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Does Innovation Benefit Exporters in Pakistan more than Non-Exporters? An Analysis of Firms from the Textile, Light Engineering and Automotive Sectors

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Abstract: *Innovation is recognized as an important catalyst for growth and competitiveness in the global economy, yet its specific impacts on firm performance remain inadequately explored, particularly across different sectors in the context of developing countries. This paper examines the effects of innovation on the performance of both exporting and non-exporting firms within Pakistan's textile, light engineering, and automobile industries. Utilizing a modified version of the Crépon, Duguet, and Mairessec (1998) innovation model, we investigate the impact of various innovations on firm performance and explore how adopting complementary innovations influences outcomes. Our initial results imply that non-exporting firms benefit more from individual types of innovations and their respective combinations of innovations purely driven by younger firms. However, we get more nuanced results when we divide firms by sector. In the textile sector, dominated by exporters, innovation positively impacts firm outcomes through product and technological advancements, with the benefits focused on more extensive and established firms. Conversely, in the light engineering sector, individual innovation adoption favors exporters, while the adoption of complementary innovations benefits non-exporters, especially young firms. In the automotive sector, innovation impacts exporters and non-exporters differently and favors older firms. These results add to our understanding of the innovation-performance nexus in Pakistan's industrial landscape and can provide practical insights for policymakers, industry stakeholders, and academics.*

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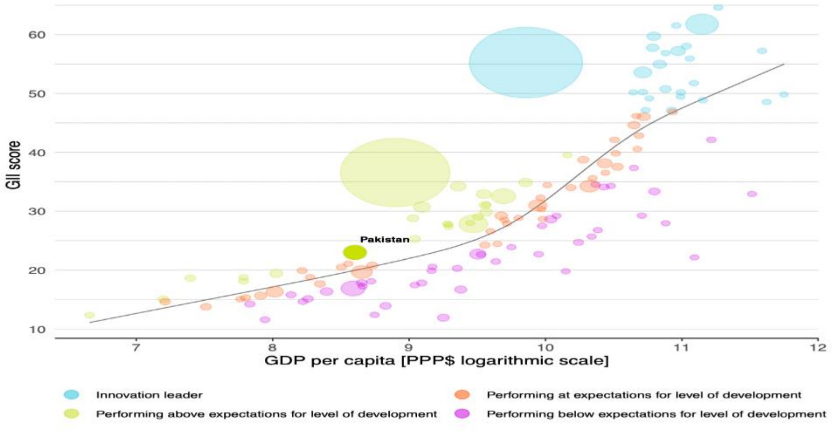
Introduction

Innovation is a significant driver of competitive advantage, productivity growth, and economic resilience in the globalized economy. This is not only true at the macroeconomic level but also holds the same importance at the firm level. As firms face intensifying pressures to adapt and remain competitive, innovation becomes a catalyst for internal efficiencies and a vital component for sustaining international competitiveness. By promoting productivity improvements, enhancing competitiveness, and enabling firms to penetrate international markets, innovation is also crucial for sustaining economic progress. The economic literature has widely studied the relationship between innovation and firm performance. Pioneers like Schumpeter (1942) highlighted the role of innovation as a driver of economic dynamism, enabling firms to create monopolistic advantages and thus improve performance. However, innovation as a source of growth is essential for both developed and developing countries. However, it is particularly significant in developing countries like Pakistan, where firms navigate resource constraints and operate in rapidly evolving markets.

Figure 1.1 below shows that there is a strong positive correlation between the GII score (measuring the level of innovation in a country) and its respective GDP per capita. The trend line is a projection of expected innovation performance levels based on a country's GDP per Capita. Countries above the trend are better than the projected innovation levels based on their income levels, and those below are performing poorly relative to their projections of GII scores.

Figure 1.1: Relationship between GDP per capita and innovation performance (GII score), across Countries



Source: Global Innovation Index, 2022- ranks approx. 132 countries based upon 80 indicators are released annually by the World Intellectual Property Organization (WIPO)

Pakistan's economy, characterized by its reliance on traditional manufacturing sectors like textiles, light engineering, and automotive, still needs to catch up in the context of innovation. According to the Global Innovation Index 2021, Pakistan stands at 107th (118th in innovation inputs and 88th in innovation output), which is very low compared to peer countries in the lower middle-income group. In Pakistan, innovation can enable firms to enhance performance, especially when engaging in exports. Exporters and non-exporters alike can benefit from innovations; however, the ways these benefits manifest—and whether they are amplified when innovations are adopted in complementary combinations—remains underexplored in the context of Pakistan's industrial sectors.

Recent literature has moved beyond the broad benefits of innovation. It has begun to differentiate between types of innovation—such as product, process, technological, marketing, and business model innovations—as each type contributes. Product, process, technological, marketing, and business model innovations contribute differently to firm performance, influencing revenue growth, cost reduction, and market expansion. Another more intricate aspect is also attached to it: the nature and types of innovations. The most suitable type of innovation a country can adopt, as a one-size-fits-all policy, cannot work in many cases. Also, it is essential to understand whether these types of innovations can be adopted in isolation or simultaneously. In the global context, empirical studies have shown that product and technological innovations tend to improve firm productivity, particularly among exporting firms, due to the increased competition and demand for high standards in international markets. Studies by Griliches (1998), O'Mahony et al. (2010), Abazi-Alili et al. (2017), and Exposito & Sanchis-Liopis (2018) have established that innovation, particularly when paired with robust R&D efforts, can significantly boost a firm's productivity and market reach.

Complementary innovation, which involves adopting multiple types of innovation simultaneously, has garnered attention for its potential to create synergistic effects. For example, pairing process and business model innovations may streamline operations and reduce costs, while product and technological innovations can drive market expansion and improve product differentiation (Hervas-Oliver et al., 2014; George & Teimuraz, 2018). However, Studies in emerging economies suggest that complementary innovation's benefits are context-dependent. Resource limitations, market conditions, and sector-specific dynamics can shape the efficacy of combined innovation efforts. In Pakistan, where sectors vary widely in technological readiness and export intensity, understanding these dynamics is essential for tailoring innovation strategies that maximize firm performance.

Relevance to Pakistan’s Textile, Light Engineering, and Automotive Sectors

Pakistan's industrial landscape is diverse, with the textile, light engineering, and automotive sectors forming a significant portion of its economy. The textile sector, heavily export-oriented, has shown a proclivity for product innovation, which aids in meeting international standards and responding to shifting consumer demands (Wadho & Chaudhry, 2018). However, the light engineering sector, characterized by both exporters and non-exporters, reveals a different trend where process innovation is central to enhancing operational efficiencies. The automotive sector, meanwhile, faces high costs in adopting dual or complementary innovations but stands to benefit substantially in terms of cost reduction and product differentiation. These sector-specific dynamics suggest that the effects of innovation on firm performance are heterogeneous and are potentially influenced by the firm's export orientation.

While prior research underscores the importance of innovation in enhancing firm competitiveness, relatively few studies address how different types of innovation—and their combinations—impact exporters versus non-exporters in a developing country context. In Pakistan, limited evidence exists on the comparative benefits of innovation across firms of varying sizes, ages, and sectors, especially regarding their export activities. Moreover, little is known about whether the combination of innovations offers distinct advantages, such as cost efficiency and product development, or whether sectoral constraints limit these benefits. This study aims to evaluate the impacts of five key types of innovation—product, process, technological, marketing, and business model—on crucial performance indicators such as revenue growth, cost reductions, and price adjustments. By assessing whether complementary adoption yields additional benefits, this analysis also addresses whether dual innovations enhance firm outcomes beyond those achieved by singular innovation. Importantly, we have examined how these effects differ between exporting and non-exporting firms, reflecting sectoral heterogeneity across Pakistan's textile, light engineering, and automotive industries. This disaggregation allows us to address the possibility that sectoral dynamics may mask broader trends in innovation’s impact on firm performance, thereby providing insights into how industry-specific characteristics influence the effectiveness of innovation strategies in Pakistan’s economy.

Literature Review

Innovation is widely acknowledged as a critical force behind economic growth, competitive advantage, and firm performance (Schumpeter, 1942). Schumpeter's early work underscored innovation's role in creating temporary monopolistic advantages that drive industrial progress and catalyze economic development. In recent decades, economic literature has explored this concept in greater detail, with firm-level analyses highlighting the importance of innovation and R&D in boosting productivity, efficiency, and profitability (Griliches, 1998; O'Mahony et al., 2010; Abazi-Alili et al., 2017; Exposito & Sanchis-Llopis, 2018). Griliches (1998) emphasized that innovation and R&D are highly correlated with productivity gains, particularly in high-tech sectors, where firms face constant pressure to improve products and processes. In addition to the traditional view of innovation, scholars have increasingly focused on distinguishing between different types of innovation, each of which impacts firms in unique ways. Hervas-Oliver et al. (2014) and George & Teimuraz (2018) argue that product, process, technological, marketing, and business model innovations contribute differently to firm performance, with each type of innovation being more or less relevant depending on industry characteristics and market demands. For instance, product innovation is critical in industries where differentiation is necessary to meet evolving consumer needs, while process innovation can be more valuable in sectors focused on cost efficiency and streamlined production (Dosi, 1988). In Pakistan, Wadho and Chaudhry (2018) found that product innovation significantly enhanced performance in textile and apparel manufacturing, highlighting its importance in sectors where export competitiveness is driven by quality and uniqueness.

The literature also discusses the potential for synergistic effects when firms adopt multiple types of innovation in tandem. Combining types of innovation—often referred to as complementary or dual adoption—can create valuable synergies that leverage the strengths of each type to amplify firm outcomes (Cassiman & Veugelers, 2006; Belderbos et al., 2006). Studies indicate that dual or complementary innovations, such as pairing process innovation with business model innovation, can help firms streamline operations while improving value proposition, ultimately enhancing revenue growth and profitability (Bouncken et al., 2016). A similar case is made for product and technological innovations, which together can foster product differentiation and elevate market competitiveness. However, while complementary innovations offer considerable potential, their adoption poses challenges, particularly in resource-constrained environments. The high costs of implementing dual innovation strategies and the risk of negative synergies are noted as significant barriers, especially for small and medium-sized enterprises (SMEs) (Exposito & Sanchis-Llopis, 2018).

Innovation in Developing Economies and the Role of Export Orientation

In developing economies, the impact of innovation on firm performance is influenced by various contextual factors, including resource limitations, institutional frameworks, and market structures. The literature suggests that innovation can be transformative for firms in these economies, particularly for those engaged in exports, as exporters face higher competitive pressures to meet international standards and deliver innovative products (Freeman, 2002; Girma et al., 2004). Export-oriented firms in developing countries are often more inclined to adopt product and process innovations, as these can provide a competitive edge in quality-sensitive markets. Studies on export-led economies like China and India illustrate how product and technological innovations significantly bolster firms' export performance, thereby contributing to national economic growth (Aw et al., 2000; Fu, 2008; Chen & Tang, 2013). Conversely, non-exporting firms, which tend to operate in domestic markets with different competitive dynamics, may prioritize innovation types that drive cost efficiency over differentiation. These firms are more likely to benefit from process and business model innovations, which enhance internal operations without necessitating the same level of R&D investment as product or technological innovations. Research by Cohen and Levinthal (1990) and Lall (1992) suggests that cost-efficient innovation types for non-exporters in developing countries are crucial for maintaining profitability in the face of local competition.

The influence of innovation on firm performance also varies widely across industrial sectors. Sector-specific studies prove that innovation types yield different benefits depending on industry characteristics, technological intensity, and competitive structure (Pavitt, 1984; Malerba, 2002). In the manufacturing sector, particularly in textiles, process and product innovations have significantly boosted productivity and competitiveness (Nadvi, 1999; Wadho & Chaudhry, 2018). In Pakistan's textile sector, which is highly export-oriented, firms that adopt product innovation are better positioned to meet global demand for high-quality and unique products. Meanwhile, in sectors like light engineering, where technological advancement is relatively slower, firms often benefit more from process innovations that improve operational efficiency and cost control.

