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INNOVATION AND EXPORT PERFORMANCE: FIRM-LEVEL EVIDENCE FROM DEVELOPING, EMERGING, AND ADVANCED ECONOMIES

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This paper investigates the relationship between firm-level innovation and export performance across different stages of economic development. Data from 10,000 firms in the 2023 World Bank Enterprise Survey are used to analyze the effects of product innovation, process innovation, and research and development (R&D) activities on export intensity. A fractional probit model is employed to account for the bounded nature of export shares. Results show that capital intensity and R&D are positively associated with export propensity, while product innovation exhibits a negative short-run effect, particularly among smaller firms. No significant effect is found for process innovation. Export behavior varies across income groups, with firms in high-income countries displaying higher export intensity than those in low- and middle-income economies. These findings highlight the conditional role of innovation in promoting export activity and suggest the importance of targeted policies to enhance innovation capacity and export readiness in developing economies.

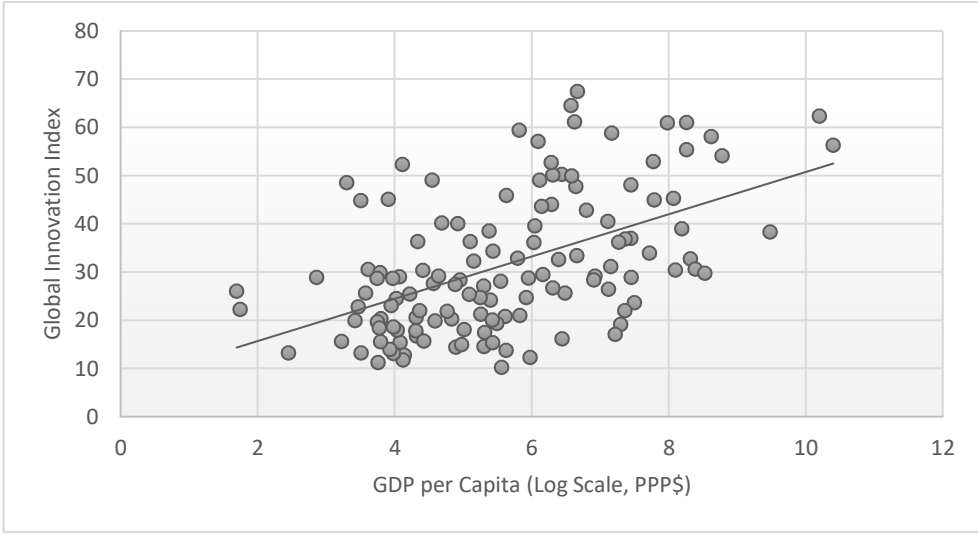
Keywords: Export Performance; Firm Innovation; Innovation Policy; Fractional Probit Model; World Bank Enterprise Survey
JEL Classification: F14; O31; L25; C25; O33

1. INTRODUCTION

Technological innovation is a critical driver of long-term economic growth and a key tool for addressing global challenges (Romer, 1994). Empirical evidence has established a strong correlation between innovation and economic progress in both developed and developing economies (Lundvall, 2016; Cirera and Maloney, 2017; Edler and Fagerberg, 2017). By the 21st century, economies worldwide have widely embraced the idea that

innovation is a driving force for economic growth and is essential for maintaining the viability of enterprises (Chursin et al., 2017). Recent research utilizing double correlation-regression analysis highlights a significant relationship between a country's innovative potential and its level of economic development (Rajabov et al., 2023).

To further elucidate this relationship, the Global Innovation Index (GII) has been employed as a proxy for the state of scientific development, while GDP per capita (adjusted for purchasing power parity in US$) serves as an indicator of economic development. A scatter plot analysis of 129 countries, Figure 1, demonstrates a positive correlation between GII (Y-axis) and GDP per capita (X-axis, on a logarithmic scale). The dotted trend line underscores this relationship, indicating that countries with higher GDP per capita tend to score higher on the GII. Among nations with lower GDP per capita, the GII's impact diminishes, as illustrated by the clustering of blue bubbles. This observation aligns with Cavalcante (2023), who reported that higher GII scores are generally associated with wealthier economies.



Source: Global Innovation Index, 2024

Figure 1. Relationship Between Global Innovation Index and GDP per Capita (Log Scale, PPP$) Across 129 Countries

This positive correlation extends beyond national-level indicators to firm-level dynamics, particularly as globalization reshapes competitive markets. The interplay between firm-level innovation and export behavior has emerged as a pivotal area of economic research. While numerous studies have explored the influence of innovation on export performance, traditional metrics such as patents and R&D investments often

fail to capture the breadth of innovation activities, especially in diverse economic settings (Fu and Kingiri, 2020). Consequently, there is a knowledge gap regarding the direct effects of product Innovation on firm-level export dynamics in both developed and developing economies.

