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ORIGINAL ARTICLE

The Challenge of Productivity-Based Development: Innovation Gaps and Economic Structure in Latin America

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Abstract
In this paper, we analyze how firm-level capabilities and characteristics affect firm innovation activities and innovation outputs in seven Latin American countries in 2016. We include eight innovation activities in accordance with OECD/Eurostat. Using data from the World Bank Enterprise Surveys for manufacturing and services, we distinguish two steps in the innovation process: firm engagement with innovation inputs and the translation of innovation inputs into innovation outputs. The empirical results demonstrate the importance of considering the broad spectrum of innovation activities rather than only focusing on R&D for the production of innovation outputs. The estimates underscore the significance of the impact of economic structure (firm size and sector) on innovation focusing at the micro level. They also suggest a role for government policies in reducing innovation gaps.

Keywords Innovation activities · Innovation outcomes · Firm capabilities · Innovation gaps · Economic structure · Government policies · Latin America

Résumé
Dans cet article, nous analysons en quoi les capacités et les caractéristiques d'une entreprise peuvent affecter ses activités d'innovation et les résultats de cette innovation. Cette analyse est conduite dans sept pays d'Amérique latine sur l'année 2016. Nous incluons huit activités d'innovation conformément à l'OCDE/Eurostat. En utilisant les données issues des enquêtes auprès des entreprises de la Banque mondiale, dans le secteur manufacturier et des services, nous distinguons deux étapes dans le processus d'innovation: l'engagement de l'entreprise concernant les intrants de l'innovation et la traduction des intrants d'innovation en produits d'innovation. Les résultats empiriques démontrent l'importance de prendre en compte le large éventail d'activités d'innovation plutôt que de se concentrer uniquement sur la R&D pour la production de produits d'innovation. Les estimations soulignent l'importance de l'impact de la structure économique (taille de l'entreprise et secteur) sur l'innovation, en se con-

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centrant sur le niveau micro. Elles suggèrent également un rôle pour les politiques gouvernementales dans la réduction des écarts en matière d'innovation.

JEL Classification 014 · 030 · 031 · 038 · 054

Introduction

Many Latin American economies have been at the middle-income level for several decades. For the region as a whole, GDP p.c. grew at an average annual rate of 1.1% in the 1990s, 1.6% in the 2000s, and 1.2% between 2010 and 2019.[1] Premature de-industrialization, low productivity growth, and persistent large productivity gaps across firm size and economic sectors are key economic challenges facing countries in the region. A broad-based increase in productivity is necessary to escape from the middle-income trap, and innovation and technological upgrading are critical for increasing productivity growth (Andreoni and Tregenna 2020; Paus 2020). Production and the furthering of productive capabilities are at the heart of the economic development process (Chang and Andreoni 2021). Increasing innovation on a broad scale is a complex process shaped by the nature of the economic structure and incentives, the cohesion of the innovation eco-system, and the extent to which governments make it a strategic priority. At the heart of this effort is the advancement of innovative capabilities of domestic firms (Cimoli et al. 2009; Fagerberg 1988).

This article contributes to our understanding of the key factors shaping firm level innovation in Latin America, with particular attention to structural heterogeneity. In our analysis of firm-level innovation, we distinguish two stages in the innovation process: firm engagement with innovation inputs and the connection between innovation inputs and the generation of innovation outputs (new processes and new products). While the two stages are conceptually similar to the first two stages in the model by Crepon, Duguet and Mairesse (CDM) (Crepon et al. 1998), our analysis includes a broad set of innovation inputs. Research and development (R&D), the only innovation input in the CDM model, often is not the most important in developing economies, especially for small and medium-sized companies. We consider eight innovation inputs, following the latest Oslo Manual (OECD/Eurostat 2018). Our empirical analysis uses firm data from the World Bank's Enterprise Surveys (WBES), which cover manufacturing and services. We use the WBES for 2016–2017, as they include the broad spectrum of innovation activities for seven Latin American countries: Argentina, Bolivia, Colombia, Ecuador, Paraguay, Peru, and Uruguay.

This article contributes to the literature in several ways. The analysis is broader in scope and uses recent data on firm innovation in Latin America. Most existing studies tend to focus at the individual country level and use data from innovation surveys of the early 1990s (Chudnovsky et al. 2006; Crespi and Zuniga 2012; De

[1] Author's calculations based on values in 2015 constant U.S. dollars from the World Development Indicators.

Negri and Laplane 2009). To the best of our knowledge, this is also the first study of firm innovation in Latin America and developing economies, which includes all eight innovation inputs. The empirical investigation shows that engagement with each of the innovation inputs is correlated with the probability of producing innovation outputs. Our analysis confirms the relevance of economic structure for explaining innovation behavior and outcomes. Some international organizations and other authors have long argued and shown at the macro level that economic structure matters for productivity and economic growth in Latin America and other developing country areas (ECLAC 2012, 2022; Paus 2020; Salazar-Xirinachs and Chacaltana 2018; Rodrik 2016, Ocampo and Vos 2008). This paper demonstrates the significance of the impact of economic structure on innovation focusing at the micro level.

Following this introduction, the next section offers analytical considerations on the meaning of innovation and structural heterogeneity across firm size and sector of economic activity. The third section discusses the model, data, and descriptive statistics; and in section four, we present the results. We conclude with implications of the findings and suggestions for further research.

Structural Heterogeneity and Innovation: Analytical Considerations

Premature de-industrialization is one of the key characteristics of economic development in Latin America over the past four decades. The manufacturing sector's share in GDP and total employment declined at a much earlier level of GDP p.c. than has been the case historically in today's industrialized economies (Rodrik 2016; Palma 2005). While developing Africa and Asia experienced de-industrialization as well, it was has been most pronounced in Latin America (Rodrik 2016). That is particularly true in South American countries, whereas the relative decline of manufacturing has been less pronounced in many Central American countries, as firms became integrated into global value chains, often driven by direct foreign investment, with the final output aimed at the U.S. market.

Slow economic growth and low productivity growth accompanied the de-industrialization process. During the 2010s, labor productivity in the region increased at an average annual rate of 0.8%, compared to 1.4% for low-income countries, and 4.2% for all middle-income countries (see Fig. 1). Productivity growth in Latin America has been especially low compared to the 9% annual growth in China, its fiercest competitor in many tradeable goods and services in home and third markets. Between 2000 and 2019, 76% of economic growth in Latin America and the Caribbean was due to employment growth and only 24% to productivity growth. In China, the respective shares are 4% and 94% (ECLAC 2022, p. 53).

