovation by firm size category

Innovation type	Firm size	Total	Innovative firms	Share (in %)
Product Innovation	Large	1402	410	29.2
Product Innovation	Medium	2483	610	24.6
Product Innovation	Small	3434	838	24.4
Process Innovation	Large	1402	319	22.8
Process Innovation	Medium	2483	498	20.1
Process Innovation	Small	3434	560	16.3
R&D Investment	Large	1402	389	27.7
R&D Investment	Medium	2483	393	15.8
R&D Investment	Small	3434	326	9.5

Source: Computed using our sample data from the World Bank Enterprise Survey.

Table 4 shows that larger firms are generally more engaged in innovation compared to medium and small firms. For product innovation, 29.2% of large firms are innovative, followed by 24.6% of medium firms and 24.4% of small firms. This indicates that product innovation is common across all firm sizes, though slightly more prevalent in larger firms. A similar pattern appears in process innovation, where 22.8% of large firms report engagement, compared to 20.1% of medium firms and just 16.3% of small firms. The difference becomes more pronounced when looking at R&D investment: 27.7% of large firms invest in R&D, while this figure drops to 15.8% for medium firms and only 9.5% for small firms. These results suggest that while product and process innovation occur across firms of all sizes, larger firms are significantly more likely to invest in R&D, likely due to having more financial and technical resources. This results also suggest that small firms use other modes of innovation other than the than R&D based innovation (Tiwari & Masso, 2025).

Tabel 5: Firm growth and Innovation status – Descriptives

Innovation	Innovation status	Observations	Mean growth	Median growth	Minimum growth	Maximum growth
Product Innovation	Innovative	1858	0.236	0.187	-1.397	2.000
Process Innovation	Innovative	1377	0.255	0.193	-1.936	2.000
R&D Investment	Innovative	1108	0.264	0.222	-1.053	2.000
All three above	Innovative	341	0.239	0.182	-1.053	2.000
None of the three above	Non-innovative	4472	0.280	0.222	-1.596	2.000

Source: Computed using our sample data from the World Bank Enterprise Survey.

Table 5 shows how firm growth differs depending on whether a firm is involved in innovation. Firms that carried out product innovation had an average growth of 23.6%, with most firms growing around 18.7%. Firms that did process innovation grew slightly more on average (25.5%) but also showed more variation, with growth between –1.9 and 2.0. Firms that invested in R&D had the highest average growth among the innovators (26.4%) and less risk of decline, as their lowest growth was –1.053. Firms that did all three - product innovation, process innovation, and R&D, had an average growth of 23.9%, with growth mostly between 1.053 and 2.000. Surprisingly, firms that did not do any of these innovations grew the most on average, with an average growth of 28% and most firms grew around 22.2%. In short, while innovative firms generally grew well, non-innovative firms in this sample grew just as much or even slightly more. This finding suggests that other factors, besides innovation, may be helping these firms grow.

Tabel 6: Firm growth and Firm size – Descriptives

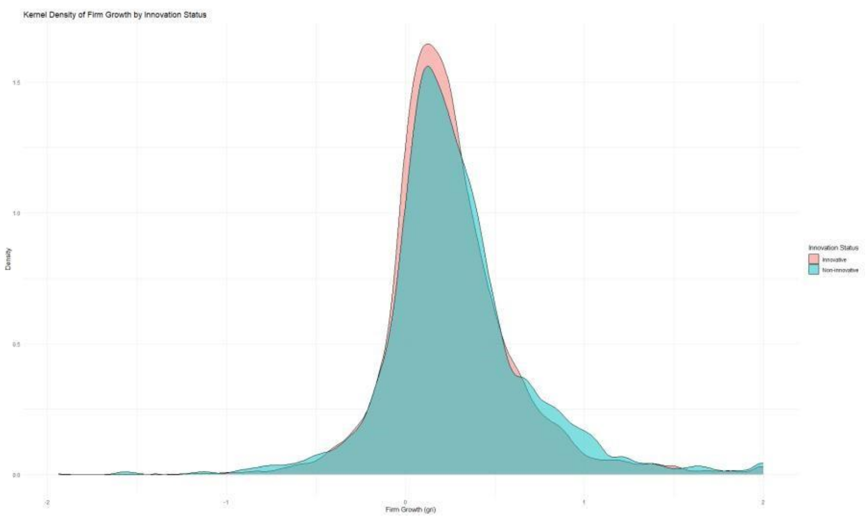
Size category	Observations	Mean growth	Median growth	Minimum growth	Maximum growth
Small	1402	0.250	0.222	-1.94	2

