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Three Essays on the Relationship Between Innovation, Value-Added, and Employment Industrialization in the Context of Developing Countries

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General Abstract

This thesis explores the role of innovation and technology in driving industrialization in developing countries. It constructs an innovation index for 53 countries (1996–2018) in Chapter 1. Results highlight that a certain level of national innovation is essential for positive impacts on manufacturing value-added, while countries below this threshold face premature deindustrialization and labour-saving effects that reduce overall manufacturing employment. Sector-specific analysis shows that innovation benefits certain sectors by fostering demand, though science-based sectors see growth only in high-innovation countries and often without employment gains, emphasizing the need for skill development.

The firm-level analysis of Colombian manufacturing in Chapter 2 reveals that product innovation significantly boosts employment, especially among highly educated workers, while Chinese import competition negatively impacts innovative firms, particularly in low-tech sectors. Finally, results in Chapter 3 show that productivity growth is driven by shifts in employment across firms of different sizes. Large firms benefit from imported technologies, while exports aid smaller firms. However, strict regulations can limit these productivity and employment benefits across firm types.

Keywords: Industrialization · Structural Change · Technology · Labour Productivity Growth · Manufacturing Firms.

JEL Classification: O14, O30, J24, O14, O40.

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General Introduction

Industrialization involves the structural transformation of an economy, where resources shift from low-productivity sectors like agriculture to high-productivity manufacturing industries that produce more complex goods (Naudé & Nagler, 2015). The importance of sustained industrialization is closely linked to economic development (Szirmai & Verspagen, 2015). According to Kaldor's growth laws, industrialization drives labour productivity growth through increasing returns to scale in the manufacturing sector (Di Meglio et al., 2018). Rodrik (2013) shows that periods of rapid growth are linked to an expanding manufacturing sector, which is the only sector that consistently achieves labour productivity convergence. Manufacturing also absorbs a substantial portion of a developing country's workforce and provides higher wages as workers move from rural to urban areas (Sen, 2019).

Szirmai (2012) provides empirical and theoretical evidence highlighting industrialization as a key driver of economic development, largely through its links to innovation and technological advancements. First, the manufacturing sector offers unique opportunities for economies of scale and capital accumulation, which are major sources of overall growth. Second, capital accumulation is linked to both embodied and disembodied technological progress and innovation, originating in the manufacturing sector and spreading to other parts of the economy. As countries develop, their manufacturing industries shift from labour-intensive to capital-intensive technology (Haraguchi, 2015). This transformation enables greater economies of scope and the production of a wider variety of goods, leading to rapid economic growth (Hausmann et al., 2007; Hidalgo et al., 2007).

However, the growth benefits of technology- and innovation-driven industrialization have become increasingly complex due to two key factors: the accelerating pace of technological change and the globalization and fragmentation of production (Naudé & Nagler, 2015). On one hand, rapid technological change and innovation have predominantly taken a labour-saving form, reducing the share of manufacturing employment in developing countries, particularly for unskilled workers. On the other hand, globalization has intensified competition, especially from countries with comparative advantages in manufacturing, such as China and other Asian exporters, adversely affecting both manufacturing value-added and employment in developing countries (Rodrik, 2016).

Both technological change and globalization contribute to the premature deindustrialization observed in African and Latin American countries. Studies by Dasgupta and Singh (2006), Palma (2005), and Rodrik (2016) provide evidence that these regions have experienced deindustrialization at lower levels of manufacturing shares and GDP per capita than advanced economies. This premature deindustrialization suggests that manufacturing may no longer serve as the primary engine of growth and economic convergence (Lautier, 2024).

Hence, the objective of my thesis is to contribute to the existing literature by examining how innovation and technological activities influence the processes of industrialization or deindustrialization in a sample of developing countries. Specifically, this thesis investigates the relationship between innovation, manufacturing value-added, and employment shares at both the national, sectoral, and firm levels, while considering the impacts of globalization and increased foreign trade competition.

In this introduction, I review the relevant context of this thesis. First, it is defined the sources of structural transformation that explain both processes of industrialization and (premature) deindustrialization. It contextualises the relevance of innovation and technological advancements as an important explanation for these processes, and it describes the importance, risks, and opportunities of Chinese manufacturing competition for the industrialization processes of developing countries. Then, I present the research questions and the contributions of each chapter of the thesis.

1 Sources of Structural Transformation, Industrialization, and Premature Deindustrialization

The concept of structural change, or structural transformation, has typically been understood as the shift of resources and production from traditional sectors, like agriculture, to manufacturing, and eventually to the service sectors as a country develops (Fisher, 1939; Clark, 1940). Lewis (1954), Kuznets (1966), and later Rowthorn and Ramaswamy (1999), suggest that during structural transformation, a country's manufacturing sector grows in the early stages of development as part of the industrialization process, but contracts once the country attains a high level of development or income. This phenomenon is known as deindustrialization. This trend is observed in all countries as they progress along their development path, and is regarded as a stylized fact, where manufacturing measures follow an inverted U-shape relative to income or GDP per capita (Herrendorf et al., 2014).

In this thesis the term "industrialization" refers to the expansion of the manufacturing sector (Szirmai, 2012), which can be measured as the rise in manufacturing employment (as a share of total employment) and in manufacturing output (manufacturing value-added as a share of GDP) following the definitions used by Tregenna (2009), Herrendorf et al. (2014), Rodrik (2016), among others. The literature points to various factors driving structural transformation, industrialization, and deindustrialization, which, as Van Neuss (2019) notes, are complementary rather than mutually exclusive.

One area of research on structural change suggests that shifts in economic activity across sectors are shaped by non-homothetic preferences and changes in demand patterns

as real income evolves (Van Neuss, 2019). Drawing on Engel's law, studies by Clark (1940), Rowthorn and Wells (1987), and Rowthorn and Ramaswamy (1997) illustrate that the portion of income allocated to manufacturing goods rises in the early stages of development, levels off at mid-income stages, and eventually decreases beyond a certain per capita income threshold. As incomes increase, the relative demand for goods changes, causing a shift in activity toward sectors meeting higher-order needs, which in turn prompts labour and economic adjustments.

Another body of literature focuses on macroeconomic policies and institutional factors. Poor policy choices and misaligned incentives can foster corruption and create risky business environments, which deter productive investments and hinder innovation and technology adoption, ultimately weakening industrial performance (Naudé & Tregenna, 2023). For example, Acemoglu et al. (2001, 2013) argue that the impact of colonialism on development varies based on whether it involved extractive institutions or the introduction of institutions that support long-term investments. Extractive institutions, rooted in colonial legacies, can create political economy challenges, such as rent-seeking by political elites who use exclusive rights to exploit and export natural resources to accumulate wealth and maintain power (Dosi & Tranchero, 2018). Additionally, a surge in primary commodity exports, often triggered by new natural resource discoveries, can lead to deindustrialization, in what is called Dutch Disease. This shift occurs because the wealth from resource exports appreciates the real exchange rate, diminishing investments in manufacturing, and eroding the sector's global competitiveness (Palma, 2005).

The financial development of a country, in particular, the institutions that provide stability and property rights protection (Bhattacharyya & Hodler, 2014) represent an alternative proxy for institutional quality. A key factor in a country's industrialization is the effect of establishing and enhancing property rights, allowing fixed assets to be used as collateral. This phenomenon, often referred to as the "De Soto Effect" (De Soto, 2000), plays a significant role in facilitating industrial growth as it improves access to credit and increases investment (Karas et al., 2015). With this respect, Hsieh et al. (2014) and Diao et al. (2021) emphasize that informal and small firms often face credit constraints, limiting their ability to invest in technology and expand their productivity and size into medium or large enterprises. Similarly, Lall (2004) and Castellacci and Natera (2013) point out that ineffective financial policies hinder investment in both human and physical capital, making it harder for entrepreneurial start-ups to emerge. This, in turn, negatively impacts a country's commitment to technological advancement and industrialization efforts.

Another stream of literature that explores structural change, industrialization, and deindustrialization focuses on the theoretical and empirical effects of trade and globalization. Uy and Zhang (2013) introduce a two-country Ricardian trade model, illustrating how sectoral shifts—from agriculture to manufacturing, and later to services—are shaped by international trade, driven by differences in both sectoral and national productivity levels. According to the authors, a country with a comparative advantage in manufacturing can experience industrialization through increased manufacturing productivity and labour share growth within a two-country trade context. These findings align with Matsuyama (2009), who suggests that countries with faster productivity gains in manufacturing may delay deindustrialization.

Additional aspects of globalization influence the industrialization process. Trade liberalization measures, including maintaining a competitive real exchange rate, play a crucial role in supporting and promoting the growth of the manufacturing sector (Rodrik, 2007; Martorano & Sanfilippo, 2015). Haraguchi et al. (2019) find that successful industrializing countries often implemented undervalued exchange rate regimes to enhance the competitiveness of their domestic manufacturing industries. On the other hand, Shu and Steinwender (2019) show that import competition enhances productivity in emerging economies, particularly for larger, more productive firms. At the same time, increased export opportunities drive innovation and productivity gains, with the most productive firms benefiting the most. Furthermore, trade openness enables domestic firms to acquire foreign technology at lower costs. Imported, capital- and skill-intensive inputs improve production efficiency and product quality (Amiti & Konings, 2007; Bas & Paunov, 2019, 2021).

This body of literature highlights how globalization prompts the redistribution of resources across different sectors as countries diversify and focus on industries aligned with their comparative advantages, which are determined by both factor endowments and technological capabilities (Imbs & Wacziarg, 2003). This is closely connected to the central theme of this thesis, which examines innovation and technological advancement as key drivers of structural change, industrialization, and deindustrialization.

Innovation and technological progress lead to higher sectoral productivity, which subsequently results in lower relative sectoral prices (Matthess & Kunkel, 2020). One proponent of this idea was Baumol (1967), who introduced the hypothesis of 'cost disease' or 'structural burden', commonly referred to in the literature as the Baumol effect. In this hypothesis, the more productive sectors (such as manufacturing) release resources, particularly labour, which are absorbed by the slower-growing sectors (such as services) of the economy. Along similar lines, Ngai and Pissarides (2007) explain that when the elasticity of substitution between final goods across sectors is low (below one), labour tends to move toward the sector with the lowest total factor productivity (TFP) in a balanced growth path model, where aggregate economic ratios remain constant, consistent with the Kaldor facts.

Acemoglu and Guerrieri (2008) and Swiecki (2017) emphasize that sector-specific technological change and labour-augmenting technological progress increase the relative output of more capital-intensive sectors and prompt a reallocation of resources toward the less capital-intensive sectors, primarily represented by the service sector. Additionally, Caselli and Coleman (2001), Acemoglu and Autor (2011), and Buera et al. (2011) find that an increase in GDP per capita and the decline in education costs lead to a structural shift toward sectors that require more skilled labour, that is in manufacturing and high-productivity services. Herrendorf et al. (2015) and Alvarez-Cuadrado et al. (2017) show that structural change is also related to sectoral differences in the elasticity of substitution between capital and labour. The manufacturing sector exhibits greater substitutability compared to services. As a result, if labour costs rise relative to capital, the capital-labour ratio in manufacturing is likely to shift in favour of capital, leading the sector to become more capital-intensive, which is linked to both embodied and disembodied technological progress and innovation (Szirmai, 2012).

Innovation and technology play a crucial role in driving industrialization, as industrial development is seen as a process of enhancing technological capabilities. This leads to higher productivity, advancement, diversification, and increased competitiveness of industrial activities (Park et al., 2021). In this regard, the technological capability of a country refers to "the ability to develop, search for, absorb, and exploit knowledge commercially" (Fagerberg et al., 2010, p. 839). On the other hand, in the Oslo Manual, innovation is defined as a "new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)" (OECD/Eurostat, 2018, p. 20).

Technological change and innovation thus promote the shift of resources from low-productivity sectors, such as agriculture, to higher-productivity sectors like manufacturing (Samaniego & Sun, 2016). Empirical findings by Haraguchi et al. (2019) show that a nation's level of innovation—measured by R&D investments, the strength of its scientific and technological base, and the quality of its educational system—increases the chances of successful industrialization through diversification, the creation of new industrial activities, employment and productivity growth.

Haraguchi et al. (2019), Kunst (2019), and Dosi et al. (2021) document the existence of a variety of patterns of industrialization across manufacturing sub-sectors. Dosi et al. (2021) highlight that Supplier Dominated and Scale Intensive sectors mark the early stages of industrialization, with industries like food products, textiles, and clothing playing a key role by absorbing labour from agriculture and generating low-tech value-added products. However, these sectors are the first to experience deindustrialization. To sustain growth, countries must develop technological capabilities that enable them to acquire and generate knowledge and innovations, facilitating the creation of new activities in more advanced sectors such as Specialised Suppliers and Science-Based industries, including machinery, chemicals, medical, and precision instruments. These high-tech sectors continue to expand in terms of both employment and value-added as per capita income increases, showing no signs of deindustrialization. The authors argue that countries can foster economic catch-up and achieve higher GDP per capita by gradually transitioning from low-tech to high-tech manufacturing industries.

However, the industrialization process has proven challenging for developing countries due to the effects of globalization. Dasgupta and Singh (2006), Palma (2005), and Rodrik (2016) have revived the premature deindustrialization debate, pointing out the trend of premature declines in both manufacturing employment and value-added shares in developing economies since the 1990s. Rodrik (2016) argues that small open economies, which act as price takers on the global market, can import deindustrialization from abroad due to trade and competition with more productive foreign countries. In this context, more rapid technological progress abroad, which reduces global manufacturing prices, could lead to a decrease in both domestic manufacturing output and employment shares. This body of work emphasizes that when domestic manufacturing productivity grows more slowly than foreign manufacturing productivity, the share of domestic manufacturing, in both value-added and employment, declines. These results can be attributed to the development policies implemented in developing countries.

According to the literature, many developing nations in Latin America and Africa pursued industrialization based on the Prebisch-Singer hypothesis. This theory argues that specializing in natural resource production hampers growth because primary products have a low-price elasticity of demand. As a result, when prices fall, it tends to decrease revenue rather than boost demand, leading to a deterioration in the terms of trade (Dosi & Tranchero, 2018). To address this outcome, during the 1950s to 1980s, governments implemented a State-driven industrialization strategy, focusing on development policies centred around import-substitution industrialization (ISI) (Palma, 2005).

Under the ISI policies developing countries constructed a low-tech manufacturing sector dependent on mature technologies, low-skilled labour, and state-owned enterprises. However, this approach lacked incentives for innovation, product quality improvement, or human capital development (Lawrence, 2005; Firpo and Pieri, 2017). Since the 1990s, trade liberalization introduced competition from both high-income and developing nations, including advanced Asian manufacturers, pressuring ISI-based industries. This shift in policy regime leads to a process of premature deindustrialization in Africa and deeply in Latin America, which remains predominantly dependent on agriculture, mining, natural resources-processing industries, as well as non-tradable and low productivity services (Timmer et al. 2015; Rodrik, 2016), and in some cases specialized in assembly industries of low value-added in electronics, vehicles and garments (maquiladora type), as presented by Cimoli and Katz (2003).

Kim and Lee (2014) demonstrate that countries reliant on commodity or natural resource exports have experienced rapid deindustrialization, largely due to competitive manufacturing imports from China, which offer lower prices and outcompete domestic manufacturers. Similarly, Coricelli and Ravasan (2017) identify trade with China as a major contributor to deindustrialization in open economies. Lautier (2024) also highlights China's economic surge from 1990 to 2010 as a critical factor. On the demand side, China's substantial increase in raw material imports spurred a global commodity boom, improving terms of trade and raising prices for resources like oil, copper, and zinc. This price surge boosted export revenues for resource-rich nations, increasing the primary sector's share of GDP while contributing to a relative decline in manufacturing. On the supply side, China's rapid manufacturing growth reduced opportunities for industrial expansion in other developing countries, concentrating manufacturing activities in China and limiting industrial growth elsewhere (Atolia et al., 2020, among others).

China's rapid rise in global manufacturing share is primarily due to the development policies pursued by its government, which followed a similar approach to that of the East Asian Tigers. Since the 1960s, these nations combined import substitution policies with export promotion strategies, among which is the undervaluation of the exchange rate to boost the industry's size (Rodrik, 2007). In this framework, firms were granted subsidies and access to protected domestic markets, but in exchange, they were obligated to export. The excess profits from domestic sales were reinvested to enhance learning, build economies of scale, and compete internationally, ultimately securing new export licenses (MacBean, 2000; Di Maio, 2008). China's shift toward market-oriented reforms and expansion in trade accelerated significantly following its entry into the World Trade

Organization in 2001. At this time, the Chinese government reduced export barriers, lowered import tariffs, encouraged foreign investments, and enabled labour shifts from agriculture to the manufacturing sector (Naughton, 2007, as cited in Hanson, 2020).

These trade and industrial policies were paired with a focus on technological advancement to drive structural transformation within industries, shifting over time from replicating foreign technologies to fostering domestic innovation within the country (Zhou et al., 2021). According to Park et al. (2021), China's technological development can be understood in three stages. Initially, in the technology introduction phase, the government relied significantly on technology trade to absorb advanced foreign technologies. The next phase, technology internationalization, saw a boost in domestic innovation capacity, supported by ongoing technology transfers through international joint ventures and foreign direct investment (FDI). The final stage, technology creation, involves private companies leading national R&D initiatives, with increased collaboration between universities and industry. These stages resulted from a series of large-scale science and technology (S&T) policies introduced in China since the 1970s, aimed at establishing a domestic innovation infrastructure and strengthening the competitiveness of local research institutions.

Chen et al. (2015) highlight key S&T policy measures that enabled China to strengthen its competitive position in manufacturing. These include: (i) the establishment of National Research Projects and National Laboratories (1978–1985), during which Lenovo (Legend Computer) was founded; (ii) the introduction of the Science and Technology System Reform Act (1985–1995), aimed at bridging gaps between research institutions, universities, and industry, funding both basic and applied research, and encouraging the return of Chinese scholars from abroad; (iii) the enactment of the Act of Promoting Commercialization of S&T Discoveries and Inventions (1996–2006), focused on shifting innovation drivers from public research to industry, strengthening industrial R&D and innovation, and improving commercialization efficiency for academic research; and (iv) the release of the Medium- and Long-Term National S&T Development Plan (2006–2010), which set guidelines for S&T development, such as fostering independent innovation, advancing key technologies, building critical infrastructure, and positioning China as a future global leader. This phase marked a shift from merely promoting R&D to establishing a comprehensive innovation ecosystem (Chen et al., 2015, p. 106). China is currently promoting high-tech industries and the integration of advanced technology in manufacturing through its "Made in China 2025" initiative (Felipe et al., 2019; Hanson, 2020). Due to these policy initiatives, China's export strength initially surged in labour-intensive manufacturing before shifting toward capital- and knowledge-intensive production, with advancements in automation, robot adoption, and a rise in AI patents from 2000 to 2016 (Mondolo, 2022).

China's experience shows how combining technology and innovation efforts with trade openness can accelerate industrialization, enhance diversification, and advance up the value chain. In contrast, many developing countries, particularly in Latin America and Africa, struggled to maintain competitiveness in their industries when trade liberalization began in the 1990s, following initial efforts in ISI development strategies (Atolia et al., 2020). The subsequent policy shift towards more market-friendly strategies, such as unilateral trade opening, financial deregulation, currency appreciation aimed

at inflation control, and the retreat of the developmental State led to a reduced public investment and State intervention (UNCTAD, 2016, p. 82) which negatively affected the promotion of indigenous innovation and joint ventures with foreign companies in manufacturing (Naudé, 2017).

Since then, countries in Latin America and Africa often face innovation policy implementation challenges, resulting in an "innovation paradox": limited investment in innovation, even though it could potentially yield significant benefits in terms of efficiency, diversification, and economic growth. This paradox arises due to existing innovation barriers (Cirera & Maloney, 2017). According to Atolia et al. (2020), these barriers stem from a lack of essential innovation-supporting factors, known as private (such as physical capital and skills) and public fundamentals (such as infrastructure and institutions). Consequently, limited technological and innovative capacities have constrained these countries' potential to expand and diversify their manufacturing sectors within a globalized economy. This has also limited their opportunities for backward or forward linkages in global value chains (GVC), exposing them to intense competitive pressure from foreign manufacturers, primarily from China (Rodrik, 2022).

Many researchers have shown that this foreign competitive pressure on less competitive domestic manufacturing sectors has contributed to premature deindustrialization in developing countries. The term 'premature' highlights that, in these countries, manufacturing has begun to decline at much lower income levels and manufacturing shares than in advanced economies when they started to deindustrialize (Palma, 2005; Dasgupta & Singh, 2006; Rodrik, 2016). Consequently, Latin American and African countries have shifted toward specialization patterns focused on their static comparative advantages, that is on natural resources and low-productivity services, with a limited manufacturing sector that remains primarily labour-intensive and low in value-added (Brandt et al., 2016; Nuvolari & Russo, 2021).

This model of international trade specialization centred around resource-extraction industries, generates income that is then used to import tradable manufactured goods. Alongside this, there is a growing demand for traditional, non-tradable, and low-productivity services—such as wholesale, retail, and personal services—that complement the low-value-added manufacturing sector (Atolia et al., 2020). The movement of labour towards low-productive services, as an outcome of the process of premature deindustrialization, means a growth-reducing strategy for Latin American and African countries (McMillan & Rodrik, 2011). Therefore, in the absence of substantial manufacturing industries, these economies will need to adopt a service-driven growth model focused on high-productivity, tradable services, such as IT, finance, and other knowledge-intensive business services (KIBS), as in the Indian case. These sectors could act as engines of growth, similar to the manufacturing sector, by fulfilling Kaldor's Growth Laws. According to these laws, both manufacturing and KIBS sectors stimulate growth through two key mechanisms: they experience increasing returns to scale, and their output growth has a positive impact on productivity growth across other sectors (Di Meglio et al., 2018).

Nevertheless, the service-led growth model poses additional challenges for developing countries. First, KIBS development and subsequent commercialization depend on the

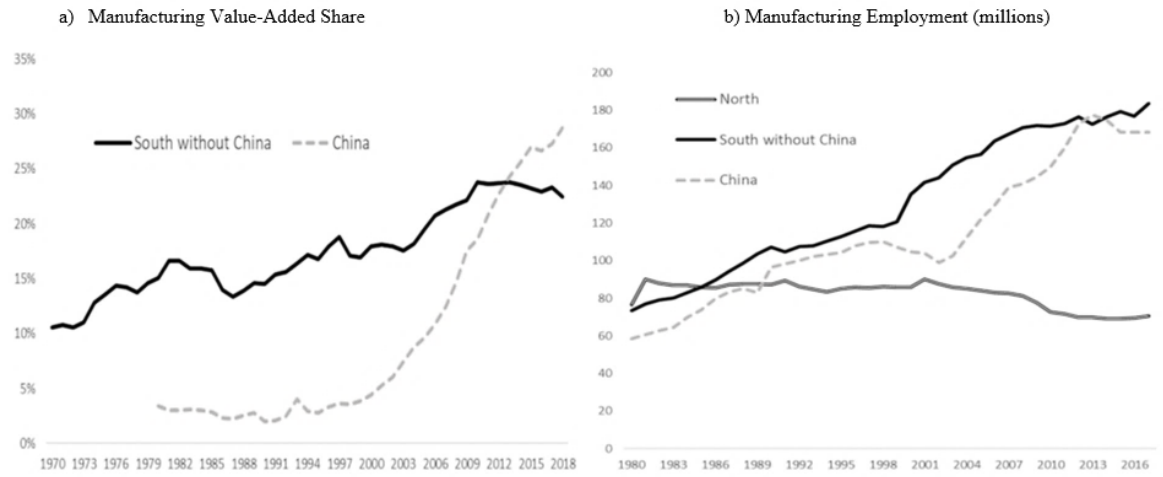
level of industrialization of a country. Cassini (2023), applying an evolutionary and neo-Schumpeterian approach, shows that countries achieving a high level of industrialization before deindustrializing are more likely to develop KIBS. These sectors offer knowledge resources and create forward and backward linkages with Science-Based and Specialised Suppliers manufacturing industries (such as machinery, chemicals, pharmaceuticals, and computer products). In fact, developing countries that are major exporters of these types of manufactured goods also export KIBS, as seen in India and Costa Rica. Second, and as a consequence of the previous point, the development of KIBS depends on the capacities of the National Innovation System for the generation, use, and diffusion of codified and tacit knowledge (Di Meglio et al., 2018; Cassini, 2023);

These arguments highlight the importance of technology and innovation in a service-led development strategy, but also as the main driver in the formation of a productive structure and subsequent industrialization of a country as argued in previous paragraphs. Technological upgrading, along with knowledge formation and accumulation, fosters the creation of value-added through product and process innovations. These innovations, in turn, lead to the development of dynamic comparative advantages (Ocampo, 2005) and the evolution of manufacturing industries (Malerba, 2006; Dosi & Nelson, 2010), enabling a country's efficient participation in a globalized market (Dahlman, 2008). This suggests that developing countries may seek to enhance economic growth through a new process of manufacturing development.

In this regard, the concept of a deterministic process of premature deindustrialization is not widely accepted in the literature. For instance, Kruse et al. (2021) observe that in many developing countries, the peak in the share of manufacturing employment has not yet been reached. According to McMillan et al., (2014) and Diao et al., (2018, 2021), Africa has shown a significant trend of industrialization since the 2000s, driven by small and unregistered firms that are expanding employment, while large firms increase productivity through capital-intensive technologies. Dosi et al. (2021) identify various industrialization opportunities across manufacturing sectors based on their technological characteristics. According to Pavitt's industrial taxonomy (Pavitt, 1984), Supplier Dominated and Scale Intensive sectors absorb the largest share of the labour force but are the first to experience deindustrialization. In contrast, Specialized Suppliers and Science-Based sectors continue to grow in both value-added and employment shares, showing no signs of deindustrialization.

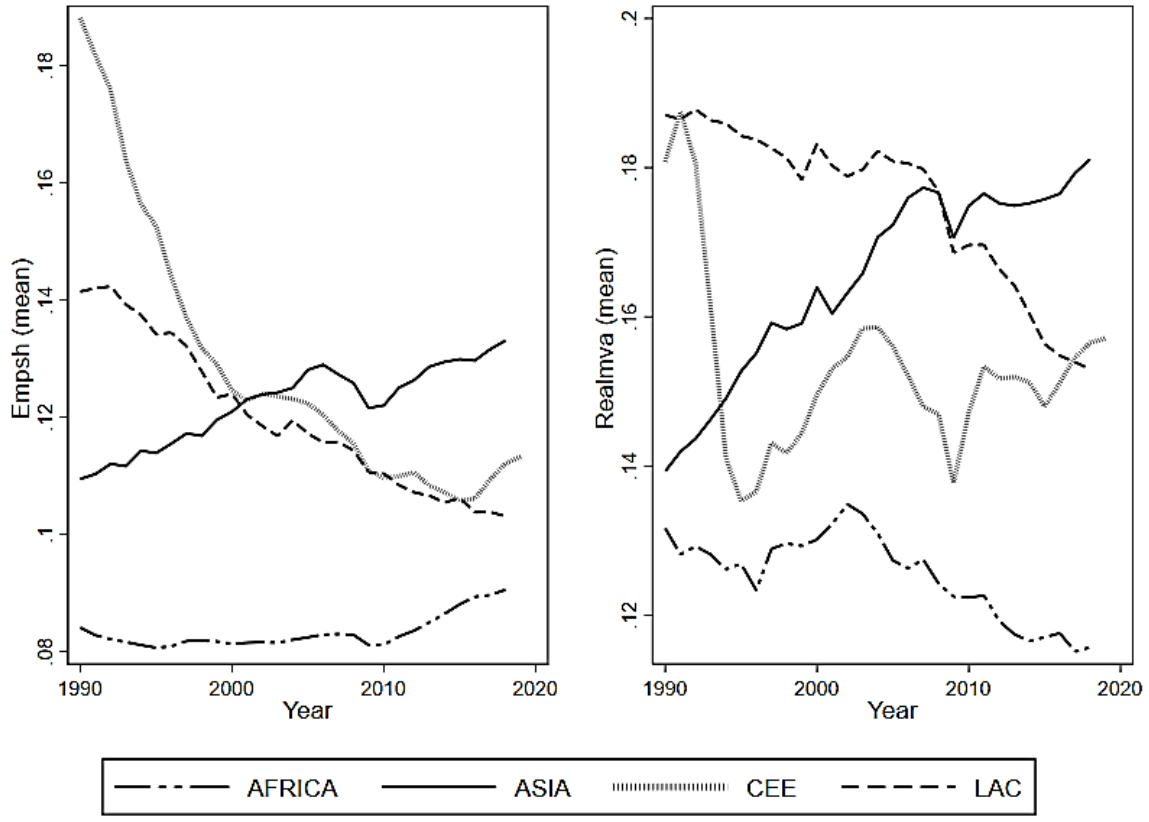
Haraguchi et al. (2017) challenge the idea that manufacturing is becoming less important for developing countries. They argue that the decline in manufacturing value added and employment in many developing nations results from the concentration of manufacturing activities in a few populous Asian countries, especially in China as presented in previous paragraphs. Nevertheless, China is undergoing a process of upgrading its economic structure, transitioning from labour-intensive industries to capital- and high-tech-intensive sectors following a technology strategy and industrial policy ("Made in China 2025"). An increase in Chinese manufacturing wages accompanies this shift. Therefore, the Chinese transformation opens a window of opportunity to reallocate the production of labour-intensive industries to other developing countries challenging the premature deindustrialization limitation (Brandt et al., 2016; Hanson, 2020).

Figure 1: World Manufacturing Value-Added and Employment



Source: Lautier (2024) based on data from UNStats, UNIDO Industrial Statistics, ILO, Groningen growth and Development centre data.

Figure 2: Manufacturing Employment (Empsh) and Value-Added Shares (Realmva) Across Regions



Source: Author's calculations based on the Economic Transformation Database and the Economic Transformation Database of Transition Economies (Groningen Data Center) (Kruse et al., 2023; Hamilton & de Vries, 2023).

The empirical findings from Lautier (2024), illustrated in Figure 1, show that the relative importance of manufacturing value-added shares and employment has not diminished over time in the developing world, challenging the theory of premature deindustrialization. Particularly, since 2010 manufacturing employment in China has stagnated while it has continued to grow at a steady pace in the rest of the developing world. Figure 2 presents the average manufacturing value-added and employment share for the sample of developing countries analysed in Chapter 1 of this thesis. On average, countries in Africa, Southeast Asia, and Central and Eastern Europe have experienced a recovery in manufacturing employment since 2010, while only Southeast Asia and Central and Eastern Europe have shown an increase in manufacturing value-added shares.

Consequently, low- and middle-income countries should adopt development strategies focused on innovation and technological advancements to produce new goods, increase productivity, and generate employment opportunities (Fagerberg et al., 2007). This requires strengthening the foundations for knowledge creation, technology, and innovation—such as enhancing human capital and skills development, improving institutions, and building better infrastructure. These efforts are essential to renew industrialization, leveraging the opportunity created by China's shift toward higher-value production (Rodrik, 2014; Atolia et al., 2020).

Yet, the impact of innovation-led industrialization on employment growth remains controversial. Technological advancement can increase manufacturing value-added and product diversity, enhance competitiveness, and ultimately drive economic growth, thereby supporting job creation in the manufacturing sector. Conversely, technological advancement may boost productivity in ways that have a labour-saving effect, with the overall impact on manufacturing employment depending on which of these forces becomes dominant (Vivarelli, 2014). These labour-creation and labour-displacement effects are also related to different innovation activities. For instance, product innovations that open new markets and boost consumer demand tend to create jobs. In contrast, process innovations that enhance production methods and efficiency may displace labour.

However, the ultimate relationship between innovation and employment is shaped not only by the direct impacts of product and process innovations but also by the compensatory mechanisms in place (Calvino & Virgillito, 2018). The market compensation mechanisms that can offset the labour-saving effects of technology include (1) additional employment in the capital goods sector where new machines are produced, (2) decreases in prices resulting from lower production costs due to technological innovations, (3) new investments made with additional profits generated by technological change, (4) wage decreases following initial job losses, and (5) the creation of new products using new technologies (Vivarelli, 2018, p. 12).