Automotive firms, particularly in developing economies, encounter distinct challenges in innovation due to high capital requirements and complex supply chains. Studies on automotive sectors in emerging markets demonstrate that technological and marketing innovations enhance firm competitiveness by improving product features and expanding market reach (Fujimoto, 2007; Iyer et al., 2009). However, the high costs of these innovations mean that only large firms or those with significant resources can fully capitalize on their benefits. Thus, sectoral heterogeneity plays a crucial role in shaping the impact of innovation on firm performance, underscoring the need for sector-specific innovation strategies.

Complementary Innovations and Synergistic Effects

While specific types of innovation can improve firm performance, the literature increasingly emphasizes the potential of complementary or dual innovations to create synergistic effects (Cassiman & Veugelers, 2002; Leiponen & Helfat, 2010). Combining innovation types can enable firms to address multiple business dimensions simultaneously, creating added value and fostering resilience in changing markets. For example, studies show that integrating technology with marketing innovation can enhance product appeal and accelerate market adoption, whereas combining process with business model innovation can reduce costs and streamline value delivery (Bouncken et al., 2016). Cassiman and Veugelers (2006) highlight that firms in high-tech industries that engage in dual innovations achieve higher profitability and are more competitive than those that innovate in isolation. However, implementing complementary innovations is challenging. In developing economies, the costs and risks associated with dual innovation are significant, especially for smaller firms with limited financial and human resources (Freel, 2005). Resource constraints may force firms to prioritize specific innovations over others, potentially limiting their capacity to achieve the full benefits of complementary innovation (Rosenbusch et al., 2011). Additionally, in sectors with low technological readiness, such as Pakistan's light engineering and automotive sectors, firms may face difficulties effectively integrating complementary innovations, leading to diminished returns or even negative synergies.

Despite the extensive literature on innovation, few studies have specifically examined how different types of innovation and their combinations affect firm performance in Pakistan's textile, light engineering, and automotive sectors. Most existing research focuses on developed economies or fast-growing emerging markets, with limited attention to the nuanced impact of innovation in Pakistan, where firms operate under distinct institutional, financial, and market constraints. Moreover, while the benefits of complementary innovation are well-documented, more is needed to know about how these benefits vary between exporting and non-exporting firms in developing countries. This study seeks to fill these gaps by analyzing the effects of individual and complementary innovations on the performance of exporters and non-exporters in Pakistan's major industrial sectors. By examining sector-specific dynamics, this study looks for a deeper understanding of innovation's role in driving competitiveness within Pakistan's economy.

Data Collection and Research Design

The primary data used in this study was collected by the Lahore School of Economics. A structured survey was conducted with textile, light engineering, and automotive sector firms in two of Pakistan's most industrialized provinces: Punjab and Sindh. These provinces were selected due to their significant industrial contributions, housing a large proportion of firms engaged in manufacturing and export activities. This approach enabled us to capture both the heterogeneity within each sector and the distinctions between exporting and non-exporting firms. The survey was administered over four years, covering 2018, 2019, 2020, and 2021. The multi-year data collection was essential to provide a time-based perspective on innovation adoption and its outcomes, particularly in light of evolving market conditions and policy changes that could influence firm behavior. The sample of firms was drawn from the Directory of Industries and the Census of Manufacturing Industries (CMI). Firms were selected based on criteria including sector affiliation, firm size, and export orientation, ensuring a representative sample across varying firm demographics.

Moreover, the survey was designed to capture information on various forms of innovation adopted by firms, including product, process, technological, marketing, and business model innovations. In addition to innovation adoption, the survey captured key performance indicators (KPIs) related to firm outcomes, such as revenue growth, cost reductions, and product pricing adjustments. Each firm was asked to report on the types of innovation they had implemented, as well as the specific impacts of these innovations on performance metrics. For example, firms were queried on whether product or process innovations had contributed to revenue increases or reductions in operational costs.

To quantify the impact of innovation impact, we have utilized a modified Crépon, Duguet, and Mairessec (CDM) model, which is commonly used to evaluate the effects of innovation on firm performance. The CDM model is well-suited for studies where innovation decisions and performance outcomes are potentially endogenous. This modification allowed us to address selection bias by estimating a latent variable that captures predicted innovation effort among firms actively investing in innovation. Additionally, the model accounts for binary response variables for firm performance indicators, such as increases in revenues or reductions in production costs, providing a robust framework for analyzing the effects of innovation.

Firms reporting significant performance changes were cross-verified through follow-up interviews to confirm the accuracy of responses. Additionally, the survey included control questions to minimize response biases and discrepancies. Data from firms with incomplete responses or inconsistencies in key indicators were excluded from the final analysis to ensure the integrity of the dataset. This rigorous approach to data collection and validation helped in compiling a reliable dataset that accurately reflects the impact of innovation on firm performance across Pakistan's diverse industrial landscape.

Empirical Strategy and Econometric Methodology

The empirical strategy for this study is centered on assessing the differential impact of various types of innovation—product, process, technological, marketing, and business model—on the exporting and non-exporting firm performance indicators, focusing on revenue growth, cost reduction, and product price adjustments. Given the complex interactions between innovation types and firm outcomes, we employed a modified version of the Crépon, Duguet, and Mairessec (CDM) model to account for potential endogeneity and selection bias and capture sectoral heterogeneity.

The CDM Model Framework

The modified CDM model in this study consists of a multi-stage approach that examines (a) firms' decisions to innovate, (b) the intensity of innovation efforts, and (c) the impact of these efforts on firm performance outcomes. The model begins by estimating firms' likelihood of innovation, given specific firm characteristics and sectoral attributes. The initial stage captures the probability of innovation, addressing the endogeneity concern that firms actively choosing to innovate may already have different performance trajectories than those that do not. Next, the model measures the innovation effort, conceptualized as a latent variable representing the extent of a firm's investment in innovation activities, which influences its performance. This stage helps distinguish the impact of the actual intensity of innovation on outcomes rather than only the presence or absence of innovation. The final stage then models the impact of innovation—both individually and in combinations—on firm performance indicators using binary response variables. These response variables capture whether a firm has achieved specific outcomes, such as revenue growth or cost reduction, due to its innovation efforts.

Econometric Specifications

The core econometric specification for this analysis involves a binary response model applied to performance indicators, capturing outcomes as binary (e.g., increase in revenues due to innovation, reduction in costs due to innovation, and reduction in prices due to innovation). For each innovation type (product, process, technological, marketing, business model) and its dual combinations, the model estimates the marginal effects on performance outcomes for exporting and non-exporting firms. The following econometric specifications are used:

Probit Model for Innovation Adoption: We use a probit model to estimate the probability of innovation adoption. In the model, the dependent variable is a binary indicator of whether a firm has adopted any form of innovation, and the independent variables include firm characteristics (such as size, age, and sector) and market orientation (exporting vs. non-exporting).

$$P(I_i = 1) = \Phi(\alpha_0 + \alpha_1 \text{FirmSize}_i + \alpha_2 \text{FirmAge}_i + \alpha_3 \text{Sector}_i + \alpha_4 \text{Export}_i + \epsilon_i)$$

Where Φ is the cumulative distribution function of the standard normal distribution (for probit). *Firm size (FirmSize*), firm age (FirmAge), the industrial sector (Sector), and *whether the firm is an exporter (Export*) are firm-specific characteristics that influence the decision to innovate.

Linear Regression for Innovation Intensity: For firms that engage in innovation, the model estimates innovation intensity as a continuous latent variable representing the firm's effort in innovation. This latent variable is estimated based on observable inputs such as R&D expenditures, frequency of new product introductions, and the number of new processes adopted. Ordinary Least Squares (OLS) is applied where possible, while instrumental variable techniques are used to address any remaining endogeneity concerns in innovation investment.

Binary Response Models for Performance Indicators: We use binary response models (such as probit or logit models) to assess the impact of innovation on performance. In these models, the denendent variables are revenue growth, cost reduction, and price adjustment. A binary indicator is used for each performance outcome, where 1 represents a positive outcome (e.g., revenue increase due to innovation) and 0 otherwise.

$$P(Yij = 1) = \Phi(\gamma_0 + \gamma_1\, ProductInnovationi + \gamma_2\, ProcessInnovationi + \gamma_3\, TechnologicalInnovationi + \gamma_4\, MarketingInnovationi + \gamma_5\, BusinessModelInnovationi + \gamma_5\, Exporti + \gamma_7\, Sectori + \eta_i)$$

$Yij = 1$ indicates a positive performance outcome (e.g., increase in revenue, decrease in price or decrease in cost) due to innovation type j Each innovation type *ProductInnovation, TechnologyInnovation, ProcessInnovation,* etc.) is a binary variable, indicating whether firm i has adopted that type.

Moreover, to capture the synergies arising from complementary innovations, this study introduces interaction terms between pairs of innovation types (e.g., product and process, technological and marketing). Interaction terms allow for the estimation of whether the combined adoption of two innovation types has a multiplicative effect on firm performance. The model tests these dual adoption effects by including interaction variables and evaluating their statistical significance and effect sizes. Additionally, sectoral dummy variables are introduced to capture the industry-specific effects of innovation in the textile, light engineering, and automotive sectors. These dummy variables help control for unobserved sectoral characteristics that may influence innovation impact, allowing for a more nuanced understanding of how innovation outcomes differ across sectors.

Addressing Sectoral and Export Heterogeneity

By including interaction terms, we account for heterogeneity in innovation effects between exporters and non-exporters and across sectors. These interaction terms combine innovation types with export orientation and sectoral indicators. This enables the model to estimate differential impacts for exporting firms within each sector compared to non-exporting firms. These interactions reveal how innovation types and their combinations may yield distinct outcomes depending on a firm's market orientation and the sectoral context in which it operates.

Results and Discussion

Overall descriptive Statistics

The descriptive statistics in Table 1 provide an overview of the firms in Pakistan's textile, light engineering, and automotive sectors, detailing firm demographics, innovation adoption, and sectoral characteristics. The sample comprises 300 firms from the country's primary industrial provinces, Punjab and Sindh, which collectively house a significant portion of Pakistan's manufacturing and export-driven activities. The distribution of firms includes approximately 29% from textiles, 25.4% from automotive, and 43.8% from light engineering. Each sector reflects unique market dynamics; for instance, the textile sector is primarily export-oriented, while light engineering includes a mix of both exporters and non-exporters. Within this sample, 49.9% of firms are engaged in exporting, providing a balanced comparison between firms with international exposure and those focused solely on domestic markets. Firm age and size are important characteristics influencing innovation practices and potential outcomes. In terms of age, around 35.1% of firms are classified as "young" (15 years or younger), whereas 64.8% are considered "older" (over 15 years). This age distribution may influence innovation decisions, as younger firms often experiment with newer approaches while older firms may have established processes that affect their innovation strategies. Firm size also shows variation, with small firms (those with 50 or fewer employees) making up 38.13% of the sample, while larger firms (more than 50 employees) comprise 61.9%. Since size is closely linked to financial and operational capacity, larger firms generally allocate more resources toward innovation than smaller firms, which may focus on cost-effective innovations.

Innovation adoption is prevalent within the sample, though the extent and type vary across firms. Approximately 64.9% of firms reported engaging in some form of innovation, highlighting a strong interest in innovation-driven growth. Product innovation is the most widely adopted type, with 47.2% of firms introducing new or improved products. This type of innovation is prevalent in the textile sector, where product differentiation is crucial for competitiveness in export markets. Technological innovation, adopted by 31.2% of firms, reflects investments in new technology to enhance operational capabilities. Process innovation, aimed at improving efficiency and reducing costs, is adopted by 8.4% of firms while marketing innovation—targeted at reaching new markets and building brand differentiation—is reported by another 8.4%. Business model innovation, however, is relatively rare, with only 4% of firms employing it, suggesting limited strategic restructuring efforts among firms in these sectors.