This study addresses this gap by analyzing data from the World Bank Enterprise Survey to assess the impact of innovation and firm characteristics on export behavior. The methodology emphasizes the role of product and process innovations in driving export performance, offering a detailed perspective on how firms' innovative activities contribute to export development. Previous research has identified product and process innovation as critical drivers of export performance across economic contexts (Deng et al., 2014). However, resource constraints and the public-good nature of certain technological fields, such as those targeting societal challenges related to human welfare and sustainable development, often limit their development, particularly in developing economies (Paunov, 2013). Furthermore, imported or adapted innovations may not always align with local economic structures or social and geographical conditions.

In developed economies, innovation is often regarded as a strategic asset for enhancing competitiveness in international markets through the introduction of new products and process improvements (Becker and Egger, 2013). Conversely, in developing economies, innovation dynamics are shaped by limited financial resources, resulting in selective technological advancements influenced by local economic, social, and environmental conditions (Acemoglu, 2002; Stewart, 1983). This selectivity may hinder firms' ability to simultaneously innovate and expand exports, potentially exacerbating economic disparities between developed and developing nations (Fu and Gong, 2011).

This paper examines these complexities by exploring (1) the innovation trajectories of developed and developing economies, (2) the drivers of these trajectories, and (3) their roles in shaping global innovation trends. In doing so, we classify countries into low-, middle-, and high-income groups based on the World Bank's income classification, allowing for a more granular analysis of innovation patterns across diverse economic contexts. By focusing on the direct and mediating roles of product and process innovations, this study provides nuanced insights into how various types of innovation impact export behavior across different income groups. These findings aim to guide policymakers and business leaders in fostering innovation as a strategic lever for achieving sustained export growth, particularly in emerging markets.

2. LITERATURE REVIEW

This section focuses on the theoretical foundations and empirical analyzes essential for examining the innovations driving export performance. By integrating these

approaches, the study aims to systematically identify and evaluate the key determinants influencing export dynamics.

2.1. Theoretical Framework: Innovation and Export Performance

2.1.1. Model Setup

We consider a continuum of profit-maximizing firms, each producing a differentiated product under monopolistic competition. Firms can engage in two types of innovative activities: product innovation (introducing new products or improving product quality) and process innovation (improving production efficiency to reduce cost). These innovation decisions are made at the firm level and influence the firm's cost structure and demand. After innovating, firms compete in both the domestic market and a foreign market (exports). We assume there is a fixed cost for entering the export market, reflecting sunk costs of distribution, regulation, etc. Only firms that expect non-negative profit from exporting will pay this cost and become exporters. This setup captures the stylized fact that only a subset of firms export, typically those with higher productivity or superior products (Panda and Sharma, 2023).

To capture differences between developing and developed countries, we allow key parameters to vary by economy type. In a developed economy, firms face relatively *lower R&D costs* (due to better innovation infrastructure and funding), *higher innovation efficiency* (greater probability that R&D leads to successful innovation), and *larger market size or demand* for new products. In a developing economy, firms may have *higher R&D costs, lower innovation efficiency*, and a smaller effective market for novel products (due to weaker consumer purchasing power or global market access). These differences will be reflected in the model's equilibrium outcomes, as discussed later. Empirical evidence supports such distinctions: for example, domestic innovation activities more directly translate into export gains in developed countries, whereas in developing countries the payoff is weaker (Panda and Sharma, 2023).

2.1.2. Firm Behavior and Innovation Decisions

Production and Demand

Each firm has an initial unit production cost c_0. Through process innovation, a firm can reduce its unit cost. Let I_c denote the firm's investment in process innovation (e.g. R&D spending on efficiency); this lowers the marginal cost to $c = c_0 - \Delta c(I_c)$, where $\Delta c(.)$ is an increasing, concave function (diminishing returns to R&D). Process innovation thus directly improves productivity by saving labor or input costs per unit (Jitsutthiphakorn, 2021).

Through product innovation (investment I_p), a firm can create new product varieties or improve the quality/appeal of its existing product. We represent the outcome of

product innovation as an increase in the firm's demand intercept or quality index A. For instance, if the firm's product has quality q, product R&D raises it to $q + \Delta q(I_p)$, enhancing consumers' willingness to pay. Equivalently, the firm can introduce $\Delta n(I_p)$ new product varieties (with Δn increasing in I_p), expanding the set of goods it sells. In either interpretation, product innovation enables the firm to generate additional revenue by better satisfying demand or by offering new goods (Sasaki, 2020).