Although there is not a clear-cut outcome to the nexus of innovation-employment growth, Calvino & Virgillito (2018) highlight as a stylized fact from the most recent empirical evidence that at the firm level, there is a positive association of innovation with employment growth, mainly in high-technology firms. On the other hand, at the sectoral level, the effects of process innovations are less pronounced due to the competitive forces in the market, while the effects of product innovations tend to have a positive effect on sectoral employment, making it a significant driver of employment growth at the industry

level.

In addition to the quantitative effects of innovation on employment, there are also qualitative effects, particularly on the types of workers, their skills, and tasks (Vivarelli, 2014). A substantial body of research highlights two main theories that explore the qualitative impact of technological progress. The first is the Skill-Biased Technological Change hypothesis, which suggests that recent technologies complement highly skilled and educated workers while displacing those with lower skill and education levels. The second is the Routine-Biased Technological Change hypothesis, which focuses on the nature of tasks rather than education, proposing that technology and innovation replace routine tasks while enhancing non-routine ones (Mondolo, 2022).

Both the quantitative and qualitative effects of innovation on employment are evident in developing countries. Rodrik (2022) notes that production methods in these countries are largely shaped by foreign innovation trends to stay competitive. Consequently, low-skill-intensive production techniques are limited, often giving way to capital-intensive or skill-intensive approaches. Understanding the potential effects of innovation on manufacturing employment within a developmental context is therefore essential. This focus is critical, as Felipe et al. (2019) argue that manufacturing job expansion is a strong predictor of economic development. They show that nearly all non-oil wealthy countries today had high shares of manufacturing employment and that manufacturing employment growth often preceded development and wealth accumulation. Therefore, all three chapters of the present thesis focus on the effect of innovation on manufacturing employment, while only the first chapter evaluates both manufacturing value-added and employment to study the role of innovation in manufacturing development.

2 Research Questions

Based on the preceding literature review on the role of innovation and technological progress in the industrialization process, the present thesis' chapters aim to answer the following three research questions:

Chapter 1: In light of the trade liberalization of the 1990s, which placed pressure on ISI-based industries in developing countries, is the relationship between innovation capacity and industrialization linear (whether positive or negative) or non-linear? If it is non-linear, is there a threshold of innovation beyond which the relationship with industrialization turns positive?

Chapter 2: In the context of a developing country like Colombia, how do innovation activities affect employment growth at the manufacturing firm level? Additionally, how does sectoral foreign competition, particularly from China, influence the employment outcomes of these innovations?

Chapter 3: The literature indicates that in some African countries, small manufacturing firms have seen employment growth, while larger firms have experienced productivity gains. To what extent, then, is labour productivity growth in the manufacturing sectors of a broader range of developing countries driven by productivity

improvements within firms of different sizes, as opposed to shifts in employment shares among these firms? Additionally, how have knowledge and technology embedded in imported inputs influenced labour productivity and the reallocation of labour across firms of various sizes?

3 Contributions

This thesis focuses on the intersection of innovation, value-added, and employment industrialization, primarily in the context of developing countries, with a specific case study on Colombia. The analysis uses national (Chapter 1), sectoral, and firm-level (Chapters 2 and 3) data, covering the period from 1996 to 2019. It also considers external factors, such as trade competition, to understand their role in shaping industrial outcomes.

Chapter 1 investigates the relationship between innovation and industrialization, particularly in terms of manufacturing value-added and employment in developing countries. The paper aims to determine whether the innovation-industrialization relationship in developing countries is linear or non-linear, employing a two-step approach. First, I construct a national innovation index for 53 developing and emerging countries from 1996 to 2018 using the innovation indicators from the Global Innovation Index (GII). The index, sub-indexes, pillars, and sub-pillar of the GII are calculated using a principal component analysis (PCA).

Second, using a panel estimation with fixed effects I show a U-shaped relationship between the innovation index and manufacturing value-added shares. A possible explanation for this convex correlation is as follows: low innovation levels were evident during the early phase of this analysis, particularly in the 1990s, when countries underwent significant trade liberalization after having industrialized within closed national borders under ISI policies. In the era of globalization, developing countries saw some technological advancement domestically, as indicated by the rise in the innovation index through the adoption of foreign technologies, including FDI inflows, royalty payments, and imported inputs. This enabled them to engage in imitation and reverse engineering. However, competition from foreign manufacturers in domestic markets outpaced this technological progress, which was mostly concentrated in low-tech sectors, unskilled labour, and traditional products, leading to deindustrialization in terms of value-added (Rodrik, 2016).

Increased foreign competition could result in two potential outcomes. First, trade liberalization may force low-productivity manufacturing firms to exit domestic markets, leading to a reallocation of resources toward more productive and expanding firms. The second outcome is that greater competition pushes surviving firms to improve technology and innovation, enabling them to boost productivity, compete more effectively, and differentiate their products from competitors. My findings indicate that productivity gains and increased manufacturing value-added become possible when the national innovation index reaches a range of 0.4 to 0.5, which according to the PCA results countries in South East Asia and Central and Eastern Europe regions tend to have innovation index levels at or above this empirical threshold.

Conversely, a negative correlation between innovation and manufacturing employ-

ment is observed. In low-innovation contexts, foreign competition drives low-productivity firms out of the market, resulting in job losses. At higher innovation levels, labour-saving technologies enhance productivity but decrease employment. Yet, the market mechanisms that offset the labour-saving effect of technology are present in the sectoral analysis. A linear positive relationship between innovation and employment is evident in the Supplier-Dominated, Scale-Intensive, and Specialized Suppliers sectors, while Science-Based sectors show a U-shaped correlation, requiring innovation indexes to exceed 0.7 for value-added increases. Negative correlations in Science-Based sectors may arise from diminished demand for unskilled labour due to technological changes favouring skilled workers.

Chapter 2 analyses the labour-saving effect of product and process innovation and the offset mechanisms in manufacturing employment in Colombian firms. Using data from the Development and Technological Innovation Industrial Survey (EDIT) from 2007 to 2018, the study extends the structural model by Harrison et al. (2014) to examine how Chinese competition affects employment growth differently, depending on the firm's levels of innovative activity.

The empirical analysis yields three key findings. First, aligning with existing literature, sales growth from new products significantly boosts employment growth across all manufacturing sectors during the period of study. In contrast, process and organizational innovations typically do not have a notable impact on employment at the firm level. Second, product innovation exerts a greater influence on employment growth among highly educated workers than on those with lower levels of education, a trend observed in both high-tech and low-tech sectors. Lastly, competition from Chinese imports has a more pronounced negative effect on highly innovative firms, particularly in low-tech sectors and among highly educated workers. This indicates that although innovative firms often pursue product innovation as a defensive strategy against competition, this approach is largely ineffective.

Finally, **Chapter 3** connects the results of the first two chapters by studying the impact of foreign technologies embedded in imported inputs (proxy of backward GVC participation) and the export of output (proxy of forward GVC participation) on labour productivity and employment shares across manufacturing firms according to their size. The research is motivated by observed trends in the African manufacturing sector, where small and unproductive firms have increased their employment shares, while larger firms tend to show higher productivity but contribute minimally to overall employment expansion.

Using firm-level data from the World Bank's Enterprise Survey collected between 2006 and 2019, firms are categorized into three groups: small (1-19 employees), medium (20-99 employees), and large (100 or more employees). The analysis is divided into two parts. The first employs a shift-share decomposition method to break down labour productivity growth in the manufacturing sector into two components: (i) the within component, which captures productivity growth within each firm size group, and (ii) the between component, which reflects productivity gains or losses due to the reallocation of labour toward more productive or less productive groups of firms, also referred to as growth-enhancing or growth-reducing structural change. Findings reveal that small and

medium firms in the Africa, South Asia, Europe and Central Asia regions have positive between components but low within components. Large firms in Africa experience the highest productivity growth despite workforce reductions, while in Latin America, large firms achieve both productivity growth and increased labour absorption. In contrast, firms in the Middle East and North Africa exhibit low or negative values in both components.

The second part examines factors that explain differences in labour productivity and employment levels among firm sizes. The analysis indicates that capital-intensive technologies enhance productivity, with large firms benefiting more from imported inputs (proxy of backward GVC participation), while small firms see greater productivity gains from exports (proxy of forward GVC participation). This suggests that GVC primarily support small firms through forward linkages, while large firms benefit from backward linkages. Factors like skilled labour, innovation, and capital stock are significant for productivity improvements in larger firms, albeit often at the expense of employment share. Additionally, stronger labour and financial regulations can undermine the positive effects of imported inputs on productivity and employment.

4 References

Acemoglu, D., & Autor, D. (2011). Skills, tasks and technologies: Implications for employment and earnings. In: O. Ashenfelter & D. Card (Ed.), *Handbook of Labor Economics*, edition 1, volume 4, chapter 12, pp. 1043-1171, Elsevier.

Acemoglu, D., & Guerrieri, V. (2008). Capital deepening and non-balanced economic growth. *Journal of Political Economy*, 116, 467 – 498.

Acemoglu, D., Johnson, S., & Robinson, J. (2001). The colonial origins of comparative development: an empirical investigation. *American Economic Review*, American Economic Association, 91(5), 1369-1401.

Acemoglu, D., & Robinson, J. (2013). *Why Nations Fail: The Origins of Power, Prosperity and Poverty*. London: Profile Books.

Alvarez-Cuadrado, F., Van long, N., & Markus, P. (2017). Capital-labour substitution, structural change and growth. *Theoretical Economics*, 12(3), 1229 – 1266.

Amiti, M., & Konings, J. (2007). Trade liberalization, intermediate inputs, and productivity: evidence from Indonesia. *American Economic Review*, 97(5), 1611 - 1638.

Atolia, M., Loungani, P., Marquis, M., & Papageorgiou, C. (2020). Rethinking development policy: What remains of structural transformation? *World Development*, 128(C).

Bas, M., & Paunov, C. (2019). What gains and distributional implications result from trade liberalization? *MERIT Working Papers 2019-003*, United Nations University - Maastricht Economic and Social Research Institute on Innovation and Technology (MERIT).

Bas, M., & Paunov, C. (2021). Input quality and skills are complementary and increase output quality: Causal evidence from Ecuador's trade liberalization. *Journal of Development Economics*, 151(C).

Baumol, W. (1967). Macroeconomics of unbalanced growth: the anatomy of urban crisis. *The American Economic Review*, 415 – 426.

Bhattacharyya, S., & Hodler, R. (2014). Do natural resource revenues hinder financial development? The role of political institutions. *World Development*, 57, 101–113.

Brandt, L., Ma, D., & Rawski, T. (2016). Industrialization in China. *IZA Discussion Papers 10096*, Institute of Labor Economics (IZA).

Bogliaccini, J. (2013). Trade liberalization, deindustrialization and inequality: evidence from middle-income Latin American countries. *Latin American Research Review*, 48(2), 79 – 105.

Buera, F. J., Kaboski, J., & Shin, Y. (2011). Finance and Development: A Tale of Two Sectors. *American Economic Review*, 101, 1964-2002.

Calvino, F., & Virgillito, M.E. (2018). The innovation-employment nexus: a critical survey of theory and empirics. *Journal of Economic Surveys*, 32(1), 83 – 117.

Caselli, F., & Coleman, W. (2001). Cross-country technology diffusion: the case of computers. *American Economic Review*, 91(2), 328 – 335.

Cassini, L. (2023). Path-dependent productive specialization: Should prematurely deindustrialized countries shift to a KIBS export-led strategy? *Structural Change and Economic Dynamics*, 65(C), 199 - 209.

Castellacci, F., & Natera, J. (2013). The dynamics of national innovation systems: a panel cointegration analysis of the coevolution between innovative capability and absorptive capacity. *Technological Forecasting and Social Change*, 76, 709 – 722.

Chen, D., Zheng, S., & Guo, L. (2015). The impact of science and technology policies on rapid economic development in China. In Cornell University, INSEAD, and WIPO (Eds.), *The Global Innovation Index 2015: Effective Innovation Policies for Development*, (pp. 105 – 111).

Cimoli, M., & Katz, J. (2003). Structural reforms, technological gaps and economic development: A Latin American perspective. *Industrial and Corporate Change*, 12(2), 387 – 411.

Cirera, X., & Maloney, W. F. (2017). *The innovation paradox: Developing-country capabilities and the unrealized promise of technological catch-up.* World Bank.

Clark, C. (1940). *The Conditions of Economic Progress.* Macmillan, New York.

Coricelli, F., & Ravasan, F. (2017). Structural change and the China syndrome: Baumol vs trade effects. *Centre for Economic Policy Research Discussion Paper*, DP12069.

Dahlman, J. (2008). Technology, globalization, and international competitiveness: challenges for developing countries. In D. O. Kjollerstrom, *Industrial Development for the 21st Century* (pp. 29 - 83). Ed. Zed Books.

Dasgupta, S., & Singh, A. (2006). Manufacturing, services and premature deindustrialization in developing countries: A Kaldorian analysis. *WIDER Working Paper Series RP2006-49*, World Institute for Development Economic Research (UNU-WIDER).

De Soto, H. (2000). *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else*. Basic Books, New York.

Di Maio, M. (2008). Industrial policies in developing countries: History and perspectives. *Working Papers 48-2008*, Macerata University, Department of Finance and Economic Sciences.

Di Meglio, G., Gallego, J., Maroto, A., & Savona, M. (2018). Services in developing economies: the deindustrialization debate in perspective. *Development and Change*, 49(6), 1495 – 1525.

Diao, X., Ellis, M., McMillan, M., & Rodrik, D. (2021). Africa's Manufacturing Puzzle: Evidence from Tanzanian and Ethiopian Firms. *NBER Working Papers*, 28344, National Bureau of Economic Research, Inc.

Dosi, G., & Nelson, R. (2010). Technical change and industrial dynamics as evolutionary processes. In: B. Hall & N. Rosenberg (Eds.), *Handbook of the Economics of Innovation*, (pp. 51 – 127).

Dosi, G., Riccio, F., & Virgillito, M. (2021). Varieties of deindustrialization and patterns of diversification: why microchips are not potato chips. *Structural Change and Economic Dynamics*, 57, 182 – 202.

Dosi, G., & Tranchero, M. (2018). The role of comparative advantage, endowments and technology in structural transformation. *LEM Papers Series*, 2018/33, Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies, Pisa, Italy.

Fagerberg, J., Srholec, M., & Knell, M. (2007). the competitiveness of nations: why some countries prosper while others fall behind. *World Development*, 35(10), 1595 - 1620.

Fagerberg, J., Srholec, M., & Verspagen, B. (2010). Innovation and economic development. In Bronwyn H. Hall
Nathan Rosenberg (Eds.), *Handbook of the Economics of Innovation* (pp. 833 – 872).

Felipe, J., Mehta, A., & Rhee, C. (2019). Manufacturing matters... but it's the jobs that count. *Cambridge Journal of Economics*, 43(1), 139 - 168.

Firpo, S., & Renan, P. (2017). Structural change, productivity growth, and trade policy in Brazil. In M. McMillan, D. Rodrik
C. Sepulveda (Eds.), *Structural Change, Fundamentals, and Growth: A Framework and Case Studies*. International Food Policy Research Institute (Washington, D.C.).

Fisher, A. (1939). Primary, secondary, and tertiary production. *Economic Record*, 15(8), 24 – 38.

Godin, B. (2007). Science, accounting and statistics: The input-output framework. *Research Policy*, 36(9), 1388 – 1403.

Hamilton, C., & de Vries, G. J. (2023). The structural transformation of transition economies. *GGDC Research Memorandum*, 196.

Hanson, G. (2020). Who will fill China's shoes? The global evolution of labour-intensive manufacturing. *East Asian Economic Review*, 24(4), 313 - 336.

Haraguchi, N. (2015). Global patterns of growth, structural change and inclusive and sustainable industrial development. *Background Document prepared for Chapter 1 of the IDR 2015. Vienna: UNIDO.*

Haraguchi, N., Cheng, C., & Smeets, E. (2017). the importance of manufacturing in economic development: has this changed? *World Development*, 93(C), 293 - 315.

Haraguchi, N., Martorano, B., & Sanfilippo, M. (2019). What factors drive successful industrialization? Evidence and implications for developing countries. *Structural Change and Economics Dynamics*, 49, 266 – 276.

Hausmann, R., Hwang, J., & Rodrik, D. (2007). What you export matters. *Journal of Economic Growth*, 12(1), 1 - 25.

Herrendorf, B., Rogerson, R., & Valentinyi, A. (2014). Growth and Structural Transformation. In P. Aghion
S. Durlauf (Eds.), *Handbook of Economic Growth* (1st ed., Volume 2B, chapter 6). Elsevier.

Herrendorf, B., Herrington, C., & Valentinyi, A. (2015). Sectoral technology and structural transformation. *American Economic Journal: Macroeconomics*, 7(4), 104 – 133.

Hidalgo, C., Klinger, B., Barabàsi, A., & Hausmann, R. (2007). The product space conditions the development of nations. *Science*, 317(5837), 482 – 487.

Hsieh, C.T., & Klenow, P. J. (2009). Misallocation and manufacturing TFP in

China and India. *Quarterly Journal of Economics*, 124(4),1403–1448.

Imbs, J., & Wacziarg, R. (2003). Stages of diversification. *The American Economic Review*, 93(1), 63 – 86.

Karas, A., & Pyle, W., & Schoors, K. (2015). A "de Soto Effect" in industry? Evidence from the Russian Federation. *Journal of Law and Economics*, 58(2), 451-480.

Kim, C., Lee, S. (2014). Different paths of deindustrialization: Latin American and Southeast Asian countries. *Journal of International and Area Studies*, 21(2), 65 – 81.

Kruse, H., Mensah, E., Sen, K., & de Vries, G. (2021). A manufacturing renaissance? Industrialization trends in the developing world. *WIDER Working Paper Series wp-2021-28*, World Institute for Development Economic Research (UNU-WIDER).

Kruse, H., Mensah, E., Sen, K., & de Vries, G. J. (2023). A manufacturing renaissance? Industrialization trends in the developing world. *IMF Economic Review*, 71, 439 – 473.

Kunst, D. (2019). Premature deindustrialization through the lens of occupations: Which jobs, why, and where? *Tinbergen Institute Discussion Paper*, TI 2019-033/V.

Kuznets, S. (1966). *Modern economic growth: rate, structure and spread.* Yale University Press, London.

Lall, S. (2004). Selective Industrial and Trade Policies in Developing Countries: Theoretical and Empirical Issues. In C, Soludo., O, Ogbu., & H-J, Chang (Eds.). *The Politics of Trade and Industrial Policy in Africa: Forced Consensus?* Africa World Press and IDRC (pp. 4 – 41).

Lautier, M. (2024). Manufacturing still matters for developing countries. *Structural Change and Economic Dynamics*, 70(C), 168 - 177.

Lawrence, P. (2005). Explaining Sub-Saharan Africa's manufacturing performance. *Development and Change*, 36(6), 1121 - 1141.

Lewis, A. (1954). Economic development with unlimited supplies of labour. *The Manchester School*, 22, 139 – 191.

Lin, J., & Treichel, V. (2012). Learning from China's rise to escape the middle-income trap: a new structural economics approach to Latin America. *Policy Research working paper*, no. WPS 6165 Washington, D.C.: World Bank Group.

MacBean, A. (2000). Export promotion in transitional economies. In A. MacBean (Ed.), *Trade and Transition. Trade Promotion in Transitional Economies* (pp. 1 – 17).

Malerba, F. (2006). Innovation and the evolution of industries. *Journal of Evolu-*

tionary Economics, 16(1), 3 – 23.

Martorano, B., & Sanfilippo, M. (2015). Structural change and wage inequality in the manufacturing sector: Long run evidence from East Asia. *Oxford Development Studies*, 43(2), 212 - 231.

Matsuyama, K. (2009). Structural change in an interdependent world: a global view of manufacturing decline. *Journal of the European Economic Association*, 7(2 – 3), 478 – 486.

Matthess, M., & Kunkel, S. (2020). Structural change and digitalization in developing countries: Conceptually linking the two transformations. *Technology in Society*, 63(C).

McMillan, M., & Rodrik, D. (2011). Globalization, Structural Change, and Productivity Growth. In M. Bachetta and M. Jansen, (Eds.), *Making Globalization Socially Sustainable*. Geneva: International Labour Organization and World Trade Organization.

McMillan, M., Rodrik, D., & Verduzco-Gallo, I. (2014). Globalization, structural change, and productivity growth with an update on Africa. *World Development*, 63, 11 – 32.

Mondolo, J. (2022). The composite link between technological change and employment: A survey of the literature. *Journal of Economic Surveys*, 36(4), 1027 - 1068.

Naudé, W., & Nagler, P. (2015). Industrialization, innovation, inclusion. *MERIT Working Papers 2015-043*. United Nations University - Maastricht Economic and Social Research Institute on Innovation and Technology (MERIT).

Naudé, W. (2017). Entrepreneurship, education and the fourth industrial revolution in Africa. *IZA Discussion Papers*, 10855, Institute of Labor Economics (IZA).

Naudé, W., & Tregenna, F. (2023). Africa's industrialization prospects: a fresh look. *IZA Discussion Papers*, 16043, Institute of Labor Economics (IZA).

Ngai, L., & Pissarides, C. (2007). Structural change in a multisector model of growth. *American Economic Review*, 97(1), 429 – 443.

Nuvolari, A., & Russo, E. (2021). Technical progress and structural change: A long-term view. In L. Alcorta, et al. (Eds.), *New perspectives on structural change: Causes and consequences of structural change in the global economy* (online ed.). Oxford Academic.

Ocampo, J.A. (2005) *Beyond Reforms: Structural Dynamics and Macroeconomic Vulnerability*. Palo Alto, CA: Stanford University Press; Washington, DC: World Bank.

OECD/Eurostat. (2018). *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation*, 4th Edition, The Measurement of Scientific, Technologi-

cal and Innovation Activities, OECD Publishing, Paris/Eurostat, Luxembourg.

Palma, J. (2005). Four sources of de-industrialization and a new concept of the Dutch Disease. In Ocampo J.A (Ed.), *Beyond Reforms: Structural Dynamic and Macroeconomic Vulnerability*. Stanford University Press.

Palma, J. (2014). De-industrialization, premature de-industrialization and the Dutch Disease. *Revista NECAT*, 3(5).

Park, D., Park, H., Kim, Y., Baek, S., Lee, D., Jang, Y., Jung, T., & Santiago, F. (2021). *The role of science, technology, and innovation policies in the industrialization of developing countries. Lessons from East Asian countries*. UNIDO, United Nations Industrial Development Organization.

Pavitt, K. (1984). Sectoral patterns of technical change: towards a taxonomy and a theory. *Research Policy*, 13(6), 343 – 373.

Rodrik, D. (2007). Industrial development: Some stylized facts and policy directions. *Industrial Development for the 21st Century*. U.N. Department of Economic and Social Affairs: Division for Sustainable Development.

Rodrik, D. (2013). Unconditional convergence in manufacturing. *Quarterly Journal of Economics*, 128(1), 165 - 204.

Rodrik, D. (2014). The Past, Present, and Future of Economic Growth. In F. Allen and others, *Towards a Better Global Economy: Policy Implications for Citizens Worldwide in the 21st Century*, Oxford University Press, Oxford and New York.

Rodrik, D. (2016). Premature deindustrialization. *Journal of Economic Growth*, 21(1), 1 - 33.

Rodrik, D. (2022). Prospects for global economic convergence under new technologies. In Z. Qureshi (Eds.), *An inclusive future? Technology, new dynamics, and policy challenges* (pp. 65 – 82).

Rowthorn, R., & Ramaswamy, R. (1997). Deindustrialization: causes and implications. In *Staff Studies for the World Economic Outlook*, by the Research Department of the International Monetary Fund. Washington, D.C.: International Monetary Fund.

Rowthorn, R., & Ramaswamy, R. (1999). Growth, trade and deindustrialization. *IMF Staff Papers*, 46(1).

Rowthorn, R., & Well, J. R. (1987). *Deindustrialization and Foreign Trade*. Cambridge: Cambridge University Press.

Samaniego, R., & Sun, J. (2016). Productivity growth and structural transformation. *Review of Economic Dynamics*, 21, 266 – 285.

Sen, K. (2019). What explains the job-creating potential of industrialisation in the developing world? *The Journal of Development Studies*, 55(7), 1565 - 1583.

Shu, P., & Steinwender, C. (2019). The impact of trade liberalization on firm productivity and innovation. *Innovation Policy and the Economy*, 19(1), 39 - 68.

Swiecki, T. (2017). Determinants of structural change. *Review of Economic Dynamics*, 24, 95 – 131.

Szirmai, A. (2012). Industrialisation as an engine of growth in developing countries, 1950–2005. *Structural Change and Economic Dynamics*, 23(4), 406 - 420.

Szirmai, A., & Verspagen, B. (2015). Manufacturing and economic growth in developing countries, 1950–2005. Structural Change and Economic Dynamics, 34(C), 46–59.

Timmer, M., de Vries, G., & de Vries, K. (2015). Patterns of structural change in developing countries. In J. Weiss, M. Tribe (Eds.), *Routledge Handbook of Industry and Development* (pp. 65 - 83). Routledge.

Tregenna, F. (2009). Characterizing deindustrialization: an analysis of changes in manufacturing employment and output internationally. *Cambridge Journal of Economics*, 33(3), 433 – 466.

UNCTAD. (2016). *Trade and development report, 2016: structural transformation for inclusive and sustained growth.* United Nations, New York

Uy, T., & Zhang, J. (2013). Structural change in an open. *Journal of Monetary Economics*, 60, 667 - 682.

Van Neuss, L. (2019). The drivers of structural change. *Journal of Economic Surveys*, 33(1), 309-349.

Vivarelli, M. (2014). Structural change and innovation as exit strategies from the middle-income trap. *IZA Discussion Papers*, 8148, Institute of Labor Economics (IZA).

Vivarelli, M. (2018). Globalisation, structural change and innovation in emerging economies: The impact on employment and skills. *MERIT Working Papers*, 2018-037, United Nations University - Maastricht Economic and Social Research Institute on Innovation and Technology (MERIT).

Zhou, X., Cai, Z., Tan, K., Zhang, L., Du, J., & Song, M. (2021). Technological innovation and structural change for economic development in China as an emerging market. *Technological Forecasting and Social Change*, 167(C).

Introduction Générale

L'industrialisation implique la transformation structurelle d'une économie, où les ressources passent de secteurs à faible productivité comme l'agriculture à des industries manufacturières à forte productivité qui produisent des biens plus complexes (Naudé & Nagler, 2015). L'importance d'une industrialisation soutenue est étroitement liée au développement économique (Szirmai & Verspagen, 2015). Selon les lois de la croissance de Kaldor, l'industrialisation stimule la croissance de la productivité du travail grâce à l'augmentation des rendements d'échelle dans le secteur manufacturier (Di Meglio et al., 2018). Rodrik (2013) montre que les périodes de croissance rapide sont liées à l'expansion du secteur manufacturier, qui est le seul secteur à réaliser systématiquement une convergence de la productivité du travail. Le secteur manufacturier absorbe également une part importante de la main-d'œuvre d'un pays en développement et offre des salaires plus élevés lorsque les travailleurs passent des zones rurales aux zones urbaines (Sen, 2019).

Szirmai (2012) fournit des preuves empiriques et théoriques montrant que l'industrialisation est un moteur essentiel du développement économique, en grande partie grâce à ses liens avec l'innovation et les progrès technologiques. Premièrement, le secteur manufacturier offre des possibilités uniques d'économies d'échelle et d'accumulation de capital, qui sont des sources majeures de croissance globale. Deuxièmement, l'accumulation de capital est liée au progrès technologique et à l'innovation, incorporés et désincarnés, qui naissent dans le secteur manufacturier et s'étendent à d'autres parties de l'économie. À mesure que les pays se développent, leurs industries manufacturières passent d'une technologie à forte intensité de main-d'œuvre à une technologie à forte intensité de capital (Haraguchi, 2015). Cette transformation permet des économies de gamme plus importantes et la production d'une plus grande variété de biens, ce qui conduit à une croissance économique rapide (Hausmann et al., 2007 ; Hidalgo et al., 2007).

Toutefois, les avantages pour la croissance d'une industrialisation axée sur la technologie et l'innovation sont devenus de plus en plus complexes en raison de deux facteurs clés : l'accélération du rythme du changement technologique et la mondialisation et la fragmentation de la production (Naudé & Nagler, 2015). D'une part, l'évolution technologique rapide et l'innovation ont principalement pris la forme d'une économie de main-d'œuvre, réduisant la part de l'emploi manufacturier dans les pays en développement, en particulier pour les travailleurs non qualifiés. D'autre part, la mondialisation a intensifié la concurrence, en particulier de la part de pays disposant d'avantages comparatifs dans

le secteur manufacturier, tels que la Chine et d'autres exportateurs asiatiques, ce qui a eu un impact négatif sur la valeur ajoutée manufacturière et l'emploi dans les pays en développement (Rodrik, 2016).

Le changement technologique et la mondialisation contribuent tous deux à la désindustrialisation prématurée observée dans les pays d'Afrique et d'Amérique latine. Les études de Dasgupta et Singh (2006), Palma (2005) et Rodrik (2016) montrent que ces régions ont connu une désindustrialisation à des niveaux de parts manufacturières et de PIB par habitant inférieurs à ceux des économies avancées. Cette désindustrialisation prématurée suggère que l'industrie manufacturière pourrait ne plus être le principal moteur de la croissance et de la convergence économique (Lautier, 2024).

L'objectif de ma thèse est donc de contribuer à la littérature existante en examinant comment l'innovation et les activités technologiques influencent les processus d'industrialisation ou de désindustrialisation dans un échantillon de pays en développement. Plus précisément, cette thèse étudie la relation entre l'innovation, la valeur ajoutée manufacturière et les parts d'emploi au niveau national, sectoriel et de l'entreprise, tout en tenant compte des impacts de la mondialisation et de la concurrence accrue du commerce extérieur.

Dans cette introduction, je passe en revue le contexte pertinent de cette thèse. Tout d'abord, nous définissons les sources de transformation structurelle qui expliquent à la fois les processus d'industrialisation et de désindustrialisation (prématurée). Elle met en contexte la pertinence de l'innovation et des avancées technologiques en tant qu'explication importante de ces processus, et décrit l'importance, les risques et les opportunités de la concurrence manufacturière chinoise pour les processus d'industrialisation des pays en développement. Ensuite, je présente les questions de recherche et les contributions de chaque chapitre de la thèse.

1 Sources of Structural Transformation, Industrialization, and Premature Deindustrialization

Le concept de changement structurel, ou de transformation structurelle, a généralement été compris comme le déplacement des ressources et de la production des secteurs traditionnels, tels que l'agriculture, vers l'industrie manufacturière, et finalement vers les secteurs des services au fur et à mesure du développement d'un pays (Fisher, 1939 ; Clark, 1940). Lewis (1954), Kuznets (1966) et, plus tard, Rowthorn et Ramaswamy (1999), suggèrent qu'au cours de la transformation structurelle, le secteur manufacturier d'un pays se développe dans les premières phases du développement, dans le cadre du processus d'industrialisation, mais se contracte une fois que le pays atteint un niveau élevé de développement ou de revenu. Ce phénomène est connu sous le nom de désindustrialisation. Cette tendance est observée dans tous les pays au fur et à mesure qu'ils progressent sur la voie du développement et est considérée comme un fait stylisé, où les mesures du secteur manufacturier suivent une forme de U inversé par rapport au revenu ou au PIB par habitant (Herrendorf et al., 2014).

Dans cette thèse, le terme " industrialisation " fait référence à l'expansion du secteur

manufacturier (Szirmai, 2012), qui peut être mesurée par la hausse de l'emploi manufacturier (en part de l'emploi total) et de la production manufacturière (valeur ajoutée manufacturière en part du PIB) suivant les définitions utilisées par Tregenna (2009), Herrendorf et al. (2014), Rodrik (2016), entre autres. La littérature met en évidence divers facteurs de transformation structurelle, d'industrialisation et de désindustrialisation qui, comme le note Van Neuss (2019), sont complémentaires plutôt que mutuellement exclusifs.