Medium	2483	0.269	0.222	-1.56	2
Large	3434	0.277	0.207	-1.60	2

Source: Computed using our sample data from the World Bank Enterprise Survey.

On average, growth gets a little bigger as size increases. Small firms have an average growth of 25%, In medium firms, growth is slightly higher at 2.7%, and large have the at growth of 2.8%. The median growth stays about the same for small and medium firms (around 2.2%) but is a bit lower for large (2.1%). The smallest growth recorded in all groups is negative, meaning some growth was shrinking, with the small group showing the biggest drop. The highest growth in all groups is the same, reaching up to 2. Overall, as size increases, growth tends to be a little higher on average, but there is still a wide range of growth within each group.

Kernel density for firm growth



The kernel density plot presents the distribution of firm growth rates based on innovation status, where firms are classified as innovative if they engage in product innovation, process innovation, R&D, or any combination thereof. Firms that do not engage in any of these activities are considered non-innovative. The plot shows that both innovative and noninnovative firms have growth rates concentrated around zero, indicating modest average growth across the board. However, innovative firms exhibit a slightly more concentrated distribution, suggesting more stable and consistent growth patterns. In contrast, non-innovative firms display a wider spread in outcomes, particularly toward higher growth levels, indicating greater variability in performance. Overall, the plot suggests that engaging in innovation activities is associated with more predictable and steady firm growth.

4. METHODOLOGY

Our strategy is to investigate the relationship between firm growth and product innovation, firm growth and process innovation, firm growth, process innovation and **Investment in R&D.**

4.1. Ordinary Least Squares Regression

Model 1 is the pooled OLS regression model. It is well known that the OLS only allows estimation of mean effects. It is likely that the effect of innovation on firm growth differs between low and high-growth firms. The model linearly links dependent variables as follows:

$$gri = \alpha_{10} + \alpha_{11} \cdot \text{ProductInnovation} + \alpha_{12} \cdot \text{InvestR\&D} + \alpha_{13} \cdot \text{Age} + \alpha_{14} \cdot \text{Firmsize} + \alpha_{15} \cdot \text{CostR\&D}_{\text{per employee}} + \alpha_{16} \cdot \text{Age}_2 + \varepsilon_1$$

$$gri = \alpha_{20} + \alpha_{21} \cdot \text{ProcessInnovation} + \alpha_{22} \cdot \text{InvestR\&D} + \alpha_{23} \cdot \text{Age} + \alpha_{24} \cdot \text{Firmsize} + \alpha_{25} \cdot \text{CostR\&D}_{\text{per employee}} + \alpha_{26} \cdot \text{Age}_2 + \varepsilon_2$$

$$gri = \alpha_{30} + \alpha_{31} \cdot \text{ProdInnovation} \cdot \text{ProcessInnovation} + \alpha_{32} \cdot \text{InvestR\&D} + \alpha_{33} \cdot \text{Age} + \alpha_{34} \cdot \text{Firmsize} + \alpha_{35} \cdot \text{CostR\&D}_{\text{per employee}} + \alpha_{36} \cdot \text{Age}_2 + \varepsilon_3$$

We also run other OLS models where we include country dummies to account for institutional differences. The main hypothesis is that innovation has a positive significant effect on firm growth. The limitation of this model is that it only estimates mean effects, yet intensity on firm growth differs between low and high growth firms. We used instrumental variable approach to address potential endogeneity in the OLS models. The instrument we used was the industry-level average of innovation. These instruments capture exogenous variation in innovation driven by industry-wide trends. While this approach helps mitigate endogeneity bias, it may not fully eliminate all sources of endogeneity.