Domestic vs. Export Markets

The firm sells output in the home market and can choose to export. Let demand in the domestic market be $D_d(p)$ and in the foreign market $D_f(p)$, both downward-sloping in price p. A higher quality or a new variety due to product innovation effectively increases the demand the firm faces (shifting its demand curve outward or allowing a higher price for a given quantity), whereas a lower cost from process innovation allows the firm to profitably supply more at a given price. We assume firms set prices to maximize profit in each market (e.g. charging a markup over cost in monopolistic competition). As a result, the firm's operating profit in market $m \in \{d, f\}$ can be written as: $\pi_m = (p_m - c)\, y_m(A, c)$ where $y_m(A, c) = D_m(p_m)$ is the equilibrium quantity sold in market m, which depends on the demand factor A (reflecting product appeal) and the unit cost c. The function $y_m(A, c)$ increases if A increases or if c decreases (since a higher quality or variety allows more sales, and a lower cost permits a lower optimal price).

Because exporting entails a fixed cost F, the firm will choose to serve the foreign market only if the additional profit from exporting is non-negative. Thus, *the export entry condition* is: $\pi_f = (A, c) - F \geq 0$, with $\pi_f = (A, c) = (p_f - c) y_f(A, c)$. This inequality defines an *export cutoff condition*. For a given product attractiveness A, there is a threshold cost level $c^*(A)$ such that only firms with $c \leq c^*(A)$ can profitably export. Equivalently, for a given cost c, there may be a minimum demand/quality level $A^*(c)$ required to export. In this formulation, *product innovation* raises A (making it easier to satisfy $\pi_f \geq F$ by effectively increasing the term $A - c$) while *process innovation* lowers c (directly increasing $A - c$). Both types of innovation thus relax the constraint for profitable exporting: product innovation shifts the demand-side threshold upward, and process innovation shifts the cost-side threshold downward. In other words, introducing new/improved products opens up additional market opportunities abroad, and cutting costs improves price competitiveness in foreign markets (Jitsutthiphakorn, 2021; Panda and Sharma, 2023).

Optimization Problem

Prior to entering the product market, each firm chooses I_p and I_c to maximize its total expected profit. The profit can be written as: $\Pi = \pi_d(A, c) + 1\{\pi_f(A, c) \geq F\}[\pi_f(A, c) - F] - C_p(I_p) - C_c(I_c)$, where $C_p(I_p)$ and $C_c(I_c)$ are the R&D cost

functions for product and process innovation respectively (increasing in I_p, I_c). The term $1\{\pi_f \geq F\}$ is an indicator that equals 1 if the firm exports (i.e. if the export profit covers the fixed cost). Solving the firm's problem involves two stages: (1) choose innovation investments I_p, I_c; (2) given the resulting A and c, decide whether to export and set prices. We solve by backward induction. In stage (2), the firm exports if A and c satisfy the entry condition (as derived above) and earns $\pi_f - F$ extra profit from exporting. In stage (1), anticipating this outcome, the firm chooses I_p, I_c to maximize Π. Assuming an interior optimum, the first-order conditions (FOCs) for I_p and I_c characterize the equilibrium innovation levels:

$$\frac{\partial \Pi}{\partial I_p}: \frac{\partial \pi_d}{\partial A}\frac{\partial A}{\partial I_p} + 1\{\pi_f \geq F\}\frac{\partial \pi_f}{\partial A}\frac{\partial A}{\partial I_p} = \frac{\partial C_p}{\partial I_p},$$

$$\frac{\partial \Pi}{\partial I_c}: \frac{\partial \pi_d}{\partial c}\frac{\partial c}{\partial I_c} + 1\{\pi_f \geq F\}\frac{\partial \pi_f}{\partial c}\frac{\partial c}{\partial I_c} = \frac{\partial C_c}{\partial I_c}.$$

These FOCs equate the *marginal benefit (MB)* of each type of innovation to its *marginal cost (MC)*. The left-hand side of each equation is the increase in operating profit from a marginal increase in innovation effort, accounting for both domestic and (if exporting) foreign profit effects; the right-hand side is the marginal R&D cost. Intuitively, a firm will invest in product innovation until the point where an additional dollar spent on developing new products yields the same incremental profit as that dollar's cost, and similarly for process innovation. The term $\frac{\partial \pi_f}{\partial A}$ in the first equation captures how valuable a higher demand/quality is for export profit. This term will be zero if the firm is not exporting (since then $1\{\pi_f \geq F\} = 0$, but positive if the firm exports. Likewise, $\frac{\partial \pi_f}{\partial c} < 0$ reflects that a lower cost (higher efficiency) increases export profit when exporting.