A highly heterogeneous production structure is a consequence and reflection of de-industrialization and low productivity growth in most Latin American countries. Structural heterogeneity is the "coexistence in a single economy of production sectors that would be characteristic of economies at different stages of development, with low-productivity segments figuring prominently" ECLAC (2012, p. 198). Grouping the main economic sectors by productivity levels, Infante (2016, p. 45) shows that, in 2008, low productivity sectors accounted for 40% of employment, but

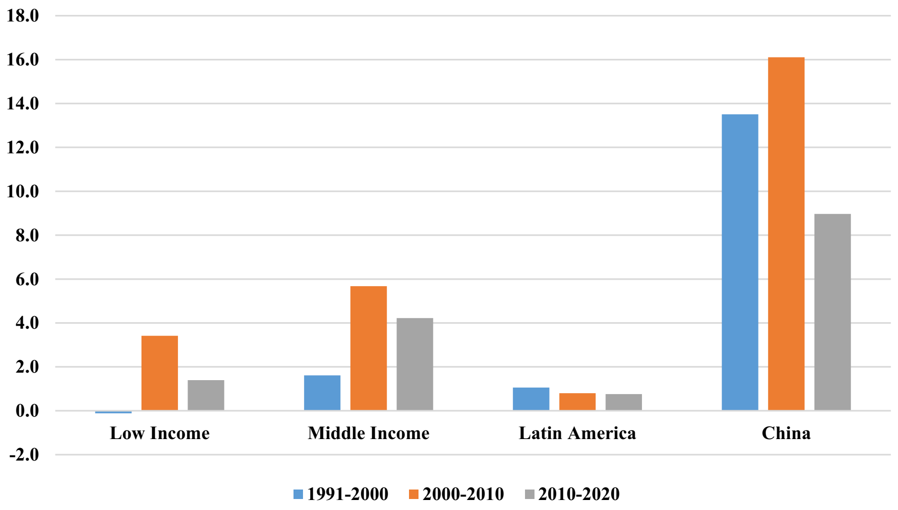

Fig. 1 GDP per Person Employed (constant 2017 PPP), average annual growth rate, 1990–2020. *Source* Authors' calculations based on World Bank. World Development Indicators

Table 1 Economic structure in 11 Latin American countries, 1990 and 2008. *Source* Infante (2016, Table 4, p. 45)

Sectors by productivity level	1990			2008		
	GDP (%)	Employment (%)	Productivity (Index)	GDP (%)	Employment (%)	Productivity (Index)
High	31.7	12.9	245.8	35.4	13.9	254.7
Medium	39.9	42.9	93	38.9	45.2	86.1
Low	28.5	44.3	64.3	25.7	40.9	32.8
Total	100	100	100	100	100	100

High productivity: transport, electricity, finance, mining; medium productivity: commerce, construction, industry; low productivity: agriculture, services

Countries included: Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Mexico, Peru, Uruguay, Venezuela

only a quarter of output. Their productivity level relative to the high productivity sectors had declined considerably between 1990 and 2008, from 26.1 to 12.9% (see Table 1).

Data from the Economic Transformation Database shows that labor productivity gaps across sectors vary across the nine Latin American countries included in the database (DeVries et al. 2021).[2] In 2018, the coefficient of variation was greater than

[2] Between 1999 and 2009, productivity in large Mexican firms (> 500 workers) increased at an annual rate of 5.8%, while it declined by 6.5% per year in small companies (< 10 workers) (Sabel and Ghezi 2020, p. 1).

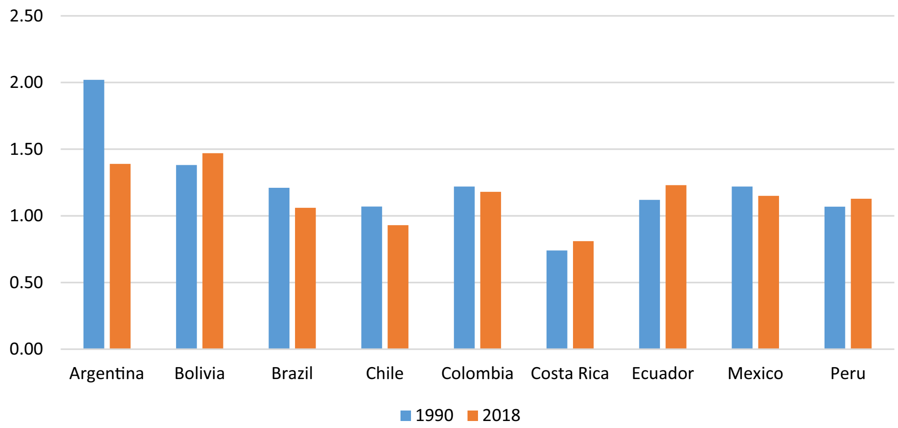

Fig. 2 Coefficient of Variation: Labor Productivity in Economic Sectors, 1990, 2018. *Source* Authors' calculations based on DeVries et al. (2021)

one in all countries except Chile and Costa Rica. However, compared to 1990, it had declined in Argentina, Brazil, Colombia, and Mexico, while it had increased in the other countries (see Fig. 2).[3]

Large productivity gaps by firm size are another key characteristic of structural heterogeneity. Micro and small firms constitute the vast majority of firms in Latin America, yet their productivity level is only a small fraction of that of large firms. In 2016, micro enterprises accounted for 88.4% of all firms in Latin America, small firms for 9.6%, medium-sized firms for 1.5%, and large firms for a mere 0.5% (Dini and Stumpo 2019).[4] The productivity level of micro firms was less than 10% of that of large firms (see Table 2). In high-income economies, in contrast, productivity gaps across firms are much smaller, even in the countries with relatively lower income levels, e.g. in Italy and Spain.

Incorporating size, sector and productivity, ECLAC (2012) differentiates countries by the degree of heterogeneity. Countries with severe structural heterogeneity: Bolivia, DR, Ecuador, El Salvador, Guatemala, Honduras, Paraguay, Peru. Countries at an intermediate level of heterogeneity: Brazil, Colombia, Panama, Mexico, Venezuela. And countries with moderate heterogeneity: Argentina, Chile, Costa Rica, Uruguay.

Variation across countries notwithstanding, the existence of structural heterogeneity highlights the importance of decreasing productivity gaps in order to increase productivity and generate renewed and sustained growth in the region. Economists

[3] The Economic Transformation Database (ETD) in DeVries et al. (2021) includes the informal sector and contains data on employment and value added in constant 2015 prices for the 12 economic sectors in the national accounts. Our calculations of the coefficients of variation excludes real estate, since the data for the sector are based on an equivalent rent approach and do not have and employment equivalent.

[4] Dini and Stumpo (2019) used country-specific classifications of firm size. The firm size shares are based on data for Argentina, Brazil, Chile, Ecuador, and Mexico.

Table 2 Productivity of micro, small, and medium-sized companies relative to large companies, 2016. *Source* Dini and Stumpo (2019)

	Microenterprises (%)	Small companies (%)	Medium-sized companies (%)	Large companies (%)
Brazil	4.5	22.4	50.7	100
Chile	7.2	16.6	22.4	100
Ecuador	8.2	29.7	46.2	100
Mexico	8.1	23.9	48.3	100
France	73.6	76.0	85.4	100
Germany	62.5	64.3	83.4	100
Italy	40.4	69.2	91.1	100
Spain	45.2	69.9	96.1	100

from different schools of thought agree on the importance of innovation for productivity growth, economic growth, and competitiveness (Solow 1957; Schumpeter 1983; Romer 1990). They also concur that firms are key actors in the innovation process. Of course, firms do not operate in a vacuum. Structural characteristics of the economy, the nature of government policies, and the cohesiveness of the national innovation system more broadly condition innovation at the firm level (Cimoli et al. 2011; Lundvall 1992).

In industrialized economies, R&D is the critical innovation input, as operating on the technological frontier offers especially high potential to advance productivity growth and firm profitability. However, R&D is not the only innovation activity, and for many firms it may not be the most important one, especially in developing economies. The OECD/Eurostat *Oslo Manual* (2018, p. 35) distinguishes eight innovation activities, recognizing that some of them may also be carried out for other purposes. They are R&D; engineering, design and other creative work activities; marketing and branding activities; intellectual property-related activities; employee training activities; software development and database activities; activities related to the acquisition or lease of tangible assets; and innovation management activities.