Sectoral differences in innovation patterns are also evident. In the textile sector dominated by exporters, product and technological innovations are prominent as firms seek to meet international standards and adapt to global market demands. Light engineering firms catering to domestic and export markets show varied innovation preferences, often focusing on cost-saving process innovations that enhance efficiency. The automotive sector, facing higher capital requirements and technological barriers, displays moderate levels of product and technological innovation, driven primarily by larger firms. This sector-specific variation highlights the influence of industry-specific dynamics on innovation decisions, with firms tailoring their innovation strategies to align with sectoral demands and resource availability.

Average Impact of Innovation Type & its Complementarities

The analysis reveals that, on average, firms adopting specific types of innovation outperform non-innovators across key performance metrics, particularly in revenue growth, cost reduction, and pricing strategies. Product innovation is a significant driver since firms introducing new or improved products report higher revenues. This innovation type allows firms to better meet market demand and expand their customer base while also achieving cost efficiencies in production, positioning them favorably compared to non-innovators. Technological innovation plays a crucial role in helping firms reduce the prices of their final products. By implementing automation and advanced production techniques, firms lower input costs and enhance production efficiency, passing these savings on to customers. This price reduction is particularly advantageous for non-exporting firms, which face intense domestic competition and benefit from competitive pricing strategies. Moreover, younger firms are among those that benefit most from innovation. These firms, typically more flexible in adopting new technologies, experience significant performance gains in revenue and cost metrics. Younger and non-exporting firms, in particular, achieve notable advantages when adopting new products, technologies, or marketing strategies, which enable them to adapt quickly to market demands and establish competitive price points. In contrast, older firms with more established processes may see more limited immediate benefits from innovation. Moreover, firm size also affects the impact of innovation. Small firms that engage in technological innovation report higher revenues and reduced prices than non-innovating small firms. For non-exporting small firms, these price reductions improve their positioning in price-sensitive domestic markets, allowing them to reach a broader customer base and compete effectively against larger firms. More concisely, product and technological innovations have the most substantial positive impact on firm performance, particularly for younger, smaller, and non-exporting firms. These insights highlight the importance of aligning innovation strategies with firm characteristics to maximize performance outcomes.

Effect of Pairwise innovation adoption on the increase in Firm Revenue

Figure 1 illustrates the effects of adopting dual (pairwise) innovations on firm revenue, comparing the impacts of different innovation combinations. The results indicate that specific pairs of innovation types yield significantly higher revenue gains than others, highlighting the synergistic potential of complementary innovation strategies. Notably, two pairs of innovations stand out for their strong positive impact on revenue: Process Innovation with Business Model Innovation and Product Innovation with Technological Innovation**.** The combination of Process Innovation and Business Model Innovation is particularly effective in driving revenue growth. This pairing enhances both operational efficiency and strategic positioning, as process improvements streamline production or service delivery, while business model innovation allows firms to restructure their value propositions. Together, these innovations enable firms to optimize costs and simultaneously create new revenue channels or improve existing ones, significantly boosting overall revenue.

Similarly, the combination of product innovation and technological innovation has a robust positive effect on revenue. Product Innovation enables firms to introduce new or improved products that meet market demands, while Technological Innovation supports these efforts by enhancing the efficiency and quality of production. When adopted together, these innovations allow firms to differentiate their products in the market while benefiting from cost-effective and scalable production, leading to increased sales and higher revenue. This combination is especially advantageous in competitive sectors where product quality and differentiation are crucial for revenue growth. These complementary innovation strategies, particularly these two combinations, provide firms with a significant revenue advantage over single or isolated innovation efforts, which highlights the importance of adopting synergistic innovation approaches for firms seeking to enhance their market position and maximize revenue potential.

The Impact of Pairwise Adoption of Innovation on Decreases in Output Prices

Figure 2 highlights the effects of adopting dual (pairwise) innovations on the output prices of firms' products, shedding light on how different innovation combinations influence pricing strategies and cost competitiveness. The results underscore that specific combinations of innovations can significantly reduce output prices, illustrating the value of strategic innovation pairing in enhancing market competitiveness and driving cost efficiencies.

The combination of product innovation and technological innovation is especially impactful in decreasing output prices. Product Innovation often leads to the creation or improvement of offerings tailored to market needs, while Technological Innovation enhances production efficiency, reduces costs, and supports scalable output. These innovations allow firms to introduce high-quality products at more competitive prices. By leveraging technological advancements, firms can optimize processes, minimize production costs, and increase economies of scale, enabling them to offer more cost-effective products without compromising on quality. This strategic pairing thus provides a solid basis for firms to capture market share through lower pricing strategies while maintaining profitability.

Additionally, pairwise combinations such as Process Innovation with Business Model Innovation notably reduce output prices. Process Innovation focuses on improving production or operational efficiency, resulting in cost savings that can be passed on to customers through lower prices. When combined with Business Model Innovation, which redefines how value is delivered to customers, firms can further optimize cost structures and pricing strategies. This synergy enables firms to offer differentiated value at reduced prices, enhancing market competitiveness and potentially increasing market penetration. Figure 2 illustrates that pairing complementary innovations can be a powerful strategy for firms to achieve cost leadership in their industries. By strategically adopting combinations like Product and Technological Innovation or Process and Business Model Innovation, firms can achieve substantial cost efficiencies, translating into lower output prices and a stronger market position. These findings emphasize the critical role of innovation synergies in creating competitive advantages and driving business success.

Impact of Different Types of Innovation on Firm Performance Across Age and Export Status

The analysis in Table 3 in the Appendix shows that the young firms that engaged in any form of innovation experienced a varied impact on performance. Non-exporting young firms showed a negative effect on revenues (-0.318) and a slight negative impact on prices and cost effect. In contrast, exporting young firms exhibited a strong negative effect on revenue (-1.502***) and price, suggesting that innovation efforts might be associated with cost increases or challenges in market adaptation for young exporters. For older firms, the effects were somewhat different: non-exporters showed a negative revenue effect (-0.588***), while the price and cost effects were relatively neutral or positive. Exporting older firms had positive effects on price, cost efficiency, and revenue performance, indicating more maturity in leveraging innovation for market gains.

The impact of business modeling innovation varied considerably based on firms' age and market status. Young non-exporting firms showed a significant positive revenue impact (0.560***) but a negative effect on cost (-0.433***), indicating that although they gained from reshaping their business models, it came at a higher expense. Exporting young firms had a mixed impact, negatively affecting prices and costs. For older firms, non-exporters saw a consistent negative impact on cost and price indicators, while exporters did not experience statistically significant benefits. This suggests that business model innovation may require careful cost control, particularly for older non-exporting firms. Young exporting firms experienced an extremely high positive impact on revenue from product innovation (28.886***), though with mixed results on cost and pricing.

On the other hand, non-exporting young firms displayed significant but smaller revenue increases. Older firms, both exporters and non-exporters, often face negative revenue effects from product innovation, implying that the potentially high costs and market risks of developing new products may outweigh immediate revenue benefits for more mature companies. Exporting young firms benefited greatly from product differentiation, while older firms struggled to leverage new products profitably.

Also, young exporting firms showed a highly significant negative impact on revenue and costs from process innovation (-3.379***). Non-exporting young firms also experienced a negative impact on costs and prices. Older firms exhibited a more muted response, with relatively minor changes across the board. This suggests that adopting new processes might present initial cost challenges for young firms, especially those engaged in exporting, whereas older firms may have already optimized their operations or may not see immediate benefits. The impact of technological innovation was markedly positive for young exporting firms, with a significant increase in revenues (2.797***), indicating that new technologies provide substantial competitive advantages in international markets. Young non-exporting firms experienced modest revenue gains. On the other hand, older non-exporters showed a positive impact on revenues (1.043*), though the cost impact was variable. Older exporting firms demonstrated mixed results, with negative price effects suggesting challenges in managing costs or market competition.

Moreover, while engaging in marketing innovation, young firms experienced a notable increase in revenue, particularly exporters (6.529**), but faced a negative impact on cost-effectiveness. This suggests that marketing strategies can drive sales but may require careful cost management. For older firms, the impact of marketing innovation was minimal or negative, with marginal changes across revenue, price, and cost indicators. This implies that younger firms are more likely to benefit from marketing innovation by capturing new market segments, while older firms might struggle to achieve similar results.

Impact of Innovation Types on Performance across size, small and large Firms

The impact of engaging in any type of innovation differed significantly between small and big firms. Small non-exporting firms faced a substantial negative impact on revenue (-0.948***) and prices as given in Table 4, while cost changes were relatively minor. Exporting small firms exhibited more pronounced negative revenue effects (-2.450), though the results were not statistically significant, suggesting that innovation efforts may introduce initial inefficiencies or market challenges for these firms. For large firms, non-exporters experienced marginal changes in revenue and cost, with a minor positive shift in price. Exporting large firms saw some positive effects, notably with a slight price increase, but overall effects were small. This disparity indicates that while large firms may have more resources and capacity to buffer innovation-related costs, small firms may face greater challenges in reaping immediate benefits from general innovation adoption.

Business modeling innovation displayed mixed results for small and large firms. Small non-exporting firms saw a marginally positive revenue impact (0.151) but faced a significant negative impact on costs (-0.294**), indicating potential challenges in controlling expenses during business model adjustments. For small exporters, the effects were more balanced, with no substantial positive or negative impact observed. Among large firms, non-exporters experienced a significant negative impact on both revenue and costs (-0.298***, -0.472***), suggesting potential inefficiencies or market incompatibility with new business models. Exporting large firms experienced relatively neutral effects, highlighting that size and market access can moderate the outcomes of business model transformations.

Moreover, product innovation yielded contrasting results between small and large firms. Small non-exporters experienced a significant negative cost impact (-3.426***), indicating high production or R&D costs related to new products, while revenue and price impacts were less pronounced. Small exporters showed no significant gains or losses, implying that they may struggle to capitalize on new products in competitive markets. For large firms, product innovation outcomes were mixed, with some observing a substantial revenue gain (10.234 for exporters) but inconsistencies in cost and pricing effects. This suggests that while product innovation can offer revenue potential for large firms, it may also introduce complexities that affect cost management.

Also, the effects of process innovation varied with firm size and market engagement. Small firms generally exhibited minor changes across revenue, price, and costs, with only slight improvements or declines noted. For large firms, non-exporting entities experienced relatively moderate shifts, but there were no substantial or statistically significant gains or losses, implying that process adjustments alone might not be transformative for either group without complementary strategies. The limited influence on performance indicates that process innovation may have a more long-term, incremental effect rather than immediate transformative results. Furthermore, small firms, particularly exporters, displayed positive revenue and price effects from technological innovation (1.783** and 1.957**), highlighting their ability to leverage technology for competitive advantage. Non-exporting small firms also saw positive but lesser impacts. For large firms, non-exporters had a mixed response with moderate gains in revenue, while large exporters showed variable outcomes. These results suggest that small firms might achieve significant gains through technological innovation due to their flexibility and market responsiveness, while large firms might face more complex dynamics in fully harnessing technological advancements. Lastly, marketing innovation had a strong positive revenue impact on small non-exporting firms (0.247***), demonstrating its potential to drive sales in local markets. For small exporters, the effects were minimal. Among large firms, non-exporters faced more substantial challenges with negative impacts on revenue and costs, suggesting that marketing strategies alone may be insufficient without a broader support structure. Large exporting firms experienced minor negative changes in prices and costs, indicating that market-specific marketing adjustments may be required to achieve positive results. The results highlight the importance of tailored marketing strategies for different firm sizes and market engagements.

Impact of Innovation Complementries on the Performance of the Firms for Exporters & Non-exporters

The combination of business and market innovation shows mixed effects for exporters and non-exporters. Exporters experienced marginal negative impacts across all performance indicators, with coefficients around -0.025 to -0.049, indicating minimal improvements or slight declines due to this innovation pairing, as shown in Table 5. In contrast, non-exporters saw positive and statistically significant effects on revenue (0.178*) and cost efficiency (0.145**), highlighting that aligning business strategies with market needs can improve performance for firms primarily focused on domestic markets. Also, the combination of business and product innovation led to generally negative but insignificant effects for exporters, with a minor impact on performance indicators. Non-exporters displayed marginal results with a slight positive impact on revenue (0.051), though cost and pricing changes were negligible. This suggests that integrating business model adjustments with new products might not yield immediate, substantial gains for exporters, while non-exporters may see limited benefits in aligning business practices with product innovation.