Equilibrium Conditions

An equilibrium for this closed-form model can be defined as a set of outcomes $\{I_p{}^*, I_c{}^*, A^*, c^*, p_d{}^*, p_f{}^*\}$ such that: (i) each firm's innovation choices $I_p{}^*, I_c{}^*$ satisfy the FOCs above (profit maximization); (ii) prices $p_d{}^*, p_f{}^*$ maximize profits given the cost and demand (markups are set optimally); (iii) the export participation condition is satisfied consistently (firms with c^*at the margin earn zero net export profit, and those with lower cost or higher A export with positive profit); and (iv) markets clear. In a symmetric equilibrium (if firms are ex-ante identical aside from idiosyncratic innovation outcomes), all firms that invest similarly will attain the same (A^*, c^*) and either all export or a fixed fraction export depending on any ex-ante heterogeneity. If there is a distribution of firm types (e.g. heterogeneous base cost c_0), the equilibrium will feature a cutoff rule: firms below a certain cost (or above certain quality) export, others serve

only the domestic market. The innovation choices may also be heterogeneous – for simplicity, one can consider a representative firm analysis for each country context. The key theoretical result from the firm's optimization is that *both product and process innovation raise a firm's competitiveness* and thus tend to improve its export performance, but they do so through different channels. In equilibrium, a balance is achieved where firms allocate their innovation resources such that no further profitable reallocation between product and process innovation is possible – at this point, the marginal gains from each type equal their costs. This general result is in line with prior theoretical studies that emphasize the distinct roles of product vs. process innovation (Sasaki, 2020).

Innovation–Export Equilibrium in Developed vs. Developing Countries

While the general model structure applies to any economy, equilibrium outcomes for innovation and exporting differ between developed and developing countries due to parameter differences.

In developed economies, the marginal benefit of product innovation - represented by an increase in the demand factor $A = q + \Delta q(I_p)$ - tends to be high. Firms can introduce cutting-edge products that command strong foreign demand and premium prices. Consequently, developed-country firms invest relatively more in product innovation (I_p) to expand product variety or improve quality, effectively shifting their demand curves outward. Process innovation (I_c) also plays a role by reducing marginal production costs to $c = c_0 - \Delta c(I_c)$, but the returns to further cost reduction may be smaller due to the already high efficiency of production processes.

In developing economies, firms often face lower effectiveness of product innovation because of limited market size, weaker consumer purchasing power, and reduced international brand recognition. Thus, process innovation (I_c) is generally more critical, as cost reduction is essential for price-competitiveness in foreign markets. In this context, achieving a lower c is often the most direct path to entering export markets, whereas product innovation may yield lower or delayed returns (Sasaki, 2020).

2.2. Empirical background

2.2.1. Firm-Level Innovation and Export Behavior

Firms make strategic decisions regarding the allocation of resources to innovation activities, and the resulting benefits -market expansion, cost reductions, and the creation of temporary monopoly rents- are likewise realized at the firm level. This firm-specific nature of innovation outcomes justifies the use of firm-level analysis to examine the role of innovation in shaping export behavior. Nonetheless, firms operate within structural conditions determined by sectors and countries, which in turn influence the returns to innovation and the propensity to export.

Technological progress, especially in developing economies, is often constrained by the slow diffusion and transfer of knowledge and capital goods (Dosi, 1988). Nevertheless, the prospect of long-term benefits encourages firms to accumulate innovations gradually, frequently through learning-by-doing, incremental adaptation, and technology absorption. Firms' capacity to innovate is further enhanced through experience gained during production, enabling them to implement technological changes and improve their competitive position.

Importantly, firms exhibit heterogeneity in terms of technological capabilities, innovation capacity, and economic performance. These differences create asymmetries in export behavior between innovating and non-innovating firms, motivating scholars to investigate how firm-level innovation affects firms' export decisions.

2.2.2. Empirical Evidence on the Export–Innovation Relationship

Early empirical studies on the innovation-export relationship were dominated by the Schumpeterian hypothesis, emphasizing a positive link between firm size and innovation, and subsequently, export performance. Early contributions predominantly used R&D expenditure as a proxy for innovation (Pavitt et al., 1987). This approach, however, tends to favor larger firms or sectors with formal R&D structures, potentially neglecting smaller firms engaged in innovation without official R&D budgets. Kumar and Siddharthan (1994) used data from over 600 Indian firms across various industries between 1988 and 1990 and found that innovation positively affected export performance, especially in low- and medium-technology sectors. Similarly, Hirsh and Bijaoui (1985) analyzed Israeli firms during the 1970s and found that innovating firms exhibited higher export propensities compared to industry averages. However, Willmore (1992), focusing on Brazilian firms, concluded that there was no significant relationship between R&D expenditure and exports, pointing to the limitations of using R&D intensity alone as an innovation proxy.

To address this limitation, subsequent studies focused on direct measures of innovation (e.g., counts of product or process innovations) rather than R&D spending. Wakelin (1998), using UK firm-level data, demonstrated that while non-innovating firms were sometimes more likely to export than innovating firms of similar size, the number of innovations positively affected the probability of export participation. Lefebvre et al. (1998) confirmed this pattern among Canadian firms, showing that product innovation was a key differentiator between exporters and non-exporters. Yet, other studies such as Reid (1986) and Sriram et al. (1989) found weak or even negative relationships between technology indicators and export intensity, underscoring the mixed and context-dependent nature of the empirical evidence.

2.2.3. Innovation Patterns in Developing Economies

Innovation patterns differ significantly between developed and developing countries.