The OECD/Eurostat *Oslo Manual* (2018, p. 18) defines a business innovation output as "a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm."[5] Firms in developing economies generally do not operate on the technological frontier, and thus business innovation most commonly means the adaptation of innovations developed in the Global North. These may be new to the firm, but not necessarily to the market. They are also more likely to consist of incremental advances rather than dramatic changes.

[5] "The definition does not require an innovation to be a commercial, financial or strategic success at the time of measurement. A product innovation can fail commercially or a business process innovation may require more time to meet its objectives." (p. 69).

Nonetheless, many empirical studies of firm innovation in developing economies focus only on R&D expenditures as innovation inputs (De Fuentes et al. 2020). That may be due to data availability or to the fact that spending on R&D is the only innovation input, which is unequivocally aimed at innovation. Other studies are broader in their consideration of innovation inputs. For example, Hussen and Cokgezen (2020) and Adeyeye et al. (2016) include R&D and training; Gallego et al. (2013) consider R&D, investment in machinery, information and communication technology (ICT), and others. Fernandez (2017) focuses on R&D expenditures, and participation in one of a number of innovation activities. D'Este et al. (2012) separate firms into groups by the number of activities they engage in, but they do not investigate the innovation inputs separately. However, none of the studies includes all eight innovation activities suggested in the OECD/Eurostat *Oslo Manual* (2018).

A number of firm-level innovation studies have addressed the issues of size and sector specificity. Studies of firm innovation consistently find that innovation activities increase with the size of the firm (Paus and Robinson 2022, on Argentina, Colombia, Ecuador, Peru, and Uruguay; Gallego et al. 2013, on Colombia; Chudnovsky et al. 2006, on Argentina). In an analysis of European regions, Hervás-Oliver et al. (2021) find that the engagement of small and medium-sized firms with innovation activities is indeed not primarily through R&D, but rather through non-R&D channels. Other authors find that organizational changes and design, ICT, and user-producer interactions are much more important than R&D for innovation in services (Tacsir et al. 2011; Rubalcaba et al. 2016; OECD 2011).

Our empirical analysis explicitly focuses on the role of firm size and sector in the engagement with the different innovation activities and production of innovation outcomes. There are several reasons why we would expect small firms, and to some extent medium-sized firms, to engage less with innovation activities. Small firms have shorter time horizons, they are more risk-averse, they are more likely to lack the necessary resources, and they are less likely to have access to the requisite knowledge (Hwang et al. 2015). In low-tech sectors, which tend to produce more standardized goods and services, they also often serve a population with a greater orientation to price-point (Moreno Muñoz et al. 2022). Yet, to keep competing, these firms may also have to introduce some innovations. However, depending on the sector, such innovation activities may be more of the kind that require fewer resources and are more readily employable. With respect to investments in R&D, large firms have a clear advantage, as they are more likely to have market power due to barriers of entry, and can spread the costs over a larger volume of sales (Schumpeter 1942).

Model, Methodology, and Data

Model

In the analysis of the factors driving firm-level innovation, we distinguish two steps. The first step is the firm decision to engage with innovation inputs; the second step is the role of innovation inputs in the production of innovation outputs.

Equation (1) specifies our hypothesis about step one: the impact of firm characteristics on firm engagement with innovation inputs.

$$P\left(II_{ijc}^{k} = 1\right) = \Phi(\beta_0 + \beta_1 FC_{ijc} + \beta_2 CD_c + \beta_3 ISD_{sjc}) \quad (1)$$

where Φ is the cumulative distribution function of the standard normal distribution; II_{ijc}^{k} represents engagement with innovation input ‘k’ of firm ‘i’ in economic sector ‘j’ in country ‘c,’ and is a dummy variable equal to 1, if the firm undertook that innovation input and 0 otherwise; FC_{ijc} is a vector of firm characteristics; CD_c is a vector of country dummies; ISD_{sjc} is a set of size/industry dummies.

We consider eight different innovation activities: R&D; capital equipment for upgrades or acquiring new technology associated with new or significantly improved products or services (capital investment); training; software development and database activities; intellectual property related (IPR) activities; design and other creative work; marketing and branding of new products or services; and organizational development.

For firm characteristics, we chose variables that capture firm capabilities and resources, and others that condition firm behavior. Many of them are used in other studies of firm level innovation (Paus and Robinson 2022; Paus et al. 2022; Hussen and Çogezen 2020; Adeyeye et al. 2016, Crespi et al. 2014; Aboal et al. 2012). Among firm capabilities and resources, we include the skill level of employees, digital presence, access to funding, foreign market participation, manager experience, and age of the firm. The variables conditioning firm behavior are the potential for reaping agglomeration benefits, foreign ownership, and firm size and sector (see Table 3 for details). We include country dummies to account for differences among countries.

All variables enter the model as dummies except for the skill level of employees, the age of the firm, and manager experience. To take account of heterogeneity within manufacturing and services, we group firms into two different categories by average technology-intensity of the sectors. In manufacturing, we distinguish between low and low/medium technology-intensive sectors on the one hand and high and medium/high technology-intensive sectors on the other.[6] In services, we also distinguish two subsectors: low and low/medium technology-intensive (construction, service of motor vehicles, wholesale trade, retail trade, hotels & restaurants, and transport) and high technology-intensive (telecommunications and information technology).[7] To analyze innovation gaps by firm size and sector, we use a variable, which captures the interconnectedness of the size of the firm and the sector in which it operates. We distinguish three firm sizes (small, medium, and large) in two aggregate sectors: a low and low/medium technology-intensive sector, which includes the relevant subsectors of both manufacturing and services, and a medium/

[6] We chose the classification of the OECD (2011), which uses R&D intensity of an economic sector to assign it to one of their four technology groupings in manufacturing.

[7] Other technology-intensive sectors (business services and financial services) are not included in the WBES.

Table 3 Firm characteristics and measurements

Firm characteristics	Measurement
Capabilities and resources	
Skill level of employees	Share of permanent workers with completed secondary education
Digital outreach	Existence of a firm website
Access to funding	Firm has an established credit line
Foreign market participation	
(a) Exports	Exports account for more than 10% of sales
(b) Adherence to international standards	Firm has an international recognized quality certificate
Experience	
(a) Firm age	Number of years since the establishment was established
(b) Manager experience	Years of manager's experience
Conditioning variables	
Potential agglomeration benefits	Firm is located in a city with a population > 1 million
	Firm has multiple locations
Foreign ownership	Foreign ownership > 10%
Size/sector	Small firm in low/medium technology-intensive sector
	Medium-sized firm in low/medium technology-intensive sector
	Large firm in low/medium technology-intensive sector
	Small medium/high technology-intensive sector
	Medium-sized firm in medium/high technology-intensive sector
	Large firm in medium/high technology-intensive sector

high and high technology-intensive sector, which again subsumes the respective parts in manufacturing and services.

In a second step, we analyze the likelihood that firms, which engage in one of the eight innovation activities, introduce a new product or new process.

$$P(IO^n_{ijc} = 1) = \Phi\left(\beta_0 + II^k_{ijc} + \beta_1 FC_{ijc} + \beta_2 CD_c + \beta_3 ISD_{sjc}\right) \tag{2}$$

where IO^n is a dummy variable equal to 1 if the firm introduced a new product or process and 0 otherwise. In addition to the eight innovation inputs, we include the same firm characteristics as in Eq. (1) to see whether they have an impact on introducing a new product or process over and above their impact on the innovation activities.