4.2. Quantile Regression Model

Model 2 is the quantile regression model. To analyse the impact of product and process innovation on firm growth, we apply quantile regression techniques. Quantile regression was originally designed for analysis of cross-sectional datasets (Coad et al., 2016). We apply quantile regression to investigate the distribution of product and process innovation effects on firm growth. Traditional regression analysis captures the behaviour of the “the average firm”, only delivering a partial picture. We therefore turn to a quantile regression approach, which allows us to explore the association between innovation and firm growth along the whole spectrum of the growth rate distribution.

The quantile regression model describes a conditional quantile function linking the dependent variable and independent variables. It is estimated via least squares. The linear regression in 4.1 can be expressed as:

$$\text{gri} = \alpha_\theta + \alpha_{\theta i} \cdot \text{Inno}_i + \beta_\theta x_i + u_{\theta i}$$

where 0<θ<1 shows the share of firms with a growth rate gri below the quantile θ. The θth conditional quantile given x_i is then $\text{Quant}_\theta(\text{gri}\,^{\cdot}\,\boldsymbol{x_i}) = \alpha_\theta + \alpha_{\theta i} \cdot \text{Innoi} + \beta_\theta \boldsymbol{x_i}$. The distribution of the error term is unspecified provided it satisfies the quantile restriction $\text{Quant}_\theta\,(u_{\theta i}\,^{\cdot}\,\boldsymbol{x_i}) = 0$ (Capasso et al., 2015). The parameters are computed as solutions to the minimization of a weighted sum of absolute residuals.

$$\min \alpha\theta, \beta\theta\{ \sum_{+\beta\theta_{xi}} \theta \mid \text{gri} - \alpha\theta - \alpha\theta\text{iInnoi} - \beta\theta\text{xi}_{\,\text{gri}<=\alpha\theta + \alpha\theta\text{iInnoi}}$$

$$+ \sum (1-\theta) \mid \text{gri} - \alpha\theta - \alpha\theta iInnoi - \beta\theta xi \}_{\,\text{gri} > \alpha\theta + \alpha\theta\text{iInnoi} + \beta\theta_{xi}}$$

The quantile θ shows a weighting factor between the left and right terms that is the sum of all negative and positive residuals. The positive residuals are observations above the quantile, ie faster growing firms. Observations used in the estimation of different quantile parameters differ by the weights they are given. In each regression, faster growing firms are given higher weight at higher quantiles.

5. RESULTS

Tabel 7: Firm growth and product innovation

Variables	OLS	OLS (with country dummies)	IV First stage	IV Second stage	Q25	Q50	Q75
Prod_Inno	-0.036*** (0.010)	0.019 (0.011)		-1.024*** (0.307)	-0.003 (0.010)	0.017 (0.010)	0.021 (0.014)