Un domaine de recherche sur les changements structurels suggère que les changements dans l'activité économique entre les secteurs sont façonnés par des préférences non homothétiques et des changements dans les modèles de demande au fur et à mesure que le revenu réel évolue (Van Neuss, 2019). S'appuyant sur la loi d'Engel, les études de Clark (1940), Rowthorn et Wells (1987), et Rowthorn et Ramaswamy (1997) illustrent que la part du revenu allouée aux biens manufacturiers augmente aux premiers stades du développement, se stabilise aux stades intermédiaires du revenu, et finit par diminuer au-delà d'un certain seuil de revenu par habitant. À mesure que les revenus augmentent, la demande relative de biens change, entraînant un déplacement de l'activité vers des secteurs répondant à des besoins plus importants, ce qui provoque des ajustements économiques et de main-d'œuvre.

Une autre partie de la littérature se concentre sur les politiques macroéconomiques et les facteurs institutionnels. De mauvais choix politiques et des incitations mal alignées peuvent favoriser la corruption et créer des environnements commerciaux risqués, ce qui décourage les investissements productifs et entrave l'innovation et l'adoption de technologies, affaiblissant en fin de compte les performances industrielles (Naudé & Tregenna, 2023). Par exemple, Acemoglu et al. (2001, 2013) affirment que l'impact du colonialisme sur le développement varie selon qu'il s'agit d'institutions extractives ou de l'introduction d'institutions qui soutiennent les investissements à long terme. Les institutions extractives, enracinées dans l'héritage colonial, peuvent créer des problèmes d'économie politique, tels que la recherche de rentes par les élites politiques qui utilisent les droits exclusifs d'exploitation et d'exportation des ressources naturelles pour accumuler des richesses et conserver le pouvoir (Dosi & Tranchero, 2018). En outre, une augmentation des exportations de matières premières, souvent déclenchée par la découverte de nouvelles ressources naturelles, peut conduire à la désindustrialisation, dans ce que l'on appelle le syndrome hollandais. Ce changement se produit parce que la richesse provenant des exportations de ressources apprécie le taux de change réel, diminuant les investissements dans l'industrie manufacturière et érodant la compétitivité mondiale du secteur (Palma, 2005).

Le développement financier d'un pays, en particulier les institutions qui assurent la stabilité et la protection des droits de propriété (Bhattacharyya & Hodler, 2014), représente un autre indicateur de la qualité institutionnelle. Un facteur clé de l'industrialisation d'un pays est l'effet de l'établissement et du renforcement des droits de propriété, permettant aux actifs fixes d'être utilisés comme garantie. Ce phénomène, souvent appelé "effet De Soto" (De Soto, 2000), joue un rôle important dans la facilitation de la croissance industrielle, car il améliore l'accès au crédit et augmente l'investissement (Karas et al., 2015). À cet égard, Hsieh et al. (2014) et Diao et al. (2021) soulignent que les entreprises informelles et les petites entreprises sont souvent confrontées à des contraintes de crédit, ce qui limite leur capacité à investir dans la technologie et à

accroître leur productivité et leur taille pour devenir des moyennes ou des grandes entreprises. De même, Lall (2004) et Castellacci et Natera (2013) soulignent que des politiques financières inefficaces entravent l'investissement dans le capital humain et physique, ce qui rend plus difficile l'émergence de nouvelles entreprises. Ceci, à son tour, a un impact négatif sur l'engagement d'un pays en faveur du progrès technologique et des efforts d'industrialisation.

Un autre courant de littérature qui explore les changements structurels, l'industrialisation et la désindustrialisation se concentre sur les effets théoriques et empiriques du commerce et de la mondialisation. Uy et Zhang (2013) introduisent un modèle de commerce ricardien à deux pays, illustrant comment les changements sectoriels - de l'agriculture à l'industrie manufacturière, puis aux services - sont façonnés par le commerce international, sous l'effet des différences entre les niveaux de productivité sectoriels et nationaux. Selon les auteurs, un pays disposant d'un avantage comparatif dans le secteur manufacturier peut s'industrialiser en augmentant la productivité de ce secteur et la part de la main-d'œuvre dans un contexte de commerce entre deux pays. Ces résultats s'alignent sur ceux de Matsuyama (2009), qui suggère que les pays qui enregistrent des gains de productivité plus rapides dans le secteur manufacturier peuvent retarder la désindustrialisation.

D'autres aspects de la mondialisation influencent le processus d'industrialisation. Les mesures de libéralisation des échanges, y compris le maintien d'un taux de change réel compétitif, jouent un rôle crucial dans le soutien et la promotion de la croissance du secteur manufacturier (Rodrik, 2007 ; Martorano & Sanfilippo, 2015). Haraguchi et al. (2019) constatent que les pays qui se sont industrialisés avec succès ont souvent mis en œuvre des régimes de taux de change sous-évalués pour renforcer la compétitivité de leurs industries manufacturières nationales. D'autre part, Shu et Steinwender (2019) montrent que la concurrence des importations renforce la productivité dans les économies émergentes, en particulier pour les entreprises plus grandes et plus productives. Dans le même temps, l'augmentation des opportunités d'exportation favorise l'innovation et les gains de productivité, les entreprises les plus productives en bénéficiant le plus. En outre, l'ouverture commerciale permet aux entreprises nationales d'acquérir des technologies étrangères à moindre coût. Les intrants importés, à forte intensité de capital et de compétences, améliorent l'efficacité de la production et la qualité des produits (Amiti & Konings, 2007 ; Bas & Paunov, 2019, 2021).

Ce corpus de littérature souligne la manière dont la mondialisation incite à la redistribution des ressources entre les différents secteurs, les pays se diversifiant et se concentrant sur les industries alignées sur leurs avantages comparatifs, qui sont déterminés à la fois par les dotations en facteurs et les capacités technologiques (Imbs & Wacziarg, 2003). Ceci est étroitement lié au thème central de cette thèse, qui examine l'innovation et le progrès technologique en tant que moteurs clés du changement structurel, de l'industrialisation et de la désindustrialisation.

L'innovation et le progrès technologique entraînent une hausse de la productivité sectorielle, qui se traduit ensuite par une baisse des prix sectoriels relatifs (Matthess & Kunkel, 2020). L'un des partisans de cette idée était Baumol (1967), qui a introduit l'hypothèse de la "maladie des coûts" ou de la "charge structurelle", communément

appelée "effet Baumol" dans la littérature. Selon cette hypothèse, les secteurs les plus productifs (tels que l'industrie manufacturière) libèrent des ressources, en particulier de la main-d'œuvre, qui sont absorbées par les secteurs à croissance plus lente (tels que les services) de l'économie. Dans le même ordre d'idées, Ngai et Pissarides (2007) expliquent que lorsque l'élasticité de substitution entre les biens finaux des différents secteurs est faible (inférieure à un), la main-d'œuvre tend à se diriger vers le secteur dont la productivité totale des facteurs (PTF) est la plus faible dans un modèle de croissance équilibrée, où les ratios économiques agrégés restent constants, ce qui est conforme aux faits de Kaldor.

Acemoglu et Guerrieri (2008) et Swiecki (2017) soulignent que le changement technologique spécifique au secteur et le progrès technologique augmentant la main-d'œuvre augmentent la production relative des secteurs à plus forte intensité de capital et entraînent une réaffectation des ressources vers les secteurs à plus faible intensité de capital, principalement représentés par le secteur des services. En outre, Caselli et Coleman (2001), Acemoglu et Autor (2011), et Buera et al. (2011) constatent qu'une augmentation du PIB par habitant et la baisse des coûts de l'éducation entraînent un changement structurel vers les secteurs qui nécessitent une main-d'œuvre plus qualifiée, c'est-à-dire l'industrie manufacturière et les services à forte productivité. Herrendorf et al. (2015) et Alvarez-Cuadrado et al. (2017) montrent que le changement structurel est également lié aux différences sectorielles dans l'élasticité de substitution entre le capital et le travail. Le secteur manufacturier présente une plus grande substituabilité par rapport aux services. Par conséquent, si les coûts du travail augmentent par rapport au capital, le ratio capital-travail dans l'industrie manufacturière est susceptible de se déplacer en faveur du capital, ce qui conduit le secteur à devenir plus intensif en capital, ce qui est lié au progrès technologique et à l'innovation incorporés et désincarnés (Szirmai, 2012).

L'innovation et la technologie jouent un rôle crucial dans l'industrialisation, car le développement industriel est considéré comme un processus d'amélioration des capacités technologiques. Cela permet d'accroître la productivité, les progrès, la diversification et la compétitivité des activités industrielles (Park et al., 2021). À cet égard, la capacité technologique d'un pays correspond à "l'aptitude à développer, rechercher, absorber et exploiter commercialement les connaissances" (Fagerberg et al., 2010, p. 839). D'autre part, dans le Manuel d'Oslo, l'innovation est définie comme un "produit ou processus nouveau ou amélioré (ou une combinaison de ceux-ci) qui diffère sensiblement des produits ou processus précédents de l'unité et qui a été mis à la disposition d'utilisateurs potentiels (produit) ou mis en service par l'unité (processus)" (OCDE/Eurostat, 2018, p. 20).

Le changement technologique et l'innovation favorisent donc le transfert des ressources des secteurs à faible productivité, tels que l'agriculture, vers des secteurs à plus forte productivité, tels que l'industrie manufacturière (Samaniego & Sun, 2016). Les conclusions empiriques de Haraguchi et al. (2019) montrent que le niveau d'innovation d'une nation - mesuré par les investissements de R & D, la force de sa base scientifique et technologique et la qualité de son système éducatif - augmente les chances d'une industrialisation réussie grâce à la diversification, à la création de nouvelles activités industrielles, à la croissance de l'emploi et de la productivité.

Haraguchi et al. (2019), Kunst (2019) et Dosi et al. (2021) documentent l'existence d'une variété de modèles d'industrialisation dans les sous-secteurs manufacturiers. Dosi et al. (2021) soulignent que les secteurs dominés par les fournisseurs et à forte intensité d'échelle marquent les premières étapes de l'industrialisation, avec des industries telles que les produits alimentaires, le textile et l'habillement jouant un rôle clé en absorbant la main-d'œuvre de l'agriculture et en générant des produits à valeur ajoutée de faible technicité. Toutefois, ces secteurs sont les premiers à connaître la désindustrialisation. Pour soutenir la croissance, les pays doivent développer des capacités technologiques qui leur permettent d'acquérir et de générer des connaissances et des innovations, facilitant ainsi la création de nouvelles activités dans des secteurs plus avancés tels que les fournisseurs spécialisés et les industries fondées sur la science, notamment les machines, les produits chimiques, les instruments médicaux et de précision. Ces secteurs de haute technologie continuent de se développer en termes d'emploi et de valeur ajoutée à mesure que le revenu par habitant augmente, ne montrant aucun signe de désindustrialisation. Les auteurs affirment que les pays peuvent favoriser le rattrapage économique et atteindre un PIB par habitant plus élevé en passant progressivement d'industries manufacturières à faible technologie à des industries manufacturières à haute technologie.

Cependant, le processus d'industrialisation s'est avéré difficile pour les pays en développement en raison des effets de la mondialisation. Dasgupta et Singh (2006), Palma (2005) et Rodrik (2016) ont relancé le débat sur la désindustrialisation prématurée, en soulignant la tendance au déclin prématuré de l'emploi manufacturier et de la part de la valeur ajoutée dans les économies en développement depuis les années 1990. Rodrik (2016) affirme que les petites économies ouvertes, qui agissent comme des preneurs de prix sur le marché mondial, peuvent importer la désindustrialisation de l'étranger en raison du commerce et de la concurrence avec des pays étrangers plus productifs. Dans ce contexte, un progrès technologique plus rapide à l'étranger, qui réduit les prix mondiaux de l'industrie manufacturière, pourrait entraîner une diminution de la production manufacturière nationale et de la part de l'emploi. Cet ensemble de travaux souligne que lorsque la productivité manufacturière nationale augmente plus lentement que la productivité manufacturière étrangère, la part de l'industrie manufacturière nationale, à la fois en termes de valeur ajoutée et d'emploi, diminue. Ces résultats peuvent être attribués aux politiques de développement mises en œuvre dans les pays en développement.

Selon la littérature, de nombreux pays en développement d'Amérique latine et d'Afrique ont poursuivi leur industrialisation sur la base de l'hypothèse de Prebisch-Singer. Cette théorie affirme que la spécialisation dans la production de ressources naturelles entrave la croissance parce que les produits primaires ont une faible élasticité de la demande par rapport au prix. Par conséquent, lorsque les prix baissent, cela tend à réduire les revenus plutôt qu'à stimuler la demande, ce qui entraîne une détérioration des termes de l'échange (Dosi & Tranchero, 2018). Pour remédier à cette situation, entre les années 1950 et 1980, les gouvernements ont mis en œuvre une stratégie d'industrialisation pilotée par l'État, axée sur des politiques de développement centrées sur l'industrialisation par substitution des importations (ISI) (Palma, 2005).

Dans le cadre des politiques de l'ISI, les pays en développement ont mis en place un secteur manufacturier de faible technicité dépendant de technologies matures, d'une

main-d'œuvre peu qualifiée et d'entreprises d'État. Toutefois, cette approche n'incitait pas à l'innovation, à l'amélioration de la qualité des produits ou au développement du capital humain (Lawrence, 2005 ; Firpo et Pieri, 2017). Depuis les années 1990, la libéralisation des échanges a introduit la concurrence des pays à revenu élevé et des pays en développement, y compris des fabricants asiatiques avancés, ce qui a exercé une pression sur les industries d'ISI. Ce changement de régime politique conduit à un processus de désindustrialisation prématurée en Afrique et profondément en Amérique latine, qui reste principalement dépendante de l'agriculture, de l'exploitation minière, des industries de transformation des ressources naturelles, ainsi que des services non échangeables et à faible productivité (Timmer et al. 2015 ; Rodrik, 2016), et dans certains cas spécialisée dans les industries d'assemblage à faible valeur ajoutée dans l'électronique, les véhicules et les vêtements (type maquiladora), comme l'ont présenté Cimoli et Katz (2003).

Kim et Lee (2014) démontrent que les pays qui dépendent des exportations de matières premières ou de ressources naturelles ont connu une désindustrialisation rapide, en grande partie en raison des importations manufacturières compétitives en provenance de Chine, qui offrent des prix plus bas et surpassent les fabricants nationaux. De même, Coricelli et Ravasan (2017) identifient le commerce avec la Chine comme un contributeur majeur à la désindustrialisation dans les économies ouvertes. Lautier (2024) souligne également que l'essor économique de la Chine entre 1990 et 2010 est un facteur essentiel. Du côté de la demande, l'augmentation substantielle des importations de matières premières de la Chine a stimulé un boom mondial des produits de base, améliorant les termes de l'échange et augmentant les prix de ressources telles que le pétrole, le cuivre et le zinc. Cette flambée des prix a dopé les recettes d'exportation des pays riches en ressources, augmentant la part du secteur primaire dans le PIB tout en contribuant à un déclin relatif de l'industrie manufacturière. Du côté de l'offre, la croissance rapide de l'industrie manufacturière chinoise a réduit les possibilités d'expansion industrielle dans d'autres pays en développement, en concentrant les activités manufacturières en Chine et en limitant la croissance industrielle ailleurs (Atolia et al., 2020, entre autres).

L'augmentation rapide de la part de la Chine dans l'industrie manufacturière mondiale est principalement due aux politiques de développement menées par son gouvernement, qui a suivi une approche similaire à celle des tigres d'Asie de l'Est. Depuis les années 1960, ces pays ont combiné des politiques de substitution des importations avec des stratégies de promotion des exportations, parmi lesquelles la sous-évaluation du taux de change pour augmenter la taille de l'industrie (Rodrik, 2007). Dans ce cadre, les entreprises bénéficiaient de subventions et d'un accès à des marchés intérieurs protégés, mais en échange, elles étaient obligées d'exporter. Les bénéfices excédentaires des ventes intérieures étaient réinvestis pour améliorer l'apprentissage, réaliser des économies d'échelle et faire face à la concurrence internationale, afin d'obtenir en fin de compte de nouvelles licences d'exportation (MacBean, 2000 ; Di Maio, 2008). L'évolution de la Chine vers des réformes axées sur le marché et l'expansion des échanges s'est considérablement accélérée après son entrée dans l'Organisation mondiale du commerce en 2001. À cette époque, le gouvernement chinois a réduit les barrières à l'exportation, abaissé les droits de douane à l'importation, encouragé les investissements étrangers et permis à la main-d'œuvre de passer de l'agriculture au secteur manufacturier (Naughton, 2007, cité dans Hanson, 2020).

Ces politiques commerciales et industrielles ont été associées à une focalisation sur le progrès technologique afin de favoriser la transformation structurelle des industries, passant au fil du temps de la reproduction des technologies étrangères à la promotion de l'innovation nationale (Zhou et al., 2021). Selon Park et al. (2021), le développement technologique de la Chine peut se comprendre en trois étapes. Dans un premier temps, au cours de la phase d'introduction de la technologie, le gouvernement s'est largement appuyé sur le commerce de la technologie pour absorber les technologies étrangères de pointe. La phase suivante, l'internationalisation de la technologie, a vu un renforcement de la capacité d'innovation nationale, soutenue par des transferts de technologie continus par le biais de coentreprises internationales et d'investissements directs étrangers (IDE). La dernière étape, celle de la création technologique, implique que les entreprises privées dirigent les initiatives nationales de R & D, avec une collaboration accrue entre les universités et l'industrie. Ces étapes résultent d'une série de politiques scientifiques et technologiques à grande échelle introduites en Chine depuis les années 1970, visant à établir une infrastructure nationale d'innovation et à renforcer la compétitivité des institutions de recherche locales.

Chen et al. (2015) soulignent les principales mesures politiques de S & T qui ont permis à la Chine de renforcer sa position concurrentielle dans le secteur manufacturier. Il s'agit notamment de (i) la création de projets de recherche nationaux et de laboratoires nationaux (1978-1985), au cours de laquelle Lenovo (Legend Computer) a été fondée ; (ii) l'introduction de la loi sur la réforme du système scientifique et technologique (1985-1995), visant à combler les écarts entre les institutions de recherche, les universités et l'industrie, à financer la recherche fondamentale et appliquée et à encourager le retour des universitaires chinois de l'étranger ; (iii) la promulgation de la loi sur la promotion de la commercialisation des découvertes et des inventions en matière de science et de technologie (1996-2006), visant à déplacer les moteurs de l'innovation de la recherche publique vers la recherche appliquée et à encourager le retour des universitaires chinois de l'étranger.T (1996-2006), axée sur le transfert des moteurs de l'innovation de la recherche publique vers l'industrie, le renforcement de la R&D et de l'innovation industrielles et l'amélioration de l'efficacité de la commercialisation de la recherche universitaire ; et (iv) la publication du plan national de développement de la science et de la technologie à moyen et long terme (2006-2010), qui définit les lignes directrices du développement de la science et de la technologie, telles que la promotion de l'innovation indépendante, l'avancement des technologies clés, la construction d'infrastructures essentielles et le positionnement de la Chine en tant que futur leader mondial. Cette phase a marqué le passage d'une simple promotion de la R & D à la mise en place d'un écosystème d'innovation complet (Chen et al., 2015, p. 106). La Chine promeut actuellement les industries de haute technologie et l'intégration des technologies de pointe dans la fabrication par le biais de son initiative "Made in China 2025" (Felipe et al., 2019 ; Hanson, 2020). En raison de ces initiatives politiques, la force des exportations de la Chine a d'abord bondi dans le secteur manufacturier à forte intensité de main-d'œuvre avant de s'orienter vers une production à forte intensité de capital et de connaissances, avec des progrès dans l'automatisation, l'adoption de robots et une augmentation des brevets d'IA entre 2000 et 2016 (Mondolo, 2022).

L'expérience de la Chine montre comment la combinaison des efforts en matière de tech-

nologie et d'innovation avec l'ouverture commerciale peut accélérer l'industrialisation, renforcer la diversification et faire progresser la chaîne de valeur. En revanche, de nombreux pays en développement, en particulier en Amérique latine et en Afrique, ont lutté pour maintenir la compétitivité de leurs industries lorsque la libéralisation du commerce a commencé dans les années 1990, après les efforts initiaux des stratégies de développement des ISI (Atolia et al., 2020). La réorientation ultérieure des politiques vers des stratégies plus favorables au marché, telles que l'ouverture commerciale unilatérale, la déréglementation financière, l'appréciation de la monnaie visant à contrôler l'inflation, et le recul de l'État développementiste ont conduit à une réduction de l'investissement public et de l'intervention de l'État (UNCTAD, 2016, p. 82), ce qui a eu un impact négatif sur la promotion de l'innovation locale et des coentreprises avec des entreprises étrangères dans le secteur manufacturier (Naudé, 2017).

Depuis lors, les pays d'Amérique latine et d'Afrique sont souvent confrontés à des difficultés de mise en œuvre des politiques d'innovation, ce qui se traduit par un "paradoxe de l'innovation" : des investissements limités dans l'innovation, alors qu'ils pourraient potentiellement apporter des avantages significatifs en termes d'efficacité, de diversification et de croissance économique. Ce paradoxe est dû aux obstacles à l'innovation existants (Cirera & Maloney, 2017). Selon Atolia et al. (2020), ces obstacles découlent d'un manque de facteurs essentiels de soutien à l'innovation, connus sous le nom de facteurs fondamentaux privés (tels que le capital physique et les compétences) et publics (tels que l'infrastructure et les institutions). Par conséquent, les capacités technologiques et d'innovation limitées ont restreint le potentiel de ces pays à étendre et à diversifier leurs secteurs manufacturiers au sein d'une économie mondialisée. Cela a également limité leurs possibilités d'établir des liens en amont ou en aval dans les chaînes de valeur mondiales (CVM), les exposant à une pression concurrentielle intense de la part des fabricants étrangers, principalement de la Chine (Rodrik, 2022).

De nombreux chercheurs ont montré que cette pression de la concurrence étrangère sur des secteurs manufacturiers nationaux moins compétitifs a contribué à une désindustrialisation prématurée dans les pays en développement. Le terme "prématurée" souligne le fait que, dans ces pays, l'industrie manufacturière a commencé à décliner à des niveaux de revenus et des parts de l'industrie manufacturière beaucoup plus faibles que dans les économies avancées lorsqu'elles ont commencé à se désindustrialiser (Palma, 2005 ; Dasgupta & Singh, 2006 ; Rodrik, 2016). En conséquence, les pays d'Amérique latine et d'Afrique ont adopté des schémas de spécialisation axés sur leurs avantages comparatifs statiques, c'est-à-dire sur les ressources naturelles et les services à faible productivité, avec un secteur manufacturier limité qui reste essentiellement à forte intensité de main-d'œuvre et à faible valeur ajoutée (Brandt et al., 2016 ; Nuvolari & Russo, 2021).

Ce modèle de spécialisation du commerce international, centre´ sur les industries d'extraction des ressources, génère des revenus qui sont ensuite utilisés pour importer des produits manufacturés commercialisables. Parallèlement, il existe une demande croissante de services traditionnels, non échangeables et a‘ faible productivité´, tels que le commerce de gros, le commerce de détail et les services personnels, qui complètent le secteur manufacturier a‘ faible valeur ajoutée (Atolia et al., 2020). Le déplacement de la main-d'œuvre vers les services peu productifs, résultat du processus de

désindustrialisation prématurée, signifie une stratégie de réduction de la croissance pour les pays d'Amérique latine et d'Afrique (McMillan & Rodrik, 2011). Par conséquent, en l'absence d'industries manufacturières importantes, ces économies devront adopter un modèle de croissance axe´ sur les services a‘ haute productivité´ et commercialisables, tels que les technologies de l'information, la finance et d'autres services commerciaux a‘ forte intensité´ de connaissances (KIBS), comme dans le cas de l'Inde. Ces secteurs pourraient agir comme des moteurs de croissance, a‘ l'instar du secteur manufacturier, en respectant les lois de Kaldor sur la croissance. Selon ces lois, les secteurs manufacturiers et les KIBS stimulent la croissance par le biais de deux mécanismes clés : ils connaissent des rendements d'échelle croissants et la croissance de leur production a un impact positif sur la croissance de la productivité´ dans d'autres secteurs (Di Meglio et al., 2018).

Néanmoins, le modèle de croissance basé sur les services pose des défis supplémentaires aux pays en développement. Tout d'abord, le développement des KIBS et leur commercialisation ultérieure dépendent du niveau d'industrialisation d'un pays. Cassini (2023), en appliquant une approche évolutionniste et néo- schumpétérienne, montre que les pays qui atteignent un niveau élevé d'industrialisation avant de se désindustrialiser sont plus susceptibles de développer des KIBS. Ces secteurs offrent des ressources en connaissances et créent des liens en amont et en aval avec les industries manufacturières basées sur la science et les fournisseurs spécialisés (tels que les machines, les produits chimiques, les produits pharmaceutiques et les produits informatiques). En fait, les pays en développement qui sont de grands exportateurs de ces types de produits manufacturés exportent également des KIBS, comme le montrent l'Inde et le Costa Rica. Deuxièmement, et en conséquence du point précédent, le développement des KIBS dépend des capacités du système national d'innovation à générer, utiliser et diffuser des connaissances codifiées et tacites (Di Meglio et al., 2018 ; Cassini, 2023) ;

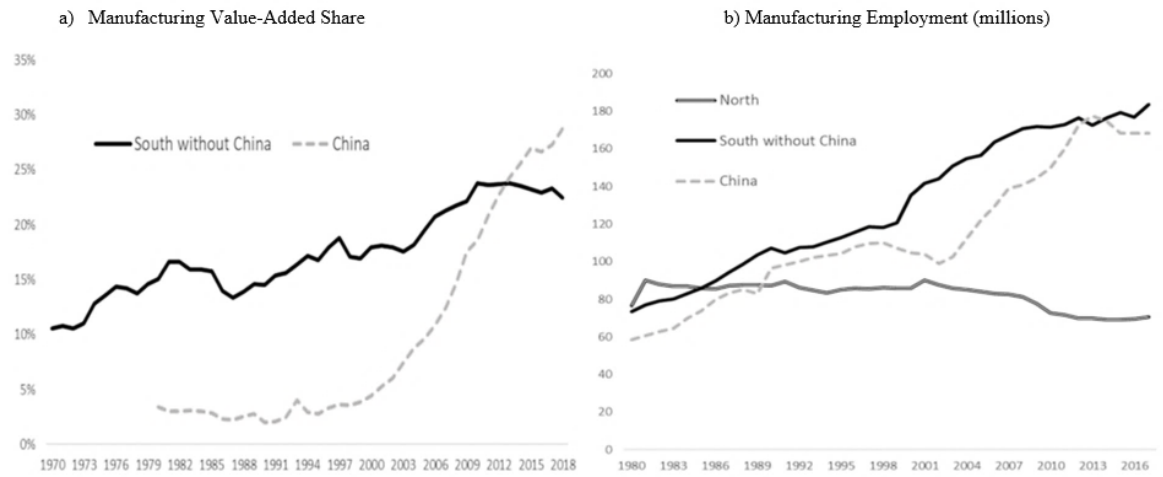
Ces arguments soulignent l'importance de la technologie et de l'innovation dans une stratégie de développement axée sur les services, mais aussi en tant que principal moteur de la formation d'une structure productive et de l'industrialisation ultérieure d'un pays, comme nous l'avons expliqué dans les paragraphes précédents. La mise à niveau technologique, ainsi que la formation et l'accumulation de connaissances, favorisent la création de valeur ajoutée par le biais d'innovations de produits et de processus. Ces innovations, à leur tour, conduisent au développement d'avantages comparatifs dynamiques (Ocampo, 2005) et à l'évolution des industries manufacturières (Malerba, 2006 ; Dosi & Nelson, 2010), permettant à un pays de participer efficacement à un marché mondialisé (Dahlman, 2008). Cela suggère que les pays en développement peuvent chercher à renforcer leur croissance économique par un nouveau processus de développement de l'industrie manufacturière.

À cet égard, le concept d'un processus déterministe de désindustrialisation prématurée n'est pas largement accepté dans la littérature. Par exemple, Kruse et al. (2021) observent que dans de nombreux pays en développement, le pic de la part de l'emploi manufacturier n'a pas encore été atteint. Selon McMillan et al. (2014) et Diao et al. (2018, 2021), l'Afrique affiche une tendance significative à l'industrialisation depuis les années 2000, sous l'impulsion de petites entreprises non enregistrées qui développent l'emploi, tandis que les grandes entreprises augmentent leur productivité grâce à des technologies à forte intensité de capital. Dosi et al. (2021) identifient diverses opportunités

d'industrialisation dans les secteurs manufacturiers en fonction de leurs caractéristiques technologiques. Selon la taxonomie industrielle de Pavitt (Pavitt, 1984), les secteurs dominés par les fournisseurs et à forte intensité d'échelle absorbent la plus grande part de la main-d'œuvre, mais sont les premiers à connaître la désindustrialisation. En revanche, les fournisseurs spécialisés et les secteurs fondés sur la science continuent de croître en termes de valeur ajoutée et d'emploi et ne montrent aucun signe de désindustrialisation.

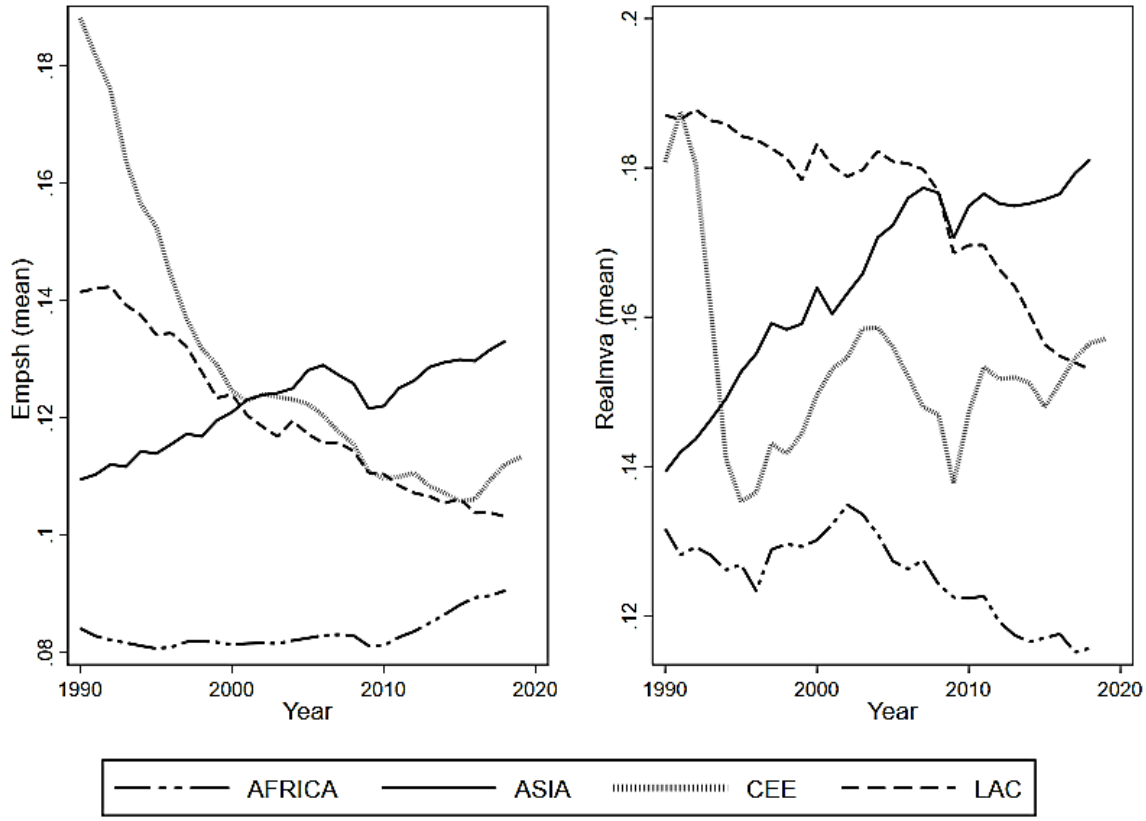
Haraguchi et al. (2017) contestent l'idée selon laquelle l'industrie manufacturière perd de son importance pour les pays en développement. Ils affirment que le déclin de la valeur ajoutée manufacturière et de l'emploi dans de nombreuses nations en développement résulte de la concentration des activités manufacturières dans quelques pays asiatiques très peuplés, en particulier en Chine, comme nous l'avons vu dans les paragraphes précédents. Néanmoins, la Chine est en train de moderniser sa structure économique, passant d'industries à forte intensité de main-d'œuvre à des secteurs à forte intensité de capital et de haute technologie dans le cadre d'une stratégie technologique et d'une politique industrielle ("Fabriqué en Chine 2025"). Cette évolution s'accompagne d'une augmentation des salaires dans l'industrie manufacturière chinoise. Par conséquent, la transformation chinoise ouvre une fenêtre d'opportunité pour réaffecter la production des industries à forte intensité de main-d'œuvre vers d'autres pays en développement, remettant en cause la limitation de la désindustrialisation prématurée (Brandt et al., 2016 ; Hanson, 2020).