Data and Descriptive Statistics

For the empirical analysis, we use data from the World Bank's World Enterprise Surveys, which include firms in services as well as manufacturing. We use the 2016–2017 surveys, since they are the only ones, which include questions about the eight different innovation inputs for Latin American countries. These surveys are available for Argentina, Bolivia, Colombia, Ecuador, Paraguay, Peru, and Uruguay. The great advantage of the WBES is that it provides information on the same variables for many countries.

However, the WBES have two drawbacks. First, the surveys do not have data on value added. While some studies use sales as a proxy for value added, we consider sales per worker a problematic proxy for labor productivity, especially for cross-section data, where one cannot use averages over a longer period. Furthermore, there should be a link between innovation outputs and productivity growth over time and not productivity levels at a point in time. As a result, we do not investigate the link between the production of an innovation output and productivity. Rather, our empirical focus is on innovation gaps rather than productivity gaps. The existing literature, theoretical and empirical, gives us a fair amount of confidence in the existence of a positive link between innovation outputs and productivity growth, even though it may manifest only over time and may be differently for product and process in different countries.[8]

The second limitation of the WBES is that the surveys do not include the informal sector, which accounts for a significant share of employment in many developing economies. In the seven Latin American countries in our study, employment in the informal economy as a share of total employment in the non-agricultural sectors range from a low of 24.1% in Uruguay to a high of 68.2% in Bolivia, with an unweighted average of 54.7% for the seven countries (ILO on-line data for 2016).[9] Although the informal sector absorbs a significant share of employment, it accounts for a much smaller share of output; and it is not likely to generate many decent jobs, given the suboptimal and resource-constrained environment in which the firms operate.

Thus, our analysis addresses only heterogeneity in the formal sector. It cannot address the heterogeneity arising from the existence of a large informal sector. Nonetheless, it is in the formal sector where nearly all innovation takes place, and where firms, if they are or become competitive, will be in a better position to expand decent employment opportunities.

[8] There are many empirical studies, which find a positive and statistically significant impact of innovation outputs on productivity. That is especially true for product innovation; the evidence on process innovation is a bit more mixed (Aboal and Garda 2012; Morris 2018). Analyses of the impact of innovation outputs on productivity growth in Latin American countries generally find a positive link, though there are exceptions. Arza and López (2010) show that product and process innovation are important determinants of labor productivity in Argentina. Crespi and Zuñiga (2012) find a positive impact of product innovation on productivity growth in Brazil and Mexico, but not in Argentina. Their results indicate that the introduction of a new process has a positive impact on productivity in Argentina, Chile, Colombia, Panama and Uruguay, but not in Costa Rica. For the likely existence of such a link, we point to the many empirical studies, which find a positive and statistically significant impact of innovation outputs on productivity. That is especially true for product innovation; the evidence on process innovation is a bit more mixed (Aboal and Garda 2012; Morris 2018).

[9] The informal economy, as defined by the ILO, includes the informal sector as well as informal employment in the formal sector, i.e., employment with decent employment deficiencies (ILO. Statistics on Informality). Thus, the share of employment in the informal non-agricultural sector by itself (rather than informal economy) is smaller than the percentages indicated in the text.

The seven countries included in the empirical analysis are predominantly middle-income countries, though their income levels differ. Based on World Bank classification, Bolivia is the only lower middle-income country in the sample, with a GNI p.c. of $ 3040 in 2016; and Uruguay is the only high-income country, with a GNI p.c. of $ 15,440. The other five countries are in the upper middle-income category: Argentina ($ 12,220), Colombia ($ 6460), Ecuador ($ 5800), Paraguay ($ 5400), and Peru ($ 6110).[10] Even though Uruguay is a high-income country, we include it here, as it shares many of the same structural challenges as the middle-income countries in the region.

Table 4 shows the means for all the variables in the model, for the full sample as well as by size categories and economic sectors. There is no uniform definition of firm size categories. While statistical offices in many countries focus on the number of employees, in some, they also include a measure of assets or sales.[11] Here we adopt the size categories used in the WBES: small (5–19 employees), medium (20–99 employees), and large (100+ employees).Our full sample includes 4423 firms. More than three quarters are small and medium-sized firms, and they are split evenly between manufacturing and services.

Regarding differences and similarities in innovation behavior across firm sizes, we find that engagement with each of the innovation inputs and production of innovation outputs increases with firm size. Yet, the size of the gap between small and large firms varies. The share of small firms spending on R&D, investment, and IPR is less than half that of large firms; but for design and organizational change, it is more than 70% of that of large firms. Surprisingly, there is little difference in the ranking of means of the different innovation inputs across firm sizes. Training consistently ranks first; but R&D and IPR rank lowest, even for large firms. The only exception is investment in fixed assets, whose mean ranks considerably higher for large firms.

Comparing innovation behavior between main economic sectors, we find that the means are higher in manufacturing for innovation outputs and two of the innovation inputs: training and R&D. In services, on the other hand, the means are higher for software, design, and organizational change. However, manufacturing and services are not homogenous sectors. There are considerable differences in both between the low & low/medium technology-intensive subsector and the medium & medium/high technology-intensive subsector, where a considerably larger share of firms is active in innovation.

To capture the differences in innovation by both firm size and sector, we group firms by size in two sectors, which separate firms by technology intensity across manufacturing and services. The data clearly show that economic structure matters for innovation behavior. While the means for innovation engagement are always higher in the med/high tech sector than in the low/med tech sector, the means for the combination of size/sector offers a more complex picture (see Table 5).

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[10] The data are in current U.S. $ from the World Development Indicators.

[11] In a study of innovation activities of U.S. companies, Acs and Audretsch (1987) define innovations in firms with less than 500 employees as 'small-firm innovation.'.

Table 4 Variable means

	Pooled	Small	Medium	Large	Manufact.	Low and low/med tech manuf	Med and med/high tech manuf	Services	Low and low/med tech services	High tech services	Low and low/med tech sectors	Med/high tech sectors
Innovation outputs												
New product	0.64	0.57	0.66	0.72	0.66	0.65	0.71	0.61	0.60	0.79	0.62	0.73
New process	0.47	0.41	0.48	0.57	0.51	0.51	0.53	0.43	0.42	0.57	0.46	0.54
Innovation inputs												
R&D	0.27	0.18	0.28	0.42	0.31	0.29	0.42	0.22	0.21	0.51	0.25	0.44
Fixed assets	0.37	0.24	0.39	0.58	0.40	0.41	0.37	0.33	0.32	0.46	0.36	0.39
Training	0.6	0.46	0.64	0.81	0.62	0.6	0.69	0.59	0.58	0.75	0.59	0.70
Software	0.46	0.37	0.48	0.6	0.39	0.39	0.39	0.53	0.52	0.80	0.46	0.48
IPR	0.23	0.16	0.25	0.32	0.22	0.21	0.28	0.23	0.22	0.39	0.22	0.31
Design	0.49	0.43	0.51	0.56	0.54	0.54	0.55	0.44	0.43	0.59	0.48	0.56
Marketing	0.41	0.33	0.42	0.55	0.40	0.39	0.46	0.43	0.43	0.41	0.41	0.45
Organizational change	0.41	0.35	0.43	0.48	0.39	0.39	0.37	0.43	0.43	0.55	0.41	0.41
Independent variables												
Firm age	26.02	20.07	26.25	36.25	28.58	27.81	32.31	23.43	23.64	19.44	25.59	29.35
Managerial experience (years)	24.24	23.31	25.18	24.55	25.26	24.93	26.86	23.19	23.18	23.40	24.00	26.06
Part of large firm	0.21	0.11	0.22	0.36	0.19	0.19	0.19	0.23	0.23	0.17	0.21	0.19
Website	0.73	0.58	0.78	0.91	0.76	0.75	0.82	0.69	0.68	0.90	0.71	0.84
In city > 1 million	0.81	0.83	0.79	0.81	0.84	0.84	0.86	0.77	0.77	0.89	0.80	0.87
Line of credit	0.65	0.53	0.69	0.82	0.66	0.67	0.63	0.64	0.64	0.63	0.65	0.63