In developing countries, innovation is often driven by diffusion, adaptation, and technology spillovers from advanced economies. The process typically yields incremental improvements rather than radical innovations. Middle-income countries such as Brazil, India, and China have made remarkable advances in science- and capital-intensive sectors (Arouri et al., 2014). Yet, in many lower-income economies, innovation remains focused on adapting imported technologies suited to labor-intensive production structures.

Macro-level studies generally show a positive correlation between innovation and export performance (Willmore, 1992; Roper and Love, 2002; Filatotchev et al., 2009). Nevertheless, firm-level studies often produce mixed results. Some studies emphasize that innovation reduces production costs and enhances export capacity (Wakelin, 1998; Bustos, 2011), while others highlight risks, adjustment costs, and uncertain returns, which may lead to negative or insignificant impacts on export outcomes (Atkeson and Burstein, 2010; Lileeva and Trefler, 2010).

More recent work has explored the specific case of Chinese firms, which operate within a transition economy. Dai et al. (2020) found that innovation positively impacts the survival probability of Chinese direct exporters, though an inverted-U relationship exists, suggesting that excessive innovation may reduce export survival. For indirect exporters, innovation's effect was found to be statistically insignificant or even negative. Similarly, Chang and Webster (2018) showed that innovation positively affects the export probability of SMEs, but the effect differs substantially based on export mode (direct vs. indirect) and firm characteristics.

2.2.4. Towards a More Comprehensive Understanding of the Innovation–Export Nexus

Despite the abundant literature, the empirical evidence on the export–innovation–R&D nexus remains inconclusive. Many earlier studies treated R&D spending as both an input and a proxy for innovation, failing to separate the role of actual innovation output (Greenhalgh et al., 1994; Hirsch and Bijaoui, 1985). However, recent studies emphasize that R&D and innovation should be considered as distinct constructs, where R&D serves as an input facilitating innovation, and innovation serves as the actual driver of export performance (Ganotakis and Love, 2011; Zaman and Tanewski, 2024).

Moreover, firm characteristics such as size, ownership, export experience, and integration into global value chains introduce additional heterogeneity into the innovation-export relationship. Studies such as Goldberg et al. (2010) and Fernandes and Tang (2015) highlight the risk of biased results when ignoring firm heterogeneity, especially in developing countries.

Path analysis and instrumental variable regressions have recently been applied to explicitly model the mediating role of innovation between R&D and export outcomes (Zaman and Tanewski, 2024). Results indicate that R&D and innovation are both important, yet distinct, drivers of export performance. Importantly, learning to export

(the notion that innovation helps firms prepare for and enter export markets) and learning by exporting (the idea that exposure to international markets enhances firms' future innovation) are not uniform across firm types. While large firms show evidence of simultaneous innovation and export linkages, SMEs often face constraints limiting the benefits from such dynamics.

3. DATA AND EMPIRICAL MODEL

Following the theoretical framework and empirical background presented in Sections 1 and 2, this section introduces the dataset and empirical specification used to examine the relationship between innovation and export behavior at the firm level. Given the theoretical distinction between product and process innovation and their differing effects on export outcomes, the empirical analysis places particular emphasis on the heterogeneous effects of innovation across firm types and country income levels.

3.1. Dataset and Sample Characteristics

The dataset used for the empirical analysis comprises cross-sectional firm-level data from the *World Bank Enterprise Surveys (ES)* conducted in 2023. It includes a sample of 10,000 firms operating in various industries, including manufacturing, retail, wholesale, construction, hospitality, and services. These surveys are a rich source of information, capturing firm-level characteristics, innovation behavior, labor dynamics, capital investment, and export activities.

To ensure comparability across diverse economic structures, countries are categorized based on the World Bank's Gross National Income (GNI) classification into three income groups: low-income, middle-income, and high-income economies. Middle-income countries serve as the baseline in the empirical analysis. This classification enables a nuanced exploration of how innovation influences export behavior across different stages of economic development. Low-income economies, such as the Central African Republic, Chad, Gambia, Lesotho, Nepal, Rwanda, and Sierra Leone, typically face challenges related to limited resources, weak infrastructure, and low levels of technological adoption. High-income economies -including Greece, Hong Kong, Hungary, New Zealand, Portugal, Seychelles, Singapore, and Slovakia- benefit from robust innovation ecosystems, greater human capital, and strong export competitiveness. Middle-income economies, which vary in their development trajectories, include countries such as Colombia, Indonesia, Mexico, Romania, and Vietnam. While these nations often have emerging manufacturing sectors and growing market potential, structural constraints continue to affect their innovation capabilities.