Invest_R&D	0.014 (0.013)	0.003 (0.013)	0.231*** (0.013)	0.252*** (0.074)	-0.004 (0.011)	0.003 (0.011)	-0.0007 (0.016)
Age	-0.005*** (0.0006)	-0.005** (0.0006)	-0.0004 (0.0005)	-0.005*** (0.0006)	-0.002*** (0.0003)	-0.004*** (0.0005)	-0.007*** (0.002)
I(age^2)	-2.9^10-5*** (5.2^10^{-06})	3.0^10-05*** (5.3^10^{-06})	6.6^10-06 (3.9^10^{-06})	3.7^10-05*** (5.6^10^{-06})	0.00001*** (0.000)	0.00003*** (0.000)	0.00004** (0.00002)
Medium size	0.006 (0.010)	0.009 (0.010)	0.003 (0.010)	0.014 (0.010)	0.029*** (0.008)	0.019* (0.009)	0.003 (0.013)
Large size	0.0003 (0.012)	0.007 (0.013)	0.043 (0.012)	0.054** (0.018)	0.032** (0.010)	0.020 (0.011)	-0.007 (0.015)
Cost R&D per employee	3.4^10^{-08} (1.8^10^{-08})	2.7^10^{-08} (2.0^10^{-08})			0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Country dummies		Yes		Yes	Yes	Yes	Yes
Constant	0.375*** (0.014)	0.275*** (0.019)	0.042* (0.019)	0.348*** (0.029)	0.049*** (0.012)	0.210*** (0.014)	0.460*** (0.031)
Instrument			0.141*** (0.042)				
Number of Observations	7319	7319		7319	7319	7319	7319

Standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1

Table 7 presents the relationship between product innovation and firm growth using a combination of Ordinary Least Squares (OLS), Instrumental Variables (IV), and quantile regression models. The goal is to assess whether firms that introduce new or significantly improved products tend to grow more or less than those that do not, while accounting for other firm characteristics and country-specific differences.

In the first OLS specification, where country dummies are not included, on average, firms that report product innovation grow 3.6% less than those that do not, and it is statistically significant at the 1% level. Although the size of the difference is modest, the negative coefficient may indicate that firms investing in product innovation do not immediately translate those efforts into faster growth. When country dummies are added to the model, firms that report product innovation on average grow 1.9% faster than those who do not. This change implies that cross-country differences may influence the observed relationship, and once these are controlled for, the average difference in growth between product innovators and nonproduct innovators becomes negligible.

A more refined estimate is provided when we use the instrumental variable method. After applying IV, firms in product innovation grow 102.4% lower than those not engaging in it and is statistically significant at the 10% level. This shift indicates that, once deeper sources of bias are corrected for, firms engaged in product innovation are growing more slowly than those that are not. One possible explanation is that product innovation requires up-front investments in time and resources, which may temporarily slow firm growth before any potential gains are realized.

To explore whether the relationship between product innovation and growth differs across firms at different growth levels, quantile regressions are presented in the final three columns. These estimates allow for a more understanding by analysing firms at the 25th, 50th, and 75th percentiles of the growth distribution. At the 25th percentile, representing slowergrowing firms, the coefficient on product innovation is –0.3% and statistically insignificant, suggesting little to no difference in growth between innovators and non-innovators in this group. At the median (50th percentile), the coefficient is 1.7% and remains statistically insignificant. Similarly, at the 75th percentile, where faster-growing firms are represented, the coefficient is 2.1% and not significant. Across all quantiles, the lack of statistical significance indicates that product innovation does not show a consistent pattern of association with growth, even among top-performing firms. The study by Audretsch et al., 2014 also shows that the relationship between product innovation and firm growth is complex. Some firms may benefit from innovation in terms of growth, while others may not.

These results suggest that product innovation, as measured in this study, is not clearly linked to higher firm growth. In fact, the IV model reveals a large negative association, which may reflect delays between innovation and commercial outcomes, or that only certain types of firms are well-positioned to benefit from innovation. The quantile regression results reinforce this point by showing that the relationship remains weak across the distribution of growth outcomes.