Table 4 (continued)

	Pooled	Small	Medium	Large	Manufact.	Low and low/med tech manuf	Med and med/high tech manuf	Services	Low and low/med tech services	High tech services	Low and low/med tech sectors	Med/high tech sectors
Quality certificate	0.21	0.06	0.2	0.47	0.27	0.24	0.42	0.14	0.13	0.28	0.18	0.39
Skilled workers	81.74	79.2	81.67	86.93	79.21	78.25	83.82	84.15	83.65	93.27	81.12	85.99
Employees (number)	124.65	10.01	43.73	443.76	128.74	136.37	91.89	120.52	120.88	114.63	128.14	97.12
Foreign-owned	0.09	0.04	0.07	0.2	0.09	0.08	0.14	0.09	0.09	0.11	0.08	0.13
Exporter	0.11	0.05	0.11	0.22	0.17	0.16	0.22	0.05	0.04	0.16	0.10	0.21
n	4423	1865	1503	1055	2221	1839	382	2202	2088	114	3927	496
Share of total	100.0%	42.2%	34.0%	23.9%	50.2%	41.6%	8.6%	49.8%	47.2%	2.6%	88.8%	11.2%

Table 5 Variable means by size/sector

	Low and low/med technology-intensive sector			Medium/high and high technology-intensive sector		
	Small	Medium	Large	Small	Medium	Large
Innovation outputs						
New product	0.40	0.46	0.57	0.47	0.59	0.60
New process	0.56	0.65	0.71	0.70	0.75	0.75
Innovation inputs						
R&D	0.16	0.25	0.39	0.31	0.48	0.61
Fixed assets	0.24	0.39	0.58	0.27	0.41	0.57
Training	0.44	0.63	0.79	0.58	0.70	0.92
Software	0.36	0.48	0.61	0.40	0.53	0.55
IPR	0.15	0.23	0.31	0.23	0.34	0.36
Design	0.42	0.49	0.56	0.47	0.65	0.57
Marketing	0.32	0.41	0.55	0.35	0.45	0.60
Organizational change	0.36	0.43	0.47	0.31	0.46	0.50
Independent variables						
Firm age (years)	19.88	25.82	35.56	21.71	29.51	41.51
Managerial experience (years)	22.88	25.03	24.56	26.86	26.30	24.48
Part of large firm	0.11	0.23	0.36	0.11	0.18	0.30
Website	0.56	0.77	0.91	0.74	0.87	0.95
In city > 1 million	0.82	0.77	0.80	0.88	0.88	0.83
Line of credit	0.53	0.69	0.83	0.49	0.69	0.78
Quality certificate	0.05	0.17	0.43	0.17	0.39	0.74
Skilled workers	0.79	0.81	0.87	0.84	0.87	0.89
Employees (number)	10	43.5	461.4	10.5	45.7	310.2
Foreign-owned	0.04	0.07	0.18	0.05	0.11	0.29
Exporter	0.04	0.09	0.20	0.11	0.23	0.32
n	1668	1328	931	197	175	124
Share of total	37.7%	30.0%	21.0%	4.5%	4.0%	2.8%

Large firms in the med/high & high tech sector are most active in innovation. However, they constitute barely 3% of the firms in the sample, while the small firms in the low/medium tech sector make up nearly 40%. Thus, in the regression analysis, we estimate the size/sector impact on innovation behavior, with the large med/high tech sector as the omitted category. Appendix 1 shows the distribution of firms by size/sector for each of the seven countries.

The vast majority of firms in the sample spent on more than one innovation activity, in manufacturing as well as services: 37.1% of firms undertook 0–2 innovation activities, 44.3% undertook 3 to 5 activities, and 18.6% engaged with 6 to 8 activities. The share of firms introducing a new product or a new process increases with the number of innovation activities they engage with. Among firms with only one innovation input, 30% introduced a new product and 46% introduced a new process.

For firms engaging with all innovation inputs, however, the share producing a new product and process was 90 and 78%, respectively.

As mentioned earlier, several studies suggest that, in contrast to manufacturing, firms in the service sector are more prone to introduce a new product or process in response to and in collaboration with customers (Gallaouj and Windrum 2009). The data from the WBES suggests that this is not necessarily the case. Slightly over two thirds of firms in both manufacturing and services indicated that they introduced a new product because of specific customer requests or direct demand.

Results

Table 6 shows the probit estimates of Eqs. (1) and (2) for the full sample. Columns 1–8 present the results of the first-step regressions, with each of the eight measures of innovation activities as alternative dependent variables. Columns 9 and 10 show the second-step results, with innovation outcomes in the form of new products and new processes as the dependent variables, respectively. The table shows the marginal impact at the mean for each of the variables.

The results of the first step estimates highlight the importance of digital connectivity and access to funding for all innovation activities. Having a website and having a line of credit have a consistently positive and statistically significant impact on innovation engagement across the eight innovation activities. Other firm characteristics, which capture capabilities and resources, are statistically significant for some innovation activities, but not others.

The skill level of employees raises the likelihood of firm spending on design, marketing and organizational development. The absence of a significant coefficient for R&D is surprising. It may be that firms undertaking R&D also spend on design, marketing, and organizational development, with the positive impact of skilled labor on innovation then captured by the coefficients on these variables.

The two variables capturing foreign market participation have a differing impact. Possession of an internationally recognized quality certificate increases the likelihood for innovation through R&D, capital investment, and training. Exporting, on the other hand, raises the likelihood for innovation only for R&D.

Regarding firm age, older firms are less likely to make capital investments, perhaps because they have already built up their core asset base. Managerial experience has a statistically significant negative impact on the introduction of organizational changes. It may be that managers already made in the past the organizational changes they wanted (a positive view) or that managers become more complacent with more years on the job (a less favorable interpretation).

The regression results show that the size of the firm and the sector in which it operates are significant factors conditioning firm innovation behavior. Large firms in the high/medium technology-intensive sector are the omitted category, since they are the most innovative sector. The coefficients on the five sector/size variables reflect the innovation gap between firms in each of the five categories and large firms in the high/medium technology-intensive (HMT) sector. For example, controlling for all other characteristics, small firms in the HMT sector are, at the

Table 6 Regression results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	First step								Second step	
	R&D	Investm.	Training	Software	IPR	Design	Marketing	Organiz. change	New product	New process
R&D									0.086***	0.144***
									(0.021)	(0.022)
Investment									0.118***	0.151***
									(0.018)	(0.019)
Training									0.053***	0.045**
									(0.019)	(0.020)
Software									0.013	0.040**
									(0.019)	(0.019)
IPR									0.043*	− 0.010
									(0.023)	(0.024)
Design									0.084***	0.080***
									(0.019)	(0.020)
Marketing									0.143***	0.057***
									(0.019)	(0.020)
Org. ch.									0.025	0.100***
									(0.018)	(0.019)
Skilled labor	0.000	0.000	0.000	0.001***	0.000	0.001***	0.002***	0.001**	0.000	− 0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Website	0.124***	0.056***	0.147***	0.123***	0.078***	0.155***	0.175***	0.072***	0.096***	0.026
	(0.016)	(0.020)	(0.020)	(0.020)	(0.015)	(0.019)	(0.019)	(0.019)	(0.021)	(0.022)
Line of credit	0.058***	0.108***	0.076***	0.064***	0.022	0.015	0.051***	0.046**	0.052***	0.054***
	(0.016)	(0.018)	(0.018)	(0.018)	(0.015)	(0.019)	(0.018)	(0.018)	(0.019)	(0.020)