Figure 1: Valeur ajoutée et emploi dans l'industrie manufacturière mondiale



Source : Lautier (2024) sur base de données de UNStats, UNIDO Industrial Statistics, ILO, Groningen growth and Development centre.

Figure 2: Emploi manufacturier (Empsh) et part de la valeur ajoutée (Realmva) dans les régions



Source : Calculs de l'auteur basés sur la base de données sur la transformation économique et la base de données sur la transformation économique des économies en transition (Centre de données de Groningue) (Kruse et al., 2023 ; Hamilton & de Vries, 2023).

Les résultats empiriques de Lautier (2024), illustrés dans la Figure 1, montrent que l'importance relative des parts de valeur ajoutée manufacturière et de l'emploi n'a pas diminué au fil du temps dans les pays en développement, ce qui remet en question la théorie de la désindustrialisation prématurée. En particulier, depuis 2010, l'emploi manufacturier en Chine a stagné alors qu'il a continué à croître à un rythme régulier dans le reste du monde en développement. La Figure 2 présente la valeur ajoutée manufacturière moyenne et la part de l'emploi pour l'échantillon de pays en développement analysé dans le chapitre 1 de cette thèse. En moyenne, les pays d'Afrique, d'Asie du Sud-Est et d'Europe centrale et orientale ont connu une reprise de l'emploi manufacturier depuis 2010, tandis que seuls l'Asie du Sud-Est et l'Europe centrale et orientale ont enregistré une augmentation de la part de la valeur ajoutée manufacturière.

Par conséquent, les pays à revenu faible et intermédiaire devraient adopter des stratégies de développement axées sur l'innovation et les avancées technologiques afin de produire de nouveaux biens, d'accroître la productivité et de créer des opportunités d'emploi (Fagerberg et al., 2007). Pour ce faire, il faut renforcer les bases de la création de connaissances, de la technologie et de l'innovation, notamment en améliorant le capital humain et le développement des compétences, en renforçant les institutions et

en construisant de meilleures infrastructures. Ces efforts sont essentiels pour renouveler l'industrialisation, en tirant parti de l'opportunité créée par l'évolution de la Chine vers une production à plus forte valeur ajoutée (Rodrik, 2014 ; Atolia et al., 2020).

Pourtant, l'impact de l'industrialisation fondée sur l'innovation sur la croissance de l'emploi reste controversé. Le progrès technologique peut accroître la valeur ajoutée manufacturière et la diversité des produits, renforcer la compétitivité et, en fin de compte, stimuler la croissance économique, soutenant ainsi la création d'emplois dans le secteur manufacturier. Inversement, le progrès technologique peut stimuler la productivité de manière à économiser la main-d'œuvre, l'impact global sur l'emploi dans l'industrie manufacturière dépendant de laquelle de ces forces devient dominante (Vivarelli, 2014). Ces effets de création et de déplacement de main- d'œuvre sont également liés à différentes activités d'innovation. Par exemple, les innovations de produits qui ouvrent de nouveaux marchés et stimulent la demande des consommateurs tendent à créer des emplois. En revanche, les innovations de procédé qui améliorent les méthodes de production et l'efficacité peuvent déplacer la main-d'œuvre.

Toutefois, la relation finale entre l'innovation et l'emploi est déterminée non seulement par les effets directs des innovations de produits et de procédés, mais aussi par les mécanismes de compensation en place (Calvino & Virgillito, 2018). Les mécanismes de compensation du marché qui peuvent compenser les effets d'économie de main-d'œuvre de la technologie comprennent (1) l'emploi supplémentaire dans le secteur des biens d'équipement où de nouvelles machines sont produites, (2) les baisses de prix résultant de la diminution des coûts de production due aux innovations technologiques, (3) les nouveaux investissements réalisés grâce aux profits supplémentaires générés par le changement technologique, (4) les baisses de salaire consécutives aux pertes d'emploi initiales, et (5) la création de nouveaux produits utilisant de nouvelles technologies (Vivarelli, 2018, p. 12).

Bien qu'il n'y ait pas d'issue claire au lien entre l'innovation et la croissance de l'emploi, Calvino & Virgillito (2018) soulignent comme un fait stylisé à partir des preuves empiriques les plus récentes qu'au niveau de l'entreprise, il existe une association positive entre l'innovation et la croissance de l'emploi, principalement dans les entreprises de haute technologie. D'autre part, au niveau sectoriel, les effets des innovations de procédé sont moins prononcés en raison des forces concurrentielles sur le marché, tandis que les effets des innovations de produit ont tendance à avoir un effet positif sur l'emploi sectoriel, ce qui en fait un moteur important de la croissance de l'emploi au niveau de l'industrie.

Outre les effets quantitatifs de l'innovation sur l'emploi, il existe également des effets qualitatifs, notamment sur les types de travailleurs, leurs compétences et leurs tâches (Vivarelli, 2014). Un grand nombre de recherches mettent en évidence deux théories principales qui explorent l'impact qualitatif du progrès technologique. La première est l'hypothèse d'un changement technologique biaisé par les compétences, qui suggère que les technologies récentes complètent les travailleurs hautement qualifiés et éduqués tout en déplaçant ceux dont les compétences et le niveau d'éducation sont moindres. La seconde est l'hypothèse du changement technologique basé sur la routine, qui se concentre sur la nature des tâches plutôt que sur l'éducation, et propose que la technologie et l'innovation

remplacent les tâches routinières tout en améliorant les tâches non routinières (Mondolo, 2022).

Les effets quantitatifs et qualitatifs de l'innovation sur l'emploi sont évidents dans les pays en développement. Rodrik (2022) note que les méthodes de production dans ces pays sont largement façonnées par les tendances de l'innovation étrangère afin de rester compétitif. Par conséquent, les techniques de production à faible intensité de compétences sont limitées et cèdent souvent la place à des approches à forte intensité de capital ou de compétences. Il est donc essentiel de comprendre les effets potentiels de l'innovation sur l'emploi dans le secteur manufacturier dans un contexte de développement. Ce point est essentiel, car Felipe et al. (2019) affirment que l'expansion de l'emploi dans l'industrie manufacturière est un puissant prédicteur du développement économique. Ils montrent que presque tous les pays riches non pétroliers d'aujourd'hui avaient des parts élevées d'emplois manufacturiers et que la croissance de l'emploi manufacturier précédait souvent le développement et l'accumulation de richesses. Par conséquent, les trois chapitres de la présente thèse se concentrent sur l'effet de l'innovation sur l'emploi manufacturier, tandis que seul le premier chapitre évalue à la fois la valeur ajoutée manufacturière et l'emploi pour étudier le rôle de l'innovation dans le développement manufacturier.

2 Questions de recherche

Sur la base de l'analyse bibliographique précédente sur le rôle de l'innovation et du progrès technologique dans le processus d'industrialisation, les chapitres de la présente thèse visent à répondre aux trois questions de recherche suivantes :

Chapitre 1: À la lumière de la libéralisation du commerce des années 1990, qui a exercé une pression sur les industries d'innovation dans les pays en développement, la relation entre la capacité d'innovation et l'industrialisation est-elle linéaire (qu'elle soit positive ou négative) ou non linéaire ? Si elle est non linéaire, existe-t-il un seuil d'innovation au-delà duquel la relation avec l'industrialisation devient positive ?

Chapitre 2: Dans le contexte d'un pays en développement comme la Colombie, comment les activités d'innovation affectent-elles la croissance de l'emploi au niveau des entreprises manufacturières ? En outre, comment la concurrence étrangère sectorielle, en particulier celle de la Chine, influe-t-elle sur les résultats de ces innovations en termes d'emploi ?

Chapitre 3: La littérature indique que dans certains pays africains, les petites entreprises manufacturières ont connu une croissance de l'emploi, tandis que les grandes entreprises ont enregistré des gains de productivité. Dans quelle mesure la croissance de la productivité du travail dans les secteurs manufacturiers d'un plus grand nombre de pays en développement est-elle due à des améliorations de la productivité au sein d'entreprises de tailles différentes, plutôt qu'à des changements dans la répartition de l'emploi au sein de ces entreprises ? En outre, comment les connaissances et les technologies intégrées dans les intrants importés ont-elles influencé la productivité du travail et la réaffectation de la main-d'œuvre dans les entreprises de différentes tailles ?

3 Contributions

Cette thèse se concentre sur l'intersection de l'innovation, de la valeur ajoutée et de l'industrialisation de l'emploi, principalement dans le contexte des pays en développement, avec une étude de cas spécifique sur la Colombie. L'analyse utilise des données nationales (chapitre 1), sectorielles et au niveau de l'entreprise (chapitres 2 et 3), couvrant la période de 1996 à 2019. Elle prend également en compte des facteurs externes, tels que la concurrence commerciale, afin de comprendre leur rôle dans l'évolution des résultats industriels.

Chapitre 1 étudie la relation entre l'innovation et l'industrialisation, en particulier en termes de valeur ajoutée manufacturière et d'emploi dans les pays en développement. Le document vise à déterminer si la relation innovation-industrialisation dans les pays en développement est linéaire ou non linéaire, en utilisant une approche en deux étapes. Tout d'abord, je construis un indice national d'innovation pour 53 pays en développement et émergents de 1996 à 2018 en utilisant les indicateurs d'innovation de l'Indice mondial de l'innovation (IME). L'indice, les sous-indices, les piliers et les sous-piliers de l'IIG sont calculés à l'aide d'une analyse en composantes principales (ACP).

Deuxièmement, en utilisant une estimation par panel avec des effets fixes, je montre une relation en forme de U entre l'indice d'innovation et les parts de la valeur ajoutée manufacturière. Une explication possible de cette corrélation convexe est la suivante : de faibles niveaux d'innovation étaient évidents au cours de la première phase de cette analyse, en particulier dans les années 1990, lorsque les pays ont connu une libéralisation commerciale significative après s'être industrialisés à l'intérieur de frontières nationales fermées dans le cadre de politiques d'ISI. À l'ère de la mondialisation, les pays en développement ont connu un certain progrès technologique au niveau national, comme l'indique la hausse de l'indice d'innovation, grâce à l'adoption de technologies étrangères, y compris les entrées d'IDE, les paiements de redevances et les intrants importés. Cela leur a permis de s'engager dans l'imitation et l'ingénierie inverse. Toutefois, la concurrence des fabricants étrangers sur les marchés nationaux a dépassé ce progrès technologique, qui était principalement concentré dans les secteurs à faible technologie, la main-d'œuvre non qualifiée et les produits traditionnels, ce qui a entraîné une désindustrialisation en termes de valeur ajoutée (Rodrik, 2016).

L'augmentation de la concurrence étrangère pourrait avoir deux conséquences. Premièrement, la libéralisation des échanges peut contraindre les entreprises manufacturières à faible productivité à quitter les marchés nationaux, ce qui entraîne une réaffectation des ressources vers des entreprises plus productives et en expansion. Le second résultat est qu'une concurrence accrue pousse les entreprises survivantes à améliorer la technologie et l'innovation, ce qui leur permet d'accroître leur productivité, d'être plus compétitives et de différencier leurs produits de ceux de leurs concurrents. Mes conclusions indiquent que les gains de productivité et l'augmentation de la valeur ajoutée manufacturière deviennent possibles lorsque l'indice d'innovation national atteint une fourchette de 0,4 à 0,5. D'après les résultats de l'ACP, les pays d'Asie du Sud-Est et d'Europe centrale et orientale ont tendance à avoir des niveaux d'indice d'innovation égaux ou supérieurs à ce seuil empirique.

À l'inverse, on observe une corrélation négative entre l'innovation et l'emploi dans l'industrie manufacturière. Dans les contextes de faible innovation, la concurrence étrangère chasse du marché les entreprises à faible productivité, ce qui entraîne des pertes d'emplois. À des niveaux d'innovation plus élevés, les technologies permettant d'économiser de la main-d'œuvre augmentent la productivité mais diminuent l'emploi. Cependant, les mécanismes de marché qui compensent l'effet d'économie de main-d'œuvre de la technologie sont présents dans l'analyse sectorielle. Une relation positive linéaire entre l'innovation et l'emploi est évidente dans les secteurs dominés par les fournisseurs, à forte intensité d'échelle et spécialisés, tandis que les secteurs fondés sur la science présentent une corrélation en forme de U, exigeant que les indices d'innovation dépassent 0,7 pour que la valeur ajoutée augmente. Les corrélations négatives dans les secteurs scientifiques peuvent résulter d'une diminution de la demande de main-d'œuvre non qualifiée en raison des changements technologiques qui favorisent les travailleurs qualifiés.

Chapitre 2 analyse l'effet d'économie de main-d'œuvre de l'innovation de produit et de processus et les mécanismes de compensation dans l'emploi manufacturier dans les entreprises colombiennes. En utilisant les données de l'enquête industrielle sur le développement et l'innovation technologique (EDIT) de 2007 à 2018, l'étude étend le modèle structurel de Harrison et al. (2014) pour examiner comment la concurrence chinoise affecte différemment la croissance de l'emploi, en fonction des niveaux d'activité innovante de l'entreprise.

L'analyse empirique aboutit à trois résultats clés. Premièrement, conformément à la littérature existante, la croissance des ventes de nouveaux produits stimule de manière significative la croissance de l'emploi dans tous les secteurs manufacturiers au cours de la période étudiée. En revanche, les innovations de procédé et d'organisation n'ont généralement pas d'impact notable sur l'emploi au niveau de l'entreprise. Deuxièmement, l'innovation de produit exerce une plus grande influence sur la croissance de l'emploi chez les travailleurs très instruits que chez ceux dont le niveau d'instruction est moins élevé, une tendance observée à la fois dans les secteurs de haute technologie et de faible technologie. Enfin, la concurrence des importations chinoises a un effet négatif plus prononcé sur les entreprises très innovantes, en particulier dans les secteurs à faible technologie et parmi les travailleurs très instruits. Cela indique que, bien que les entreprises innovantes poursuivent souvent l'innovation de produits comme stratégie défensive contre la concurrence, cette approche est largement inefficace.

Enfin, le **Chapitre 3** relie les résultats des deux premiers chapitres en étudiant l'impact des technologies étrangères intégrées dans les intrants importés (proxy de la participation aux CVM en amont) et l'exportation de la production (proxy de la participation aux CVM en aval) sur la productivité du travail et les parts d'emploi dans les entreprises manufacturières en fonction de leur taille. La recherche est motivée par les tendances observées dans le secteur manufacturier africain, où les petites entreprises peu productives ont augmenté leur part d'emploi, tandis que les grandes entreprises ont tendance à afficher une productivité plus élevée mais contribuent peu à l'expansion globale de l'emploi.

À l'aide des données de l'enquête sur les entreprises de la Banque mondiale recueillies entre 2006 et 2019, les entreprises sont classées en trois catégories : petites (1-19

employés), moyennes (20-99 employés) et grandes (100 employés ou plus). L'analyse est divisée en deux parties. La première utilise une méthode de décomposition des parts de marché pour décomposer la croissance de la productivité du travail dans le secteur manufacturier en deux composantes : (i) la composante interne, qui saisit la croissance de la productivité au sein de chaque groupe de taille d'entreprise, et (ii) la composante interentreprises, qui reflète les gains ou les pertes de productivité dus à la réaffectation de la main-d'œuvre vers des groupes d'entreprises plus ou moins productifs, également appelée changement structurel stimulant ou réduisant la croissance. Les résultats révèlent que les petites et moyennes entreprises d'Afrique, d'Asie du Sud, d'Europe et d'Asie centrale ont des composantes positives entre elles, mais faibles à l'intérieur de chacune d'elles. Les grandes entreprises d'Afrique enregistrent la plus forte croissance de la productivité malgré les réductions d'effectifs, tandis qu'en Amérique latine, les grandes entreprises parviennent à la fois à une croissance de la productivité et à une meilleure absorption de la main-d'œuvre. En revanche, les entreprises du Moyen-Orient et de l'Afrique du Nord affichent des valeurs faibles ou négatives dans les deux composantes.

La deuxième partie examine les facteurs qui expliquent les différences de productivité du travail et de niveaux d'emploi selon la taille des entreprises. L'analyse indique que les technologies à forte intensité de capital améliorent la productivité, les grandes entreprises bénéficiant davantage des intrants importés (indicateur de la participation aux chaînes de valeur mondiales en amont), tandis que les petites entreprises enregistrent des gains de productivité plus importants grâce aux exportations (indicateur de la participation aux chaînes de valeur mondiales en aval). Cela suggère que les chaînes de valeur mondiales soutiennent principalement les petites entreprises par le biais de liens en amont, tandis que les grandes entreprises bénéficient de liens en aval. Des facteurs tels que la main-d'œuvre qualifiée, l'innovation et le stock de capital jouent un rôle important dans l'amélioration de la productivité des grandes entreprises, mais souvent au détriment de la part de l'emploi. En outre, des réglementations plus strictes en matière de travail et de finances peuvent compromettre les effets positifs des intrants importés sur la productivité et l'emploi.

4 Références

Acemoglu, D., & Autor, D. (2011). Skills, tasks and technologies: Implications for employment and earnings. In: O. Ashenfelter & D. Card (Ed.), *Handbook of Labor Economics*, edition 1, volume 4, chapter 12, pp. 1043-1171, Elsevier.

Acemoglu, D., & Guerrieri, V. (2008). Capital deepening and non-balanced economic growth. *Journal of Political Economy*, 116, 467 – 498.

Acemoglu, D., Johnson, S., & Robinson, J. (2001). The colonial origins of comparative development: an empirical investigation. *American Economic Review*, American Economic Association, 91(5), 1369-1401.

Acemoglu, D., & Robinson, J. (2013). *Why Nations Fail: The Origins of Power, Prosperity and Poverty.* London: Profile Books.

Alvarez-Cuadrado, F., Van long, N., & Markus, P. (2017). Capital-labour substi-

tution, structural change and growth. *Theoretical Economics*, 12(3), 1229 – 1266.

Amiti, M., & Konings, J. (2007). Trade liberalization, intermediate inputs, and productivity: evidence from Indonesia. *American Economic Review*, 97(5), 1611 - 1638.

Atolia, M., Loungani, P., Marquis, M., & Papageorgiou, C. (2020). Rethinking development policy: What remains of structural transformation? *World Development*, 128(C).

Bas, M., & Paunov, C. (2019). What gains and distributional implications result from trade liberalization? *MERIT Working Papers 2019-003*, United Nations University - Maastricht Economic and Social Research Institute on Innovation and Technology (MERIT).

Bas, M., & Paunov, C. (2021). Input quality and skills are complementary and increase output quality: Causal evidence from Ecuador's trade liberalization. *Journal of Development Economics*, 151(C).

Baumol, W. (1967). Macroeconomics of unbalanced growth: the anatomy of urban crisis. *The American Economic Review*, 415 – 426.

Bhattacharyya, S., & Hodler, R. (2014). Do natural resource revenues hinder financial development? The role of political institutions. *World Development*, 57, 101–113.

Brandt, L., Ma, D., & Rawski, T. (2016). Industrialization in China. *IZA Discussion Papers 10096*, Institute of Labor Economics (IZA).

Bogliaccini, J. (2013). Trade liberalization, deindustrialization and inequality: evidence from middle-income Latin American countries. *Latin American Research Review*, 48(2), 79 – 105.

Buera, F. J., Kaboski, J., & Shin, Y. (2011). Finance and Development: A Tale of Two Sectors. *American Economic Review*, 101, 1964-2002.

Calvino, F., & Virgillito, M.E. (2018). The innovation-employment nexus: a critical survey of theory and empirics. *Journal of Economic Surveys*, 32(1), 83 – 117.

Caselli, F., & Coleman, W. (2001). Cross-country technology diffusion: the case of computers. *American Economic Review*, 91(2), 328 – 335.

Cassini, L. (2023). Path-dependent productive specialization: Should prematurely deindustrialized countries shift to a KIBS export-led strategy? *Structural Change and Economic Dynamics*, 65(C), 199 - 209.

Castellacci, F., & Natera, J. (2013). The dynamics of national innovation systems: a panel cointegration analysis of the coevolution between innovative capability and absorptive capacity. *Technological Forecasting and Social Change*, 76, 709 – 722.

Chen, D., Zheng, S., & Guo, L. (2015). The impact of science and technology policies on rapid economic development in China. In Cornell University, INSEAD, and WIPO (Eds.), *The Global Innovation Index 2015: Effective Innovation Policies for Development*, (pp. 105 – 111).

Cimoli, M., & Katz, J. (2003). Structural reforms, technological gaps and economic development: A Latin American perspective. *Industrial and Corporate Change*, 12(2), 387 – 411.

Cirera, X., & Maloney, W. F. (2017). *The innovation paradox: Developing-country capabilities and the unrealized promise of technological catch-up.* World Bank.

Clark, C. (1940). *The Conditions of Economic Progress.* Macmillan, New York.

Coricelli, F., & Ravasan, F. (2017). Structural change and the China syndrome: Baumol vs trade effects. *Centre for Economic Policy Research Discussion Paper*, DP12069.

Dahlman, J. (2008). Technology, globalization, and international competitiveness: challenges for developing countries. In D. O. Kjollerstrom, *Industrial Development for the 21st Century* (pp. 29 - 83). Ed. Zed Books.

Dasgupta, S., & Singh, A. (2006). Manufacturing, services and premature deindustrialization in developing countries: A Kaldorian analysis. *WIDER Working Paper Series RP2006-49*, World Institute for Development Economic Research (UNU-WIDER).

De Soto, H. (2000). *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else.* Basic Books, New York.

Di Maio, M. (2008). Industrial policies in developing countries: History and perspectives. *Working Papers 48-2008*, Macerata University, Department of Finance and Economic Sciences.

Di Meglio, G., Gallego, J., Maroto, A., & Savona, M. (2018). Services in developing economies: the deindustrialization debate in perspective. *Development and Change*, 49(6), 1495 – 1525.

Diao, X., Ellis, M., McMillan, M., & Rodrik, D. (2021). Africa's Manufacturing Puzzle: Evidence from Tanzanian and Ethiopian Firms. *NBER Working Papers*, 28344, National Bureau of Economic Research, Inc.

Dosi, G., & Nelson, R. (2010). Technical change and industrial dynamics as evolutionary processes. In: B. Hall & N. Rosenberg (Eds.), *Handbook of the Economics of Innovation*, (pp. 51 – 127).

Dosi, G., Riccio, F., & Virgillito, M. (2021). Varieties of deindustrialization and patterns of diversification: why microchips are not potato chips. *Structural Change and Economic Dynamics*, 57, 182 – 202.

Dosi, G., & Tranchero, M. (2018). The role of comparative advantage, endowments and technology in structural transformation. *LEM Papers Series*, 2018/33, Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies, Pisa, Italy.

Fagerberg, J., Srholec, M., & Knell, M. (2007). the competitiveness of nations: why some countries prosper while others fall behind. *World Development*, 35(10), 1595 - 1620.

Fagerberg, J., Srholec, M., & Verspagen, B. (2010). Innovation and economic development. In Bronwyn H. Hall
Nathan Rosenberg (Eds.), *Handbook of the Economics of Innovation* (pp. 833 – 872).

Felipe, J., Mehta, A., & Rhee, C. (2019). Manufacturing matters... but it's the jobs that count. *Cambridge Journal of Economics*, 43(1), 139 - 168.

Firpo, S., & Renan, P. (2017). Structural change, productivity growth, and trade policy in Brazil. In M. McMillan, D. Rodrik
C. Sepulveda (Eds.), *Structural Change, Fundamentals, and Growth: A Framework and Case Studies*. International Food Policy Research Institute (Washington, D.C.).

Fisher, A. (1939). Primary, secondary, and tertiary production. *Economic Record*, 15(8), 24 – 38.

Godin, B. (2007). Science, accounting and statistics: The input-output framework. *Research Policy*, 36(9), 1388 – 1403.

Hamilton, C., & de Vries, G. J. (2023). The structural transformation of transition economies. *GGDC Research Memorandum*, 196.

Hanson, G. (2020). Who will fill China's shoes? The global evolution of labour-intensive manufacturing. *East Asian Economic Review*, 24(4), 313 - 336.

Haraguchi, N. (2015). Global patterns of growth, structural change and inclusive and sustainable industrial development. *Background Document prepared for Chapter 1 of the IDR 2015. Vienna: UNIDO.*

Haraguchi, N., Cheng, C., & Smeets, E. (2017). the importance of manufacturing in economic development: has this changed? *World Development*, 93(C), 293 - 315.

Haraguchi, N., Martorano, B., & Sanfilippo, M. (2019). What factors drive successful industrialization? Evidence and implications for developing countries. *Structural Change and Economics Dynamics*, 49, 266 – 276.

Hausmann, R., Hwang, J., & Rodrik, D. (2007). What you export matters. *Journal of Economic Growth*, 12(1), 1 - 25.

Herrendorf, B., Rogerson, R., & Valentinyi, A. (2014). Growth and Structural Transformation. In P. Aghion
S. Durlauf (Eds.), *Handbook of Economic Growth* (1st ed., Volume 2B, chapter 6). Elsevier.

Herrendorf, B., Herrington, C., & Valentinyi, A. (2015). Sectoral technology and structural transformation. *American Economic Journal: Macroeconomics*, 7(4), 104 – 133.

Hidalgo, C., Klinger, B., Barabàsi, A., & Hausmann, R. (2007). The product space conditions the development of nations. *Science*, 317(5837), 482 – 487.

Hsieh, C.T., & Klenow, P. J. (2009). Misallocation and manufacturing TFP in China and India. *Quarterly Journal of Economics*, 124(4),1403–1448.

Imbs, J., & Wacziarg, R. (2003). Stages of diversification. *The American Economic Review*, 93(1), 63 – 86.

Karas, A., & Pyle, W., & Schoors, K. (2015). A "de Soto Effect" in industry? Evidence from the Russian Federation. *Journal of Law and Economics*, 58(2), 451-480.

Kim, C., Lee, S. (2014). Different paths of deindustrialization: Latin American and Southeast Asian countries. *Journal of International and Area Studies*, 21(2), 65 – 81.

Kruse, H., Mensah, E., Sen, K., & de Vries, G. (2021). A manufacturing renaissance? Industrialization trends in the developing world. *WIDER Working Paper Series wp-2021-28*, World Institute for Development Economic Research (UNU-WIDER).

Kruse, H., Mensah, E., Sen, K., & de Vries, G. J. (2023). A manufacturing renaissance? Industrialization trends in the developing world. *IMF Economic Review*, 71, 439 – 473.

Kunst, D. (2019). Premature deindustrialization through the lens of occupations: Which jobs, why, and where? *Tinbergen Institute Discussion Paper*, TI 2019-033/V.

Kuznets, S. (1966). *Modern economic growth: rate, structure and spread.* Yale University Press, London.

Lall, S. (2004). Selective Industrial and Trade Policies in Developing Countries: Theoretical and Empirical Issues. In C, Soludo., O, Ogbu., & H-J, Chang (Eds.). *The Politics of Trade and Industrial Policy in Africa: Forced Consensus?* Africa World Press and IDRC (pp. 4 – 41).

Lautier, M. (2024). Manufacturing still matters for developing countries. *Structural Change and Economic Dynamics*, 70(C), 168 - 177.

Lawrence, P. (2005). Explaining Sub-Saharan Africa's manufacturing performance.

Development and Change, 36(6), 1121 - 1141.

Lewis, A. (1954). Economic development with unlimited supplies of labour. *The Manchester School*, 22, 139 – 191.

Lin, J., & Treichel, V. (2012). Learning from China's rise to escape the middle-income trap: a new structural economics approach to Latin America. *Policy Research working paper*, no. WPS 6165 Washington, D.C.: World Bank Group.

MacBean, A. (2000). Export promotion in transitional economies. In A. MacBean (Ed.), *Trade and Transition. Trade Promotion in Transitional Economies* (pp. 1 – 17).

Malerba, F. (2006). Innovation and the evolution of industries. *Journal of Evolutionary Economics*, 16(1), 3 – 23.

Martorano, B., & Sanfilippo, M. (2015). Structural change and wage inequality in the manufacturing sector: Long run evidence from East Asia. *Oxford Development Studies*, 43(2), 212 - 231.

Matsuyama, K. (2009). Structural change in an interdependent world: a global view of manufacturing decline. *Journal of the European Economic Association*, 7(2 – 3), 478 – 486.

Matthess, M., & Kunkel, S. (2020). Structural change and digitalization in developing countries: Conceptually linking the two transformations. *Technology in Society*, 63(C).

McMillan, M., & Rodrik, D. (2011). Globalization, Structural Change, and Productivity Growth. In M. Bachetta and M. Jansen, (Eds.), *Making Globalization Socially Sustainable*. Geneva: International Labour Organization and World Trade Organization.

McMillan, M., Rodrik, D., & Verduzco-Gallo, I. (2014). Globalization, structural change, and productivity growth with an update on Africa. *World Development*, 63, 11 – 32.

Mondolo, J. (2022). The composite link between technological change and employment: A survey of the literature. *Journal of Economic Surveys*, 36(4), 1027 - 1068.

Naudé, W., & Nagler, P. (2015). Industrialization, innovation, inclusion. *MERIT Working Papers 2015-043*. United Nations University - Maastricht Economic and Social Research Institute on Innovation and Technology (MERIT).

Naudé, W. (2017). Entrepreneurship, education and the fourth industrial revolution in Africa. *IZA Discussion Papers*, 10855, Institute of Labor Economics (IZA).

Naudé, W., & Tregenna, F. (2023). Africa's industrialization prospects: a fresh look. *IZA Discussion Papers*, 16043, Institute of Labor Economics (IZA).

Ngai, L., & Pissarides, C. (2007). Structural change in a multisector model of growth. *American Economic Review*, 97(1), 429 – 443.

Nuvolari, A., & Russo, E. (2021). Technical progress and structural change: A long-term view. In L. Alcorta, et al. (Eds.), *New perspectives on structural change: Causes and consequences of structural change in the global economy* (online ed.). Oxford Academic.

Ocampo, J.A. (2005) *Beyond Reforms: Structural Dynamics and Macroeconomic Vulnerability*. Palo Alto, CA: Stanford University Press; Washington, DC: World Bank.

OECD/Eurostat. (2018). *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation*, 4th Edition, The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing, Paris/Eurostat, Luxembourg.

Palma, J. (2005). Four sources of de-industrialization and a new concept of the Dutch Disease. In Ocampo J.A (Ed.), *Beyond Reforms: Structural Dynamic and Macroeconomic Vulnerability*. Stanford University Press.

Palma, J. (2014). De-industrialization, premature de-industrialization and the Dutch Disease. *Revista NECAT*, 3(5).

Park, D., Park, H., Kim, Y., Baek, S., Lee, D., Jang, Y., Jung, T., & Santiago, F. (2021). *The role of science, technology, and innovation policies in the industrialization of developing countries. Lessons from East Asian countries*. UNIDO, United Nations Industrial Development Organization.

Pavitt, K. (1984). Sectoral patterns of technical change: towards a taxonomy and a theory. *Research Policy*, 13(6), 343 – 373.

Rodrik, D. (2007). Industrial development: Some stylized facts and policy directions. *Industrial Development for the 21st Century*. U.N. Department of Economic and Social Affairs: Division for Sustainable Development.

Rodrik, D. (2013). Unconditional convergence in manufacturing. *Quarterly Journal of Economics*, 128(1), 165 - 204.

Rodrik, D. (2014). The Past, Present, and Future of Economic Growth. In F. Allen and others, *Towards a Better Global Economy: Policy Implications for Citizens Worldwide in the 21st Century*, Oxford University Press, Oxford and New York.