Other firm characteristics included in the models provide useful context. Firm age consistently shows a negative association with growth across all models, including the quantiles. The study by (Yasuda, 2005) also shows that firm age has a negative effect on firm growth. Younger firms appear to grow more than older ones, even though the year-to-year differences are small. This pattern is more pronounced among faster-growing firms, suggesting that younger firms may be more agile or better able to take advantage of growth opportunities. This finding is consistent with (Coad et al., 2016), who also show that younger firms involved in innovation experience more growth as compared to older firms. Firm size shows mixed associations with growth depending on the model and quantile. Medium-sized firms are generally positively associated with growth as compared to small ones, especially in the quantile models, where the effect is statistically significant at the 25th and 50th percentiles. However, the relationship between large firm size and growth is less consistent. While the IV model suggests a positive and significant effect, the coefficient turns negative and insignificant at the 75th percentile, indicating that among the fastest-growing firms, being large does not necessarily confer an advantage. This result suggests that while medium-sized firms may benefit from scaling efficiencies, larger firms might face diminishing returns to scale or structural rigidities that limit growth.

Tabel 8: Firm growth and process innovation

Variables	OLS	OLS (with country dummies)	IV First stage	IV Second stage	Q25	Q50	Q75
Process_Inno	-0.006 (0.011)	0.049*** (0.012)		-0.487 (0.359)	0.025** (0.010)	0.023* (0.011)	0.048*** (0.014)
Invest_R&D	0.004 (0.011)	-0.003 (0.013)	0.187*** (0.012)	0.104 (0.070)	-0.008 (0.011)	0.003 (0.011)	-0.008 (0.015)
Age	-0.005*** (0.0006)	-0.005*** (0.0006)	-0.0006 (0.0005)	-0.005*** (0.0006)	-0.001*** (0.0003)	-0.004*** (0.0005)	-0.007*** (0.001)
I(age^2)	2.9^10-05*** (5.2^10-06)	3.0^10-05*** (5.3^10-06)	4.9^10-06*** (3.6^10-06)	3.2^10-05*** (5.5^10-06)	0.00001*** (0.000)	0.00003*** (0.000)	0.00004** (0.00002)
Medium size	0.007 (0.010)	0.007 (0.010)	0.041*** (0.010)	0.030 (0.018)	0.025** (0.008)	0.016 (0.009)	-0.001 (0.013)
Large size	0.002 (0.012)	0.005 (0.013)	0.066*** (0.021)	0.041 (0.027)	0.029** (0.010)	0.021* (0.011)	-0.004 (0.015)
Cost R&D per employee	3.5^10-08* (1.8^10-08)	2.9^10-08 (2.0^10-08)			0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Country dummies		Yes		Yes	Yes	Yes	Yes

Constant	0.370*** (0.014)	0.278*** (0.019)	0.004 (0.017)	0.290*** (0.021)	0.045*** (0.012)	0.214*** (0.014)	0.450*** (0.029)
Instrument			0.138** (0.047)				
Number of Observations	7319	7319		7319	7319	7319	7319

Standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1

Table 8 examines the relationship between process innovation and firm growth using a range of models: Ordinary Least Squares (OLS), Instrumental Variables (IV), and quantile regressions. The analysis focuses on whether firms that adopt new or significantly improved production processes grow faster than those that do not. Growth is the dependent variable, measured as a continuous outcome, and the process innovation indicator compares "Yes" responses against the base category "No."

In the first OLS model, which excludes country-specific factors, process innovation is associated with a –0.6% difference in firm growth compared to non- process innovators, though the result is not statistically significant. This suggests that, on average, introducing new production processes does not lead to higher growth when comparing firms across all countries and conditions. Once country dummies are added in the second OLS model to account for structural and economic differences across countries, the coefficient becomes positive at 4.9% and statistically significant. This indicates that within the same national context, process innovators tend to grow 4.9% more than non-process innovators. When the instrumental variables (IV) approach is used to correct for potential endogeneity in the process innovation, the coefficient on process innovation becomes –49%. However, this estimate is not statistically significant, and the diagnostics show that OLS is consistent, meaning the IV adjustment was not necessary. This supports the reliability of the OLS estimates, especially the one that includes country dummies.