Exporters benefitted significantly from pairing process and business innovation, as evidenced by a strong positive effect on revenue (0.109***). Non-exporters saw a similar trend with a notable impact on revenue (0.194***) and cost efficiency (0.145*). This combination suggests that improvements in operational efficiency, coupled with strategic business adjustments, can drive performance gains for both market groups. Moreover, this innovation combination yielded mixed and largely negative outcomes for both exporters and non-exporters. Exporters experienced negative impacts on performance indicators, particularly in prices and revenue, with coefficients of -0.055 to -0.116. Non-exporters faced a more significant negative impact on revenues (-0.370***), with some negative pricing effects as well. These results indicate potential difficulties in aligning process improvements with market strategies, possibly due to mismatches between operational capabilities and market demands. Exporters showed mixed results from combining process and technological innovations, with some positive effects on cost efficiency (0.274*) and negative price impacts (-0.200**). Non-exporters, however, saw a notable positive impact on cost efficiency (0.561***), indicating that technological upgrades within production processes can substantially enhance operational efficiency for firms with limited market exposure.

Moreover, exporters showed a slightly positive impact from product and market innovation combinations, but with a statistically significant negative effect on prices (-0.324*), suggesting difficulties in aligning product differentiation with market expectations. Non-exporters displayed minor positive effects on revenue (0.095*), but cost improvements were not evident, indicating limited but targeted market gains. This combination resulted in mixed outcomes for exporters, with a negative impact on prices (-0.391**) but neutral effects on other indicators. Non-exporters experienced a slight positive impact on revenue (0.109), though cost efficiency was negatively affected (-0.174*). This suggests that while integrating product and process innovations can support revenue, it may come at the expense of cost control.

Exporters generally faced negative impacts from this pairing, though results were mostly insignificant. In contrast, non-exporters experienced a strong positive effect on revenue (0.372***) and prices (0.150***), suggesting that combining product development with technological enhancements can drive market gains, particularly for firms focused on domestic markets. Also, this combination yielded mixed results, with exporters facing a significant negative impact on pricing (-0.369***) but some positive effects on cost efficiency. Non-exporters saw moderate positive effects on revenue (0.114*) and cost efficiency (0.353***), indicating that technological advancements aligned with market strategies can boost domestic firm performance. The pairing of business and technological innovation negatively impacted exporters, particularly in pricing (-0.260***). Non-exporters faced a similarly negative impact on revenues (-0.202***), highlighting potential challenges in aligning broad business changes with new technologies for both market segments. The results suggest that while combining these innovations may introduce operational complexity, the benefits might not be immediately apparent without careful implementation strategies.

Sectoral Analysis: Types of Innovation and the Impact on Sector -wise Firms Performance

Innovation and Firms Performance in the Textile Sector

We report the results for the textile sector in Table 6. All 87 firms in the textile sector are exporters. This suggests that international market conditions primarily influence innovation and performance dynamics in this sector. A significant proportion (74.7%) of firms in the textile sector are established, with over 15 years of operation. The remaining 25.3% are relatively younger. This distribution suggests that older firms may have more resources and experience to engage in innovation compared to newer firms. A majority (93.1%) of textile firms are large, indicating that large firms dominate the sector and are likely better positioned to invest in and benefit from innovation activities.65.5% of textile firms report engaging in innovation, which reflects a relatively high level of innovation activity in the sector.

Out of all, 4.6% of firms have innovated in business models and process improvements, suggesting that these areas are not a primary focus, as shown in Table 6. Only 2.2% of firms have focused on marketing innovation, indicating that firms in the textile sector may not prioritize changes to marketing strategies. A significant 57.5% of firms have engaged in product innovation, which is the most common form of innovation in the sector, highlighting its importance for competitive advantage. 31% of firms have undertaken technological innovations, suggesting a moderate focus on technological advancements to improve production and operations. The coefficient for overall innovation is negative (-0.358), though it is not statistically significant (indicated by the p-value in brackets), implying that general innovation activities may not have a significant impact on revenue in the textile sector. There is also a slight negative impact on pricing (-0.024), though again not statistically significant, suggesting that innovation does not drastically affect pricing strategies. A negative effect on costs (-0.285), but this is not statistically significant either, suggesting limited cost-related benefits from innovation.

The impact of business modeling innovation on revenue is marginal (-0.058) and not statistically significant, indicating that this form of innovation has a negligible effect on revenue for textile exporters. Similarly, the effects on pricing (-0.013) and cost (-0.069) are small and not statistically significant, suggesting that business modeling innovation does not significantly influence these performance metrics. Product innovation has a strong positive and statistically significant impact on revenue (0.303***), which indicates that firms investing in product innovation tend to experience significant revenue gains. There is also a significant positive impact on pricing (0.253***), suggesting that product innovation enables firms to charge higher prices, likely due to improved product differentiation. The negative effect on cost (-0.280***) suggests that product innovation, while boosting revenues and prices, may lead to some increases in cost, possibly due to research, development, and production adjustments. Both revenue and price effects from process innovation are insignificant (-0.055 for revenue and -0.216 for price), suggesting that improvements in production processes have a neutral or negligible impact on revenue and pricing strategies. The effect on costs (-0.080) is also negligible, indicating that process innovation does not significantly reduce costs.

Technological innovation significantly impacts revenue (18.666*), indicating that firms implementing new technologies see substantial revenue increases, possibly through increased efficiency or new product offerings. The positive effect on pricing (6.018) is statistically insignificant, suggesting that while technological innovation increases revenues, it may not necessarily result in higher prices. Technological innovation has a significant positive effect on cost (21.439*), indicating that while it increases revenues, it may also come with higher costs, likely due to investment in new technologies. Marketing innovation shows negative impacts on revenue (-0.081), price (-0.005), and cost (-0.082), though none of these effects are statistically significant. This suggests that marketing innovation does not substantially affect the performance indicators for firms in the textile sector.

Innovation Complementaries and Firms' Performance in the Textile Sector

In the textile sector, the effects of complementary innovation combinations on firm performance reported in Table 7 are varied, with some combinations showing positive results, while others lead to negative impacts. The combination of business and market innovation (bus_market) shows a small negative effect on revenue (-0.048), which is not statistically significant. However, it does result in a statistically significant negative effect on price (-0.029*), suggesting that aligning business strategies with market needs may reduce the ability to charge higher prices. The effect on cost is also negative (-0.062), but not statistically significant, indicating that there is no major impact on operational costs from this combination. Business and product innovation (bus_prod) shows significant negative effects on both revenue (-0.380) and cost (-0.442), and while these results are not statistically significant for revenue, they suggest that the integration of business modeling with product innovation may not result in desired outcomes.

Additionally, the negative effect on price (-0.142) implies that this combination might lower pricing power and may lead to cost increases due to inefficiencies. The combination of process and business innovation (proc_bus) stands out as one of the more successful pairings, with a statistically significant positive impact on revenue (0.092***) and cost (0.103***), suggesting that aligning process improvements with business strategy can enhance revenue and reduce costs. The price impact is negligible (-0.010), showing that the changes in business and process innovations do not significantly affect pricing strategies.

For process and market innovation (process_market), the results show a positive but statistically insignificant effect on revenue (0.206), while the effect on cost (0.266) is also positive but not significant. The price effect is negative (-0.135) and statistically insignificant, indicating that although this combination shows some promise in terms of reducing costs, it doesn't significantly impact revenues or pricing strategies. When process and technological innovation (process_tech) are combined, revenue has a positive effect (0.217), but it is not statistically significant. The most notable result here is the significant negative effect on cost (-2.227**), suggesting that technological improvements combined with process changes can lead to substantial cost savings, although revenue growth may not be strongly impacted. The combination of product and market innovation (prod_market) results in negligible effects on revenue (0.003) and price (-0.115), both statistically insignificant. However, the significant negative effect on cost (-0.362) suggests that this pairing can lead to cost reductions, likely due to better alignment between products and market needs, though it may result in lower prices due to market competition.

Product and process innovation (prod_proc) yields a positive but statistically insignificant effect on revenue (-0.110) and a negligible effect on price (-0.014). However, the significant positive effect on cost (0.800**) suggests that integrating product development with process innovation leads to higher operational costs, potentially due to investments in production or process improvements. The combination of product and technological innovation (prod_tech) leads to significant negative impacts on both revenue (-2.869) and price (-1.912), with a smaller negative effect on cost (-1.223). These results suggest that combining product and technological innovations may result in reduced revenue, lower prices, and higher costs, indicating that this combination is not favorable for performance in the textile sector.

The combination of technological and market innovation (tech_market) shows a negative effect on revenue (-0.429), a positive but insignificant effect on price (0.225), and a positive but insignificant effect on cost (0.487). This suggests that while technological and market innovations may lead to higher costs and potentially higher prices, they fail to increase revenue significantly, making this pairing less effective. Finally, business and technological innovation (bus_tech) leads to small positive effects on revenue (0.129) and price (0.061), but these effects are not statistically significant. The cost effect (0.236) is also small and not significant, indicating that while combining business and technological innovations may result in minor increases in revenue and price, the overall effect on performance is not substantial.

This shows that the most effective innovation pairings in the textile sector are process and business innovation, which lead to increased revenue and reduced costs, and process and technological innovation, which significantly reduce costs. Conversely, combinations like product and technological innovation and business and product innovation show substantial negative impacts, particularly in terms of revenue and pricing, indicating that these pairings might not be suitable for firms in this sector. These results suggest that firms, especially older and larger exporters, should prioritize process innovations and product innovation while being cautious with more complex combinations that may not yield positive outcomes.

Different types of Innovation and Innovation Complementaries and Firms Performance in the Light Engineering Sector

In the light engineering sector, the impact of innovation varies across different types of innovation and adoption strategies. Out of 131 firms in this sector, only 18.6% export their products abroad, indicating that the majority of firms operate within domestic markets. The sector is composed of 41.2% young firms, with the remaining 58.8% being older firms. In terms of size, 58% of firms are small (with fewer than 50 workers), while 41.9% are large (with more than 50 workers). Regarding innovation, 63.4% of firms report engaging in some form of innovation, with 34.4% of firms adopting technological innovation, 47.3% pursuing product innovation, 7.6% engaging in process innovation, 9.92% pursuing marketing innovation, and a very small percentage (0.76%) adopting business modeling innovation.

The results show some significant negative effects of innovation on average, particularly driven by the adoption of process innovation and marketing innovation individually. For instance, firms adopting process innovation saw a decrease in revenues and a significant increase in costs, suggesting that while process improvements may offer long-term operational benefits, they may not immediately translate into financial gains. Similarly, marketing innovation led to a decline in revenues and a notable increase in costs, which might be due to the costs associated with implementing new marketing strategies that did not effectively boost sales. These results indicate that process and marketing innovation alone may not be sufficient for improving overall performance, especially in terms of revenue generation and cost control. However, exporters in the light engineering sector were able to significantly reduce their prices when they adopted business modeling innovation, process innovation, and marketing innovation individually. This price reduction benefit was notably more substantial for younger firms, which suggests that younger firms may be more adaptable and better positioned to leverage these innovations to adjust their pricing strategies. The ability to lower prices might provide younger exporters with a competitive advantage, potentially helping them capture a larger share of the market.

When looking at the effects of complementary innovation adoption, several pairings were particularly effective in further reducing prices. These include process and technological innovation, product and technological innovation, and technological and marketing innovation. In each of these combinations, prices decreased, showing that aligning technological advancements with other forms of innovation can drive down costs and help firms compete more effectively in the market. For example, combining process and technological innovation may enhance operational efficiency, allowing firms to reduce costs and pass those savings on to consumers through lower prices. It is important to note that non-exporters, rather than exporters, drove the most significant positive effects from dual adoption of innovations. This suggests that non-exporting firms, which primarily operate in domestic markets, may benefit more from combining these types of innovations, possibly because their market dynamics are less complex, allowing for more targeted improvements. On the other hand, exporters might face additional challenges when combining innovations, as they must navigate the complexities of international markets, which can limit the immediate benefits of innovation pairings.