This broad sectoral coverage enhances the generalizability of the findings across industry types and country income levels. However, due to missing values in certain

variables, the number of valid observations varies across specifications

3.2. Variables and Measurement

To operationalize innovation, this study adopts two complementary methods. First, firms are classified as innovators if they report having introduced new or significantly improved products, processes, or engaged in research and development activities within the past three years. This classification facilitates a direct comparison between innovating and non-innovating firms and aligns with the theoretical framework established in Section 2. Second, to explore how the level of national development influences the relationship between innovation and export behavior, two dummy variables are introduced to indicate low- and high-income countries, using middle-income economies as the reference group.

This empirical design supports the core theoretical proposition that innovation alters firm behavior, thereby necessitating distinct considerations for innovating versus non-innovating firms.

Table 1. Variable Definitions and Classifications

Type	Variable	Definition
Export behavior	PROPEX	Proportion of exports to total sales
Firm characteristics	CAPINT	Capital intensity (total capital expenditure / total sales)
	ALABORC	Unit labor cost (total compensation / total sales)
	LABOR	Total number of employees
	LABORSQ	Square of total number of employees
	LOW	Dummy = 1 if firm is located in a low-income country
	HIGH	Dummy = 1 if firm is located in a high-income country
Innovation-related	IMPRODUCT	Dummy = 1 if firm introduced new/improved products/services in last 3 years
	IMPROCESS	Dummy = 1 if firm implemented new process improvements in last 3 years
	RD	Dummy = 1 if firm reported R&D expenditures

The selection of control variables in this study is grounded in both economic theory and empirical literature. Capital intensity (CAPINT) captures the efficiency with which firms utilize fixed assets to generate sales and serves as an indicator of potential process innovation. Unit labor cost (ALABORC) reflects cost competitiveness, with lower values generally expected to enhance export performance, particularly in price-sensitive international markets. Firm size, represented by the number of employees (LABOR) and its squared term (LABORSQ), is included to capture a potential non-linear relationship

with exports, where larger firms may benefit from economies of scale up to a point, beyond which organizational inefficiencies could hinder export potential. Lastly, the innovation-related variables -product innovation (IMPRODUCT), process innovation (IMPROCESS), and research and development expenditure (RD)- represent different dimensions of a firm's innovation capacity. While RD captures formal investment in innovation activities, IMPRODUCT and IMPROCESS reflect realized innovation outcomes within firms.

In particular, the model distinguishes *product innovation* as being more relevant to larger firms with structured R&D functions, whereas *process innovation* and *adaptive product improvements* are often more prevalent in smaller firms that innovate informally.

This specification also corresponds closely to the theoretical framework in Section 2. Export behavior is influenced through two principal channels: a *demand-side effect*, where product innovation shifts the firm's demand curve outward by increasing product appeal; and a *cost-side effect*, where process innovation and R&D reduce marginal costs, enhancing the firm's price competitiveness. Additionally, income group dummies (LOW, HIGH) capture institutional and infrastructural differences that mediate the effectiveness of innovation strategies across development contexts.

3.3. Model Specification

Given that a significant portion of firms in the dataset report zero exports, the dependent variable PROPEX, the proportion of exports to total sales, takes on values ranging from 0 to 1. To account for the bounded nature of this variable, this study considers three model specifications: a Tobit model, a fractional logit model, and a fractional probit model.

The Tobit model is appropriate when the dependent variable is censored, as it models the level of exports (intensive margin). It includes all observations, allowing for estimates that consider scale effects. Alternatively, the fractional logit and fractional probit models are suited to dependent variables that are proportions, particularly when values lie strictly within the [0,1] interval. These models account for the bounded nature of the export share and relax the assumption of censoring, instead treating the dependent variable as a fractional outcome. The fractional logit model assumes a logistic distribution of the latent variable, while the fractional probit model assumes a normal distribution.

The general empirical specification for all models is given as:

$$\begin{aligned} PROPEX = {} & \alpha + \beta_1\, CAPINT + \beta_2\, ALABORC + \beta_3 \mathrm{LABOR} + \beta_4 \mathrm{LABORSQ} \\ & + \beta_5\, LOW + \beta_6\, HIGH + \beta_7\, IMPRODUCT + \beta_8\, IMPROCESS \\ & + \beta_9\, RD + \varepsilon. \end{aligned} \tag{1}$$

This model allows for the estimation of the effects of innovation inputs and outputs on export behavior, controlling for firm characteristics and national development context.

4. RESULTS

4.1. Descriptive Statistics

Table 2 presents the descriptive statistics for four firm categories based on their innovation and export behavior: (1) innovators and exporters, (2) innovators and non-exporters, (3) non-innovators and exporters, and (4) non-innovators and non-exporters. All values are annual averages calculated from the 2023 World Bank Enterprise Survey data.