Table 6 (continued)

	(1) First step	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9) Second step	(10)
	R&D	Investm.	Training	Software	IPR	Design	Marketing	Organiz. change	New product	New process
Exports	0.068***	0.056*	0.042	− 0.009	0.024	0.067**	0.042	0.042	0.116***	0.010
	(0.026)	(0.029)	(0.030)	(0.029)	(0.023)	(0.028)	(0.029)	(0.028)	(0.028)	(0.031)
Quality certif.	0.124***	0.067***	0.165***	0.011	0.017	− 0.040*	− 0.007	0.001	− 0.019	0.046*
	(0.021)	(0.024)	(0.022)	(0.023)	(0.019)	(0.023)	(0.023)	(0.023)	(0.025)	(0.025)
Firm age	0.000	− 0.001***	0.000	0.000	0.000	0.000	0.001	0.001	0.000	− 0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Managerial exp.	0.000	0.000	0.000	0.003***	0.000	0.000	− 0.001	− 0.003***	0.000	0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Small HMT	− 0.100**	− 0.194***	− 0.348***	− 0.067	− 0.060	− 0.041	− 0.155***	− 0.117**	0.141**	0.035
	(0.041)	(0.045)	(0.077)	(0.064)	(0.042)	(0.066)	(0.056)	(0.058)	(0.058)	(0.072)
Medium HMT	− 0.036	− 0.093	− 0.287***	0.018	− 0.003	0.091	− 0.099*	0.010	0.084	0.016
	(0.050)	(0.057)	(0.085)	(0.066)	(0.049)	(0.066)	(0.060)	(0.065)	(0.067)	(0.073)
Small LMT	− 0.216***	− 0.238***	− 0.445***	− 0.098*	− 0.147***	− 0.080	− 0.155***	− 0.053	0.048	− 0.028
	(0.041)	(0.050)	(0.070)	(0.056)	(0.038)	(0.056)	(0.054)	(0.054)	(0.063)	(0.063)
Medium LMT	− 0.175***	− 0.112**	− 0.328***	− 0.027	− 0.096***	− 0.053	− 0.127**	− 0.024	0.043	− 0.061
	(0.037)	(0.050)	(0.076)	(0.055)	(0.036)	(0.056)	(0.053)	(0.054)	(0.061)	(0.061)
Large LMT	− 0.116***	0.041	− 0.222***	0.087	− 0.051	− 0.019	− 0.046	− 0.011	0.007	− 0.029
	(0.037)	(0.055)	(0.081)	(0.055)	(0.037)	(0.056)	(0.054)	(0.053)	(0.063)	(0.061)
City > 1 million	0.073***	− 0.004	− 0.014	− 0.011	0.020	0.015	0.036	0.007	0.009	0.008
	(0.025)	(0.030)	(0.029)	(0.030)	(0.024)	(0.030)	(0.030)	(0.029)	(0.031)	(0.033)

Table 6 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	First step								Second step	
	R&D	Investm.	Training	Software	IPR	Design	Marketing	Organiz. change	New product	New process
Multiple locations	0.025	0.018	0.044**	0.068***	0.030*	0.025	0.088***	0.081***	0.088***	0.072***
	(0.019)	(0.022)	(0.022)	(0.022)	(0.018)	(0.022)	(0.022)	(0.021)	(0.022)	(0.024)
Foreign ownership	0.033	− 0.001	0.061*	− 0.016	− 0.003	0.013	0.057*	− 0.042	0.089***	0.023
	(0.027)	(0.031)	(0.033)	(0.031)	(0.024)	(0.032)	(0.032)	(0.030)	(0.032)	(0.034)
Observations	3752	3598	3819	3820	3812	3819	3820	3821	3490	3495
ll	− 1958	− 2170	− 2232	− 2495	− 1915	− 2552	− 2391	− 2510	− 1975	− 2140
r2_p	0.100	0.080	0.132	0.054	0.053	0.036	0.076	0.027	0.138	0.114
chi2	434.8	377.2	678.8	285.0	215.3	187.8	395.6	140.6	635.0	551.0

Country dummies not shown. Coefficients show the marginal impact at the mean

HMT high/medium technology-intensive sector, *LMT* low/medium technology-intensive sector

Standard errors below coefficients. Significance shown as ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

mean, 19.4% less likely to spend on capital investment than large firms in HMT. The gaps are particularly large for small firms in the low/medium technology-intensive (LMT) sector. Compared to large firms in the HMT sector, small firms in the LMT sector are 21.6% less likely to spend on R&D, 23.8% less likely to invest, and 44.5% less likely to spend on training.

Among the other variables conditioning firm innovation, nationality of ownership generally has no impact on innovation engagement. The potential for agglomeration benefits has a positive and significant impact on innovation, but through different channels for different innovation activities. Being located in a city with more than a million people only has a positive impact on engagement with R&D, while a firm having multiple locations has a positive and significant impact on five innovation activities.

Our second-step regressions estimate how the eight innovation inputs affects firms' innovation outputs, in terms of new products (Column 9) and new processes (Column 10). The results show that each of the eight innovation activities increases the likelihood of the production of an innovation output. Thus it underscores the importance of considering the broad spectrum of innovation activities rather than only focusing on R&D.

Spending on R&D, capital investment, training, design, and marketing have a positive and statistically significant impact on the production of a new product as well as a new process. The positive coefficients on R&D spending, capital investment, and training are in line with the findings of other studies (Paus and Robinson 2022; Hussen and Çokgezen 2020; Aboal and Garda 2012; Ayalew et al. 2020; Adeyeye et al. 2016; Hadhri et al. 2016; Mesade and Abdul-Basit 2020; Crespi et al. 2014). Our results show that design and marketing have a significant positive effect on innovation outcomes as well. Spending on design increases the probability that the firm introduces a new product and a new process by 8%.

R&D and capital investment are the two innovation activities, which increase the likelihood of introducing a new process the most. For the introduction of a new product, on the other hand, the top two innovation activities are investment and marketing, followed by R&D. Given the importance of marketing for the promotion of a new product, it is not surprising that the coefficient on marketing is statistically significantly larger for the introduction of a new product than a new process.

The remaining three innovation inputs only have a statistically significant impact on the production of either the production of a new product or a new process. Spending on software and organizational development impact the introduction of a new process, which makes good sense. So does the result that spending on IPR-related activities only impacts the creation of a new product.

Considering firm-level variables in the second step, we find that some of the same variables that affected innovation activities also have additional direct effects on innovation outcomes. Having a line of credit continues to have a positive and statistically significant impact for the production of innovation outputs; i.e. it has an impact over and above the impact on engagement with innovation inputs. The finding supports the critical importance of access to credit, which many authors have emphasized on a theoretical level (Mazzucato 2013; Schumpeter 1983), and other studies have confirmed empirically as well (Hussen and Çokgezen 2020; Ayalew et al. 2020; Adeyeye et al. 2016; Beck and Demirguc-Kunt 2006).

We use the estimates from the CDM model to assess the weight of the different factors behind the large gaps in innovation activities. To evaluate the impact of the variables in the model on the differences in innovation, we multiply the difference in innovation activities between each size/sector and large firms in the HMT sector with the average marginal impact of each of the variables (the regression coefficients shown in Table 6) and express the outcome as a percentage of the difference. Tables 7 and 8 show the results for the decomposition for innovation inputs and outputs, respectively.