This shows that, while individual innovations like process and marketing innovation led to negative outcomes, certain combinations of innovations—especially those involving technology—proved beneficial, particularly in reducing prices. Exporters, particularly younger firms, may benefit from adopting specific innovations like business modeling and process innovation to improve their pricing strategies. Additionally, complementary innovation pairings such as product and technological innovation seem to hold promise for improving price competitiveness, although non-exporters may experience more pronounced benefits from these strategies.

Different types of Innovation and Innovation Complementaries and Firms Performance in the Automotive Sector

In the automobile sector, out of 76 firms, 35% export their final products abroad, with the remaining firms focusing on domestic markets. The sector is composed of 36.84% young firms, with the remaining 63.2% being older firms. In terms of size, 38.2% of firms are small (with fewer than 50 workers), while 61.8% are large (with more than 50 workers). Regarding innovation, 67.11% of firms report engaging in some form of innovation, with 9.2% adopting business modeling innovation, 13.2% engaging in marketing innovation, 14.5% pursuing process innovation, 34.2% adopting product innovation, and 27.63% opting for technological innovation.

The results show that innovation synergies, or the combination of different types of innovation, tend to be more beneficial for non-exporters. Specifically, combinations such as business modeling with marketing innovation, process innovation with business modeling innovation, process with technological innovation, product with technological innovation, and marketing with technological innovation were particularly advantageous for non-exporting firms. This suggests that non-exporters, who are typically more focused on the domestic market, may benefit more from aligning innovations across different dimensions, enhancing overall performance and competitiveness.

On average, the results indicate that innovation outcomes are largely driven by product innovation, which significantly increases revenues, and marketing innovation, which not only increases revenues but also significantly reduces prices. This demonstrates that product innovations can drive significant revenue growth while marketing innovation helps firms both increase sales and become more competitive by lowering their prices. Older firms that adopted marketing innovation experienced significantly increased revenues and reduced prices, suggesting that older firms are particularly well-positioned to benefit from marketing innovations. This could be due to their established market presence, allowing them to effectively implement strategies that attract more customers while lowering prices.

Both small and large firms that adopted product innovation saw significant revenue increases, but the magnitude of the effect was much larger for big firms, with the revenue increase being at least ten times larger than for small firms. Similarly, firms that adopted technological innovation experienced significant revenue increases and cost reductions. This indicates that technological advancements are particularly impactful in improving the financial performance of automobile firms, especially in terms of cost efficiency. However, big firms that adopted marketing innovation were able to reduce the price of their final products significantly. This points to the fact that larger firms have the capacity to implement broad marketing strategies that not only improve their revenue but also allow them to lower prices, enhancing their competitive advantage. On the other hand, non-exporters experienced more negative effects from adopting product innovation, including significantly reduced revenues and increased costs. This suggests that for non-exporters, product innovations may not always be aligned with market demands, leading to inefficiencies and financial losses when these innovations are not carefully managed.

When innovation types were adopted in combinations there were notable positive effects. Specifically, combinations like business modeling with marketing innovation and process innovation with business modeling innovation led to significantly higher revenues and reduced costs. Additionally, synergies like process and technological innovation, product, and technological innovation, and marketing and technological innovation significantly reduced costs for the firms that adopted them. These results highlight that combining different types of innovation can amplify the benefits, particularly in reducing costs and enhancing revenue, with certain combinations offering more efficient pathways to improved performance. These results show that the key drivers of innovation success in the automobile sector are product and marketing, which both lead to significant revenue growth. However, the impact of these innovations is more pronounced for larger, older firms. Non-exporters in the sector face challenges with product innovation, which can result in reduced revenues and increased costs. For firms that adopted complementary innovation strategies, such as combining business modeling with marketing innovation or product with technological innovation, the results were more positive, particularly in terms of reducing costs and increasing revenues. This suggests that firms in the automobile sector should focus on adopting a holistic approach to innovation, where multiple types of innovations work together to achieve optimal results.

Conclusion

In conclusion, our analysis reveals a nuanced understanding of how various innovation types and their combinations impact firms across different sectors. While the average results across sectors suggest some common trends, they often fail to capture the underlying heterogeneity of the effects, highlighting the importance of considering firm-specific characteristics, sectoral dynamics, and innovation synergies. In the textile sector, the effects of innovation differ significantly between larger, older firms and smaller, younger ones. Product innovation, in isolation, primarily benefits larger and more established firms, enhancing their ability to generate revenue. On the other hand, technological innovation predominantly supports larger firms, helping them improve operational efficiency and productivity. However, there is a clear synergistic effect when innovation types are combined, particularly process innovation with business modeling innovation. This combination results in increased revenues and reduced costs, demonstrating that firms, especially larger ones, can achieve better performance by aligning different types of innovation. This synergy underscores the importance of integrating various innovation strategies to achieve optimal outcomes, particularly in the textile sector, where the impact of individual innovations can be limited without complementary strategies.

In the light engineering sector, our findings show how export status plays a critical role in determining the benefits derived from innovation. Younger, non-exporting firms benefit significantly from adopting business modeling, process innovation, and marketing innovation. These firms tend to leverage innovation to drive improvements in operational efficiency and revenue generation, although the benefits are more pronounced for non-exporters. Moreover, the combination of process and technological innovation, product and marketing innovation, and product and technological innovation further strengthens their performance by reducing costs. These combinations illustrate how strategic innovation adoption can help non-exporting firms compete effectively, particularly when they are aligned with market demands. For exporters in this sector, innovation impacts are more varied, with specific innovations helping to create efficiencies or increase revenue depending on the firm's age and size.

The automobile sector provides another interesting case, where product and marketing innovation are crucial in driving revenue growth. However, the magnitude of these effects differs by firm size. Larger firms benefit more from marketing innovation, which allows them to reduce product prices and expand their market share. In contrast, technological innovation delivers more significant cost reductions for smaller firms, which may not have the same resources or market power as their larger counterparts. This sector also illustrates the importance of innovation combinations. Notably, the combination of process and technological innovation and marketing with technological innovation proved particularly beneficial for non-exporters, further emphasizing the need for targeted innovation strategies that address the unique needs of non-exporting firms.

Our results suggest that certain innovation synergies have particularly positive effects across sectors. For instance, combinations like process innovation with technological innovation and product innovation with technological innovation consistently led to cost reductions across sectors, especially for non-exporting firms. These synergies help firms streamline their operations, reduce inefficiencies, and improve their competitive position in the market. Similarly, **marketing innovation**, when paired with other types of innovation, helped firms lower prices and improve their market positioning, although its benefits were more pronounced for larger firms in certain sectors. Overall, our findings underscore the critical importance of understanding the sector-specific dynamics of innovation adoption. While the average results may provide useful insights into general trends, they often mask the variation in impacts that different types of innovation have on firms of different sizes, ages, and export statuses. In particular, the complementary nature of various innovation strategies is essential to understanding how firms can optimize their performance through innovation. Policymakers and business leaders must recognize that innovation is not a one-size-fits-all solution. For firms to truly benefit from innovation, they must adopt strategies that are tailored to their specific characteristics and market contexts.

Thus, our analysis stresses the importance of a differentiated approach to innovation management, where firms consider the type of innovation they adopt and how different innovations can work together to drive long-term growth and competitiveness. The impact of innovation, whether positive or negative, depends on the sector, the firm's position within the sector (exporter vs. non-exporter), and the firm's size and age. Therefore, for businesses looking to remain competitive, adopting a holistic and context-specific approach to innovation will be vital to maximizing the benefits and minimizing the risks associated with innovation adoption.

Annexes

Figure 1: Examining the Impact of Pair-wise Adoption of Innovation on Increases in Firm Revenues

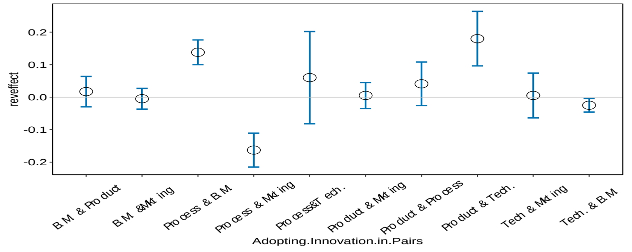


Figure 2: Examining the Impact of Pairwise Adoption of Innovation on Decreases in Output Prices

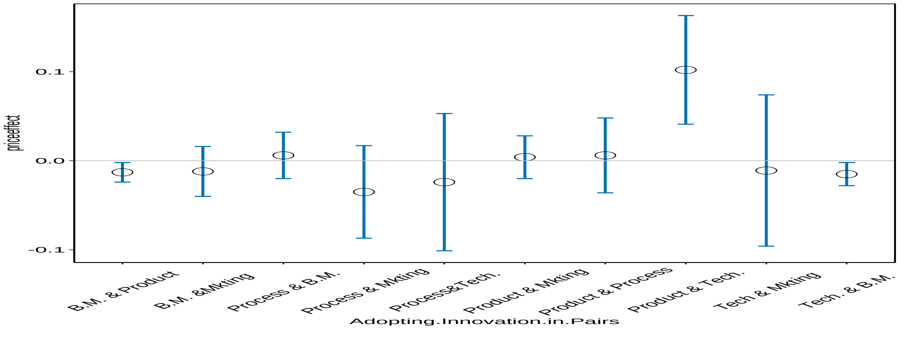


Figure 3: Examining the Impact of Pairwise Adoption of Innovation on Decreases in Firm's Costs

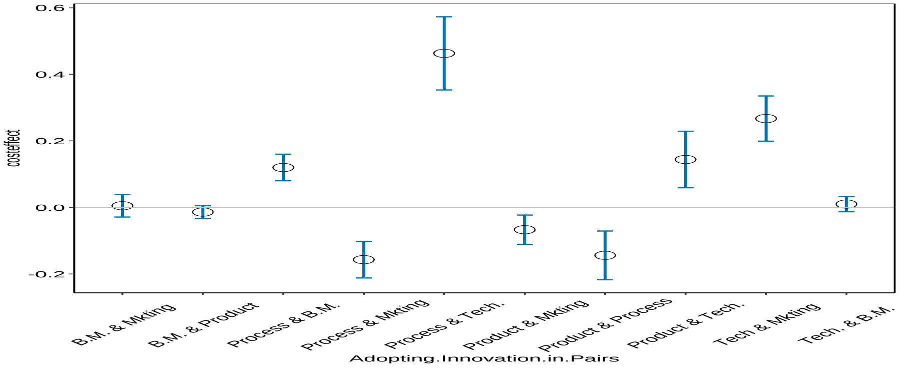


Table 2: Measuring the Impact of the Type of Innovation on the Firm's Performance for Exporters & Non-exporters

Types of Innovation	Exporters			Non-exporter		
Any innovation	0.028	0.043	0.182	-0.287	-0.393**	-0.328
	[0.394]	[0.289]	[0.391]	[0.180]	[0.190]	[0.206]
Business Modelling Innovation	-0.032	0.006	-0.043	-0.083	-0.023	-0.106
	[0.052]	[0.039]	[0.062]	[0.074]	[0.054]	[0.103]
Product Innovation	0.071	0.414	-0.227	-0.052	-0.634**	-1.483***
	[0.489]	[0.376]	[0.588]	[0.493]	[0.307]	[0.516]
Process Innovation	-0.084	0.010	-0.013	-0.016	-0.051	-0.010
	[0.081]	[0.126]	[0.122]	[0.083]	[0.104]	[0.171]
Technological innovation	-0.760***	-0.279	0.197	0.641	1.092**	0.796
	[0.271]	[0.211]	[0.325]	[0.501]	[0.521]	[0.496]
Marketing innovation	-0.077	-0.009	-0.042	0.026	0.050	0.095
	[0.050]	[0.038]	[0.056]	[0.055]	[0.084]	[0.142]