Table 2. Descriptive statistics: means (standard deviation)

	Innovators		Non-innovators	
	Exporters	Non-exporters	Exporters	Non-exporters
Proportion exporting	0.43 (0.35)		0.49 (0.34)	
Capital intensity	0.53 (0.76)	0.47 (0.81)	0.55 (0.86)	0.53 (0.86)
Unit labor costs	0.23 (0.18)	0.24 (0.18)	0.25 (0.20)	0.25 (0.19)
Number of employees	190 (571.10)	74 (214.41)	161 (476.18)	53 (119.02)
Improve product	0.59 (0.49)	0.68 (0.47)		
Improve process	0.45 (0.50)	0.50 (0.50)		
Research and development	0.53 (0.50)	0.30 (0.46)		
Number of observations	1,507	2,412	1,814	4,267

Interestingly, firms that do not engage in innovation exhibit a slightly higher average proportion of exporting activity (49%) compared to innovating firms (43%). This suggests that innovation alone may not be the primary determinant of export participation. Capital intensity is also somewhat higher among non-innovating exporters (0.55) compared to innovating exporters (0.53). However, across both innovation types, exporters tend to be more capital-intensive than their non-exporting counterparts.

Unit labor costs are marginally lower for innovators (0.23–0.24) compared to

non-innovators (0.25), although the difference is relatively small. Notably, innovating firms -particularly exporters- tend to have significantly larger firm sizes, as evidenced by the average number of employees (190 for innovating exporters versus 161 for non-innovating exporters). This highlights the positive association between firm size and innovation activity.

In terms of innovation activities, 59% of innovators that export and 68% of innovators that do not export reported having introduced new products within the past three years. Non-exporters are also more likely to have introduced production process improvements (50%) than exporters (45%). However, engagement in research and development (R&D) is notably higher among exporting firms (53%) than domestic-focused innovators (30%). This indicates that long-term innovation, rather than short-term product improvements, is more strongly associated with export propensity.

Firm size emerges as a particularly distinguishing factor. On average, larger firms -whether innovative or not- are more likely to engage in exporting, reinforcing the importance of scale in international market participation. This underscores that innovation alone does not necessarily incentivize exporting; instead, firm size and resource capacity are important enabling factors.

4.2. Model Specification and Selection

To analyze the determinants of export propensity, three models were estimated: Tobit, fractional probit, and fractional logit. As shown in Table 3, the fractional probit model was selected as the preferred specification, given its superior model fit, evidenced by the highest log-likelihood value (−4,084.13) and the lowest Akaike Information Criterion (AIC = 8,188.26).

Table 3. The choice of specification

Independent Variable	Tobit	Fractional Probit	Fractional Logit
CAPINT	0.04 (0.01) ***	0.04 (0.01) ***	0.08 (0.02) ***
ALABORC	0.02 (0.05)	0.18 (0.07) **	0.34 (0.14) **
LABOR	0.001 (0.00) ***	0.001 (0.00) ***	0.001 (0.00) ***
LABORSQ	-0.006 (0.00) ***	-0.008 (0.00) ***	-0.001 (0.00) ***
LOW	-0.24 (0.04) ***	-0.31 (0.05) ***	-0.59 (0.11) ***
HIGH	0.18 (0.02) ***	0.18 (0.03) ***	0.34 (0.05) ***
IMPRODUCT	-0.02 (0.02)	-0.08 (0.03) **	-0.15 (0.06) **
IMPROCESS	0.004 (0.02)	-0.02 (0.04)	-0.05 (0.07)
RD	0.26 (0.02) ***	0.30 (0.03) ***	0.53 (0.06) ***
CONSTANT	-0.49 (0.02) ***	-1.26 (0.03) ***	-2.14 (0.05) ***
N	10,000	10,000	10,000
Log likelihood	-6,940.81	-4,084.13	-4,086.74
AIC	13,903.62	8,188.26	8,193.48

Notes: *Significant 10%. **Significant at 5%. ***Significant at 1%.

4.3. Regression Results

Across all three models, capital intensity ($CAPINT$) is positively and significantly associated with export propensity at the 1% level. This supports the notion that capital-intensive firms -owing to their high fixed costs and scale economies- are more inclined to access international markets to absorb excess production capacity.

Average labor costs ($ALABORC$) show a significant positive effect on export propensity in the fractional probit and fractional logit models, but not in the Tobit model. This suggests that higher labor costs, which may signal greater labor quality or specialization, can encourage productivity-enhancing investments such as automation, thereby boosting export competitiveness.

Firm size, proxied by the number of employees ($LABOR$) and its squared term ($LABORSQ$), exhibits a statistically significant quadratic relationship with export propensity. The positive linear and negative squared terms suggest a concave relationship: export propensity increases with firm size up to a point, after which the marginal benefit declines. This pattern aligns with the idea that while small firms gain from economies of scale, very large firms may shift focus toward dominating domestic markets, thus reducing export intensity.

The development level of the country also plays a critical role. Firms in low-income countries are found to export approximately 31% less than those in middle-income countries, while firms in high-income countries export approximately 18% more. These results underscore the structural constraints in low-income economies- such as inadequate capital formation and limited manufacturing capabilities -versus the technological and infrastructural advantages of high-income economies.