Column 1 shows the mean of innovation behavior for the large firms in the HMT sector. Columns 2–6 provide information for the other five size/sector groups. The second row for each innovation input/output shows the difference in means between each size/sector group and the large HMT group. For the decomposition of mean differences, we group the independent variables into four categories. The share accounted for the by size/sector factor captures the relative importance of economic structure. The share accounted for by country dummies reflects differences in the distribution of sector/size groups of the countries relative to Argentina (the omitted country variable). The share accounted for by website, line of credit, quality certificate combines the variables, which policies may be able to address most directly. The fourth category shows the share of the remaining variables. In addition, there will be a share not explained by the variables in the regressions.Since the estimated model is non-linear and we use average marginal effects, the sum of the shares does not necessarily add up to 100%.

Looking at firm engagement with R&D for example, 61% of firms in the large HMT group spent on R&D. The mean for small LMT is 44.1 percentage points lower than for that for large HMT. The size/sector factor accounts for 49% of this difference, country dummies for − 1.5%, policy-responsive variables for 33.8%, and the remaining variables for 7.8%. The peculiarity that some percentages are in the hundreds and even thousands is due to very small differences with the mean of the large HMT group.

The decomposition results in Table 7 highlight the importance of economic structure in accounting for the innovation gaps. Let us focus on small firms in the LMT sector, where the gap relative to large firms in HMT is largest. Having controlled for the other independent variables, the size/sector variable by itself accounts for the bulk of the difference in engagement with innovation inputs, reaching 94.3% for training and 72.6% for investment. However, structure is not everything. Policy-responsive variables account for around another 30% depending on the innovation input.

With respect to innovation outputs, we find that the eight innovation inputs account for nearly all the gaps in the production of a new product (84.4%) and a new process (86.6%). R&D, investment, and training are particularly important for the mean differences in both innovation outputs.

In sum, the large gaps in the production of innovation outputs are principally due to differences in engagement with R&D, investment and training, and size/sector is the main factor accounting for the gaps in engagement with these innovation inputs.

Table 7 Decomposition of difference in means in innovation inputs between large firms in HMT sector and firms in other sectors

Innovation input		(1) Large HMT	(2) Small LMT	(3) Med LMT	(4) Large LMT	(5) Small HMT	(6_ Med HMT
R&D	Large HMT (mean)	0.61					
	Difference relative to large HMT (ppt)		44.1	35.5	21.1	29.2	12.2
	Share accounted for by size/sector (%)		49.0%	49.3%	55.1%	34.2%	29.0%
	Share accounted for by country dummies (%)		− 1.5%	− 1.7%	− 2.2%	− 0.5%	− 5.0%
	Share accounted for by website, line of credit, quality certificate (%)		33.8%	28.0%	19.4%	39.1%	48.7%
	Share accounted for by all other independent variables included (%)		7.8%	8.2%	5.8%	8.0%	9.1%
Investment	Large HMT (mean)	0.57					
	Difference relative to large HMT (ppt)		32.8	18.0	− 1.0	30.0	16.1
	Share accounted for by size/sector (%)		72.6%	62.3%	401.3%	64.6%	57.8%
	Share accounted for by country dummies (%)		− 2.2%	− 1.2%	7.5%	2.1%	1.0%
	Share accounted for by website, line of credit, quality certificate (%)		29.1%	32.8%	− 175.0%	27.4%	24.0%
	Share accounted for by all other independent variables included (%)		5.5%	7.7%	− 51.8%	5.5%	4.9%
Training	Large HMT (mean)	0.92					
	Difference relative to large HMT (ppt)		47.2	28.5	12.5	33.5	21.4
	Share accounted for by size/sector (%)		94.3%	115.1%	177.7%	103.9%	134.2%
	Share accounted for by country dummies (%)		− 8.0%	− 9.1%	− 18.7%	− 2.7%	− 12.8%
	Share accounted for by website, line of credit, quality certificate (%)		40.4%	45.2%	43.0%	44.2%	36.4%
	Share accounted for by all other independent variables included (%)		7.6%	9.0%	6.7%	9.7%	9.7%
Software	Large HMT (mean)	0.55					
	Difference relative to large HMT (ppt)		18.8	7.0	− 6.2	14.7	2.3
	Share accounted for by size/sector (%)		52.3%	37.7%	140.0%	45.1%	− 80.7%
	Share accounted for by country dummies (%)		2.0%	7.9%	− 10.7%	16.9%	85.5%
	Share accounted for by website, line of credit, quality certificate (%)		38.4%	50.5%	− 9.1%	34.8%	89.9%
	Share accounted for by all other independent variables included (%)		5.2%	− 5.0%	12.8%	− 0.2%	− 3.0%
IPR	Large HMT (mean)	0.36					
	Difference relative to large HMT (ppt)		21.2	12.9	5.2	13.4	1.8

Table 7 (continued)

Innovation input		(1) Large HMT	(2) Small LMT	(3) Med LMT	(4) Large LMT	(5) Small HMT	(6_ Med HMT
	Share accounted for by size/sector (%)		69.3%	74.9%	97.9%	44.8%	16.0%
	Share accounted for by country dummies (%)		0.7%	− 0.3%	− 2.3%	14.9%	74.9%
	Share accounted for by website, line of credit, quality certificate (%)		22.5%	20.3%	14.3%	24.1%	80.2%
	Share accounted for by all other independent variables included (%)		10.5%	12.5%	7.9%	14.6%	59.0%
Design	Large HMT (mean)	0.57					
	Difference relative to large HMT (ppt)		14.8	28.5	12.5	33.5	21.4
	Share accounted for by size/sector (%)		54.3%	18.5%	15.4%	12.2%	− 42.6%
	Share accounted for by country dummies (%)		2.7%	1.0%	− 0.1%	6.3%	7.9%
	Share accounted for by website, line of credit, quality certificate (%)		25.2%	2.7%	− 5.2%	4.3%	0.2%
	Share accounted for by all other independent variables included (%)		19.5%	8.1%	7.1%	7.5%	6.0%
Marketing	Large HMT (mean)	0.6					
	Difference relative to large HMT (ppt)		27.2	18.2	4.8	24.7	14.5
	Share accounted for by size/sector (%)		57.0%	69.8%	95.1%	62.9%	68.4%
	Share accounted for by country dummies (%)		1.0%	− 0.7%	2.5%	6.2%	5.4%
	Share accounted for by website, line of credit, quality certificate (%)		28.1%	18.3%	5.6%	19.4%	11.7%
	Share accounted for by all other independent variables included (%)		20.7%	22.8%	21.5%	21.2%	22.2%
Organizational	Large HMT (mean)	0.5					
	Difference relative to large HMT (ppt)		13.9	7.0	2.1	18.1	3.3
	Share accounted for by size/sector (%)		38.0%	34.6%	51.0%	64.6%	− 30.2%
	Share accounted for by country dummies (%)		11.9%	12.1%	52.4%	9.3%	52.9%
	Share accounted for by website, line of credit, quality certificate (%)		29.1%	26.4%	5.8%	16.2%	32.7%
	Share accounted for by all other independent variables included (%)		14.6%	23.4%	− 9.2%	4.1%	42.0%

Conclusions

This article has demonstrated that engagement with R&D and non-R&D innovation inputs has a positive impact on firm production of innovation outputs. It also demonstrated the existence and importance of heterogeneity across innovation behavior across firm size and sector. It is not that small firm do not innovate or that firms in low/medium technology intensive sectors do not innovate. Rather, a smaller share of them does so, especially in R&D, investment, and training. The decomposition of the mean differences in innovation between the small low/medium tech sector and large med/high tech sector shows the predominance of the size/firm factor. In combination with the distribution of firms—a small share in the med/high tech sector, especially large firms, and a large share of in the low/med sector, especially small firms—the results underscore the importance of economic structure in explaining the generally low innovation results in Latin American countries.