Note: The three different dependent variables of the specifications comprise of dummy = 1 if the firm's revenues increased due to innovation, dummy = 1 if the firm's product price decreased due to innovation and dummy = 1 if the firm's cost decreased due to innovation. The main independent variable is dummy = 1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy = 1 if the firm exports, dummy = 1 if the firm has diversified products, dummy = 1 if the firm makes the technology, dummy = 1 if the firm buys the technology (keeping does not invest in technology), dummy = 1 if the firm is publicly owned, dummy = 1 if the firm is private limited, dummy = 1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.
Robust standard errors in brackets are clustered at firm level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3: Measuring the Impact of Type of Innovation on Firm's Performance for Exporters & Non-exporters, by the age of the firm

	young firms						old firms					
	Revenues	**Prices**	**cost-effect**	**Revenues**	**price**	**cost**	**Revenues**	**price**	**cost**	**Revenues**	**Prices**	**Cost effect**
Types of Innovation	**non-exporter**			**exporter**			**non-exporter**			**exporter**		
Any innovation	-0.318	-1.502***	-0.368	-1.194	-0.530	-0.870	-0.588***	-0.224	-0.220	0.341	0.499	0.424
	[0.517]	[0.414]	[0.459]	[0.841]	[0.528]	[0.597]	[0.206]	[0.286]	[0.339]	[0.395]	[0.327]	[0.493]
Business	0.560***	-0.079	-0.433***	-0.236**	0.148	-0.282***	-0.063	-0.062	-0.302**	-0.040	-0.030	-0.074
Modelling	[0.093]	[0.107]	[0.119]	[0.100]	[0.167]	[0.103]	[0.068]	[0.069]	[0.131]	[0.062]	[0.044]	[0.056]
Innovation												
Product	6.111	28.886***	7.078	-45.825***	-1.842	-2.996	-1.856**	-1.692**	-2.920**	0.281	0.354	0.302
Innovation	[9.940]	[7.967]	[8.829]	[6.160]	[4.581]	[4.935]	[0.914]	[0.699]	[1.116]	[0.702]	[0.621]	[0.665]
Process	-0.875	-3.379***	-1.024	-0.101	0.383***	-0.145	0.053	0.088	-0.008	-0.124	-0.116	-0.031
Innovation	[1.186]	[0.902]	[1.082]	[0.083]	[0.033]	[0.108]	[0.103]	[0.097]	[0.201]	[0.134]	[0.128]	[0.149]
Technological	0.625	2.797***	0.643	-4.357***	0.082	-0.319	1.043*	0.454	0.790	-0.607*	-0.293	0.350
innovation	[0.975]	[0.789]	[0.876]	[0.681]	[0.661]	[0.598]	[0.597]	[0.786]	[0.814]	[0.312]	[0.246]	[0.386]
Marketing	4.887	6.529**	-4.367	-0.106	0.066	-0.071	0.107	0.101	0.003	-0.085	-0.043	-0.090
innovation	[3.087]	[3.080]	[2.713]	[0.096]	[0.106]	[0.092]	[0.111]	[0.092]	[0.207]	[0.061]	[0.039]	[0.074]

Note: The three different dependent variables of the specifications comprise of dummy=1 if the firm's revenues increased due to innovation, dummy=1 if the firm's product price decreased due to innovation and dummy=1 if the firm's cost decreased due to innovation. The main independent variable is dummy=1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy=1 if the firm exports, dummy=1 if the firm has diversified products, dummy=1 if the firm makes the technology, dummy=1 if the firm buys the technology (keeping does not invest in technology), dummy=1 if the firm is publicly owned, dummy=1 if the firm is private limited, dummy=1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.

Robust standard errors in brackets are clustered at firm level.

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4: Measuring the Impact of Type of Innovation on Firm's Performance for Exporters & Non-exporters, by the size of the firm

Small firms							Big firms					
	Revenues	**Price**	**Cost**	**Revenues**	**Price**	**Cost**	**Revenues**	**Price**	**Cost**	**Revenues**	**Price**	**Cost**
Types of Innovation	**non-exporter**			**exporter**			**non-exporter**			**exporter**		
Any innovation	-0.948***	-0.991**	-0.259	-2.450	-0.570	0.003	0.219	-0.029	-0.532	0.918	0.331	-0.065
	[0.355]	[0.403]	[0.394]	[1.739]	[1.257]	[1.790]	[0.435]	[0.489]	[0.420]	[0.661]	[0.341]	[0.734]
Business Modelling Innovation	0.151	-0.168	-0.294**	-0.016	0.237	-0.088	-0.298***	-0.068	-0.472***	-0.018	-0.011	-0.044
	[0.108]	[0.155]	[0.123]	[0.190]	[0.147]	[0.138]	[0.062]	[0.072]	[0.073]	[0.060]	[0.031]	[0.063]
Product Innovation	-0.997	0.857	-3.426***	-1.031	-0.252	-0.067	-4.217	0.564	10.234	0.528	0.782	-0.377
	[1.186]	[1.181]	[1.146]	[0.827]	[0.494]	[0.698]	[8.364]	[9.411]	[8.070]	[0.839]	[0.650]	[0.569]
Process Innovation	0.123	-0.120	0.091	-0.013	0.212*	-0.094	0.423	-0.196	-1.550	-0.111	-0.179	0.085
	[0.087]	[0.107]	[0.146]	[0.160]	[0.118]	[0.116]	[1.009]	[1.119]	[0.940]	[0.170]	[0.132]	[0.117]
Technological innovation	1.783**	1.957**	0.391	-2.665	0.083	1.568	-0.387	0.072	1.066	-1.360	-0.023	0.112
	[0.696]	[0.785]	[0.761]	[2.378]	[3.471]	[4.153]	[0.831]	[0.942]	[0.796]	[1.341]	[0.511]	[1.537]
Marketing innovation	0.247***	-0.008	0.076	0.026	0.073	0.005	-2.298	-1.059	-0.439	-0.090*	-0.019	-0.044
	[0.065]	[0.093]	[0.143]	[0.130]	[0.170]	[0.136]	[1.527]	[1.722]	[1.943]	[0.052]	[0.034]	[0.062]

Note: The three different dependent variables of the specifications comprise of dummy = 1 if the firm's revenues increased due to innovation, dummy = 1 if the firm's product price decreased due to innovation and dummy = 1 if the firm's cost decreased due to innovation. The main independent variable is dummy = 1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy = 1 if the firm exports, dummy = 1 if the firm has diversified products, dummy = 1 if the firm makes the technology, dummy = 1 if the firm buys the technology (keeping does not invest in technology), dummy = 1 if the firm is publicly owned, dummy = 1 if the firm is private limited, dummy = 1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.

Robust standard errors in brackets are clustered at firm level.

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 5: Measuring the impact of Innovation Complementarities on Firm's Performance for Exporters & Non-Exporters

Dependent Variables	Exporters			Non-exporter		
bus_market	-0.025	-0.049	-0.024	0.178*	0.029	0.145**
	[0.039]	[0.031]	[0.045]	[0.104]	[0.061]	[0.071]
bus_prod	-0.12	-0.144	-0.093	0.051	0.003	-0.008
	[0.148]	[0.120]	[0.178]	[0.049]	[0.037]	[0.064]
proc_bus	0.109***	-0.001	0.068	0.194***	0.026	0.145*
	[0.039]	[0.023]	[0.056]	[0.069]	[0.055]	[0.074]
process_market	-0.055	-0.108	-0.116	-0.370***	-0.150*	0.022
	[0.095]	[0.081]	[0.125]	[0.137]	[0.079]	[0.149]
process_tech	0.125	-0.200**	0.274*	-0.063	0.028	0.561***
	[0.112]	[0.081]	[0.160]	[0.195]	[0.100]	[0.183]
prod_market	0.013	-0.324*	-0.196	0.095*	0.006	-0.073
	[0.192]	[0.186]	[0.263]	[0.054]	[0.026]	[0.064]
prod_proc	0.021	-0.391**	-0.009	0.109	0.015	-0.174*
	[0.175]	[0.192]	[0.315]	[0.078]	[0.047]	[0.096]
prod_tech	-0.043	-0.422	0.124	0.372***	0.150***	0.092
	[0.717]	[0.541]	[0.833]	[0.107]	[0.048]	[0.119]
tech_market	-0.101	-0.369***	0.179	0.033	0.114*	0.353***
	[0.182]	[0.087]	[0.116]	[0.136]	[0.066]	[0.112]
bus_tech	-0.182	-0.260***	0.1	-0.202***	-0.028	-0.083
	[0.156]	[0.082]	[0.145]	[0.075]	[0.054]	[0.091]

Note: The three different dependent variables of the specifications comprise of dummy = 1 if the firm's revenues increased due to innovation, dummy = 1 if the firm's product price decreased due to innovation and dummy = 1 if the firm's cost decreased due to innovation. The main independent variable is dummy = 1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy = 1 if the firm exports, dummy = 1 if the firm has diversified products, dummy = 1 if the firm makes the technology, dummy = 1 if the firm buys the technology (keeping does not invest in technology), dummy = 1 if the firm is publicly owned, dummy = 1 if the firm is private limited, dummy = 1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.
Robust standard errors in brackets are clustered at firm level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 6: Measuring the Impact of Type of innovation on The Textile Sector's Performance

	Textile Sector		
	Revenues	**Price**	**Cost**
Types of Innovation	**exporter**		
Any innovation	-0.358	-0.024	-0.285
	[0.551]	[0.500]	[0.539]
Business Modelling Innovation	-0.058	-0.013	-0.069
Product Innovation	0.303***	0.253***	-0.280***
	[0.059]	[0.083]	[0.065]
Process Innovation	-0.055	-0.216	-0.080
	[1.169]	[0.525]	[1.221]
Technological innovation	18.666*	6.018	21.439*
	[9.608]	[5.932]	[11.672]
Marketing innovation	-0.081	-0.005	-0.082
	[0.061]	[0.033]	[0.066]

Note: The three different dependent variables of the specifications comprise of dummy = 1 if the firm's revenues increased due to innovation, dummy = 1 if the firm's product price decreased due to innovation and dummy = 1 if the firm's cost decreased due to innovation. The main independent variable is dummy = 1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy = 1 if the firm exports, dummy = 1 if the firm has diversified products, dummy = 1 if the firm makes the technology, dummy = 1 if the firm buys the technology (keeping does not invest in technology), dummy = 1 if the firm is publicly owned, dummy = 1 if the firm is private limited, dummy = 1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.
Robust standard errors in brackets are clustered at firm level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 7: Measuring the Impact of Complimentary Adoption of innovation on The Textile Sector's Performance

Textile Sector			
Complimentary Innovation	**Revenues**	**Price**	**Cost**
bus_market	-0.048	-0.029*	-0.062
	[0.054]	[0.015]	[0.059]
bus_prod	-0.380	-0.142	-0.442
	[0.355]	[0.134]	[0.391]
proc_bus	0.092***	-0.010	0.103***
	[0.031]	[0.013]	[0.037]
process_market	0.206	-0.135	0.266
	[0.337]	[0.230]	[0.500]
process_tech	0.217	0.011	-2.227**
	[0.800]	[0.311]	[1.074]
prod_market	0.003	-0.115	-0.362
	[0.280]	[0.136]	[0.309]
prod_proc	-0.110	-0.014	0.800**
	[0.263]	[0.126]	[0.370]
prod_tech	-2.869	-1.912	-1.223
	[3.565]	[2.033]	[4.044]
tech_market	-0.429	0.225	0.487
	[0.670]	[0.426]	[0.844]
bus_tech	0.129	0.061	0.236
	[0.645]	[0.375]	[0.742]

Note: The three different dependent variables of the specifications comprise of dummy=1 if the firm's revenues increased due to innovation, dummy=1 if the firm's product price decreased due to innovation and dummy=1 if the firm's cost decreased due to innovation. The main independent variable is dummy=1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy=1 if the firm exports, dummy=1 if the firm has diversified products, dummy=1 if the firm makes the technology, dummy=1 if the firm buys the technology (keeping does not invest in technology), dummy=1 if the firm is publicly owned, dummy=1 if the firm is private limited, dummy=1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.
Robust standard errors in brackets are clustered at firm level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 8: Measuring the Impact of Type of innovation on The Textile Sector's Performance, by Age & Size