The quantile regressions provide further insight by looking at how the relationship between process innovation and growth varies across firms at different points in the growth distribution. At the 25th percentile - representing slower-growing firms, process innovators grow 2.5% faster than their non-process innovating peers, a statistically significant difference. This positive association strengthens at the median (75th percentile), where the growth difference rises to 4.8%. At the 75th percentile, representing the fastest-growing firms, the growth advantage of process innovators is statistically significant at the 1% level.

These quantile-specific results show a clear pattern: the higher a firm ranks in the growth distribution, the greater the growth difference associated with process innovation. For firms in the top quartile, process innovation is linked to nearly a 5.0% higher growth rate. This suggests that innovation in production processes may be especially beneficial for firms that are already positioned for strong growth. This finding is consistent with (Rochina-Barrachina et al., 2010) who also show that process innovation produces growth for large and small firms however, growth is more in large than in small firms. Such firms may be better able to convert operational improvements into expanded output, higher productivity, or enhanced market responsiveness.

Across all models, firm age shows a consistent and negative association with growth. For example, at the 75th percentile, each additional year of firm age is linked to a 0.7% slower growth rate. This aligns with common findings in the literature that younger firms often grow faster than older ones. The size of the firm also matters, medium and large firms generally grow faster than small ones, especially in the lower parts of the growth distribution. Medium-sized firms see a small positive association, around 1.6%, though not always statistically significant.

In summary, the results suggest that process innovation is positively related to firm growth. The strongest growth advantages are observed among faster-growing firms, indicating that the benefits of process innovation may not be evenly distributed. Firms aiming to accelerate growth may particularly benefit from process innovation if they are already positioned to scale up or respond quickly to efficiency gains.

Tabel 9: Firm growth, product and process innovation

Variables	OLS	OLS (with country dummies)	IV First stage (Product)	IV First stage (Process)	IV Second stage	Q25	Q50	Q75
Product_Inno	-0.038** (0.012)	0.019 (0.013)			-1.298*** (0.158)	0.0005 (0.012)	0.021 (0.011)	0.030 (0.016)
Process_Inno	0.005 (0.016)	0.055*** (0.016)			-1.753*** (0.355)	0.035** (0.013)	0.031* (0.015)	0.072*** (0.021)
Invest_R&D	0.013 (0.013)	-0.005 (0.013)	0.236*** (0.013)	0.187*** (0.012)	0.627*** (0.090)	-0.007 (0.011)	-0.002 (0.011)	-0.005 (0.016)
Age	-0.005*** (0.0006)	-0.005*** (0.0006)	-0.0006 (0.0005)	-0.0006 (0.0005)	-0.006*** (0.0007)	-0.002*** (0.0003)	-0.004*** (0.0005)	-0.007*** (0.001)

I(age^2)	2.9^10-05***	3.0^10-05***	7.0^10-06***	5.0^10-06***	4.6^10-05***	0.00001*** (0.0000)	0.00003*** (0.0000)	0.00004*** (0.00002)
	(5.2^10-06)	(5.3^10-06)	(3.9^10-06)	(3.6^10-06)	(5.6^10-06)			
Medium size	0.006 (0.010)	0.007 (0.010)	0.005 (0.010)	0.040*** (0.009)	0.087*** (0.018)	0.027** (0.008)	0.016 (0.009)	-0.0008 (0.013)
Large size	0.0003 (0.012)	0.004 (0.013)	0.045 (0.012)	0.065*** (0.012)	0.181*** (0.030)	0.031** (0.010)	0.018 (0.011)	-0.007 (0.015)
Cost R&D	3.4^10-08 (1.7^10-08)	2.9^10-08 (2.0^10-08)				0.0000 (0.000)	0.0000 (0.000)	0.0000 (0.000)
Product and process Inno	-0.0009 (0.022)	-0.017 (0.022)			0.164 (0.136)	-0.023 (0.018)	-0.016 (0.020)	-0.054 (0.029)
Instrument 1			0.646*** (0.088)	-0.066 (0.083)				
Instrument 2			-0.308 (0.166)	0.377* (0.156)				
Instrument 3			-0.550 (0.214)	-0.246 (0.200)				
Country dummies		Yes			Yes	Yes	Yes	Yes
Constant	0.374*** (0.014)	0.275*** (0.019)	0.007 (0.024)	-0.009 (0.022)	0.409*** (0.025)	0.045*** (0.012)	0.211*** (0.014)	0.451*** (0.029)
Number of Observations	7319	7319			7319	7319	7319	7319