Rodrik, D. (2016). Premature deindustrialization. *Journal of Economic Growth*, 21(1), 1 - 33.

Rodrik, D. (2022). Prospects for global economic convergence under new technologies. In Z. Qureshi (Eds.), *An inclusive future? Technology, new dynamics, and policy challenges* (pp. 65 – 82).

Rowthorn, R., & Ramaswamy, R. (1997). Deindustrialization: causes and implications. In *Staff Studies for the World Economic Outlook*, by the Research Department of the International Monetary Fund. Washington, D.C.: International Monetary Fund.

Rowthorn, R., & Ramaswamy, R. (1999). Growth, trade and deindustrialization. *IMF Staff Papers*, 46(1).

Rowthorn, R., & Well, J. R. (1987). *Deindustrialization and Foreign Trade*. Cambridge: Cambridge University Press.

Samaniego, R., & Sun, J. (2016). Productivity growth and structural transformation. *Review of Economic Dynamics*, 21, 266 – 285.

Sen, K. (2019). What explains the job-creating potential of industrialisation in the developing world? *The Journal of Development Studies*, 55(7), 1565 - 1583.

Shu, P., & Steinwender, C. (2019). The impact of trade liberalization on firm productivity and innovation. *Innovation Policy and the Economy*, 19(1), 39 - 68.

Swiecki, T. (2017). Determinants of structural change. *Review of Economic Dynamics*, 24, 95 – 131.

Szirmai, A. (2012). Industrialisation as an engine of growth in developing countries, 1950–2005. *Structural Change and Economic Dynamics*, 23(4), 406 - 420.

Szirmai, A., & Verspagen, B. (2015). Manufacturing and economic growth in developing countries, 1950–2005. Structural Change and Economic Dynamics, 34(C), 46–59.

Timmer, M., de Vries, G., & de Vries, K. (2015). Patterns of structural change in developing countries. In J. Weiss, M. Tribe (Eds.), *Routledge Handbook of Industry and Development* (pp. 65 - 83). Routledge.

Tregenna, F. (2009). Characterizing deindustrialization: an analysis of changes in manufacturing employment and output internationally. *Cambridge Journal of Economics*, 33(3), 433 – 466.

UNCTAD. (2016). *Trade and development report, 2016: structural transformation for inclusive and sustained growth*. United Nations, New York

Uy, T., & Zhang, J. (2013). Structural change in an open. *Journal of Monetary Economics*, 60, 667 - 682.

Van Neuss, L. (2019). The drivers of structural change. *Journal of Economic Surveys*, 33(1), 309-349.

Vivarelli, M. (2014). Structural change and innovation as exit strategies from the middle-income trap. *IZA Discussion Papers*, 8148, Institute of Labor Economics (IZA).

Vivarelli, M. (2018). Globalisation, structural change and innovation in emerging economies: The impact on employment and skills. *MERIT Working Papers*, 2018-037, United Nations University - Maastricht Economic and Social Research Institute on Innovation and Technology (MERIT).

Zhou, X., Cai, Z., Tan, K., Zhang, L., Du, J., & Song, M. (2021). Technological innovation and structural change for economic development in China as an emerging market. *Technological Forecasting and Social Change*, 167(C).

Chapter 1
Innovation and Industrialization in Developing Countries: A Non-Linear Relationship

Abstract
This paper examines the relationship between innovation and industrialization, with a focus on manufacturing value-added and employment in developing countries. Using a two-step methodology, the study constructs a national innovation index for 53 countries and analyzes the correlations between innovation and industrialization from 1996 to 2018. The results show a U-shaped relationship between innovation and manufacturing value-added, as well as a negative correlation with manufacturing employment shares. A sectoral analysis based on Pavitt's industrial taxonomy reveals that the Supplier-Dominated, Scale-Intensive, and Specialized Supplier sectors exhibit a positive correlation between innovation, manufacturing value-added, and employment shares. In contrast, in Science-Based sectors, value-added growth is observed only when a country's national innovation index surpasses a high threshold. These sectors also show a negative correlation between innovation and employment, likely due to reduced demand for unskilled labour.

Keywords: Industrialization · Structural Change · Technology.

JEL Codes: O10, O14, O30.

1 Introduction

Innovation and technological progress are widely recognized as crucial drivers of economic development and industrialization (Cirera & Maloney, 2017). The connection between innovation, technology, and industrialization is exemplified by each industrial revolution, which has advanced production systems and introduced ground-breaking innovations in mechanisation, automation, and information processing. These advancements have not only improved production efficiency but also enabled the creation of new products and industries (Malerba, 2006). Many East Asian nations have successfully leveraged innovation during their catch-up phases, leading to diversification and enhanced industrial competitiveness (Rodrik, 2008). However, numerous developing countries face difficulties in transitioning to higher value-added activities and generating employment in manufacturing, often confronting the issue of premature deindustrialization (Rodrik, 2016).

This paper aims to investigate the relationship between innovation and industrialization, particularly focusing on manufacturing value-added and employment in developing countries. The motivation for this research comes from the fact that most theoretical and empirical studies suggest a positive innovation-industrialization correlation. Fagerberg et al. (2010) argue that industrial growth is positively impacted by the rate of technological advancement. Domestic knowledge generation and the absorption of external knowledge empower countries to produce more sophisticated goods through ongoing diversification, product differentiation, and upgrading (Hidalgo et al., 2007; Hidalgo & Hausmann, 2009). Nevertheless, not all literature aligns with these findings. Stojcic and Aralica (2017) and Naudé and Tregenna (2023), for instance, find that technology variables have no or even negative effects on industrialization in Central and Eastern Europe and Africa. Similarly, Montobbio and Rampa (2005) and Bustos et al. (2019) note that Latin American countries have struggled to transition away from sectors with limited technological opportunities and traditional manufacturing industries.

The contribution of this paper lies in examining whether the relationship between innovation and industrialization in developing countries is linear (either positive or negative) or non-linear. To do this, I adopt a two-step approach. First, I use principal component analysis to construct a national innovation index based on the framework and indicators scoreboard from the Global Innovation Index (GII) for a sample of 53 developing and emerging countries in Latin America, Asia, Africa, and Central and Eastern Europe over the period from 1996 to 2018. Second, I conduct a panel estimation following the methodology proposed by Rodrik (2016), Dosi et al. (2021), and Naudé and Tregenna (2023), to test for a linear or non-linear correlation between innovation and industrialization. Specifically, in the econometric model, I introduce the national innovation index and its quadratic term to assess the innovation threshold at which an average developing country can effectively use innovation and technological progress to enhance the competitiveness of its industrial sector, as measured by increases in manufacturing value-added and employment shares.

The results indicate a U-shaped correlation between the national innovation index and manufacturing value-added shares, even when accounting for other time-varying control variables like trade openness and globalization. In the 1990s, developing countries

had low innovation levels after trade liberalization following the import-substitution industrialization era. Although technological progress occurred through foreign technologies and FDI, it was concentrated in low-tech sectors, leading to deindustrialization. Increased foreign competition forced less productive firms to exit, reallocating resources to more efficient firms and driving surviving firms to innovate. Once a country's innovation index reaches a threshold of 0.4 to 0.5, productivity and manufacturing value-added improve, boosting their competitiveness. This threshold has been met by countries in Asia and Central and Eastern Europe, explaining their higher manufacturing value-added shares within the sample.

Conversely, I observe a negative correlation between innovation and manufacturing employment. In contexts of low innovation, foreign competition forces low-productivity firms to leave the market, leading to job losses. At higher levels of innovation, labour-saving technologies boost productivity but also result in decreased employment. At the sub-sector level, a linear and positive relationship between innovation and both manufacturing value-added and employment shares is evident in the Supplier-Dominated, Scale-Intensive, and Specialized Suppliers sectors. In contrast, Science-Based sectors exhibit a U-shaped correlation, where increases in value-added occur only when the national innovation index surpasses 0.7, highlighting the necessity for internal R&D and the generation of advanced knowledge. Additionally, Science-Based sectors show a negative correlation between innovation and employment, likely due to diminished demand for unskilled labour or technological changes that favour skilled labour.

These findings should be approached with caution, as the estimated coefficients in the regression analysis may be affected by endogeneity issues, especially a positive reverse causality between innovation and industrialization, which could lead to an overestimation of the observed correlations. Nonetheless, the reported results can be exploited to evaluate policy measures that developing countries should implement to maximize the positive relationship between their innovation capacity and industrial competitiveness.

The paper is structured as follows: after this introduction, Section 2 provides a review of the literature concerning the relationship between innovation and industrialization, particularly in the context of developing countries. Section 3 outlines the data and methodology used to construct the national innovation index. Section 4 details the panel estimation approach employed to assess the correlations between innovation, manufacturing value-added, and employment shares. Finally, Section 5 presents the results and discussion of the empirical findings, while Section 6 concludes with recommendations for further research.

2 Literature Review

Several factors explain the positive relationship between innovation and industrialization. On the one hand, technological advances give rise to sectoral differences in prices (Ngai & Pissarides, 2007), in the use of skilled workers (Caselli & Colemam, 2001), and in the elasticity of substitution between capital and labour (Alvarez-Cuadrado et al., 2017; Herrendorf et al., 2015). These differences lead to a transition of the economy's resources from traditional sectors with low productivity, such as agriculture, to modern sectors with higher productivity, such as manufacturing industries (Samaniego & Sun, 2016).

On the other hand, innovation is linked to the evolution of countries' manufacturing product space or diversification which occurs mainly through two processes. First, structural upgrading allows the production of new, better, and more efficient products and processes in all manufacturing sectors (Giuliani et al., 2005). Second, structural change allows the movement of resources towards high-value-added sectors within the manufacturing industry (Janger et al., 2017). According to Dosi et al. (2021), this corresponds to increasing production in knowledge-intensity sectors such as chemicals, medical instruments, and machinery, while decreasing the importance of textiles, minerals, food, and tobacco products.

Empirically, Haraguchi et al. (2019) show that factors related to a country's level of innovation increase the probability of successful industrialization. In particular, factors such as investments in gross capital formation, human capital endowments, institutions, and the number of patent applications are positively correlated with manufacturing value-added growth in East Asia countries. These results are confirmed by De Oliveira and Da Fonseca (2022) for the case of 80 developing and developed countries from 1995 to 2016. Using a generalized method of moments (GMM), the authors demonstrate that each innovation variable positively affects industrial production, industrial employment, and the export of high-tech products. To measure the innovation process, the authors use variables classified into the following groups: innovative effort (R&D investments, number of researchers, and technicians), scientific and technological base (number of scientific articles, patents, and trademarks), and educational system (students in science and engineering).

However, not all empirical studies support the positive relationship between innovation and industrialization for all developing countries. For instance, Stojcic and Aralica (2017) find that for the period from 2009 to 2015 innovation activities have an ambiguous effect on the size of the manufacturing sector in Central and Eastern European emerging economies. The percentage of the workforce with digital skills has a positive but non-significant impact on value-added manufacturing share. Variables such as the number of patents, private and public investment in R&D, and the share of FDI in the manufacturing sector seem to have a significant but negative impact. Naudé and Tregenna (2023) find similar results for African countries from 1965 to 2018. The generalised least squares (GLS) estimates show that technological variables (such as high-tech exports, FDI, total factor productivity growth, and digital adoption index) were either statistically non-significant or when significant had a negative effect on manufacturing value-added and employment share.

Concerning manufacturing diversification and export performance, the empirical findings of Montobbio and Rampa (2005) suggest that the structural change driven by skill upgrading, FDI, and domestic technological effort had different results in the distribution of export activities in Asia and Latin America from 1985 to 1998. Asian countries built continuous improvements in technological competitiveness and high-tech exports. Meanwhile, Latin America struggled to transition away from activities with limited technological opportunities and traditional manufacturing sectors. Bustos et al. (2019) and Imbert et al. (2022) expand this analysis by demonstrating that in developing countries where rural-urban migration is still common, an inflow of unskilled

workers into the manufacturing sector induces labour-oriented technological change, the adoption of labour-intensive product varieties, and a decrease in patenting in fundamental innovation and capital- and skill-enhancing technologies. Those outcomes reinforce the export concentration of developing countries in low-tech and less sophisticated products (Vivarelli, 2018).

The ambiguous relationship between innovation, technological progress, and industrialization in developing countries, along with limited manufacturing diversification and exports, can be attributed to various factors. The literature generally highlights the influence of globalization and inadequate policies (Naudé & Tregenna, 2023). In contrast to Asian countries that adopted a development model centred on export-promoting industrialization (EPI) policies, many Latin American and African countries pursued import-substitution industrialization (ISI) policies from the 1950s to the 1980s (MacBean, 2000; Di Maio, 2008). Under the ISI model, countries developed an emerging manufacturing sector focused on low-tech and traditional products, relying on mature technologies and low-skilled labour within protected markets and state-owned enterprises. This approach failed to generate the necessary incentives to invest in efficient technologies, improve product quality, or build human capital (Lawrence, 2005; Firpo & Pieri, 2017).

Since 1990, trade liberalization has brought increased competition from high-income countries and developing countries that have comparative advantages in manufacturing, not only in low-tech products but also in more sophisticated ones as in the case of Asian manufacturing exporters (Rodrik, 2022). This has exerted significant pressure on the manufacturing industries established under the ISI model, relying mainly on labour-intensive product varieties and technologies. Despite some productivity gains through domestic technological progress, these industries have experienced declines in both output and employment, leading to premature deindustrialization (Rodrik, 2016). Then, for developing countries to sustain industrialization within global trade competition, they must prioritize accelerated innovation, focusing on knowledge creation and the adoption of cutting-edge technologies (Dahlman, 2008; Rodrik, 2016; Gries et al., 2018).

Therefore, developing countries must build private and public fundamentals (such as physical capital, skills, technology, innovation, infrastructure, and institutions) to produce new knowledge and to absorb the external knowledge available at the international level through the imports of inputs, capital goods, and FDI inflows that provide developing countries with embodied technologies, allowing them to practice imitation and reverse engineering (Lall, 1992; Vivarelli, 2014; Atolia et al., 2020). Innovation and technological progress result in dynamic comparative advantage in manufacturing, moving from labour-intensive to capital-intensive sectors, gaining industrial competitiveness in the international market, and increasing manufacturing labour shares and productivity (Ocampo, 2005; Uy & Zhang, 2013).

Given the empirical complexity of the innovation-industrialization relationship, this paper aims to examine the role of innovation in fostering industrialization in developing countries, particularly within the context of globalization and trade liberalization. It seeks to determine at what levels of national innovation the correlation with industrialization is negative, positive, or nonsignificant, both for the overall manufacturing

sector and its subsectors to assess the relationship between innovation and industrial diversification.

In the following sections, I construct a national innovation index based on the Global Innovation Index (GII) framework for a sample of 53 developing countries from 1996 to 2018. I then examine the correlation between this national innovation index and industrialization, as measured by manufacturing value-added and employment share. I anticipate that the correlation with industrial development will be negative or nonsignificant at low levels of national innovation, as highlighted in the literature. Industries established under the ISI model, coupled with the competitive pressures of the 1990s, are likely to experience declines in both output and employment, despite domestic productivity gains through technological progress. Subsequently, I aim to identify the level of national innovation at which the correlation with industrialization becomes positive—that is, the threshold of innovation index that enables a developing country to industrialize both in value-added and employment and compete effectively in a globalized market.

3 National Innovation Index

3.1 Conceptual Framework

According to the Oslo Manual, innovation is defined as a "new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)" (OECD/Eurostat, 2018, p. 20). Then, the term innovation can refer to both the process of an activity and the result of that activity. On the other hand, the technological capability of a country refers to "the ability to develop, search for, absorb, and exploit knowledge commercially" (Fagerberg et al., 2010, p. 839).

The complexity of a country's innovation systems is shaped by various agents and factors, such as firms, researchers, governments, universities, commercial flows, and institutions (Cirera & Maloney, 2017). Catellacci and Natera (2013) group these agents and factors in innovative capability and absorptive capacity. Innovative capability is based on the input-output framework, where inputs are the investments and resources necessary to conduct scientific activities, and outputs represent the knowledge and inventions that come as a product of those investments (Godin, 2007). On the other hand, absorptive capability is based on infrastructures, international trade, human capital, and institutions that enable the production of new knowledge, and the absorption and use of external knowledge and technological opportunities (Vivarelli, 2014).

Gokhberg (2013), Hollanders and Janz (2013), Khayyat and Lee (2015), and Ndege et al. (2021) present a critical review of several scoreboards and indices that summarise innovation indicators to compare innovation performance across countries. I decide to use the indicators and framework of the Global Innovation Index (GII) (WIPO, 2023) to analyse the correlation between national innovation and industrialization. The rationality of using GII comes from various factors. First, GII considers both the input-output and the enabling conditions framework previously described. Second, it provides a picture of the innovation systems across the globe, allowing comparisons among developed

and developing countries. Third, GII is a popular measure of a country's innovation competitiveness, as it is used largely across the literature (Crespo & Crespo, 2016; Huarng & Yu, 2022; Bate et al., 2023; Alqararah, 2023; Nasir & Zhang, 2024).

However, the GII has many drawbacks. Indicators used in GII (scoreboard) are constantly updated as technology develops. This feature, although positive, could be a disadvantage for my analysis as it could make difficult the comparison of national innovation levels across time and countries. I decided to work with a set of fixed indicators following the GII framework from the first year of publication in 2007 (described in Section 3.2 of this paper). On the other hand, the GII index is computed as the simple average of the input and output sub-indexes, with each sub-index being the simple average of its respective pillars and sub-pillars. Since various indicators among the index are not comparable, the simple average calculation could be problematic. Furthermore, simple averages suggest that indicators, pillars, sub-pillars, and sub-indexes have the same significance. Therefore, following the literature (Fagerberg & Srholec, 2021, among others), I use a Principal Component Analysis (PCA) to calculate the index, sub-indexes, and pillars (Section 3.3 of this paper).

3.2 Data

The GII indicators are divided into seven pillars, which are further grouped into innovation input and output sub-indices. The input sub-index captures the elements of the economy that enable and facilitate innovation activities and comprises the pillars of institutions, human capital and research, infrastructure, market sophistication, and business sophistication. The output sub-index captures the results of innovation activities within the economy and groups the pillars of scientific and creative outputs (WIPO, 2023). The pillars, sub-pillars and indicators of each sub-index are the following[1]:

Input sub-index:

1. Institutions pillar: comprises factors of good governance and levels of protection and incentives for innovation.
    - 1.1 Political environment sub-pillar: political stability, absence of violence/terrorism, and government effectiveness.
    - 1.2 Regulatory environment sub-pillar: regulatory quality and rule of law.
    - 1.3 Business environment sub-pillar: time required to start a business, cost of business and total tax rate.
2. Human capital and research pillar: allow countries to move up the value chain and creation of new products and processes. For this analysis, human capital is focused on tertiary education enrolment in sectors associated with technological innovation, such as science and engineering.
    - 2.1 Tertiary education sub-pillar: tertiary school enrolment, tertiary graduates in

[1]Novillo-Villegas et al. (2022) and Bate et al. (2023) present a systematic literature review of the effect of each GII indicator on the national innovation level.

science, technology, and mathematics programs, tertiary graduates in engineering and manufacturing programs.

2.2 Research and development (R&D) sub-pillar: researchers in R&D and R&D expenditure.

3. Infrastructure pillar: comprises factors that facilitate the production and exchange of ideas and goods, increasing productivity.

   3.1 Information and communication technologies (ICT) sub-pillar: individuals using the internet, government's online service index, and online participation index.

   3.2 General infrastructure sub-pillar: access to electricity, logistic performance index, and gross capital formation.

4. Market sophistication pillar: comprises factors that support investment, access to the international markets, and competition.

   4.1 Credit sub-pillar: depth of credit information and domestic credit to private sector.

   4.2 Trade and competition sub-pillar: tariff rate on manufacturing products, competitive industrial performance index, imports and exports of goods and services.

5. Business sophistication pillar: comprises factors that foster a business's productivity, competitiveness, and innovation.

   5.1 Indicators are royalty and license payments, high-tech imports, computer, communications, and other services imports, and foreign direct investments (FDI) inflows.

Output sub-index:

1. Scientific output pillar: comprises factors considered as the fruit of innovation activities, such as the creation, impact, and diffusion of knowledge.

   1.1 Knowledge creation sub-pillar: number of patent and utility model applications, scientific and technical journal articles.

   1.2 Knowledge diffusion and impact sub-pillar: new business density and high-tech exports.

2. Creative output pillar: comprises intangibles from innovation activities.

   2.1 Indicators are the number of trademark registrations and industrial design applications.

I use 35 out of the 80 indicators available in the GII scoreboard. These indicators were selected based on data availability for the 53 countries analysed in this study from 1996 to 2018. In turn, the sample of developing countries and years is chosen according to the data availability in the Economic Transformation Database (ETD – GGDC/UNU-WIDER) and Economic Transformation Database of Transition Economies (ETD-TE), which are used in the industrialization analysis presented in Section 4 of this paper (Kruse

et al., 2023; Hamilton & Vries, 2023). The final dataset of countries by region is the following:

- Latin America (LAC): Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Mexico and Peru.
- South East Asia (SEA): Bangladesh, Cambodia, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Thailand and Turkey.
- Africa (AFR): Botswana, Burkina Faso, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Lesotho, Malawi, Mauritius, Morocco, Mozambique, Namibia, Nigeria, Rwanda, Senegal, South Africa, Tanzania, Tunisia, Uganda and Zambia.
- Central and Eastern Europe (CEE): Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Latvia, Lithuania, Russia, Ukraine and Uzbekistan.

Before performing PCA to calculate the composite national innovation index, the raw indicators are first processed according to the method recommended by the OECD (2008). This involves normalizing the data by identifying and replacing statistical outliers[2], imputing missing values[3], and then using a max-min transformation[4]. Detailed descriptions and sources for each indicator are provided in Table A1 of Appendix A, while the regional averages for each normalized indicator are listed in Table D1 of Appendix D.

3.3 Methodology: Principal Component Analysis (PCA)

As stated before, this paper relies on Principal Component Analysis (PCA) as a weighting-aggregation method to reproduce the sub-pillars, pillars, sub-indexes, and the composite national innovation index (based on GII) to calculate the technological and innovation level of each developing country.

PCA is a statistical technique that transforms a high number of correlated indicators (Xq) into a low number of uncorrelated dimensions or principal components (Yp, where p<q), taking into account most of the variance of the original data. Each principal component Y is the linear combination of original indicators X as shown in the following equations:

[2]Identifying Positive (negative) outliers: country scores which are higher (lower) than the mean across all countries plus (minus) twice the standard deviation. Each outlier is replaced by the maximum (minimum) value observed over the years and in all countries.

[3]Single or multiple imputations are made according to: (i) Linear single interpolation: when missing data between 2 known years; (ii) Linear trend extrapolation: when missing data before or after a given year. Following UNDP (2001) missing data for patents, trademarks, and industrial designs indicate that formal innovation is not occurring. Then, missing data in those cases is replaced with zeros.

[4]The observed minimum and maximum values are calculated across time and countries for each indicator. Then each observation is normalized or standardized with a value between 0 and 1 using the following formula: Standardized indicator = (observed value – minimum value) / (maximum value-minimum value).

$$
\begin{aligned}
Y_1 &= a_{11}X_1 + a_{12}X_2 + \cdots + a_{1Q}X_Q \\
Y_2 &= a_{21}X_1 + a_{22}X_2 + \cdots + a_{2Q}X_Q \\
&\vdots \\
Y_P &= a_{P1}X_1 + a_{P2}X_2 + \cdots + a_{PQ}X_Q \\
&\vdots \\
Y_Q &= a_{Q1}X_1 + a_{Q2}X_2 + \cdots + a_{QQ}X_Q
\end{aligned} \tag{1}
$$

Where a_i is the relative weight or loadings of each indicator X_i that enter in the principal component Y_i. The final number of principal components used to construct a composite index is determined by the Kaiser rule, according to which the chosen principal components are those with an eigenvalue equal to or bigger than 1, meaning that those principal components account for the maximum proportion of the variance of the original data.

Appendix B provides the correlation of the indicators organized by pillar, along with the application of the PCA methodology for each sub-pillar, pillar, sub-index, and the overall national innovation index. In most cases, the first principal component is selected because its eigenvalue exceeds 1 (see panel A of Tables C1 to C21). Subsequently, the first principal component is calculated using the loadings (weights) presented in panel B of those tables.

The only exception is in the calculation of the business sophistication pillar (Table C14), where both the first and second principal components satisfy the Kaiser criterion, explaining 39.9% and 25.2% of the data's variance, respectively. Here, the first principal component is driven by the indicators of royalty payments and ICT services imports, while the second principal component is influenced by high-tech imports and FDI inflows. Consequently, the business sophistication pillar is computed as a weighted average of the first and second principal components, with the weights reflecting the proportion of variance explained by each component.

The final national innovation index is derived from the first principal component, which accounts for 81.7% of the original data (panel A Table C21). In this case, both the innovation input and output sub-indexes contribute equally in terms of loadings or weights to the calculation of the national innovation index. While this approach could be seen as problematic, as it implies that one unit from one sub-index can be substituted for a unit from the other, it's important to note that the output sub-index consists of only two pillars, whereas the input pillar includes five. This means that, in practice, the output pillars carry greater weight than the input pillars (Cabeza-Martinez et al., 2023).

3.4 Results

Tables D1 to D3 of Appendix D present the main results by country and region from the PCA analysis. Since all indicators are normalized, the sub-pillars, pillars, sub-indexes,

and the final innovation index range from 0 to 1.

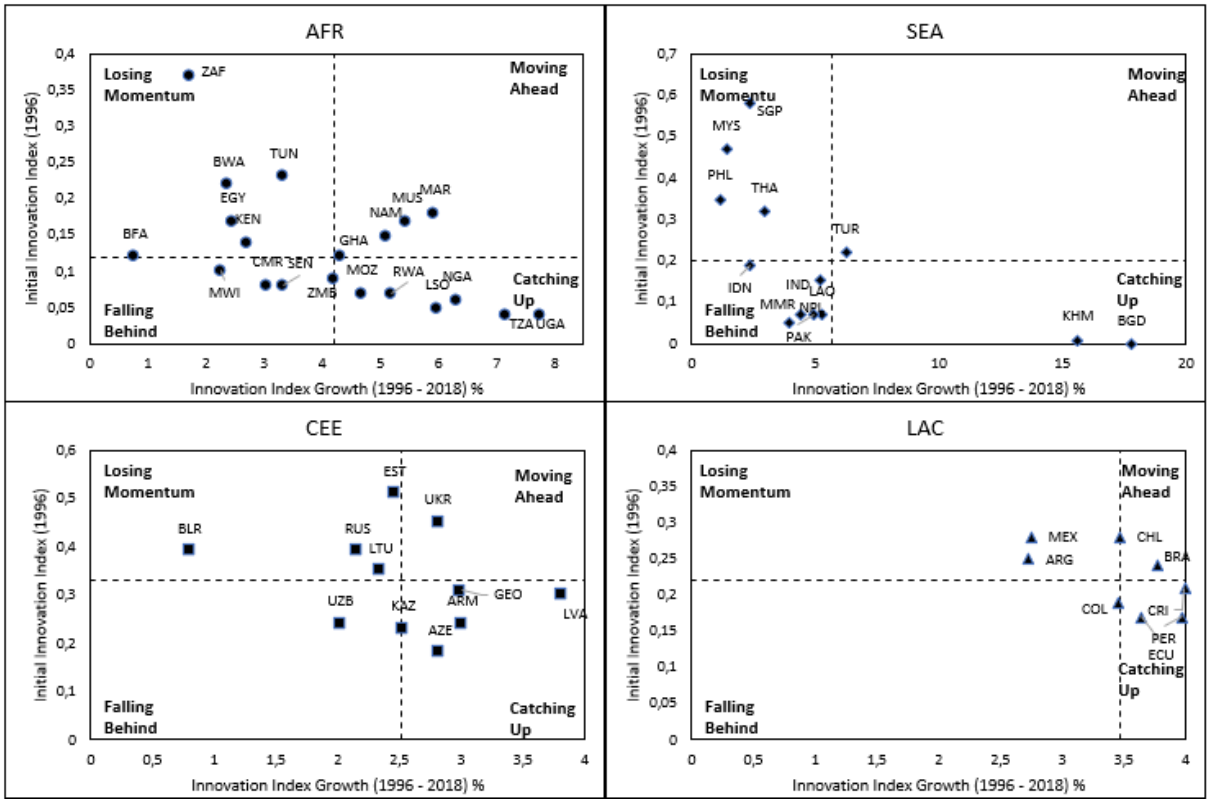
Table D1 shows that CEE is the region with the highest average national innovation index (0.44), followed by LAC (0.35), SEA (0.31), and finally AFR (0.19). On average, the innovation input sub-index is higher than the innovation output sub-index for all regions, except for CEE where both sub-indexes show the same average contribution.

The findings from Table D2 indicate that, first, all countries saw an increase in their national innovation index between 1996 and 2018. Second, in 2018, the countries with the highest innovation levels in each region were Singapore (0.97), Estonia (0.86), Morocco (0.63), and Chile (0.60). Table D3 highlights that, on average, the CEE and SEA regions had the highest levels across both the input and output sub-indexes in 2018. Infrastructure and institutions ranked the highest among the pillars across all regions, followed by market sophistication, human capital, business sophistication, scientific output, and creative output.

These findings could be concerning, as they indicate that high levels of innovation inputs may be underutilized or inefficiently converted into innovation outputs. In developing countries, the creation and registration of innovation outputs—such as patents, trademarks, and industrial designs—have historically been low. However, the factors that drive innovation, such as inputs facilitating the creation of new knowledge, the development of improved products and processes, and the absorption and imitation of foreign knowledge and existing innovations, play a more significant role. Unfortunately, these factors are not adequately reflected in the output indicators shown in scoreboards for developing countries over time (Gorodnichenko et al., 2010).

On the other hand, Figure 1 plots the development of a country's innovation from 1996 – 2018 (CAGR% - Compound Annual Growth Rate) against its initial level in 1996. For each region, four quadrants appear taking into account their average innovation growth and initial level. The countries in the top-right quadrants combine a high initial innovation level with an above-average increase. Hence, these countries are "moving ahead" in their national innovation index. Morocco, Mauritius, Namibia, and Ghana in AFR, Turkey in SEA, Ukraine in CEE, and Chile and Brazil in LAC compromise this group of countries. On the other hand, countries such as Uganda, Bangladesh, Latvia, and Costa Rica are catching up since their initial national innovation level is low but have demonstrated great innovation development over time. Surely, these national innovation trends have a crucial correlation with the industrialization opportunities of developing countries.

Figure 1: National Innovation Index Trend



Source: Author's calculations. The horizontal dashed lines give the average national innovation index in 1996 and by region. The vertical dashed lines give the average compound annual growth rate (CAGR%) from 1996 to 2018 by region.
Countries in Africa (AFR): Botswana (BWA), Burkina Faso (BFA), Cameroon (CMR), Egypt (EGY), Ethiopia (ETH), Ghana (GHA), Kenya (KEN), Lesotho (LSO), Malawi (MWI), Mauritius (MUS), Morocco (MAR), Mozambique (MOZ), Namibia (NAM), Nigeria (NGA), Rwanda (RWA), Senegal (SEN), South Africa (ZAF), Tanzania (TZA), Tunisia (TUN), Uganda (UGA), and Zambia (ZMB).
Countries in South East Asia (SEA): Bangladesh (BGD), Cambodia (KHM), India (IND), Indonesia (IDN), Laos (LAO), Malaysia (MYS), Myanmar (MMR), Nepal (NPL), Pakistan (PAK), Philippines (PHL), Singapore (SGP), Thailand (THA), and Turkey (TUR).
Countries in Central and East Europe (CEE): Armenia (ARM), Azerbaijan (AZE), Belarus (BLR), Estonia (EST), Georgia (GEO), Kazakhstan (KAZ), Latvia (LVA), Lithuania (LTU), Russia (RUS), Ukraine (UKR), and Uzbekistan (UZB).
Countries in Latin America (LAC): Argentina (ARG), Brazil (BRA), Chile (CHL), Colombia (COL), Costa Rica (CRI), Ecuador (ECU), Mexico (MEX), Peru (PER).