Among innovation-related variables, new product development ($IMPRODUCT$) shows a negative and statistically significant effect on export propensity in the fractional probit and logit models. This reflects the short-term trade-off between investing in innovation and engaging in exports, particularly among small firms that may need to test products domestically before expanding abroad.

Conversely, R&D activity (RD) demonstrates a robust and highly significant positive relationship with export propensity across all models. This finding confirms the long-term value of innovation in enhancing firm competitiveness, particularly by enabling differentiation and cost efficiency. Process innovation ($IMPROCESS$), however, does not exhibit a statistically significant effect in any model, indicating that such improvements may not directly influence export behavior in the short term.

5. DISCUSSION

5.1. Summary of Findings

This study investigates the nexus between firm-level innovation and export behavior using data from the 2023 World Bank Enterprise Survey, encompassing 10,000 firms across low-, middle-, and high-income economies. Drawing from a microeconomic framework that distinguishes between product and process innovation, the analysis employs a fractional probit model to estimate the determinants of export propensity.

The empirical results demonstrate that capital intensity and research and development (R&D) investment are positively associated with firms' likelihood of exporting. These findings underscore the importance of scale, technological upgrading, and sustained innovation efforts in enhancing international competitiveness. Additionally, higher unit labor costs correlate with increased export activity, suggesting that skilled and specialized labor -despite being costlier- contributes positively to firms' export potential, likely through productivity gains or quality improvements.

Interestingly, product innovation exhibits a negative short-run association with exports, especially for smaller firms. This finding reflects the resource trade-offs and commercialization challenges firms face during new product development. Process innovation, by contrast, shows no statistically significant effect, suggesting that its impact on export behavior may be more indirect or longer-term.

Export outcomes are also shaped by national context: firms in high-income countries report significantly higher export propensities than those in low- and middle-income economies, reflecting structural advantages such as stronger innovation ecosystems, greater access to global markets, and more favorable regulatory environments.

Taken together, these findings affirm the critical -but conditional- role of innovation in driving export behavior. To maximize innovation's impact on export performance, firms require supportive ecosystems and enabling public policies. The remainder of this chapter presents policy recommendations derived from the study's empirical insights.

5.2. Policy Implications and Recommendations

Based on the study's findings, a series of targeted policy recommendations can be made to enhance the innovation-export linkage across different economic contexts. First, strengthening innovation infrastructure in developing economies is essential. Firms in low-income countries often face structural barriers such as weak technological ecosystems and limited access to global markets. Governments should therefore invest in public R&D centers, technology parks, and innovation hubs, especially those that support SMEs. Collaborations with universities and international partners can help accelerate the diffusion of technology and knowledge. This would reduce the cost and risk associated with innovation and support firms in becoming export-ready.

Second, targeted support for R&D activities should be prioritized. The study clearly shows that R&D investment is consistently and positively associated with export performance. Policymakers can encourage sustained innovation through tax incentives, matching grants, and access to venture capital for innovation-intensive firms. Supporting R&D is particularly crucial for firms looking to scale into global markets, as it enhances

their ability to differentiate products and reduce costs through technological advancements.

Third, commercialization support is critical, particularly for product innovations. The results show that while firms invest in new products, these efforts often do not immediately translate into export gains, particularly for smaller firms. This suggests a need for export-readiness programs that assist with product testing, international certification, and adaptation to foreign market standards. Providing technical and financial support for commercialization can reduce time-to-market and help bridge the gap between innovation and export.

Fourth, innovation and export strategies should be tailored to specific sectors. Since the effectiveness of innovation differs by industry and income level, governments should implement sector-specific programs that combine innovation incentives with export promotion tools such as trade fairs, digital sales platforms, and improved logistics. This ensures that innovation efforts align with industry potential and global demand trends.

Fifth, the development of human capital is paramount. The study finds that higher labor costs -potentially reflecting more skilled or specialized workers- are associated with higher export propensity. Policymakers should therefore invest in workforce development through vocational education, upskilling initiatives, and stronger partnerships between industry and academia. A skilled labor force enhances a firm's capacity to innovate and compete globally.

Sixth, while process innovation was not a significant determinant of exports in the short term, it remains an important tool for improving long-run cost competitiveness, particularly in developing economies. Governments should support the adoption of lean production techniques, digital transformation, and energy-efficient technologies through subsidies, training, and infrastructure upgrades. This would make firms more efficient and environmentally sustainable, thereby improving their competitiveness in global markets.

Finally, inclusive innovation policies should be promoted to ensure that small and medium-sized enterprises (SMEs) are not left behind. Larger firms tend to benefit more from the synergy between innovation and exports, while SMEs often face capacity constraints. Policymakers should lower barriers for SMEs through shared innovation resources, simplified intellectual property protection, and cooperative export platforms. By creating an inclusive and enabling innovation environment, countries can foster broader participation in global trade and more equitable economic growth.

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