Types of Innovation	young			old			small			big		
	Revenues	**Price**	**Cost**	**Revenues**	**Price**	**Cost**	**Revenues**	**Price**	**Cost**	**Revenues**	**Price**	**Cost**
Any innovation	-2.358***	-0.471	-1.920**	0.210	0.648	0.566	-1.098	-5.981	-1.098	0.305***	0.301***	-0.255***
	[0.678]	[1.072]	[0.893]	[0.504]	[0.554]	[0.550]	[0.000]	[0.000]	[0.000]	[0.062]	[0.076]	[0.069]
Business	-0.316**	-0.079	-0.350**	-0.086**	-0.038*	-0.113***	-54.985	-174.953	3.946	-0.069	-0.011	-0.084
Modelling	[0.134]	[0.085]	[0.147]	[0.033]	[0.022]	[0.035]	[0.000]	[0.000]	[0.000]	[0.048]	[0.017]	[0.054]
Innovation												
Product	-0.452***	-0.049	0.106	0.296***	0.334***	-0.234***	-2.989	-7.148	1..808	0.306***	0.302***	-0.256***
Innovation	[0.141]	[0.121]	[0.163]	[0.071]	[0.092]	[0.067]	[3.010]	[8.052]	[2.058]	[0.062]	[0.076]	[0.069]
Process	-3.920	-0.045	-3.070	1.210	0.464	1.051	3.752	11.939	-0.269	0.833	-0.369	0.264
Innovation	[2.920]	[2.238]	[3.024]	[1.054]	[0.483]	[1.370]	[0.000]	[0.000]	[0.000]	[0.925]	[0.584]	[1.261]
Technological	15.711	3.251	1.987	13.133	5.287	21.462	74.343	236.546	-5.336	18.080*	4.474	21.099
innovation	[38.443]	[23.473]	[41.284]	[14.039]	[8.267]	[17.498]	[0.000]	[0.000]	[0.000]	[10.808]	[6.532]	[13.473]
Marketing	-0.048	-0.017	-0.004	-0.098	-0.023	-0.139	-0.178	-0.566	0.013	-0.105*	0.009	-0.087
innovation	[0.142]	[0.097]	[0.141]	[0.074]	[0.025]	[0.102]	[0.000]	[0.000]	[0.000]	[0.054]	[0.031]	[0.067]

Note: The three different dependent variables of the specifications comprise of dummy = 1 if the firm's revenues increased due to innovation, dummy = 1 if the firm's product price decreased due to innovation and dummy = 1 if the firm's cost decreased due to innovation. The main independent variable is dummy = 1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy = 1 if the firm exports, dummy = 1 if the firm has diversified products, dummy = 1 if the firm makes the technology, dummy = 1 if the firm buys the technology (keeping does not invest in technology), dummy = 1 if the firm is publicly owned, dummy = 1 if the firm is private limited, dummy = 1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.

Robust standard errors in brackets are clustered at firm level.

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 9: Measuring the Impact of Type of innovation on The Light Engineering Sector's Performance

Light engineering Sector			
Types of Innovation	**Revenues**	**Price**	**Cost**
Any innovation	-0.215	-0.006	0.560
	[0.256]	[0.284]	[0.356]
Business Modelling Innovation	-0.036	0.099	-0.122
	[0.068]	[0.127]	[0.136]
Product Innovation	0.271	0.329	0.323
	[0.510]	[0.515]	[0.697]
Process Innovation	-0.101**	0.081	-0.242***
	[0.047]	[0.169]	[0.064]
Technological innovation	1.983	9.119	4.325
	[4.263]	[5.675]	[6.462]
Marketing innovation	-0.105**	0.072	-0.243***
	[0.048]	[0.173]	[0.064]

Note: The three different dependent variables of the specifications comprise of dummy = 1 if the firm's revenues increased due to innovation, dummy = 1 if the firm's product price decreased due to innovation and dummy = 1 if the firm's cost decreased due to innovation. The main independent variable is dummy = 1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy = 1 if the firm exports, dummy = 1 if the firm has diversified products, dummy = 1 if the firm makes the technology, dummy = 1 if the firm buys the technology (keeping does not invest in technology), dummy = 1 if the firm is publicly owned, dummy = 1 if the firm is private limited, dummy = 1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.
Robust standard errors in brackets are clustered at firm level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 10: Measuring the Impact of Type of innovation on The Light Engineering Sector's Performance, by Age & Size

	Light Engineering											
VARIABLES	small			big			young			old		
	Revenues	Price	Cost	Revenues	Price	Cost	Revenues	Price	Cost	Revenues	Price	Cost
Any innovation	-3.484	-2.097***	1.6633**	1.84	-1.37	6.3	4.72	-1.235	11.42	-0.080	0.325	0.392
	[1,0.919]	[.408]	[6.620]	[1.014]	[8.9]	[14.326]	[8.670]	[11.15]	[8.698]	[0.329]	[0.364]	[0.417]
Business Modelling Innovation	-0.010	0.237	-0.220*	0.115	0.131	0.278	-0.103	0.430***	-0.134	-0.014	-0.032	-0.068
	[0.119]	[0.155]	[0.112]	[0.093]	[0.101]	[0.176]	[0.081]	[0.063]	[0.109]	[0.065]	[0.069]	[0.188]
Product Innovation	1.196	0.712	0.427	-0.354	-0.490	0.866	2.3509*	-4.066	10.125	0.165	-1.648	-0.139
	[1.440]	[1.294]	[1.482]	[0.545]	[0.748]	[0.893]	[1.924]	[23.813]	[14.311]	[0.997]	[1.012]	[1.174]
Process Innovation	-0.001	0.193	-0.213**	-3.686	-7.334**	-5.777	-0.080	0.370***	-0.116	-0.087	-0.104	-0.309***
	[0.108]	[0.135]	[0.093]	[2.374]	[3.060]	[5.613]	[0.070]	[0.054]	[0.090]	[0.068]	[0.078]	[0.112]
Technological innovation	0.827	12.382	-1.499	9.061	27.030*	20.422	-4.340	-19.564	-44.159***	4.336	9.289	11.472
	[6.710]	[8.050]	[10.026]	[10.768]	[13.722]	[15.329]	[16.951]	[24.271]	[12.920]	[5.261]	[6.433]	[8.157]
Marketing innovation	-0.003	0.188	-0.220**	0.035	-2.584	0.809	-0.092	0.372***	-0.128	-0.089	-0.109	-0.295***
	[0.110]	[0.143]	[0.096]	[2.113]	[3.322]	[4.318]	[0.072]	[0.054]	[0.093]	[0.067]	[0.075]	[0.112]

Note: The three different dependent variables of the specifications comprise of dummy = 1 if the firm's revenues increased due to innovation, dummy = 1 if the firm's product price decreased due to innovation and dummy = 1 if the firm's cost decreased due to innovation. The main independent variable is dummy = 1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy = 1 if the firm exports, dummy = 1 if the firm has diversified products, dummy = 1 if the firm makes the technology, dummy = 1 if the firm buys the technology (keeping does not invest in technology), dummy = 1 if the firm is publicly owned, dummy = 1 if the firm is private limited, dummy = 1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.

Robust standard errors in brackets are clustered at firm level.

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 11: Measuring the Impact of Type of innovation on The Light Engineering Sector's Performance for Exporters & Non-exporters

	Light engineering Sector					
Types of Innovation	**exporter**			**Non-exporters**		
	Revenues	**Price**	**Cost**	**Revenues**	**Price**	**Cost**
Any innovation	-0.109	0.082	1.163	-0.197	0.029	0.286
	[0.688]	[0.695]	[0.756]	[0.358]	[0.389]	[0.493]
Business Modelling Innovation	-0.131	0.293**	-0.106	-0.096	-0.150*	-0.344***
	[0.089]	[0.106]	[0.196]	[0.063]	[0.086]	[0.108]
Product Innovation	0.593	0.084	-1.730	0.168	0.579	1.076
	[1.142]	[1.074]	[1.390]	[0.575]	[0.628]	[0.743]
Process Innovation	-0.126	0.315***	-0.214**	-0.040	-0.185**	-0.355***
	[0.080]	[0.070]	[0.096]	[0.067]	[0.089]	[0.103]
Technological innovation	-19.219	50.591	45.270	-0.975	5.103	3.942
	[23.318]	[34.291]	[44.788]	[4.924]	[6.137]	[8.052]
Marketing innovation	-0.137	0.321***	-0.209**	-0.057	-0.199**	-0.357***
	[0.085]	[0.075]	[0.101]	[0.064]	[0.088]	[0.102]

Note: The three different dependent variables of the specifications comprise of dummy = 1 if the firm's revenues increased due to innovation, dummy = 1 if the firm's product price decreased due to innovation and dummy = 1 if the firm's cost decreased due to innovation. The main independent variable is dummy = 1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy = 1 if the firm exports, dummy = 1 if the firm has diversified products, dummy = 1 if the firm makes the technology, dummy = 1 if the firm buys the technology (keeping does not invest in technology), dummy = 1 if the firm is publicly owned, dummy = 1 if the firm is private limited, dummy = 1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.
Robust standard errors in brackets are clustered at firm level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 12: Measuring the impact of Innovation Complementarities on the Light Engineering Sector's Performance

Light engineering Sector			
Complimentary innovation	**Revenues**	**Price**	**Cost**
bus_market	[0.101]	[0.211]	[0.151]
	0.110	-0.313	-0.424
bus_prod	-0.045	-0.027	-0.155
	[0.197]	[0.209]	[0.218]
proc_bus	1.301*	-0.125	2.628**
	[0.715]	[0.769]	[1.109]
process_market	0.781	-1.914	0.468
	[1.300]	[1.525]	[1.866]
process_tech	0.172	2.297***	0.449
	[0.257]	[0.320]	[0.408]
prod_market	0.047	-0.546***	0.111
	[0.109]	[0.202]	[0.172]
prod_proc	-0.031	-0.843***	-0.14
	[0.093]	[0.122]	[0.155]
prod_tech	1.029	7.640**	4.611
	[3.237]	[3.271]	[3.466]
tech_market	-0.035	1.466***	-0.231
	[0.293]	[0.550]	[0.458]
bus_tech	0.200	0.102	0.373
	[0.523]	[0.562]	[0.580]

Note: The three different dependent variables of the specifications comprise of dummy = 1 if the firm's revenues increased due to innovation, dummy = 1 if the firm's product price decreased due to innovation and dummy = 1 if the firm's cost decreased due to innovation. The main independent variable is dummy = 1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy = 1 if the firm exports, dummy = 1 if the firm has diversified products, dummy = 1 if the firm makes the technology, dummy = 1 if the firm buys the technology (keeping does not invest in technology), dummy = 1 if the firm is publicly owned, dummy = 1 if the firm is private limited, dummy = 1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.
Robust standard errors in brackets are clustered at firm level.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 13: Measuring the impact of Innovation Complementarities on the Light Engineering Sector's Performance for Exporters & Non-exporters

	Light engineering Sector					
	Exporters			Non-exporter		
	Revenues	Price	Cost	Revenues	Price	Cost
bus_market	-1.516	-1.005	1.072	0.082	-0.496	-0.136
	[1.443]	[1.656]	[1.600]	[0.506]	[0.575]	[0.713]
bus_prod	0.154	0.028	0.419	-0.299	0.299	0.079
	[0.405]	[0.595]	[0.755]	[0.237]	[0.274]	[0.324]
proc_bus	1.267	1.163	4.686*	1.390	-1.731	2.818
	[1.733]	[1.925]	[2.689]	[1.172]	[1.195]	[1.728]
process_market	-0.839	-1.463	6.430*	1.001	-3.356	-4.641*
	[2.214]	[1.837]	[3.134]	[2.678]	[3.190]	[2.705]
process_tech	-15.470	-9.562	2.841	22.211	16.113	34.501**
	[12.050]	[12.527]	[33.360]	[14.173]	[17.077]	[15.781]
prod_market	11.926*	5.320	11.975	0.691	9.530***	3.094
	[6.077]	[8.141]	[7.603]	[2.966]	[2.229]	[2.551]
prod_proc				-8.861*	-5.407	-11.263
				[5.175]	[6.964]	[6.986]
prod_tech	8.476	-0.063	8.446	-0.352	11.898***	3.701
	[7.148]	[7.053]	[8.235]	[4.216]	[4.021]	[4.084]
tech_market	-32.122*	-13.510	-27.089	-1.197	-25.046***	-8.251
	[15.598]	[22.074]	[20.203]	[7.691]	[5.413]	[6.313]
bus_tech	-0.266	0.148	-1.096	0.864	-0.700	0.058
	[1.083]	[1.390]	[1.826]	[0.648]	[0.685]	[0.734]