4 Innovation and Industrialization Relationship

4.1 Data

The next step is to examine the correlation between the national innovation index and the industrialization process of the selected countries from 1996 to 2018.

Following Rodrik (2016), two variables are used to measure the level of industrialization in the selected countries: first, the manufacturing employment share (*manemp*), which is defined as the proportion of manufacturing employment relative to total employment; and second, the real manufacturing value-added share (*realmva*), defined as the manufacturing value-added as a percentage of GDP, adjusted to constant 2015 US

dollars to account for price variations across countries and over time. Both variables are sourced from the Economic Transformation Database (ETD – GGDC/UNU-WIDER) and the Economic Transformation Database of Transition Economies (ETD-TE) (Kruse et al., 2023; Hamilton & de Vries, 2023).

Also, following Rodrik (2016), as explanatory variables, it is considered population and the GDP per capita (constant 2015 US Dollars) presented in logarithms (*lnpop, lngdp*) and square logarithms (*lnpop2, lngdp2*). Both variables come from the Maddison Project Database (Bolt & Van Zanden, 2024).

Other control variables or time-varying national characteristics that may be associated with the industrialization process include (i) the logarithm of unbalanced productivity growth (*lnupg*), defined as the ratio of manufacturing labour productivity to services labour productivity, with labour productivity measured as real value-added (constant 2015 US dollars) per worker in each sector. The data for manufacturing and services value-added and employment is sourced from the ETD and ETD-TE databases (Kruse et al., 2023; Hamilton & de Vries, 2023); (ii) the logarithm of the unemployment share of the total labour force (*lnumpl*), obtained from World Bank data (modelled ILO estimate); (iii) the real effective exchange rate (*exchr*), also from World Bank data; (iv) total natural resource rents as a percentage of GDP (*natural*), sourced from World Bank data; and (v) the logarithm of manufacturing imports and exports, to and from high- and medium-low-income countries, taken from the Comtrade database via the WITS platform and UNIDO.

The sectoral analysis is based on Pavitt's industrial taxonomy (Pavitt, 1984): "(i) Science-Based industries (SB) include sectors where innovation is based on advances in science and R&D (such as the pharmaceutical, electronics, computers, radio) where research laboratories are important, leading to intense product innovation and a high propensity to patent; (ii) Specialised Supplier industries (SS) include the sectors producing machinery and equipment; their products are new processes for other industries. R&D is present but an important innovative input comes from tacit knowledge and design skills embodied in the labour force. Average firm size is small and innovation is carried out in close relation with consumers; (iii) Scale-Intensive industries (SI) include sectors (such as the automotive sector) characterized by large economies of scale and oligopolistic markets where technological change is usually incremental. New processes (often related to information technology) shape the organization of production and coexist with new product development; (iv) and Supplier Dominated industries (SD) include traditional sectors (such as food and textiles) where internal innovative activities are less relevant, small firms are prevalent and technological change is mainly introduced through the inputs and machinery provided by suppliers from other industries" (Bogliacino & Pianta, 2010, p. 801).

Sources of sectoral employment and value-added shares in 4-digit ISIC Rev. 3 codes come from UNIDO Industrial Statistical Data, ILOSTAT, and World Bank Data. Table E1 in Appendix E presents the Pavitt taxonomy for manufacturing industries, listed using 2-digit ISIC Rev. 3 codes.

Finally, Table E2 in Appendix E shows the summary statistics for each variable of this analysis.

4.2 Panel Approach

To assess the national innovation-industrialization correlation for the panel of 53 developing countries from 1996 to 2018, I use the parametric specification used by Rodrik (2016), Dosi et al. (2021), and Naudé and Tregenna (2023) presented in equation (2):

$$\begin{aligned}\text{Manufacturing Share}_{it} = \beta_0 + \beta_1 \ln \text{pop}_{it} + \beta_2 \ln \text{pop}_{it}^2 + \beta_3 \ln \text{gdp}_{it} + \beta_4 \ln \text{gdp}_{it}^2 \\ + \sum_i \gamma_i D_i + \sum_t \varphi_t \text{period}_t + \varepsilon_{it} \end{aligned} \tag{2}$$

Where *Manufacturing Share*$_{it}$ serves as the measure of industrialization—using either *realmva* or *manemp*—for each country i at time t. The logarithm of the population and its square (*lnpop, lnpop2*) account for demographic effects. The logarithm of GDP per capita and its square (*lngdp, lngdp2*) reflect the industrialization process throughout a country's development, illustrating the inverted U-shape relationship between the manufacturing sector and income per capita (Rodrik, 2016). D_i represents country fixed effects to account for differences in geography, resources, history, etc., period$_t$ is a set of year dummies that control for time fixed effects, and ε_{it} is the idiosyncratic error term.

As I aim to understand the correlation between innovation and industrialization measures, equation (2) is augmented with the innovation index and its square (both lagged one period), and control variables $X_i t$ that influence industrialization (described in Section 4.1). Thus, equation (2) can be written as:

$$\begin{aligned}\text{Manufacturing Share}_{it} = \beta_0 + \beta_1 \ln \text{pop}_{it} + \beta_2 \ln \text{pop}_{it}^2 + \beta_3 \ln \text{gdp}_{it} + \beta_4 \ln \text{gdp}_{it}^2 \\ + \beta_5 \text{innovation index}_{it-1} + \beta_6 \text{innovation index}_{it-1}^2 \\ + \mathbf{X}'_{it}\beta_7 + \sum_i \gamma_i D_i + \sum_t \varphi_t \text{period}_t + \varepsilon_{it} \end{aligned} \tag{3}$$

As discussed in Section 2, the relationship between innovation and industrialization in developing countries is empirically complex. I employ a quadratic specification to test whether there is an empirical threshold at which the correlation between national innovation levels and industrialization shifts from negative or non-significant to positive. The goal is to determine the level of innovation needed to trigger the industrialization process within the context of globalization and trade liberalization, including as main control variables trade and capital openness variables described in Section 4.1.

To assess the relationship between innovation, industrial diversification and, heterogeneity across manufacturing industries, equation (3) is changed in the following way:

$$\begin{aligned}\text{Manufacturing Share}_{ijt} = {} & \beta_0 + \beta_1 \ln \text{pop}_{it} + \beta_2 \ln \text{pop}_{it}^2 + \beta_3 \ln \text{gdp}_{it} + \beta_4 \ln \text{gdp}_{it}^2 \\ & + \beta_5 \text{innovation index}_{it-1} + \beta_6 \text{innovation index}_{it-1}^2 \\ & + \mathbf{X}'_{it}\beta_7 + \mathbf{Z}'_{ijt}\beta_8 + \sum_i \gamma_i D_i + \sum_j \gamma_j D_j + \sum_t \varphi_t \text{period}_t + \varepsilon_{it}\end{aligned} \tag{4}$$

Where *Manufacturing Share*$_{ijt}$ serves as the measure of industrialization for each country i and sector j (at a level of disaggregation of 4-digit ISIC Rev. 3) at time t. Z_ijt corresponds to control variables at sectoral level, such as sectoral exports and imports, and D_j represents sector fixed effects (2-digit ISIC Rev. 3) to account for industry specific and time invariant unobservable characteristics.

However, the panel coefficients of the innovation index in this analysis are biased due to endogeneity issues, primarily arising from measurement errors during the index construction, omitted variables, and reverse causality between industrialization measures and the national innovation index.

Reverse causality occurs because national innovation efforts not only impact industrialization, but a more productive manufacturing sector can also strengthen a country's innovation capacity and technological capabilities. A significant portion of innovation and technological progress stems from the manufacturing sector itself (Szirmai, 2012). This aligns with the "demand-pull hypothesis," where firms innovate and create new products in response to market demand (Teixeira & Queiros, 2016). In this context, Saviotti and Pyka (2017) suggest that when demand becomes saturated, it drives product differentiation and the emergence of new sectors.

Saha and Ciarli (2018) demonstrate that there are positive, reinforcing mechanisms between innovation and structural change, with structural change encouraging the adoption of new technologies. As a result, the panel estimated coefficients are likely overestimated, as the estimators capture not only the impact of innovation on industrialization but also the positive feedback from industrialization on innovation and technological advancement.

Acknowledging the endogeneity issue, in the next section, I will concentrate on examining the correlation between innovation and industrialization, along with the potential non-linear relationship reflected in the quadratic term of the national innovation index.

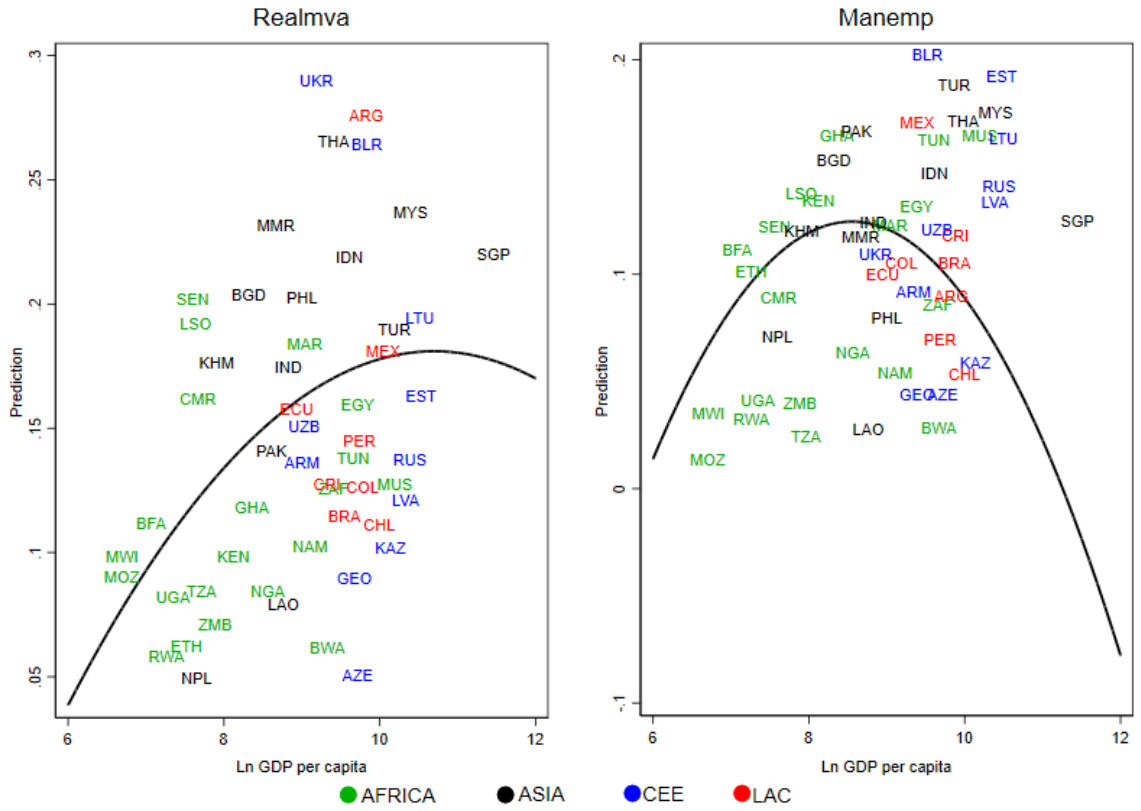
5 Results and Discussion

5.1 General Regression Results

Columns 1 in Tables 1 and 2 display the results from the equation (2) specification. The findings indicate that both measures of industrialization rise with income up to a certain point, after which they begin to decline. This pattern confirms the established observation in the literature (Rodrik, 2016; Dosi et al., 2021; Naudé & Tregenna, 2023) of an inverted

U-shape for the manufacturing sector over the course of development. The estimates reveal that the average country in the sample reaches a peak Realmva of 0.17 at a GDP per capita (logarithmic) level of 9.553. The maximum Manemp is slightly lower, peaking at approximately 0.13 when GDP per capita (logarithmic) reaches 8.550. These results suggest that countries in the sample tend to deindustrialize in employment more rapidly than in value-added.

Figure 2: Real Manufacturing Value-Added and Employment Share as a Function of Income (GDP per capita)



Source: Author's calculations. The solid curves represent the estimations of manufacturing shares with respect to the logarithm of GDP per capita for a representative country, taking the mean value for other covariates presented in Tables 1 and 2.
The scatter plot represents the observed manufacturing shares vs. the logarithm of GDP per pita for each country in the sample for the year 2018.
Countries in Africa (AFR): Botswana (BWA), Burkina Faso (BFA), Cameroon (CMR), Egypt (EGY), Ethiopia (ETH), Ghana (GHA), Kenya (KEN), Lesotho (LSO), Malawi (MWI), Mauritius (MUS), Morocco (MAR), Mozambique (MOZ), Namibia (NAM), Nigeria (NGA), Rwanda (RWA), Senegal (SEN), South Africa (ZAF), Tanzania (TZA), Tunisia (TUN), Uganda (UGA), and Zambia (ZMB).
Countries in South East Asia (SEA): Bangladesh (BGD), Cambodia (KHM), India (IND), Indonesia (IDN), Laos (LAO), Malaysia (MYS), Myanmar (MMR), Nepal (NPL), Pakistan (PAK), Philippines (PHL), Singapore (SGP), Thailand (THA), and Turkey (TUR).
Countries in Central and East Europe (CEE): Armenia (ARM), Azerbaijan (AZE), Belarus (BLR), Estonia (EST), Georgia (GEO), Kazakhstan (KAZ), Latvia (LVA), Lithuania (LTU), Russia (RUS), Ukraine (UKR), and Uzbekistan (UZB).
Countries in Latin America (LAC): Argentina (ARG), Brazil (BRA), Chile (CHL), Colombia (COL), Costa Rica (CRI), Ecuador (ECU), Mexico (MEX), Peru (PER).

Figure 2 provides a visual representation of these findings. In 2018, most LAC countries

had manufacturing shares below the estimated curve for an average country, suggesting their manufacturing shares were lower than expected based on their GDP per capita. Similarly, African countries exhibited lower manufacturing shares relative to GDP per capita than other regions. In contrast, SEA and CEE countries exhibited a different trend, with most exceeding the estimated curve. This outperformance aligns with higher national innovation index levels, as discussed in Section 3.

The findings for the correlation with the national innovation index are as follows. Table 1, Columns (2) to (5), reveals a non-linear relationship between Realmva and innovation levels. The coefficients for the innovation index are negative, while those for its square are positive, and both are statistically significant. The U-shape is confirmed by the Lind and Mehlum (2010) test, which shows a negative slope at the minimum point and a positive slope at the maximum point. These results hold even when other time-varying control variables related to industrialization, such as trade openness and unbalanced productivity growth, are included.

A possible explanation for this convex correlation is as follows: low innovation levels were evident during the early phase of this analysis, particularly in the 1990s, when countries underwent significant trade liberalization after having industrialized within closed national borders under ISI policies. In the era of globalization, developing countries saw some technological advancement domestically, as indicated by the rise in the innovation index through the adoption of foreign technologies, including FDI inflows, royalty payments, and imported inputs. This enabled them to engage in imitation and reverse engineering (Lall, 1992; Vivarelli, 2014; Atolia et al., 2020). However, competition from foreign manufacturers in domestic markets outpaced this technological progress, which was mostly concentrated in low-tech sectors, unskilled labour, and traditional products (Bustos et al., 2019; Imbert et al., 2022), leading to deindustrialization in terms of value-added (Rodrik, 2016).

Increased foreign competition could result in two potential outcomes. First, trade liberalization may force low-productivity manufacturing firms to exit domestic markets, leading to a reallocation of resources toward more productive and expanding firms (Melitz, 2003). Eslava et al. (2013) demonstrate that reduced trade protection intensifies the relationship between firm survival and productivity. The second outcome is that greater competition pushes surviving firms to improve technology and innovation, enabling them to boost productivity, compete more effectively, and differentiate their products from competitors (Teece, 2009).

My findings indicate that productivity gains and increased manufacturing value-added become possible when the national innovation index reaches a range of 0.4 to 0.5. Beyond this threshold, developing countries can compete more effectively by leveraging increased innovation capacities and technological advancements to create new products and enhance existing ones. As a result, their share of real manufacturing value-added increases. Tables D1 and D2 in Appendix D show that countries in the SEA and CEE regions tend to have innovation index levels at or above this empirical threshold, which could account for their higher real manufacturing value-added share compared to other regions, as seen in Figure 2.

Table 1: Real Manufacturing Value Added and Innovation Index

VARIABLES	(1)	(2)	(3)	(4)	(5)
Ln population	-0.141***	-0.144***	-0.137***	-0.038	-0.288***
	(0.040)	(0.040)	(0.040)	(0.043)	(0.039)
Ln population squared	0.005**	0.005**	0.004*	-0.002	0.014***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Ln GDP per capita	0.138***	0.131***	0.193***	0.132***	0.125***
	(0.033)	(0.032)	(0.035)	(0.033)	(0.027)
Ln GDP per capita squared	-0.006***	-0.006***	-0.010***	-0.016***	-0.006***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Innovation index		-0.015	-0.125***	-0.172***	-0.116***
		(0.011)	(0.023)	(0.022)	(0.020)
Innovation index squared			0.113***	0.156***	0.133***
			(0.019)	(0.018)	(0.018)
Manufacturing exports(% total exports)				0.029***	
				(0.010)	
Manufacturing imports (% total imports)				-0.086***	
				(0.016)	
Manuf.exports to high-income countries (% Apparent consumption)					0.000
					(0.000)
Manuf.imports from high-income countries (% Apparent consumption)					0.001*
					(0.001)
Manuf.exports to low-medium-income countries (% Apparent consumption)					0.012
					(0.027)
Manuf.imports from low-medium-income countries (% Apparent consumption)					-0.077***
					(0.019)
Unbalanced productivity growth				0.000017	0.000016*
				(0.000)	(0.000)
Constant	0.539**	0.605**	0.328	0.808***	0.979***
	(0.254)	(0.258)	(0.269)	(0.274)	(0.243)
Observations	1,219	1,219	1,219	1,123	794
R-squared	0.906	0.910	0.912	0.929	0.972
Year FE	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y
Region FE	N	N	N	Y	Y
Ln GDP turnover	9.553	10.775	9.988	10.012	10.737
P-value	0.000	0.000	0.000	0.000	0.000
Industrialization share turnover			0.136	0.134	0.152
Index turnover			0.554	0.554	0.433
P-value			0.000	0.000	0.000
t-test Nonlinearity index [a]			4.70	7.12	5.75
P-value			0.000	0.000	0.000
Slope at Min			-0.125***	-0.172***	-0.115***
Slope at Max			0.100***	0.138***	0.157***

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001.
[a] Lind & Mehlum (2010) overall test of presence of an Inverse U shape. Test: H1: U shape vs. H0: Monotone or Inverse U shape.

On the other hand, Table 2 presents a negative and linear relationship between innovation and the manufacturing employment share, which remains consistent after including additional control variables (columns (2) to (5)). This negative correlation can be attributed to two factors. First, at low innovation levels, the decline in manufacturing employment shares may reflect the exit of low-productivity firms due to intensified foreign competition, as previously mentioned. Second, at higher innovation levels, there may be a labour-saving effect, as new technologies often result in productivity gains that can reduce employment. This is well-documented in the literature, where technological advancements while boosting productivity, may negatively impact jobs. Furthermore, innovation has a qualitative dimension: new technologies require the support of highly skilled labour to be effectively implemented (Vivarelli, 2014; Calvino & Virgillito, 2018). However, developing countries are typically characterized by a higher proportion of unskilled labour, as indicated in Table D3 of Appendix D, where human capital ranks as one of the lowest innovation inputs across regions in 2018. These findings may help explain the decline in manufacturing employment shares as innovation increases.

Table 2: Real Manufacturing Value Added and Innovation Index

VARIABLES	(1)	(2)	(3)	(4)	(5)
Ln population	-0.132***	-0.140***	-0.142***	-0.163***	-0.287***
	(0.029)	(0.029)	(0.029)	(0.031)	(0.044)
Ln population squared	0.008***	0.008***	0.009***	0.010***	0.017***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Ln GDP per capita	0.291***	0.275***	0.255***	0.262***	0.203***
	(0.020)	(0.020)	(0.022)	(0.024)	(0.031)
Ln GDP per capita squared	-0.017***	-0.016***	-0.015***	-0.015***	-0.011***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Innovation index		-0.037***	-0.003	0.016	-0.043**
		(0.009)	(0.020)	(0.020)	(0.022)
Innovation index squared			-0.036**	-0.034**	0.019
			(0.018)	(0.017)	(0.018)
Manufacturing exports (% total exports)				0.000	
				(0.006)	
Manufacturing imports (% total imports)				-0.027**	
				(0.012)	
Manuf.exports to high-income countries (% Apparent consumption)					0.000
					(0.000)
Manuf.imports from high-income countries (% Apparent consumption)					0.003***
					(0.001)
Manuf.exports to low-medium-income countries (% Apparent consumption)					0.071***
					(0.026)
Manuf.imports from low- and medium-income countries (% Apparent consumption)					-0.030*
					(0.017)
Unbalanced productivity growth				-0.00022**	-0.00003***
				(0.000)	(0.000)
Unemployment rate				-0.00617***	-0.000
				(0.000)	(0.000)
Constant	-0.641***	-0.480***	-0.393**	-0.406**	0.324
	(0.166)	(0.171)	(0.169)	(0.184)	(0.255)
Observations	1,219	1,219	1,219	1,123	794
R-squared	0.945	0.946	0.946	0.951	0.961
Year FE	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y
Region FE	N	N	N	Y	Y
Ln GDP turnover	8.550	8.508	8.497	8.861	9.463
P-value	0.000	0.000	0.000	0.000	0.000

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001.

The correlations between innovation, manufacturing value-added, and employment remain robust when additional control variables are included. As shown in Tables F1 and F2 of Appendix F, the results for innovation and threshold levels hold with the inclusion of trade openness variables. Manufacturing exports boost both value-added and employment in the sector, as globalization grants developing countries access to foreign markets where they can gain knowledge, adopt best practices, and receive technical assistance from international clients. This promotes innovation, enhances product quality, and increases production, thus driving the demand for labour (Verhoogen, 2008). Manufacturing imports show a negative correlation with industrialization, reinforcing the negative impact of foreign competition (from both high- and low-income countries) on manufacturing employment and value-added.

Other aspects of globalization, such as the Trade and Competition Sub-Pillar and the Business Sophistication Pillar of the Innovation Index, significantly influence industrialization. Variables like high-tech and ICT imports, along with FDI, positively contribute to manufacturing value-added but have a negative effect on employment, consistent with the earlier literature. Additionally, other time-varying factors, such as the real exchange rate and natural resource endowments, are considered. In line with Haraguchi et al. (2019), a high real exchange rate and natural resource rents, often associated with Dutch Disease, have adverse effects on both industrialization measures.

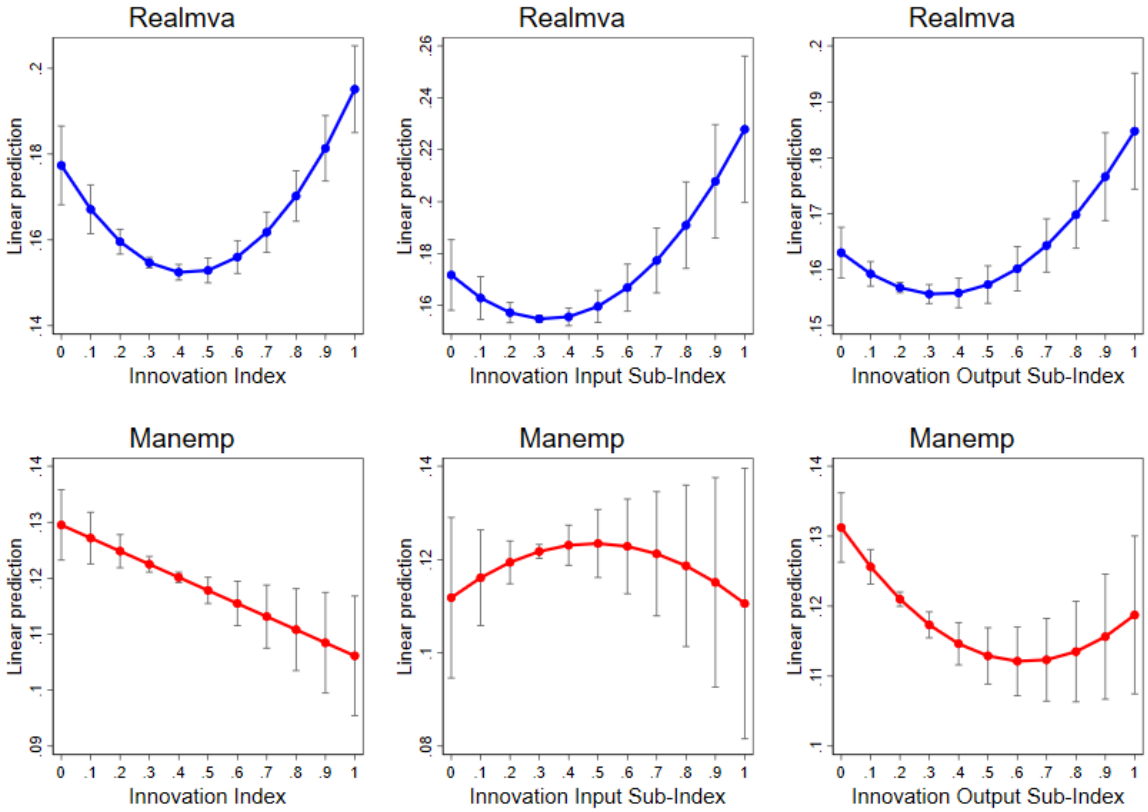
However, in my country sample, this impact is significant only for manufacturing employment shares.

Moreover, I account for unbalanced productivity growth and the national unemployment rate. As highlighted by Van Neuss (2019), both variables negatively affect manufacturing employment, while the former positively impact value-added. This indicates that higher labour productivity in manufacturing compared to services leads to an increase in industrial value-added, even as labour shifts from the more productive manufacturing sector to the less dynamic service sector— a phenomenon referred to in the literature as the Baumol effect (Baumol, 1967). On the other hand, deindustrialization in employment is often linked to persistent macroeconomic imbalances, such as structural national unemployment.

Figure 3 illustrates the results of the innovation index and its sub-indexes for both measures of industrialization, as detailed in Tables F3 and F4 of Appendix F. The results show that the input and output sub-indexes follow a U-shaped correlation and threshold with the manufacturing value-added share, similar to the national innovation index. Conversely, the negative correlation between the national innovation index and the manufacturing employment share is primarily attributed to the output sub-index. This negative effect continues up to a threshold of 0.69, after which the correlation between the output sub-index and manufacturing employment turns positive, although non-significant. This could suggest that only at high levels of innovation output, the labour-saving effect of innovation is offset by several compensation mechanisms such as increased market demand from new products, lower prices of existing products, or greater labour demand resulting from higher production (Vivarelli, 2014; Calvino & Virgillito, 2018).

For additional details, the correlation of each pillar and sub-pillar with industrialization measures is provided in Tables F5 to F9 of Appendix F. Overall, the pillars and sub-pillars display similar correlation patterns with industrialization as the sub-indexes.

Figure 3: Real Manufacturing Value-Added and Employment Share as a Function of Innovation Index and Sub-Indexes



Source: Author's calculations based on estimated correlations from Tables 1, 2, and Tables F3 and F4 of Appendix F.

5.2 Sectoral Regression Results

To evaluate the heterogeneity of the innovation-industrialization correlation across manufacturing industries, Tables 3 and 4 present the results from equation (4) for the manufacturing sectors classified according to Pavitt's industrial taxonomy (Pavitt, 1984).

For real manufacturing value-added, there is a linear and positive correlation with innovation in the Supplier-Dominated, Scale-Intensive, and Specialized Suppliers sectors. In Supplier-Dominated industries, this outcome is expected, as these sectors represent the early stages of industrialization in developing countries (Dosi et al., 2021), where production typically depends on more labour-intensive technologies (Imbert et al., 2022). Table F10 of Appendix F shows that industries such as food products, textiles, wood, leather, and metal products demonstrate this positive relationship between innovation and value-added.

For the Scale-Intensive and Specialized Suppliers sectors, the positive correlation between innovation and value-added is largely driven by industries such as mineral products, basic metals, machinery, and transport equipment, as highlighted in Table F10 in Appendix F. In these sectors, economies of scale, mass production, and the tacit

knowledge derived from imported inputs and FDI play a significant role (Nuvolari & Russo, 2021).

Science-Based sectors exhibit a U-shaped correlation between innovation and value-added. In this case, only countries with a high national innovation index (specifically above the 0.7 threshold, as shown in Table 3) are able to generate the internal R&D, scientific knowledge, and frontier technology necessary to boost value-added.

Table 3: Real Manufacturing Value Added and Innovation Index – Pavitt Taxonomy

VARIABLES	Supplier Dominated		Scale Intensive		Specialized Suppliers		Science-Based	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln population	-0.001	-0.002	-0.021***	-0.022***	-0.011*	-0.011*	-0.024*	-0.024*
	(0.008)	(0.007)	(0.005)	(0.005)	(0.005)	(0.005)	(0.013)	(0.013)
Ln population squared	-0.000	0.000	0.001***	0.001***	0.000	0.000	0.003***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Ln GDP per capita	0.016***	0.011**	0.004	-0.002	0.010	0.011	-0.110***	-0.096***
	(0.005)	(0.006)	(0.004)	(0.005)	(0.008)	(0.008)	(0.018)	(0.017)
Ln GDP per capita squared	-0.001***	-0.001**	-0.000	0.000	-0.001	-0.001	0.006***	0.005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Innovation index	0.003*	0.008**	-0.002	-0.004	0.003**	0.001	-0.005**	-0.018***
	(0.002)	(0.004)	(0.001)	(0.003)	(0.001)	(0.003)	(0.002)	(0.006)
Innovation index squared		-0.005		0.006**		0.002		0.013**
		(0.003)		(0.002)		(0.003)		(0.006)
Sectoral exports (% Apparent consumption)	0.089***	0.090***	0.000***	0.000***	0.049***	0.049***	0.062***	0.062***
	(0.007)	(0.007)	(0.000)	(0.000)	(0.005)	(0.005)	(0.008)	(0.008)
Sectoral imports (% Apparent consumption)	-0.020***	-0.020***	-0.011***	-0.011***	-0.003**	-0.003**	-0.022***	-0.022***
	(0.007)	(0.007)	(0.002)	(0.002)	(0.001)	(0.002)	(0.006)	(0.006)
Unbalanced productivity growth	-0.000	-0.000	0.000	0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-0.043	-0.021	0.093**	0.113***	0.049	0.043	0.494***	0.438***
	(0.049)	(0.048)	(0.037)	(0.037)	(0.041)	(0.043)	(0.086)	(0.091)
Observations	5,507	5,507	4,872	4,872	1,947	1,947	1,794	1,794
R-squared	0.645	0.645	0.330	0.331	0.524	0.524	0.736	0.737
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
ISIC 2-digit FE	Y	Y	Y	Y	Y	Y	Y	Y
Ln GDP turnover	8.383	8.192	13.174	5.148	8.360	8.434	8.975	8.978
P-value	0.000	0.000	0.084	0.411	0.000	0.000	0.000	0.000
Industrialization share turnover								0.004
Index turnover								0.713
P-value								0.000
t-test Nonlinearity index [a]								1.06
P-value								0.145
Slope at Min								-0.017**
Slope at Max								0.007

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001.
[a] Lind & Mehlum (2010) overall test of presence of an Inverse U shape. Test: H1: U shape vs. H0: Monotone or Inverse U shape.

Finally, unlike the results for the overall manufacturing sector, the employment shares analysed according to Pavitt's taxonomy show a positive correlation with innovation in the Supplier-Dominated, Scale-Intensive, and Specialized Suppliers sectors (Tables 4 and F11 in Appendix F). This suggests that the labour-saving effects of innovation may be offset by factors such as the increased demand for labour due to higher production levels or higher output demand following the implementation of innovations. In contrast, the Science-Based sectors display a negative correlation between innovation and employment, which could show a lower demand for unskilled labour (skilled biased technological change),

however, this effect is not statistically significant for the group of developing countries of this analysis.