Our study did not include firms in the informal sector, which is a significant characteristic of structural heterogeneity in Latin America. We know that there is little innovation in the informal sector and that firm productivity in the informal sector is a fraction of that in the formal sector.[12] An area where we need a lot more research is the nature of interactions between the informal and formal sector. Abramo (2022) argues that there is no clear-cut duality between the formal and informal sector; rather increasing interdependencies between the two blur the boundaries, e.g. through subcontracting.

What is the nature of these interdependencies and what are the implications for innovation engagement? To what extent does formal sector subcontracting with firms in the informal sector reduce the incentive for innovation for formal sector firms? To what extent does it lead to knowledge spillovers to informal sector firms raising their productivity, by however little? To what extent is competition from the informal sector an incentive for innovation in the formal sector? The WBES asks firms to rank the severity of 15 different possible obstacles to operations on a scale from ‘0’ (no obstacle) to ‘4’ (very severe obstacle). A large share of firms rank competition from the informal sector as a major (3) or very severe obstacle (4), ranging from 45% of firms in the small low/med tech sector to 27% in the large med/high tech sector.

Our results also suggest an important role for policies in reducing innovation gaps between the least and the most innovative size/sector group (and the others). The policy-response factor points to the importance of government policies in providing access to financing, affordable internet connections, and the acquisition of an internationally accepted quality control certificate. In addition, factors not captured in the regressions are crucial for innovation as well: among them, a cohesive national innovation system, a conducive exchange rate, and political stability.

Narrowing innovation and productivity gaps have to be important goals of a development strategy focused on advancing productivity growth. Such a strategy has

[12] ECLAC (2022, p. 106) estimates that productivity in the informal sector is less than six percent of that in the formal sector.

Table 8 Decomposition of difference in means in innovation outputs between large firms in HMT sector and firms in other sectors

		(1) Large HMT	(2) Small LMT	(3) Med LMT	(4) Large LMT	(5) Small HMT	(6_ Med HMT
Innovation output	Large HMT (mean)	0.75					
New product	Difference relative to large HMT (ppt)		19.9	10.4	4.3	5.9	0.3
	Share accounted for by all innovation inputs (%)		84.4%	103.2%	77.2%	227.8%	2032.8%
	Share accounted for by:						
	R&D		19.0%	29.3%	42.4%	42.6%	376.4%
	Investment		19.4%	20.4%	− 2.9%	60.2%	681.7%
	Training		12.7%	14.6%	15.7%	30.4%	408.9%
	Software		1.3%	0.9%	− 2.0%	3.4%	10.9%
	IPR		4.6%	5.3%	5.3%	9.8%	27.7%
	Design		6.2%	6.0%	1.2%	13.8%	− 246.5%
	Marketing		19.6%	25.0%	16.2%	59.9%	744.4%
	Organizational change		1.7%	1.7%	1.2%	7.6%	29.3%
	Share accounted for by size/sector (%)		− 24.3%	− 41.3%	− 17.1%	− 239.8%	− 3019.1%
	Share accounted for by country dummies (%)		− 5.6%	− 9.4%	− 3.9%	15.8%	− 198.4%
	Share accounted for by website, line of credit, quality certificate (%)		18.9%	11.6%	− 10.2%	42.1%	226.4%
	Share accounted for by all other independent variables included (%)		36.6%	51.1%	42.2%	104.7%	1291.2%
New process	Large HMT (mean)	0.61					
	Difference relative to large HMT (ppt)		19.69%	13.08%	2.61%	12.57%	0.88%
	Share accounted for by all innovation inputs (%)		86.6%	84.8%	134.8%	106.2%	621.9%
	Share accounted for by:						
	R&D		32.2%	39.1%	116.1%	33.5%	199.6%
	Investment		25.1%	20.8%	− 6.0%	36.1%	275.7%
	Training		10.9%	9.9%	21.7%	12.1%	109.6%
	Software		3.8%	2.1%	− 9.5%	4.7%	10.2%
	IPR		− 1.1%	− 1.0%	− 2.1%	− 1.1%	− 2.1%

Table 8 (continued)

	(1) Large HMT	(2) Small LMT	(3) Med LMT	(4) Large LMT	(5) Small HMT	(6_ Med HMT
Design		6.0%	4.6%	1.9%	6.2%	− 74.6%
Marketing		7.9%	8.0%	10.6%	11.2%	94.1%
Organizational change		1.7%	1.3%	2.0%	3.6%	9.2%
Share accounted for by size/sector (%)		14.1%	46.8%	111.1%	− 27.7%	− 176.6%
Share accounted for by country dummies (%)		− 7.6%	− 8.6%	− 17.1%	− 2.0%	− 145.6%
Share accounted for by website, line of credit, quality certificate (%)		28.4%	27.9%	49.3%	38.3%	268.6%
Share accounted for by all other independent variables included (%)		4.7%	− 0.1%	− 21.2%	0.2%	1.6%

to have a strategic focus on promoting the growth of the medium and medium/high technology-intensive sectors, both in manufacturing and services. They generally have a higher income elasticity, can better drive sustained output and productivity growth, as well as the creation of decent jobs.[13]

Appendix 1: Distribution of firms by size/sector for sample countries ('n' and '%')

	Low & low/med technology-intensive sector				Medium/high & high technology-intensive sector				Grand total
	Small	Medium	Large	Total	Small	Medium	Large	Total	
Argentina	337	292	217	846	63	45	37	145	991
Bolivia	174	88	73	335	10	10	9	29	364
Colombia	347	314	192	853	63	55	22	140	993
Ecuador	112	124	101	337	7	6	14	27	364
Paraguay	433	265	215	913	38	35	17	90	1003
Peru	120	125	64	309	11	11	16	38	347
Uruguay	145	120	69	334	5	13	9	27	361
Total	1668	1328	931	3927	197	175	124	496	4423
	Low & low/med technology-intensive sector				Medium/high & high technology-intensive sector				Grand total (%)
	Small (%)	Medium (%)	Large (%)	Total (%)	Small (%)	Medium (%)	Large (%)	Total (%)	
Argentina	34.0	29.5	21.9	85.4	3.5	2.5	2.1	8.1	100
Bolivia	47.8	24.2	20.1	92.0	1.4	1.4	1.3	4.2	100
Colombia	34.9	31.6	19.3	85.9	3.5	3.0	1.2	7.7	100
Ecuador	30.8	34.1	27.7	92.6	1.0	0.9	2.0	3.9	100
Paraguay	43.2	26.4	21.4	91.0	2.0	1.8	0.9	4.7	100
Peru	34.6	36.0	18.4	89.0	1.7	1.7	2.5	5.9	100
Uruguay	40.2	33.2	19.1	92.5	0.7	1.9	1.3	3.9	100
Total	37.7	30.0	21.0	88.8	2.4	2.1	1.5	6.0	100

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Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

[13] Income elasticities of demand lie between one and two for high-technology manufacturing exports, but 0.2 and 0.8 for low-technology manufactured exports (Bottega and Romero 2021).

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