Note: The three different dependent variables of the specifications comprise of dummy=1 if the firm's revenues increased due to innovation, dummy=1 if the firm's product price decreased due to innovation and dummy=1 if the firm's cost decreased due to innovation. The main independent variable is dummy=1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy=1 if the firm exports, dummy=1 if the firm has diversified products, dummy=1 if the firm makes the technology, dummy=1 if the firm buys the technology (keeping does not invest in technology), dummy=1 if the firm is publicly owned, dummy=1 if the firm is private limited, dummy=1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.
Robust standard errors in brackets are clustered at firm level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 14: Measuring the Impact of Type of innovation on The Automotive Sector's Performance

Automotive Sector			
	Revenue	**Price**	**Cost**
Any innovation	-0.058	0.024	-0.324
	[0.585]	[0.499]	[0.610]
Business Modelling Innovation	0.062	0.038	-0.140*
	[0.104]	[0.059]	[0.080]
Product Innovation	14.741***	-1.849	-4.526
	[5.527]	[2.506]	[4.375]
Process Innovation	-2.088*	-0.666	-0.539
	[1.222]	[1.101]	[1.292]
Technological innovation	42.948	-18.918	17.938
	[38.364]	[26.004]	[41.800]
Marketing innovation	0.817*	0.682**	-0.059
	[0.425]	[0.281]	[0.483]

Note: The three different dependent variables of the specifications comprise of dummy=1 if the firm's revenues increased due to innovation, dummy=1 if the firm's product price decreased due to innovation and dummy=1 if the firm's cost decreased due to innovation. The main independent variable is dummy=1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy=1 if the firm exports, dummy=1 if the firm has diversified products, dummy=1 if the firm makes the technology, dummy=1 if the firm buys the technology (keeping does not invest in technology), dummy=1 if the firm is publicly owned, dummy=1 if the firm is private limited, dummy=1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.
Robust standard errors in brackets are clustered at firm level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 15: Measuring the Impact of Type of innovation on The Automotive Sector's Performance, by Age & Size

	Automotive Industry											
	small			big			Young			Old		
	Revenues	Price	Cost	Revenues	Price	Cost	Revenues	Price	Cost	Revenues	Price	Cost
Any innovation	2.420***	1.113	2.200**	-0.053	-0.273	-1.155***	1.852	0.471	-1.752	-1.257*	-0.335	0.156
	[0.780]	[0.993]	[1.019]	[0.398]	[0.289]	[0.319]	[1.279]	[1.671]	[1.402]	[0.660]	[0.901]	[0.966]
Business Modelling Innovation	-2.887***	-0.847	-1.901*	0.102	0.077	-0.151	0.103	0.112	0.188	0.193	0.068	-0.157
	[0.773]	[0.929]	[0.996]	[0.126]	[0.084]	[0.102]	[0.211]	[0.203]	[0.274]	[0.137]	[0.086]	[0.121]
Product Innovation	2.788***	1.282	2.534**	20.515***	-2.231	-2.783	6.907	0.768	-0.619	13.654*	-0.388	-3.892
	[0.898]	[1.144]	[1.174]	[4.937]	[3.387]	[5.844]	[5.347]	[4.141]	[3.011]	[6.827]	[3.076]	[6.621]
Process Innovation	-13.945***	-2.774	-22.08***	-2.536*	-0.585	0.628	-8.926	-4.396	-20.281***	-4.189***	-1.126	0.435
	[4.570]	[4.500]	[1.658]	[1.426]	[1.198]	[1.403]	[5.322]	[4.238]	[2.908]	[1.092]	[1.510]	[1.699]
Technological innovation	160.778***	62.066	301.6***	44.468	-28.810	3.592	69.401	10.101	92.686	5.813	-80.205	74.480
	[55.845]	[59.880]	[16.712]	[37.535]	[32.947]	[45.872]	[48.235]	[30.249]	[70.888]	[53.175]	[51.717]	[64.588]
Marketing innovation	-22.333***	-7.736	-40.7***	0.710	0.708*	-0.022	-10.325	4.043	-12.195	0.837*	0.675**	-0.099
	[7.341]	[7.831]	[2.294]	[0.576]	[0.381]	[0.602]	[12.773]	[11.089]	[19.277]	[0.457]	[0.333]	[0.550]

Note: The three different dependent variables of the specifications comprise of dummy = 1 if the firm's revenues increased due to innovation, dummy = 1 if the firm's product price decreased due to innovation and dummy = 1 if the firm's cost decreased due to innovation. The main independent variable is dummy = 1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy = 1 if the firm exports, dummy = 1 if the firm has diversified products, dummy = 1 if the firm makes the technology, dummy = 1 if the firm buys the technology (keeping does not invest in technology), dummy = 1 if the firm is publicly owned, dummy = 1 if the firm is private limited, dummy = 1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.
Robust standard errors in brackets are clustered at firm level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 16: Measuring the Impact of Type of innovation on The Light Engineering Sector's Performance for Exporters & Non-exporters

Automotive Sector						
VARIABLES	**exporter**			**Non-exporters**		
	Revenues	**Price**	**Cost**	**Revenues**	**Price**	**Cost**
Any innovation	-1.077	-2.586***	-0.361	-0.332	-0.116	-0.426
	[1.764]	[0.123]	[1.257]	[0.821]	[0.780]	[0.842]
Business Modelling Innovation	0.396*	0.144	-0.229	-0.190	-0.066	-0.151
	[0.207]	[0.318]	[0.297]	[0.169]	[0.068]	[0.140]
Product Innovation	41.215	24.657	31.197	-0.329**	-0.175	-0.451***
	[39.982]	[38.075]	[25.794]	[0.146]	[0.124]	[0.122]
Process Innovation	-3.841	-2.601	1.688	-1.455	0.135	-1.508
	[5.245]	[2.096]	[4.843]	[1.811]	[1.684]	[2.278]
Technological innovation	172.744	-263.765	-246.995	22.805	-49.810	60.662
	[947.275]	[346.318]	[549.010]	[51.747]	[41.408]	[52.515]
Marketing innovation	1.363	1.046*	-0.544	-1.065	0.281	-0.115
	[1.956]	[0.595]	[1.722]	[1.548]	[1.376]	[1.187]

Note: The three different dependent variables of the specifications comprise of dummy = 1 if the firm's revenues increased due to innovation, dummy = 1 if the firm's product price decreased due to innovation and dummy = 1 if the firm's cost decreased due to innovation. The main independent variable is dummy = 1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy = 1 if the firm exports, dummy = 1 if the firm has diversified products, dummy = 1 if the firm makes the technology, dummy = 1 if the firm buys the technology (keeping does not invest in technology), dummy = 1 if the firm is publicly owned, dummy = 1 if the firm is private limited, dummy = 1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.
Robust standard errors in brackets are clustered at firm level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 17: Measuring the impact of Innovation Complementarities on the Automotive Sector's Performance

	Automotive Sector		
	Revenues	**Price**	**Cost**
bus_market	0.232***	0.073	0.199**
	[0.066]	[0.063]	[0.075]
bus_prod	0.04	0.043	0.035
	[0.066]	[0.037]	[0.068]
proc_bus	0.246***	0.092	0.184**
	[0.058]	[0.056]	[0.073]
process_market	-0.068	0.092	0.016
	[0.138]	[0.073]	[0.097]
process_tech	0.137	0.114	0.480***
	[0.192]	[0.103]	[0.140]
prod_market	0.054	0.025	0.007
	[0.057]	[0.028]	[0.068]
prod_proc	0.031	0.017	-0.075
	[0.086]	[0.045]	[0.098]
prod_tech	0.088	0.130	0.284**
	[0.117]	[0.084]	[0.121]
tech_market	0.051	0.085	0.403***
	[0.129]	[0.075]	[0.115]
bus_tech	-0.270**	-0.027	-0.027
	[0.112]	[0.088]	[0.159]

Note: The three different dependent variables of the specifications comprise of dummy=1 if the firm's revenues increased due to innovation, dummy=1 if the firm's product price decreased due to innovation and dummy=1 if the firm's cost decreased due to innovation. The main independent variable is dummy=1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy=1 if the firm exports, dummy=1 if the firm has diversified products, dummy=1 if the firm makes the technology, dummy=1 if the firm buys the technology (keeping does not invest in technology), dummy=1 if the firm is publicly owned, dummy=1 if the firm is private limited, dummy=1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.
Robust standard errors in brackets are clustered at firm level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table18: Measuring the impact of Innovation Complementarities on the Light Engineering Sector's Performance for Exporters & Non-exporters

Automotive Sector						
	Exporters			Non-exporters		
	Revenues	Price	Cost	Revenues	Price	Cost
bus_market	-0.001	-0.040	0.156	0.197	0.049	0.119
	[0.030]	[0.146]	[0.386]	[0.129]	[0.086]	[0.114]
bus_prod	-0.692	0.515	0.550	0.015	0.014	0.022
	[0.460]	[0.562]	[1.971]	[0.048]	[0.030]	[0.060]
proc_bus	0.261	-0.137	0.091	0.199*	0.055	0.134
	[0.254]	[0.213]	[0.690]	[0.102]	[0.083]	[0.113]
process_market	0.183	-0.087	0.522	-0.261**	0.060	0.082
	[0.853]	[0.329]	[0.713]	[0.122]	[0.070]	[0.112]
process_tech	2.256	1.863*	0.338	-0.262	0.094	0.479***
	[1.747]	[0.961]	[2.778]	[0.164]	[0.120]	[0.151]
prod_market	-3.122	-2.299**	-3.279	0.087	0.014	0.016
	[3.219]	[0.805]	[3.227]	[0.052]	[0.023]	[0.038]
prod_proc	4.200	-0.998	1.000	0.120	0.011	-0.031
	[9.199]	[5.144]	[7.786]	[0.078]	[0.051]	[0.067]
prod_tech	-5.060	-9.321	2.823	0.077	0.105	0.106
	[16.674]	[11.238]	[18.074]	[0.218]	[0.103]	[0.165]
tech_market	-1.766*	-1.080***	-1.098	-0.249	0.081	0.363***
	[0.937]	[0.374]	[1.344]	[0.169]	[0.080]	[0.123]
bus_tech	-0.548***	-0.116	-0.191	-0.356***	-0.041	-0.012
	[0.099]	[0.320]	[0.759]	[0.109]	[0.091]	[0.162]

Note: The three different dependent variables of the specifications comprise of dummy = 1 if the firm's revenues increased due to innovation, dummy = 1 if the firm's product price decreased due to innovation and dummy = 1 if the firm's cost decreased due to innovation. The main independent variable is dummy = 1 if the firm decides to innovate. Other independent variables comprise of the firm's characteristics such as firm's age, age squared, number of workers employed by firm, dummy = 1 if the firm exports, dummy = 1 if the firm has diversified products, dummy = 1 if the firm makes the technology, dummy = 1 if the firm buys the technology (keeping does not invest in technology), dummy = 1 if the firm is publicly owned, dummy = 1 if the firm is private limited, dummy = 1 if the firm is family owned (keeping proprietorship as base category). District fixed effects and sector fixed effects for textile, surgical, light engineering and automobile are controlled in the specification. Time fixed effects for years 2018, 2019, 2020 and 2021 are also controlled.
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*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

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