Table 4: Manufacturing Employment Share and Innovation Index – Pavitt Taxonomy

VARIABLES	Supplier Dominated		Scale Intensive		Specialized Suppliers		Science-Based	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln population	-0.039***	-0.039***	-0.014***	-0.014***	-0.009*	-0.009*	-0.028***	-0.027***
	(0.013)	(0.012)	(0.002)	(0.002)	(0.005)	(0.005)	(0.006)	(0.006)
Ln population squared	0.003***	0.002***	0.001***	0.001***	0.001*	0.001*	0.002***	0.002***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ln GDP per capita	-0.008	-0.005	0.001	0.001	0.009	0.010	-0.030***	-0.024**
	(0.006)	(0.004)	(0.002)	(0.002)	(0.009)	(0.009)	(0.010)	(0.010)
Ln GDP per capita squared	0.001*	0.000	-0.000	-0.000	-0.001	-0.001	0.002***	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Innovation index	0.005***	0.001	0.003***	0.003**	0.008***	0.007**	0.000	-0.005
	(0.001)	(0.005)	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)	(0.003)
Innovation index squared		0.004		0.000		0.001		0.005
		(0.005)		(0.001)		(0.003)		(0.003)
Sectoral exports (% Apparent consumption)	0.137***	0.137***	0.000***	0.000***	0.050***	0.050***	0.020***	0.020***
	(0.015)	(0.015)	(0.000)	(0.000)	(0.005)	(0.005)	(0.004)	(0.004)
Sectoral imports (% Apparent consumption)	-0.049***	-0.049***	-0.002***	-0.002***	-0.004**	-0.004**	-0.011***	-0.011***
	(0.009)	(0.008)	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)
Unbalanced productivity growth	0.000	0.000	-0.000	-0.000	0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Unemployment rate	0.000*	0.000	0.000	0.000	0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.184**	0.169***	0.059***	0.058***	-0.006	-0.011	0.243***	0.221***
	(0.073)	(0.061)	(0.014)	(0.015)	(0.041)	(0.044)	(0.043)	(0.047)
Observations	5,289	5,289	4,688	4,688	1,877	1,877	1,684	1,684
R-squared	0.562	0.562	0.536	0.536	0.660	0.660	0.644	0.644
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
ISIC 2-digit FE	Y	Y	Y	Y	Y	Y	Y	Y
Ln GDP turnover	6.836	5.902	7.839	7.856	8.049	8.127	9.659	9.859
P-value	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001.

6 Conclusions

This paper investigates the relationship between innovation and industrialization, driven by the mixed findings in the literature on how innovation affects the manufacturing sector in developing countries. By constructing a national innovation index for 53 developing countries covering the period from 1996 to 2018, I find that although all countries have experienced growth in innovation and technological levels, inputs such as R&D, infrastructure, and foreign technology imports are not always efficiently converted into outputs, particularly patents. On the other hand, human capital consistently ranks as the weakest innovation input across the sample.

Using the national innovation index, I identify a U-shaped correlation with manufacturing value-added shares, indicating that developing countries must surpass a certain innovation threshold to realize positive effects on industrialization. Without sufficient investment in innovation, nations risk premature deindustrialization due to intensified foreign competition and foreign technological advances. Additionally, there is a negative correlation between innovation and employment, as increased productivity often reduces labour demand through the adoption of labour-saving technologies.

A sectoral analysis reveals that innovation spurs both production and employment in the Supplier-Dominated, Scale-Intensive, and Specialized Supplier sectors, suggesting that the labour-saving effects of technological progress are offset by increased demand. However, in Science-Based sectors, significant value-added growth is observed only in countries that achieve high innovation indices, while the correlation between innovation and employment remains negative, highlighting the need for more human capital formation that proved to be one of the lowest innovation inputs available across the analysed countries.

It is concluded that developing countries must strengthen their innovation capacities to sustain industrial growth, including investing in human capital, R&D, and technological infrastructure. Such efforts are critical for enhancing their competitiveness in the global market, fostering industrial diversification, and ultimately driving economic development. Several policy implications arise from this conclusion. Various policy instruments could be implemented such as funding for public research, fellowships and postgraduate loans and scholarships, centres of excellence grants, support for research infrastructure, and tax relief supporting R&D and innovation, among others (Arundel & Hollanders, 2005).

Finally, in future analysis, the innovation index could be enhanced by incorporating data from other countries and/or indicators, while the methodology of PCA could be replaced by the weights presented in the GII to conduct a robustness check of the innovation scores presented in this analysis. On the other hand, the non-linear correlation between innovation and industrialization could be tested using an IV analysis, as the estimated coefficients presented in this paper may be influenced by endogeneity issues. In particular, a positive reverse causality between innovation and industrialization could lead to an overestimation of the observed correlations.

7 References

Alqararah, K. (2023). Assessing the robustness of composite indicators: The case of the Global Innovation Index. *Journal of Innovation and Entrepreneurship*, 12(1), 1-22.

Alvarez-Cuadrado, F., Van long, N., & Markus, P. (2017). Capital-labour substitution, structural change and growth. *Theoretical Economics*, 12(3), 1229 – 1266.

Arundel, A., & Hollanders, H. (2005). *Policy, indicators and targets: Measuring the impacts of innovation policies*. Brussels: European Commission.

Atolia, M., Loungani, P., Marquis, M., & Papageorgiou, C. (2020). Rethinking development policy: What remains of structural transformation? *World Development*, 128(C).

Bate, A. F., Wachira, E. W., & Danka, S. (2023). The determinants of innovation performance: An income-based cross-country comparative analysis using the Global Innovation Index (GII). *Journal of Innovation and Entrepreneurship*, 12(20).

Baumol, W. (1967). Macroeconomics of unbalanced growth: the anatomy of urban crisis. *The American Economic Review*, 415 – 426.

Bogliacino, F., & Pianta, M. (2010). Innovation and employment: A reinvestigation using revised Pavitt classes. *Research Policy*, 39, 799 – 809.

Bolt, J., & van Zanden, J. L. (2024). Maddison-style estimates of the evolution of the world economy: A new 2023 update. *Journal of Economic Surveys*, 1–41.

Bustors, P., Castro-Vincenzi, J., Monras, J., & Ponticelli, J. (2019). Industrialization without innovation. *NBER Working Papers*, 25871, National Bureau of Economic Research, Inc.

Cabeza-Martinez, B., Laguera, J., Neves, A., Ravanos, P., Saisana, M., Smallenbroek, O., & Tacao, M. (2023). *Statistical audit of the 2023 Global Innovation Index*. Joint Research Centre (JRC).

Calvino, F., & Virgillito, M.E. (2018). The innovation-employment nexus: a critical survey of theory and empirics. *Journal of Economic Surveys*, 32(1), 83 – 117.

Caselli, F., & Coleman, W. (2001). Cross-country technology diffusion: the case of computers. *American Economic Review*, 91(2), 328 – 335.

Castellacci, F., & Natera, J. (2013). The dynamics of national innovation systems: a panel cointegration analysis of the coevolution between innovative capability and absorptive capacity. *Technological Forecasting and Social Change*, 76, 709 – 722.

Cirera, X., & Maloney, W. F. (2017). *The innovation paradox: Developing-country capabilities and the unrealized promise of technological catch-up*. World Bank.

Crespo, N. F., & Crespo, C. F. (2016). Global innovation index: Moving beyond the absolute value of ranking with a fuzzy set analysis. *Journal of Business Research*, 69 (11), 5265–5271.

Dahlman, J. (2008). Technology, globalization, and international competitiveness: challenges for developing countries. In D. O. Kjollerstrom, *Industrial Development for the 21st Century* (pp. 29 - 83). Ed. Zed Books.

De Oliveira, B., & Da Fonseca, R. (2022). Does innovative capacity affect the deindustrialization process? A panel data analysis. *Journal of Economic Structures*, 11(1), 1 – 36.

Di Maio, M. (2008). Industrial Policies in Developing Countries: History and Perspectives. *Working Papers 48-2008, Macerata University*, Department of Finance and Economic Sciences, revised Oct 2008.

Dosi, G., Riccio, F., & Virgillito, M. (2021). Varieties of deindustrialization and patterns of diversification: why microchips are not potato chips. *Structural Change and Economic Dynamics*, 57, 182 – 202.

Eslava, M., Haltiwanger, J., Kugler, A., & Kugler, M. (2013). Trade and market selection: evidence from manufacturing plants in Colombia. *Review of Economic Dynamics*, 16(1), 135–158.

Fagerberg, J., Srholec, M., & Verspagen, B. (2010). Innovation and economic development. In Bronwyn H. Hall & Nathan Rosenberg (Eds.), *Handbook of the Economics of Innovation* (pp. 833 – 872).

Fagerberg, J., & Srholec, M. (2021). Capabilities, competitiveness, nations. In J.-D. Lee, K. Lee, D. Meissner, S. Radosevic, & N. S. Vonortas (Eds.), *The challenges of technology and economic catch-up in emerging economies* (pp. 19-47). Oxford University Press.

Firpo, S., & Renan, P. (2017). Structural change, productivity growth, and trade policy in Brazil. In M. McMillan, D. Rodrik & C. Sepulveda (Eds.), *Structural Change, Fundamentals, and Growth: A Framework and Case Studies.* International Food Policy Research Institute (Washington, D.C.).

Giuliana, E., Pietrobelli, C., & Rabellotti, R. (2005). Upgrading in global value chains: lessons from Latin American clusters. *World Development*, 33(4), 549 – 573.

Godin, B. (2007). Science, accounting and statistics: The input-output framework. *Research Policy*, 36(9), 1388 – 1403.

Gokhberg, L. (2013). Indicators for science, technology and innovation on the crossroad to foresight. In D. Meissner, L. Gokhberg, & A. Sokolov (Eds.) *Science, Technology and Innovation Policy for the Future.* Springer, Berlin, Heidelberg.

Gries, T., Grundmann, R., Palnau, I., & Redlin, M. (2018). Technology diffusion, international integration and participation in developing economies – a review of major concepts and findings. *International Economics and Economic Policy*, 15(1), 215-253.

Gorodnichenko, Y., Svejnar, J., & Terrell, K. (2010). Globalization and innovation in emerging markets. *American Economic Journal: Macroeconomics*, 2 (2), 194-226.

Hamilton, C., & de Vries, G. J. (2023). The structural transformation of transition economies. *GGDC Research Memorandum*, 196.

Haraguchi, N., Martorano, B., & Sanfilippo, M. (2019). What factors drive successful industrialization? Evidence and implications for developing countries. *Structural Change and Economics Dynamics*, 49, 266 – 276.

Herrendorf, B., Herrington, C., & Valentinyi, A. (2015). Sectoral technology and structural transformation. *American Economic Journal: Macroeconomics*, 7(4), 104 – 133.

Hidalgo, C., Klinger, B., Barabasi, A., & Hausmann, R. (2007). The product space conditions the development of nations. *Science*, 317, 482 - 87.

Hidalgo, C., & Hausmann, R. (2009). The building blocks of economic complexity. In *Proceedings of the National Academy of Sciences*, 106, No. 26, 10570-75.

Hollanders, H., & Janz, N. (2013). Scoreboards and indicator reports. In F. Gault (Ed.), *Handbook of innovation indicators and measurement* (pp. 279-298). Edward Elgar Publishing.

Huarng, K.-H., & Yu, T. H.-K. (2022). Analysis of Global Innovation Index by structural qualitative association. *Technological Forecasting and Social Change*, 182, 121839.

Imbert, C., Marlon, S., Yifan, Z., & Yanos, Z. 2022. Migrants and firms: evidence from China. *American Economic Review*, 112 (6), 1885 - 1914.

Janger, J., Schubert, T., Andries, P., Rammer, C., & Hoskens, M. (2017). The EU 2020 innovation indicator: a step forward in measuring innovation outputs and outcomes? *Research Policy*, 46(1), 30 – 42.

Khayyat, N. T., & Lee, J. D. (2015). A measure of technological capabilities for developing countries. *Technological Forecasting and Social Change*, 92, 210-223.

Kruse, H., Mensah, E., Sen, K., & de Vries, G. J. (2023). A manufacturing renaissance? Industrialization trends in the developing world. *IMF Economic Review*, 71, 439 – 473.

Lall, S. (1992). Technological capabilities and industrialization. *World Development*, 20(2), 165 - 186.

Lawrence, P. (2005). Explaining Sub-Saharan Africa's manufacturing performance. *Development and Change*, 36(6), 1121 - 1141.

Lind, J., & Mehlum, H. (2010). With or without U? The appropriate test of a U-shaped relationship. *Oxford Bulletin of Economics and Statistics*, 72(1), 109 – 118;

MacBean, A. I. (2000). Export promotion in transitional economies. In A. I. MacBean (Ed.), *Trade and Transition: Trade Promotion in Transitional Economies* (pp. 1 - 18). Routledge, Taylor & Francis Group.

Malerba, F. (2006). Innovation and the evolution of industries. *Journal of Evolutionary Economics*, 16(1), 3 – 23.

Melits, M. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71(6), 1695 – 1726.

Montobbio, F., & Rampa, F. (2005). The impact of technology and structural change on export performance in nine developing countries. *World Development*, 33(4), 527 – 547.

Nasir, M. H., & Zhang, S. (2024). Evaluating innovative factors of the global innovation index: A panel data approach. *Innovation and Green Development*, 3(1).

Naudé, W., & Tregenna, F. (2023). Africa's industrialization prospects: a fresh look. *IZA Discussion Papers*, 16043, Institute of Labor Economics (IZA).

Ndege, N., et al. (2021). *Final synthesis report: Assessing STI metrics in Africa*. African Technology Policy Studies Network (ATPS).

Ngai, L., & Pissarides, C. (2007). Structural change in a multisector model of growth. *American Economic Review*, 97(1), 429 – 443.

Novillo-Villegas, S. M., Ayala Andrade, R., Garzon, M., Lopez Cox, J. P., Marin, M., & Salazar, J. (2022). Innovation capability determinants: Literature review base [Dataset]. *Mendeley Data*, 2(1), 1–4.

Nuvolari, A., & Russo, E. (2021). Technical progress and structural change: A long-term view. In L. Alcorta, et al. (Eds.), *New perspectives on structural change: Causes and consequences of structural change in the global economy* (online ed.). Oxford Academic.

Ocampo, J.A. (2005) *Beyond Reforms: Structural Dynamics and Macroeconomic Vulnerability*. Palo Alto, CA: Stanford University Press; Washington, DC: World Bank.

OECD. (2008). *Handbook on constructing composite indicators: Methodology and user guide*. OECD Publishing.

OECD/Eurostat (2018), *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation*, 4th Edition, The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing, Paris/Eurostat, Luxembourg.

Pavitt, K. (1984). Sectoral patterns of technical change: towards a taxonomy and a theory. *Research Policy*, 13(6), 343 – 373.

Rodrik, D. (2008). *One economics, many recipes: Globalization, institutions, and economic growth*. Princeton: Princeton University Press

Rodrik, D. (2016). Premature deindustrialization. *Journal of Economic Growth*, 21(1), 1 - 33.

Rodrik, D. (2022). Prospects for global economic convergence under new technologies. In Z. Qureshi (Eds.), *An inclusive future? Technology, new dynamics, and policy challenges* (pp. 65 – 82).

Saha, A., & Ciarli, T. (2018). Innovation, structural change, and inclusion: A cross-country PVAR analysis. *SPRU Working Paper Series, 2018-01*. SPRU - Science Policy Research Unit, University of Sussex Business School.

Samaniego, R., & Sun, J. (2016). Productivity growth and structural transformation. *Review of Economic Dynamics*, 21, 266 – 285.

Saviotti, P., Pyka, A. (2017). Innovation, structural change, and demand evolution: does demand saturate? *Journal of Evolutionary Economics*, 27(2), 337 – 358.

Stojcic, N., & Aralica, Z. (2017). Choosing right from wrong: industrial policy and (de)industrialization in Central and Eastern Europe. *EIZ Working Papers*, No. EIZ-WP-1703.

Szirmai, A. (2012). Industrialization as an engine of growth in developing countries, 1950 – 2005. *Structural Change and Economic Dynamics*, 23(4), 406 – 420.

Teece, D. (2009). *Dynamic capabilities and strategic management: Organizing for innovation and growth*. Oxford University Press, Oxford

Teixeira, A., & Queiros, A. (2016). Economic growth, human capital, and structural change: A dynamic panel data analysis. *Research Policy*, 45, 1636 – 1648.

UNDP. (2001). *Human development report 2001: Making new technologies work for human development*. United Nations Development Programme.

Uy, T., & Zhang, J. (2013). Structural change in an open. *Journal of Monetary Economics*, 60, 667 - 682.

Van Neuss, L. (2019). The drivers of structural change. *Journal of Economic Surveys*, 33(1), 309-349.

Verhoogen, E. (2008), Trade, quality upgrading, and wage inequality in the Mexican manufacturing sector. *The Quarterly Journal of Economics*, 123(2), 489 - 530.

Vivarelli, M. (2014). Structural change and innovation as exit strategies from the middle-income trap. *IZA Discussion Papers*, 8148, Institute of Labor Economics (IZA).

Vivarelli, M. (2018). Globalisation, structural change and innovation in emerging economies: The impact on employment and skills. *MERIT Working Papers 2018-037*, United Nations University - Maastricht Economic and Social Research Institute on Innovation and Technology (MERIT).

World Intellectual Property Organization. (2023). *Global Innovation Index 2023: Innovation in the face of uncertainty*. WIPO.

Appendix A

National Innovation Indicators

Table A1: Definitions and Sources

Indicators	Definition	Source
1. INSTITUTIONS PILLAR		
1.1 POLITICAL ENVIRONMENT SUB-PILLAR		
Political Stability and Absence of Violence/Terrorism	Estimates perceptions of the likelihood of political instability and/or politically-motivated violence including terrorism.	World Bank Data World Governance Indicators
Government Effectiveness	Estimates perceptions of the quality of public services, the quality of the civil service, and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	World Bank Data World Governance Indicators
1.2 REGULATORY ENVIRONMENT SUB-PILLAR		
Regulatory Quality	Estimates perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.	World Bank Data World Governance Indicators
Rule of Law	Estimates perceptions of the extent to which agents have confidence in and abide by the rules of society, in particular the quality of contract enforcement, property rights, the police, and the courts as well as the likelihood of crime and violence.	World Bank Data World Governance Indicators
1.3 BUSINESS ENVIRONMENT SUB-PILLAR		

Time Required to Start a Business	Number of calendar days needed to complete the procedures to legally operate a business.	World Bank Data Doing Business project
Cost of Business Start-Up Procedures (% of GNI per capita)	The company law, the commercial code, and specific regulations and fee schedules used as sources for calculating costs. Costs include all official fees and fees for legal or professional services if such services are required by law. Fees for purchasing and legalizing company books are included if these transactions are required by law.	World Bank Data Doing Business project
Total Tax Rate	Amount of taxes and mandatory contributions borne by business case in the second year of operation, expressed as a share of commercial profit.	World Bank Data Doing Business project
HUMAN CAPITAL AND RESEARCH PILLAR		
2.1 TERTIARY EDUCATION SUB-PILLAR		
a. Tertiary school enrolment (% gross) b. Tertiary graduates in science technology and mathematics programs (% of total tertiary graduates c. Tertiary graduates in engineering and manufacturing programs (% of total tertiary graduates)	Ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Tertiary education, whether or not to an advanced research qualification, normally requires as a minimum condition of admission the successful completion of education at the secondary level.	UNESCO Institute for Statistics UIS online database
2.2 RESEARCH AND DEVELOPMENT (R&D) SUB-PILLAR		
Researchers in R&D (per million people)	Researchers in R&D are professionals engaged in the conception or creation of new knowledge products, processes, methods or systems, and in the management of the projects concerned.	UNESCO Institute for Statistics UIS online database

R&D expenditure (% of GDP)	Gross domestic expenditures on R&D include both capital and current expenditures in the four main sectors: Business enterprise, Government, Higher education, and Private non-profit. R&D covers basic research, applied research, and experimental development.	UNESCO Institute for Statistics UIS online database
INFRASTRUCTURE PILLAR		
3.1 ICT SUB-PILLAR		
Individuals using the Internet (% of population))	Internet users are individuals who have used the Internet (from any location) in the last 3 months. The Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV etc.	World Bank Data, International Telecommunication Union (ITU) World Telecommunication/ICT Indicators Database
Government's online service index	The index covers four stages of government's online service development with points assigned for (1) emerging information services; (2) enhanced information services; (3) transaction services; and (4) a connected approach. The index ranges from 0 to 1, with 1 showing greater Government's online service	United Nations Public Administration Network, e-Government Development Database
Online participation index	The index focuses on the use of the Internet to facilitate the provision of information by governments to citizens ('e-information sharing'), interaction with stakeholders ('e-consultation'), and engagement in decision-making processes ('e-decision making'). The index ranges from 0 to 1, with 1 showing greater e-participation.	United Nations Public Administration Network, e-Government Development Database
3.2 GENERAL INFRASTRUCTURE SUB-PILLAR		
Access to electricity (% of population)	Percentage of the population with access to electricity. Electrification data are collected from industry, national surveys and international sources.	World Bank Data

Logistics performance index	Score reflects perceptions of a country's logistics based on the efficiency of customs clearance process, quality of trade- and transport-related infrastructure, ease of arranging competitively priced shipments, quality of logistics services, ability to track and trace consignments, and frequency with which shipments reach the consignee within the scheduled time. The index ranges from 1 to 5, with a higher score representing better performance.	UNWorld Bank Data
Gross capital formation (% of GDP)	Gross capital formation consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings.	World Bank Data
MARKET SOPHISTICATION PILLAR		
4.1 CREDIT SUB-PILLAR		
Depth of credit information index	Measures rules affecting the scope, accessibility, and quality of credit information available through public or private credit registries. The index ranges from 0 to 8, with higher values indicating the availability of more credit information, from either a public registry or a private bureau, to facilitate lending decisions.	World Bank Data, Doing Business project
Domestic credit to private sector (% of GDP)	Refers to financial resources provided to the private sector by financial corporations, such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment.	World Bank Data, Doing Business project

4.2 TRADE AND COMPETITION SUB-PILLAR		
Tariff rate, applied, weighted mean, manufactured products (%)	Weighted mean applied tariff is the average of effectively applied rates weighted by the product import shares corresponding to each partner country.	World Bank Data
Competitive Industrial Performance Index	The Competitive Industrial Performance (CIP) index considers countries' productive capacity, intensity of industrialization and impact on the world market as major components of industrial performance.	UNIDO's database
Imports of goods and services (% of GDP)	Imports of goods and services represent the value of all goods and other market services received from the rest of the world.	World Bank Data
Exports of goods and services (% of GDP)	Exports of goods and services represent the value of all goods and other market services provided to the rest of the world.	World Bank Data
BUSINESS SOPHISTICATION PILLAR		
Royalty and license fees, payments (% of GDP)	Payments between residents and nonresidents for the authorized use of intangible, nonproduced, nonfinancial assets and proprietary rights (such as patents, copyrights, trademarks, industrial processes, and franchises) and for the use, through licensing agreements, of produced originals of prototypes (such as films and manuscripts).	World Bank Data
High-tech imports net of re-imports (% of total imports net of re-imports)	The list of commodities contains technical products with a high intensity of R&D. Commodities belong to the following sectors: aerospace; computers & office machines; electronics, telecommunications; pharmacy; scientific instruments; electrical machinery; chemistry; non-electrical machinery; and armament.	United Nations, COMTRADE database. World integrated Trade Solutions (WITS)

Computer, communications, and other services imports (% of commercial service imports)	Include such activities as international telecommunications, and postal and courier services; computer data; news-related service transactions between residents and nonresidents; construction services; royalties and license fees; miscellaneous business, professional, and technical services; and personal, cultural, and recreational services.	World Bank Data
Foreign direct investment, net inflows (% of GDP)	Net inflows of investment to acquire a lasting management interest (10% or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments.	World Bank Data
SCIENTIFIC OUTPUT PILLAR		
6.1 KNOWLEDGE CREATION SUB-PILLAR		
Number of patent applications filed by residents at the national office or through the Patent Cooperation Treaty (PCT) (per billion GDP, 2015 PPP$)	Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention–a product or process that provides a new way of doing something or offers a new technical solution to a problem.	World Intellectual Property Organization, WIPO Statistics Database
Number of utility model applications filed by residents at the national office (per billion GDP, 2015 PPP$)	Number of utility model applications filed by residents at their national patent office. Like a patent, a utility model (UM) confers a set of rights for an invention for a limited period of time, during which UM holders can commercially exploit their inventions on an exclusive basis.	World Intellectual Property Organization, WIPO Statistics Database

Number of scientific and technical journal articles (per billion GDP, 2015 PPP$)	The number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.	World Bank Data
6.2 KNOWLEDGE DIFFUSION AND IMPACT SUB-PILLAR		
New business density (new registrations per 1,000 people ages 15-64)	Number of new firms, defined as firms registered in the current year of reporting, per 1,000 working-age people (those aged 15–64).	World Bank Data
High-tech exports net of re-exports (% of total exports net of re-exports)	The list of commodities contains technical products with a high intensity of R&D. Commodities belong to the following sectors: aerospace; computers and office machines; electronics, telecommunications; pharmacy; scientific instruments; electrical machinery; chemistry; non-electrical machinery; and armament.	United Nations, COMTRADE database. World integrated Trade Solutions (WITS)
CREATIVE OUTPUT PILLAR		
Number of trademark registrations filed by residents at the national office or through the Madrid System (per billion GDP, 2015 PPP$)	A trademark is a distinctive sign, which distinguishes certain goods or services of one undertaking from those produced or provided by other undertakings. The holder of a registered trademark has the legal right to the exclusive use of the mark in relation to the products or services for which it is registered.	World Intellectual Property Organization, WIPO Statistics Database

Number of industrial design applications filed by residents (per billion GDP, 2015 PPP$)	Industrial design applications are applications to register an industrial design with a national or regional Intellectual Property (IP) offices and designations received by relevant offices through the Hague System. Industrial designs are applied to a wide variety of industrial products and handicrafts. They refer to the ornamental or aesthetic aspects of a useful article, including compositions of lines or colors or any three-dimensional forms that give a special appearance to a product or handicraft	World Bank Data

Appendix B

Pairwise Correlations of National Innovation Indicators by Pillars

Table B1: Institutions Pillar

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Political Stability	1.000						
(2) Government Effectiveness	0.566***	1.000					
(3) Regulatory Quality	0.541***	0.892***	1.000				
(4) Rule of Law	0.639***	0.892***	0.865***	1.000			
(5) Time to start a business	0.089***	-0.192***	-0.159***	-0.167***	1.000		
(6) Cost to register a business	-0.148***	-0.257***	-0.234***	-0.196***	0.105***	1.000	
(7) Total tax rate	-0.103***	-0.092***	-0.167***	-0.185***	-0.044**	-0.085***	1.000

Note: correlation coefficients that are significant at the 5% level or better.
*** p<0.01, ** p<0.05, * p<0.1

Table B2: Human Capital and Research Pillar

Variables	(1)	(2)	(3)	(4)	(5)
(1) Tertiary school enrolment ratio	1.000				
(2) Tertiary graduates in science	0.311***	1.000			
(3) Tertiary graduates in engineering	0.539***	0.727***	1.000		
(4) Researchers in R&D	0.654***	0.354***	0.460***	1.000	
(5) R&D expenditure	0.520***	0.349***	0.387***	0.779***	1.000

Note: correlation coefficients that are significant at the 5% level or better.
*** p<0.01, ** p<0.05, * p<0.1

Table B3: Infrastructure Pillar

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) Internet	1.000					
(2) Government's online service	0.801***	1.000				
(3) Online participation	0.801***	0.808***	1.000			
(4) Electricity	0.532***	0.441***	0.394***	1.000		
(5) Logistics	0.503***	0.507***	0.469***	0.311***	1.000	
(6) Gross capital formation	0.127***	0.190***	0.122***	0.245***	0.063**	1.000

Note: correlation coefficients that are significant at the 5% level or better.
*** p<0.01, ** p<0.05, * p<0.1

Table B4: Market Sophistication Pillar

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) Depth of credit information	1.000					
(2) Domestic credit to private sector	0.454***	1.000				
(3) Tariff rate manufactured products	-0.261***	-0.166***	1.000			
(4) Competitive Industrial Performance	0.388***	0.567***	-0.201***	1.000		
(5) Imports of goods and services	0.089***	0.407***	-0.271***	0.445***	1.000	
(6) Exports of goods and services	0.235***	0.523***	-0.294***	0.647***	0.902***	1.000

Note: correlation coefficients that are significant at the 5% level or better.
*** p<0.01, ** p<0.05, * p<0.1

Table B5: Business Sophistication Pillar

Variables	(1)	(2)	(3)	(4)
(1) Royalty payments	1.000			
(2) High-tech imports	0.274***	1.000		
(3) ICT services imports	0.219***	0.164***	1.000	
(4) FDI	0.275***	0.005**	0.231***	1.000

Note: correlation coefficients that are significant at the 5% level or better.
*** p<0.01, ** p<0.05, * p<0.1

Table B6: Scientific Output Pillar and Creative Output Pillar

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Patent	1.000						
(2) Utility model	0.398***	1.000					
(3) Journal articles	0.338***	0.189***	1.000				
(4) Business density	0.040**	0.049*	0.475***	1.000			
(5) High-tech exports	0.207***	0.181***	0.343***	0.130***	1.000		
(6) Trademark	0.090***	0.299***	0.326***	0.276***	0.216***	1.000	
(7) Industrial design	0.030	0.237***	0.221***	0.012	0.196***	0.340***	1.000

Note: correlation coefficients that are significant at the 5% level or better.
*** p<0.01, ** p<0.05, * p<0.1

Appendix C

PCA Methodology - Construction of the National Innovation Index

1) Institutions pillar

Table C1: Political environment sub-pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.56639	0.7832	0.7832
Comp2	0.43361	0.2168	1.0000
KMO overall	0.50		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Political Stability		0.50	
Government Effectiveness		0.50	

Table C2: Regulatory environment sub-pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.86503	0.9325	0.9325
Comp2	0.13497	0.0675	1.0000
KMO overall	0.50		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Regulatory Quality		0.50	
Rule of Law		0.50	

Table C3: Business environment sub-pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.15857	0.3862	0.3862
Comp2	0.95700	0.3190	0.7052
Comp3	0.88442	0.2948	1.0000
KMO overall	0.5267		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Time to start a business		0.325	
Cost to register a business		0.420	
Total tax rate		0.255	

Table C4: PCA calculation of Institutions Pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.90299	0.6343	0.6343
Comp2	0.96437	0.3215	0.9558
Comp3	0.13263	0.0442	1.0000
KMO overall	0.5099		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Political environment sub-pillar		0.479	
Regulatory environment sub-pillar		0.482	
Business environment sub-pillar		0.038	

2) Human capital and research pillar

Table C5: Tertiary education sub-pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	2.06914	0.6897	0.6897
Comp2	0.70637	0.2355	0.9252
Comp3	0.22448	0.0748	1.0000
KMO overall	0.5537		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Tertiary school enrolment ratio		0.245	
Tertiary graduates in science		0.339	
Tertiary graduates in engineering		0.416	

Table C6: Research and Development (R&D) sub-pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.77928	0.8896	0.8896
Comp2	0.22071	0.1104	1.0000
KMO overall	0.50		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Researchers in R&D		0.50	
R&D expenditure		0.50	

Table C7: PCA calculation of Human Capital and Pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.56596	0.7830	0.7830
Comp2	0.43404	0.2170	1.0000
KMO overall	0.50		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Tertiary education sub-pillar		0.50	
Research and Development sub-pillar		0.50	

3) Infrastructure pillar

Table C8: Information and communication technologies (ICT) sub-pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	2.60683	0.8689	0.8689
Comp2	0.20147	0.0672	0.9361
Comp3	0.19170	0.0639	1.0000
KMO overall	0.7647		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Individuals using Internet		0,332	
Government's online service index		0,334	
Online participation index		0,334	

Table C9: General infrastructure sub-pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.42807	0.4760	0.4760
Comp2	0.93857	0.3129	0.7889
Comp3	0.63335	0.2111	1.0000
KMO overall	0.5175		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Access to electricity		0.461	
Logistics performance		0.317	
Gross capital formation		0.223	

Table C10: PCA calculation of Infrastructure Pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.58864	0.7943	0.7943
Comp2	0.41136	0.2057	1.0000
KMO overall	0.50		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
ICT sub-pillar		0.50	
General infrastructure sub-pillar		0.50	

4) Market sophistication pillar

Table C11: Credit sub-pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.45377	0.7269	0.7269
Comp2	0.54623	0.2731	1.0000
KMO overall	0.50		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Depth of credit information		0.50	
Domestic credit to private sector		0.50	

Table C12: Trade and Competition sub-pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	2.48176	0.6204	0.6204
Comp2	0.86771	0.2169	0.8374
Comp3	0.58638	0.1466	0.9840
Comp4	0.06413	0.0160	1.0000
KMO overall	0.5400		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Tariff rate manufactured products		0.083	
Competitive Industrial Performance		0.225	
Imports of goods and services		0.320	
Exports of goods and services		0.371	

Table C13: PCA calculation of Market Sophistication Pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.49087	0.7454	0.7454
Comp2	0.50913	0.2546	1.0000
KMO overall	0.50		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Credit sub-pillar		0.50	
Trade and Competition sub-pillar		0.50	

5) Business sophistication pillar

Table C14: Business sophistication pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.596	**0.3990**	0.3990
Comp2	1.0112	**0.2528**	**0.6518**
Comp3	0.7909	0.1977	0.8495
Comp4	0.6018	0.1505	1.0000
KMO overall	0.5623		

Panel B. Squared factor loading (scaled to unity sum)		
Indicator	Comp1	Comp2
Royalty payments	**0,351**	0,010
High-tech imports	0,168	**0,566**
ICT services imports	**0,262**	0,019
FDI	0,219	**0,405**

The first and second principal components meet the Kaiser criterion, accounting for 39.9% and 25.2% of the data's variance, respectively.