Standard errors in parentheses ***p<0.01, **p<0.05, *p<0.1

The extended analysis includes both product and process innovation, along with their interaction, to examine how they relate to firm growth. In the basic OLS model, product innovation is associated with approximately 3.8% lower growth, and this relationship is statistically significant. However, when controlling for country-specific effects, the association becomes statistically insignificant. Using the IV method, which addresses potential biases like reverse causality, the association becomes much stronger, with product innovation linked to roughly 129.8% lower growth. In the quantile regressions, product innovation does not show a meaningful association with growth at the 25th and 50th percentiles, but at the 75th percentile, it is associated with 3.0% higher growth, suggesting that among the top-performing firms, product innovation may be more beneficial.

Process innovation, in contrast, shows a more consistent relationship with firm growth. While the OLS estimate without country controls is small and insignificant, adding country dummies reveals a 5.5% higher growth rate associated with process innovation. This pattern is further supported in the quantile regressions, where process innovation is linked to 3.5%, 3.1%, and 7.2% higher growth at the 25th, 50th, and 75th percentiles, respectively, all statistically significant. Although the IV estimate suggests a 175.3% lower growth for process innovation, this result is statistically significant, indicating unreliability of the estimate when accounting for deeper causal concerns.

The interaction term for firms that engage in both product and process innovation is generally not significant across most models. In contrast, the study by (Goedhuys & Veugelers, 2012) shows that the combination of product and process innovation significantly improves firm growth. However, in the IV model, this interaction is linked to 16.4% higher growth, suggesting that firms combining both innovations may experience substantial gains when accounting for potential endogeneity. Yet, this result is not consistent, and in the 75th percentile regression, the interaction is weakly associated with 5.4% lower growth, hinting that the benefits of combining innovations may depend on firm-specific factors.

Firm characteristics maintain patterns consistent with earlier findings. Age continues to be associated with lower growth; each additional year corresponds to about 0.5% lower growth, with a small quadratic term indicating that the decline moderates for older firms. Medium-sized firms see around 1.6% and 2.7% higher growth, large firms between 1.8% and 3.1%, and however growth is lower in the upper quantile compared to small firms. Investment in R&D and its cost do not show meaningful associations with growth, with effect sizes close to zero. In summary, process innovation shows the most consistent positive relationship with growth, while product innovation's link is more variable and may be negative unless carefully contextualized. Firm size and age remain predictors of growth throughout, and this is also showed by (Yasuda, 2005) in the study about firm growth, age size and behaviour.

6. CONCLUSION

This study explores how different types of innovation - product and process innovation associate with firm growth, using multiple econometric approaches including OLS, instrumental variables (IV), and quantile regression. The findings present a subtle picture, highlighting that innovation is not a guaranteed path to growth, and its effects depend heavily on firm characteristics and contextual factors.

Product innovation, when considered alone, does not show a consistent positive relationship with firm growth. In fact, under several model specifications, especially the IV model, product innovation is associated with significantly lower growth. This may be due to the delayed returns from investing in new products, as firms often need time to recover development costs and gain market traction. Moreover, the quantile regression results suggest that product innovation does not strongly influence growth across the distribution, except for a modest positive effect among the fastest-growing firms. This indicates that only certain firms, possibly those already performing well, may reap growth benefits from product innovation.

Process innovation, in contrast, shows a more robust and consistent positive link to growth. Once country-specific differences are accounted for, process innovators tend to grow faster, especially among higher-performing firms. The quantile regression results further reinforce this finding, showing that the positive effects of process innovation are strongest at the upper end of the growth distribution. This suggests that improving internal processes may be particularly valuable for firms already positioned to leverage efficiency gains and scale operations.

The combined effect of both product and process innovation is less clear. While most models do not show significant gains from engaging in both simultaneously, the IV estimate suggests a large positive effect. However, this result is not consistently replicated across other models or growth levels, indicating that the synergy between product and process innovation may depend on specific firm contexts or timing.

Firm characteristics such as age and size play important roles. Younger firms consistently grow faster, likely due to greater agility and responsiveness to opportunities, while older firms tend to face diminishing growth. Medium-sized firms generally outperform small ones, especially at lower growth levels, but the advantage for large firms is less consistent, particularly among the fastest growers, where large size may even hinder growth.

In conclusion, the results highlight that process innovation is more reliably associated with firm growth, especially for firms already on strong growth paths. Product innovation carries greater risk and uncertainty, with potential benefits realized only under specific conditions. These findings emphasize the importance of tailoring innovation indicators to firm capabilities and growth trajectories, rather than assuming a one-size-fits-all effect. They also stress the value of complex econometric analysis to capture the diverse ways in which innovation influences firm performance.

However, several limitations should be acknowledged, each of which points to valuable areas for future research. First, the analysis relies on cross-sectional data, limiting our ability to explore how innovation influences firm performance over time. In particular, we are unable to account for the volatility of firm growth, which is especially relevant when studying younger or fast-growing firms. Future research based on panel data could provide deeper insights into how innovation impacts both the level and stability of growth across different phases of the firm growth distribution.

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KOKKUVÕTE EESTI KEELES

ETTEVÕTTE KASVU TEGURID: EMPIIRILINE UURING TOOTE-, PROTSESSI- JA TEADUS- JA ARENDUSTEGEVUSE INNOVATSIOONI ROLLIST.

Käesolevas magistritöös uuritakse, kuidas tooteinnovatsioon, protsessiinnovatsioon ja investeeringud teadus- ja arendustegevusse on seotud ettevõtte kasvuga, kasutades Maailmapanga ettevõtlusuuringu põhjal saadud 7319 ettevõtte ristlõikeandmeid 14 Euroopa riigist. Analüüsis kasutatakse nii tavalist vähimruutude meetodidt kui ka kvantiilregressiooni lähenemist. Samuti võetakse analüüsis arvesse võimalikku endogeensust (s.t. võimalust, et just ettevõtte kiirem kasv tingib uuendustegevus) instrumentmuutujate meetodi rakendamise abil, kasutades instrumentidena innovatsiooni keskmisi näitajaid tööstusharu tasandil. Tulemused näitavad, et tooteinnovatsioon ei ole järjekindlalt seotud kiirema ettevõtte kasvuga, mis viitab sellele, et investeeringuteg uutesse toodetesse võivad kaasneda viivitused äritulemuste saavutamisel. Seevastu protsessiinnovatsioon näitab stabiilsemat ja positiivsemat seost ettevõtte kasvuga, eriti kiirema kasvuga ettevõtete puhul. Teadus- ja arendustegevusse investeerimine ei näita selget seost ettevõtte kasvuga, enamikus mudelites on erinevused investeeringuid teinud ja mitteteinud ettevõtete vahel nullilähedased. Ettevõtete karakteristikud, nagu ettevõtte vanus ja suurus, on läbivalt olulised ettevõtte kasvu selgitavate teguritena: nooremad ja keskmise suurusega ettevõtted kasvavad kiiremini kui vanemad või väiksemad ettevõtted. Kokkuvõttes toob uuring esile, et tooteinnovatsioon, protsessiinnovatsioon ja teadus- ja arendustegevusse investeerimine on ettevõtte kasvuga seotud erinevalt, sõltuvalt ettevõtte profiilist ja konkreetse riigi kontekstist.