The first principal component is primarily driven by indicators of royalty payments and ICT services imports, which are those with the highest loadings in the component. The second principal component is influenced mainly by high-tech imports and FDI inflows.

As a result, the business sophistication pillar is calculated as a weighted average of these two principal components, with the weights corresponding to the proportion of total variance each component explains

$$\text{Business Sophistication Pillar} = \frac{0.3990}{0.6518} \times \text{Comp1} + \frac{0.2528}{0.6518} \times \text{Comp2} \tag{1}$$

6) Scientific output pillar

Table C15: Knowledge creation sub-pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.6244	0.5415	0.5415
Comp2	0.8139	0.2713	0.8128
Comp3	0.5615	0.1872	1.0000
KMO overall	0.5841		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Patent applications		0.411	
Utility model applications		0.320	
Scientific and technical journal articles		0.269	

Table C16: Knowledge diffusion and impact sub-pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.12972	0.5649	0.5649
Comp2	0.87027	0.4351	1.0000
KMO overall	0.50		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
New business density		0.50	
High-tech exports		0.50	

Table C17: PCA calculation of Scientific output pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.37236	0.6862	0.6862
Comp2	0.62763	0.3138	1.0000
KMO overall	0.50		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Knowledge creation sub-pillar		0.50	
Knowledge diffusion sub-pillar		0.50	

7) Creative output pillar

Table C18: Creative output pillar

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.33959	0.6698	0.6698
Comp2	0.66040	0.3302	1.0000
KMO overall	0.50		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Trademark registrations		0.50	
Industrial design applications		0.50	

8) Innovation input sub-index

It is composed of the following pillars: Institutions pillar, Human capital and research pillar, Infrastructure pillar, Market sophistication pillar and Business sophistication pillar.

Table C19: Innovation input sub-index

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	3.24676	0.6494	0.6494
Comp2	0.71363	0.1427	0.7921
Comp3	0.48792	0.0976	0.8897
Comp4	0.34167	0.0683	0.9580
Comp5	0.21000	0.0420	1.0000
KMO overall	0.8162		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Institutions pillar		0.176	
Human capital and research pillar		0.224	
Infrastructure pillar		0.198	
Market sophistication pillar		0.252	
Business sophistication pillar		0.150	

9) Innovation output sub-index

It is composed of the following pillars: Scientific output pillar and Creative output pillar.

Table C20: Innovation output sub-index

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.36381	0.6819	0.6819
Comp2	0.63618	0.3181	1.0000
KMO overall	0.50		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Scientific output pillar		0.50	
Creative output pillar		0.50	

10) Innovation Index

Table C21: Innovation Index

Panel A. Eigenvalue of individual components			
Component	Eigenvalue	Varience (%)	Cumulative (%)
Comp1	1.63574	0.8179	0.8179
Comp2	0.36425	0.1821	1.0000
KMO overall	0.50		
Panel B. Squared factor loading (scaled to unity sum)			
Indicator		Comp1	
Innovation input sub-index		0.50	
Innovation output sub-index		0.50	

Appendix D

Results – National Innovation Index

Table D1: Average by Region: Indicators, Sub-Pillars, Pillars, Sub-Indexes, and Index

Indicators	AFR	SEA	CEE	LAC
1) Institutions pillar	0.41	0.39	0.45	0.49
1.1) Political environment sub-pillar	0.38	0.35	0.41	0.43
Political Stability	0.57	0.47	0.59	0.57
Government Effectiveness	0.31	0.36	0.34	0.41
1.2) Regulatory environment sub-pillar	0.43	0.42	0.44	0.50
Regulatory Quality	0.45	0.46	0.49	0.56
Rule of Law	0.40	0.38	0.38	0.44
1.3) Business environment sub-pillar	0.22	0.22	0.16	0.17
Time to start a business	0.21	0.24	0.13	0.26
Cost to register a business	0.03	0.02	0.00	0.01
Total tax rate	0.24	0.23	0.34	0.41
2) Human capital and research pillar	0.16	0.25	0.39	0.25
2.1) Tertiary education sub-pillar	0.27	0.40	0.58	0.44
Tertiary school enrolment ratio	0.09	0.22	0.45	0.37
Tertiary graduates in science	0.36	0.47	0.51	0.39
Tertiary graduates in engineering	0.19	0.25	0.41	0.30
2.2) Research and development sub-pillar	0.09	0.14	0.23	0.11
Researchers in R&D	0.03	0.09	0.21	0.05
R&D expenditure	0.14	0.17	0.21	0.16
3) Infrastructure pillar	0.33	0.48	0.56	0.56
3.1) ICT sub-pillar	0.18	0.25	0.36	0.38
Individuals using Internet	0.12	0.19	0.35	0.32
Government's online service index	0.26	0.33	0.44	0.44
Online participation index	0.15	0.22	0.28	0.35
3.2) General infrastructure sub-pillar	0.40	0.60	0.63	0.62

Table D1: (Continued) Indicators, Sub-pillars, Pillars, Sub-indexes, and Index

Indicators	**AFR**	**SEA**	**CEE**	**LAC**
Access to electricity	0.41	0.71	0.95	0.92
Logistics performance	0.50	0.61	0.50	0.58
Gross capital formation	0.34	0.39	0.42	0.35
4) Market sophistication pillar	0.32	0.41	0.43	0.39
4.1) Credit sub-pillar	0.20	0.27	0.33	0.33
Depth of credit information	0.15	0.16	0.28	0.30
Domestic credit to the private sector	0.18	0.31	0.26	0.23
4.2) Trade and competition sub-pillar	0.35	0.42	0.41	0.37
Tariff rate manufactured products	0.06	0.06	0.03	0.05
Competitive Industrial Performance	0.05	0.24	0.13	0.23
Imports of goods and services	0.14	0.20	0.19	0.08
Exports of goods and services	0.10	0.19	0.18	0.09
5) Business sophistication pillar	0.25	0.34	0.29	0.36
Royalty payments	0.12	0.18	0.13	0.15
High-tech imports	0.50	0.58	0.55	0.69
ICT services imports	0.21	0.25	0.23	0.22
FDI	0.06	0.07	0.11	0.07
6) Scientific output pillar	0.15	0.20	0.46	0.24
6.1) Knowledge creation sub-pillar	0.06	0.09	0.36	0.08
Patent applications	0.01	0.02	0.19	0.02
Utility model applications	0.00	0.02	0.11	0.02
Scientific and technical journal articles	0.13	0.14	0.30	0.13
6.2) Knowledge diffusion and impact sub-pillar	0.15	0.19	0.29	0.24
New business density	0.06	0.03	0.14	0.07
High-tech exports	0.24	0.38	0.42	0.45
7) Creative output pillar	0.04	0.10	0.11	0.11
Trademark registrations	0.02	0.05	0.09	0.10
Industrial design applications	0.01	0.04	0.02	0.01
Innovation input sub-index	0.19	0.29	0.34	0.32
Innovation output sub-index	0.11	0.18	0.34	0.21
Innovation index	0.19	0.31	0.44	0.35

Source: Author's calculations.

Table D2: Initial, Final, and Growth of the National Innovation Index by Country and Region

Region	Country	Input Sub-Index			Output Sub-Index			Final Index		
		1996	2018	CAGR%	1996	2018	CAGR%	1996	2018	CAGR%
AFR	Uganda	0.05	0.18	6.16	0.04	0.13	5.15	0.04	0.20	7.76
	Tanzania	0.07	0.22	5.20	0.02	0.08	5.78	0.04	0.19	7.18
	Nigeria	0.09	0.19	3.26	0.02	0.16	9.23	0.06	0.21	6.32
	Lesotho	0.08	0.17	3.15	0.02	0.10	8.74	0.05	0.16	5.98
	Morocco	0.22	0.35	2.06	0.06	0.60	11.13	0.18	0.63	5.94
	Mauritius	0.24	0.37	2.05	0.02	0.43	14.18	0.17	0.53	5.46
	Rwanda	0.03	0.24	9.30	0.11	0.10	-0.63	0.07	0.22	5.18
	Namibia	0.20	0.29	1.71	0.04	0.40	10.44	0.15	0.45	5.09
	Mozambique	0.10	0.16	2.44	0.04	0.15	6.17	0.07	0.19	4.68
	Ghana	0.17	0.29	2.52	0.04	0.18	7.52	0.12	0.31	4.33
	Zambia	0.13	0.23	2.45	0.03	0.13	6.83	0.09	0.23	4.20
	Tunisia	0.28	0.40	1.68	0.07	0.30	6.59	0.23	0.47	3.34
	Senegal	0.10	0.23	3.98	0.06	0.05	-0.91	0.08	0.17	3.34
	Cameroon	0.12	0.18	1.74	0.02	0.07	5.29	0.08	0.15	3.06
	Kenya	0.18	0.27	1.75	0.05	0.12	4.35	0.14	0.25	2.72
	Egypt	0.22	0.26	0.69	0.05	0.19	6.34	0.17	0.29	2.46
	Botswana	0.26	0.29	0.50	0.08	0.28	5.66	0.22	0.37	2.39
	Malawi	0.14	0.19	1.48	0.04	0.07	3.19	0.10	0.16	2.26
	South Africa	0.37	0.38	0.11	0.18	0.42	3.96	0.37	0.54	1.73
	Burkina Faso	0.15	0.18	0.59	0.05	0.06	0.85	0.12	0.14	0.78
	Ethiopia	0.03	0.15	7.66	0.01	0.14	14.05	0.00	0.18	
	AVERAGE	0.15	0.25	2.88	0.05	0.20	6.38	0.12	0.29	4.21
SEA	Bangladesh	0.03	0.17	7.56	0.01	0.09	10.04	0.00	0.15	17.80
	Cambodia	0.04	0.20	7.43	0.01	0.12	13.28	0.01	0.20	15.63
	Turkey	0.27	0.46	2.47	0.07	0.76	11.74	0.22	0.82	6.24
	Laos	0.09	0.24	4.71	0.05	0.09	2.96	0.07	0.21	5.27
	India	0.17	0.43	4.29	0.08	0.25	5.48	0.15	0.45	5.19
	Pakistan	0.10	0.17	2.29	0.03	0.14	8.09	0.07	0.19	4.94
	Nepal	0.13	0.23	2.63	0.01	0.07	10.79	0.07	0.19	4.41
	Myanmar	0.10	0.17	2.32	0.00	0.03	11.27	0.05	0.12	3.95
	Thailand	0.35	0.54	1.96	0.13	0.35	4.64	0.32	0.61	2.95
	Indonesia	0.25	0.33	1.28	0.05	0.16	5.35	0.19	0.32	2.38
	Singapore	0.63	0.95	1.90	0.21	0.44	3.43	0.58	0.97	2.38
	Malaysia	0.53	0.60	0.56	0.15	0.33	3.48	0.47	0.63	1.39
	Philippines	0.36	0.36	-0.03	0.17	0.32	2.92	0.35	0.45	1.13
	AVERAGE	0.24	0.37	3.03	0.07	0.24	7.19	0.20	0.41	5.66
CEE	Latvia	0.29	0.45	2.10	0.18	0.57	5.48	0.30	0.69	3.81
	Armenia	0.16	0.31	3.14	0.23	0.39	2.48	0.24	0.46	3.01
	Georgia	0.12	0.37	5.13	0.36	0.51	1.53	0.31	0.58	3.00
	Azerbaijan	0.19	0.33	2.55	0.11	0.18	2.51	0.18	0.34	2.83
	Ukraine	0.36	0.34	-0.32	0.31	0.91	4.97	0.45	0.82	2.81
	Kazakhstan	0.17	0.38	3.69	0.19	0.21	0.42	0.23	0.39	2.53
	Estonia	0.37	0.57	1.92	0.39	0.71	2.79	0.51	0.86	2.46

Table D2: (Continued) Initial, Final, and Growth of the National Innovation Index by Country and Region

Region	Country	Input Sub-Index			Output Sub-Index			Final Index		
		1996	2018	CAGR%	1996	2018	CAGR%	1996	2018	CAGR%
	Lithuania	0.39	0.52	1.39	0.14	0.35	4.10	0.35	0.59	2.35
	Russia	0.28	0.50	2.69	0.31	0.42	1.31	0.39	0.62	2.16
	Uzbekistan	0.16	0.32	3.09	0.22	0.24	0.46	0.24	0.37	2.02
	Belarus	0.27	0.42	2.04	0.32	0.26	-0.94	0.39	0.46	0.80
	AVERAGE	0.25	0.41	2.49	0.25	0.43	2.28	0.33	0.56	2.52
LAC	Costa Rica	0.26	0.37	1.71	0.07	0.38	7.70	0.21	0.50	3.99
	Peru	0.25	0.36	1.57	0.01	0.23	15.86	0.17	0.39	3.97
	Brazil	0.22	0.44	3.08	0.15	0.37	4.10	0.24	0.54	3.77
	Ecuador	0.24	0.29	0.95	0.03	0.27	10.31	0.17	0.37	3.64
	Chile	0.38	0.49	1.20	0.05	0.40	10.19	0.28	0.60	3.47
	Colombia	0.23	0.36	2.03	0.07	0.25	5.78	0.19	0.40	3.45
	Mexico	0.27	0.42	2.10	0.16	0.33	3.30	0.28	0.51	2.75
	Argentina	0.28	0.38	1.36	0.10	0.29	5.04	0.25	0.45	2.73
	AVERAGE	0.27	0.39	1.75	0.08	0.32	7.78	0.22	0.47	3.47

Source: Author's calculations.

CAGR%: Compound Annual Growth Rate = CAGR = $\left(\frac{\text{Final Value}}{\text{Initial Value}}\right)^{\frac{1}{t}} - 1$

Table D3: Pillars and Sub-Indexes by Country and Region – Year 2018

Region	Country	Input Sub-Index					Output Sub-Index	
		Institutions	Human Capital	Infrastructure	Market	Business	Scientific output	Creative output
AFR	Morocco	0.44	0.27	0.77	0.47	0.27	0.37	0.51
	South Africa	0.47	0.24	0.74	0.50	0.36	0.61	0.12
	Mauritius	0.72	0.24	0.71	0.48	0.20	0.28	0.35
	Tunisia	0.44	0.51	0.74	0.49	0.24	0.52	0.03
	Namibia	0.55	0.14	0.47	0.45	0.30	0.25	0.33
	Botswana	0.62	0.17	0.63	0.41	0.15	0.44	0.05
	Ghana	0.47	0.16	0.61	0.32	0.38	0.12	0.15
	Egypt	0.34	0.22	0.64	0.36	0.26	0.22	0.10
	Kenya	0.35	0.34	0.50	0.34	0.27	0.20	0.02
	Zambia	0.39	0.12	0.53	0.37	0.24	0.12	0.08
	Rwanda	0.52	0.16	0.53	0.35	0.19	0.12	0.05
	Nigeria	0.18	0.17	0.49	0.33	0.27	0.17	0.09
	Uganda	0.36	0.08	0.46	0.31	0.25	0.14	0.07
	Mozambique	0.26	0.10	0.43	0.30	0.26	0.12	0.11
	Tanzania	0.33	0.15	0.64	0.31	0.21	0.13	0.01
	Ethiopia	0.28	0.10	0.50	0.20	0.28	0.24	0.02
	Senegal	0.46	0.28	0.56	0.25	0.16	0.10	0.00
	Malawi	0.34	0.16	0.31	0.32	0.31	0.14	0.00
	Lesotho	0.35	0.10	0.39	0.42	0.09	0.13	0.04
	Cameroon	0.25	0.19	0.47	0.29	0.24	0.13	0.00
	Burkina Faso	0.34	0.24	0.38	0.25	0.21	0.12	0.00
	AVERAGE	0.40	0.20	0.55	0.36	0.24	0.22	0.10
SEA	Singapore	1.00	0.95	0.98	0.90	0.88	0.69	0.08
	Turkey	0.40	0.54	0.87	0.49	0.39	0.39	0.70
	Malaysia	0.67	0.65	0.86	0.65	0.43	0.48	0.09
	Thailand	0.47	0.52	0.79	0.65	0.51	0.41	0.17
	India	0.46	0.32	0.78	0.40	0.57	0.26	0.14
	Philippines	0.40	0.23	0.77	0.43	0.39	0.40	0.14
	Indonesia	0.45	0.18	0.77	0.40	0.35	0.17	0.08
	Laos	0.30	0.16	0.54	0.36	0.32	0.14	0.02
	Cambodia	0.31	0.07	0.51	0.50	0.11	0.05	0.11
	Pakistan	0.23	0.09	0.49	0.29	0.29	0.12	0.10
	Nepal	0.32	0.15	0.74	0.30	0.21	0.14	0.00
	Bangladesh	0.29	0.06	0.68	0.25	0.17	0.03	0.09
	Myanmar	0.23	0.20	0.44	0.26	0.26	0.06	0.00
	AVERAGE	0.43	0.32	0.71	0.45	0.37	0.26	0.13
CEE	Estonia	0.80	0.65	0.94	0.53	0.29	1.00	0.22
	Ukraine	0.30	0.40	0.71	0.43	0.30	0.83	0.59
	Latvia	0.73	0.43	0.79	0.47	0.27	0.54	0.36
	Russia	0.38	0.63	0.83	0.42	0.55	0.50	0.19
	Lithuania	0.76	0.58	0.81	0.52	0.32	0.41	0.17
	Georgia	0.58	0.31	0.74	0.48	0.20	0.55	0.27
	Armenia	0.47	0.23	0.71	0.45	0.19	0.30	0.29
	Belarus	0.41	0.51	0.84	0.47	0.31	0.32	0.11
	Kazakhstan	0.47	0.32	0.83	0.37	0.36	0.29	0.08
	Uzbekistan	0.30	0.32	0.81	0.36	0.30	0.25	0.14
	Azerbaijan	0.40	0.32	0.72	0.39	0.29	0.20	0.10
	AVERAGE	0.51	0.43	0.79	0.44	0.31	0.47	0.23
LAC	Chile	0.74	0.35	0.87	0.51	0.38	0.41	0.23
	Brazil	0.41	0.40	0.78	0.40	0.55	0.38	0.22
	Mexico	0.42	0.29	0.80	0.47	0.51	0.39	0.15
	Costa Rica	0.62	0.21	0.75	0.43	0.31	0.39	0.22
	Argentina	0.52	0.32	0.74	0.33	0.45	0.25	0.20
	Colombia	0.45	0.29	0.79	0.37	0.36	0.28	0.13
	Peru	0.45	0.37	0.73	0.40	0.30	0.15	0.20
	Ecuador	0.36	0.24	0.75	0.37	0.25	0.19	0.22
	AVERAGE	0.50	0.31	0.78	0.41	0.39	0.30	0.20

Source: Author's calculations.

Appendix E

Data – Panel Approach

Table E1: Pavitt Class, Industry, and ISIC Codes

Pavitt Class	Industry	ISIC
Supplier Dominated	Food products and beverages	15
	Tobacco products	16
	Textiles	17
	Wearing apparel	18
	Leather products	19
	Wood products	20
	Fabricated metal products	28
	Furniture	36
	Recycling	37
Scale Intensive	Paper products	21
	Publishing, printing and reproduction of data	22
	Coke, refined petroleum and nuclear fuel	23
	Rubber and plastic products	25
	Other non-metallic mineral products	26
	Basic metals	27
	Motor vehicles	34
Specialised Suppliers	Machinery and equipment	29
	Electrical machinery and apparatus	31
	Other transport equipment	35
Science-Based	Chemicals and chemical products	24
	Office, accounting and computing machinery	30
	Radio, television and communication equipment	32
	Medical, precision and optical instruments	33

Source: Author's calculations.

Table E2: Summary Statistics – Panel Approach

Variable	Obs	Mean	Std. dev.	Min	Max
Real manufacturing value added share at constant 2015 US dollars	1,219	0.148	0.058	0.036	0.335
Manufacturing value added share in "Supplier Dominated" products (% GDP share at constant 2015 US dollars)	6,607	0.005	0.010	0.000	0.127
Manufacturing value added share in "Scale Intensive" products (% GDP share at constant 2015 US dollars)	5,591	0.004	0.006	0.000	0.149
Manufacturing value added share in "Specialized Suppliers" products (% GDP share at constant 2015 US dollars)	2,213	0.003	0.004	0.000	0.063
Manufacturing value added share in "Science-Based" products (% GDP share at constant 2015 US dollars)	2,048	0.006	0.010	0.000	0.098
Manufacturing employment share	1,219	0.108	0.055	0.012	0.289
Employment share in "Supplier Dominated" products (% total employment)	6,353	0.005	0.010	0.000	0.163
Employment share in "Scale Intensive" products (% total employment)	5,395	0.002	0.003	0.000	0.021
Employment share in "Specialized Suppliers" products (% total employment)	2,145	0.003	0.005	0.000	0.055
Employment share in "Science-Based" products (% total employment)	1,919	0.003	0.005	0.000	0.040
GDP per capita at constant 2015 US dollars	1,219	8,918.3	8,674.0	761.9	68,402.4
Total population (thousands)	1,219	64,033	157,247	1,135	1,298,136
Unbalanced productivity growth	1,219	0.42	1.40	-6.21	7.47
Unemployment, total (% of the total labour force)	1,219	7.79	5.29	0.12	24.45
Manufacturing exports (% total exports of goods and services)	1,123	0.605	0.268	0.044	0.971
Manufacturing imports (% total imports of goods and services)	1,126	0.816	0.088	0.453	0.963
Manufacturing exports to high-income countries (% Apparent consumption in manufacturing)	795	0.345	0.232	0.008	1.138
Manufacturing imports from high-income countries (% Apparent consumption in manufacturing)	796	1.854	1.326	0.000	10.580
Manufacturing exports to low- and medium-income countries (% Apparent consumption in manufacturing)	794	0.057	0.045	0.000	0.340
Manufacturing imports from low- and medium-income countries (% Apparent consumption in manufacturing)	795	0.122	0.102	0.006	0.541
Exports of "Supplier Dominated" products (% Apparent consumption in manufacturing)	5,747	0.021	0.039	0.000	0.449
Exports of "Scale Intensive" products (% Apparent consumption in manufacturing)	4,957	0.023	0.057	0.000	0.998
Exports of "Specialized Suppliers" products (% Apparent consumption in manufacturing)	2,099	0.016	0.024	0.000	0.229
Exports of "Science-Based" products (% Apparent consumption in manufacturing)	2,612	0.031	0.061	0.000	0.577
Imports of "Supplier Dominated" products (% Apparent consumption in manufacturing)	5,747	0.024	0.042	0.000	0.824
Imports of "Scale Intensive" products (% Apparent consumption in manufacturing)	4,957	0.039	0.059	0.000	0.874
Imports of "Specialized Suppliers" products (% Apparent consumption in manufacturing)	2,099	0.052	0.055	0.001	0.492
Imports of "Science-Based" products (% Apparent consumption in manufacturing)	2,612	0.058	0.070	0.002	0.806

Appendix F

Results – Panel Approach

Table F1: Real Manufacturing Value Added and Innovation Index

VARIABLES	(1)	(2)	(3)	(4)	(5)
Ln population	-0.252***	-0.290***	-0.289***	-0.290***	-0.260***
	(0.036)	(0.039)	(0.039)	(0.039)	(0.037)
Ln population squared	0.013***	0.014***	0.015***	0.014***	0.014***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Ln GDP per capita	0.072***	0.123***	0.107***	0.124***	0.038
	(0.027)	(0.028)	(0.027)	(0.027)	(0.028)
Ln GDP per capita squared	-0.003*	-0.006***	-0.005***	-0.006***	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Innovation index	-0.142***	-0.115***	-0.092***	-0.117***	-0.117***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Innovation index squared	0.140***	0.133***	0.111***	0.134***	0.119***
	(0.017)	(0.018)	(0.017)	(0.018)	(0.016)
Manuf.exports to high-income countries (% Apparent consumption)	0.000***	-0.000	-0.000	-0.000	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Manuf.imports from high-income countries (% Apparent consumption)	0.000	0.001*	0.001*	0.001*	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Manuf.exports to low-medium-income countries (% Apparent consumption)	-0.035	-0.012	-0.008	-0.015	-0.025
	(0.025)	(0.028)	(0.027)	(0.028)	(0.025)
Manuf.imports from low-medium-income countries (% Apparent consumption)	-0.064***	-0.077***	-0.076***	-0.076***	-0.063***
	(0.018)	(0.019)	(0.019)	(0.019)	(0.017)
Unbalanced productivity growth	0.000**	0.000*	0.000*	0.000*	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Trade and competition sub-pillar	0.172***				0.177***
	(0.026)				(0.026)
Business sophistication pillar		0.002			0.017**
		(0.008)			(0.008)
Real effective exchange rate			-0.000		-0.000
			(0.000)		(0.000)
Total natural resources rents (% of GDP)				-0.000	-0.000
				(0.000)	(0.000)
Constant	0.882***	0.993***	1.004***	0.991***	1.015***
	(0.228)	(0.257)	(0.240)	(0.243)	(0.236)
Observations	794	794	777	794	777
R-squared	0.974	0.972	0.974	0.972	0.976
Year FE	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y
Ln GDP turnover	12.900	10.789	11.364	10.773	25.131
P-value 0.000	0.000	0.000	0.000	0.479	
Industrialization share turnover	0.149	0.152	0.153	0.152	0.151
Index turnover	0.507	0.432	0.412	0.435	0.494
P-value	0.000	0.000	0.000	0.000	0.000
t-test Nonlinearity index[a]	7.23	5.71	4.58	5.74	5.99
P-value	0.000	0.000	0.000	0.000	0.000
Slope at Min	-0.142***	-0.115***	-0.091***	-0.116***	-0.117***
Slope at Max	0.138***	0.151***	0.130***	0.151***	0.120***

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001.
[a] Lind & Mehlum (2010) overall test of presence of an Inverse U shape. Test: H1: U shape vs. H0: Monotone or Inverse U shape.

Table F2: Manufacturing Employment Share and Innovation Index

VARIABLES	(1)	(2)	(3)	(4)	(5)
Ln population	-0.258***	-0.294***	-0.282***	-0.281***	-0.255***
	(0.045)	(0.044)	(0.047)	(0.044)	(0.047)
Ln population squared	0.017***	0.018***	0.017***	0.017***	0.017***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Ln GDP per capita	0.162***	0.191***	0.202***	0.209***	0.143***
	(0.030)	(0.034)	(0.033)	(0.031)	(0.034)
Ln GDP per capita squared	-0.008***	-0.010***	-0.011***	-0.011***	-0.007***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Innovation index	-0.064***	-0.042*	-0.040*	-0.039*	-0.060***
	(0.022)	(0.022)	(0.023)	(0.022)	(0.023)
Innovation index squared	0.024	0.019	0.017	0.016	0.023
	(0.018)	(0.018)	(0.019)	(0.018)	(0.019)
Manuf.exports to high-income countries (% Apparent consumption)	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Manuf.imports from high-income countries (% Apparent consumption)	-0.003**	-0.003**	-0.003**	-0.003**	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Manuf.exports to low-medium-income countries (% Apparent consumption)	0.089***	0.067**	0.072***	0.062**	0.076***
	(0.025)	(0.027)	(0.027)	(0.027)	(0.025)
Manuf.imports from low-medium-income countries (% Apparent consumption)	-0.019	-0.030*	-0.030*	-0.032**	-0.021
	(0.016)	(0.017)	(0.017)	(0.016)	(0.016)
Unbalanced productivity growth	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Unemployment rate	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Trade and competition sub-pillar	-0.137***				-0.160***
	(0.024)				(0.024)
Business sophistication pillar		-0.013			-0.022***
		(0.009)			(0.008)
Real effective exchange rate			-0.000		-0.000
			(0.000)		(0.000)
Total natural resources rents (% of GDP)				-0.000***	-0.001***
				(0.000)	(0.000)
Constant	0.247	0.406	0.277	0.281	0.286
	(0.260)	(0.267)	(0.269)	(0.254)	(0.282)
Observations	794	794	777	794	777
R-squared	0.963	0.962	0.961	0.962	0.964
Year FE	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001.

Table F3: Real Manufacturing Value Added and Innovation Input / Output Sub-Indexes

VARIABLES	(1)	(2)	(3)	(4)	(5)
Ln population	-0.299***	-0.321***	-0.303***	-0.288***	-0.302***
	(0.041)	(0.040)	(0.041)	(0.040)	(0.039)
Ln population squared	0.014***	0.015***	0.015***	0.014***	0.014***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Ln GDP per capita	0.029	0.129***	0.022	0.026	0.127***
	(0.026)	(0.032)	(0.026)	(0.026)	(0.031)
Ln GDP per capita squared	-0.001	-0.006***	-0.000	-0.000	-0.006***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)
Innovation input sub-index	0.035**	-0.104***			-0.083***
	(0.018)	(0.031)			(0.030)
Innovation input sub-index squared		0.161***			0.142***
		(0.031)			(0.030)
Innovation output sub-index			0.013***	-0.045***	-0.043***
			(0.005)	(0.014)	(0.014)
Innovation output sub-index squared				0.066***	0.063***
				(0.015)	(0.014)
Constant	1.453***	1.194***	1.475***	1.374***	1.246***
	(0.252)	(0.244)	(0.249)	(0.245)	(0.242)
Observations	794	794	794	794	794
R-squared	0.969	0.970	0.969	0.970	0.971
Control Variables [a]	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y
Industrialization share turnover		0.155			0.153
Innovation Input sub-index turnover		0.325			0.289
P-value		0.000			0.000
t-test Nonlinearity Innovation Input sub-index [b]		3.34			2.73
P-value		0.000			0.003
Slope at Min		-0.104***			-0.082**
Slope at Max		0.216***			0.202***
Industrialization share turnover				0.156	0.152
Innovation Output sub-index turnover				0.336	0.340
P-value				0.000	0.000
t-test Nonlinearity Innovation Output sub-index [b]				3.18	3.17
P-value				0.001	0.000
Slope at Min				-0.044***	-0.042***
Slope at Max				0.087***	0.083***

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001.
[a] Control variable: manufacturing exports (imports) from (to) high-, medium- and low-income countries (% apparent consumption in manufacturing), and unbalanced productivity growth
[b] Lind & Mehlum (2010) overall test of presence of an Inverse U shape. Test: H1: U shape vs. H0: Monotone or Inverse U shape.

Table F4: Manufacturing Employment Share and Innovation Input / Output Sub-Indexes

VARIABLES	(1)	(2)	(3)	(4)	(5)
Ln population	-0.283***	-0.275***	-0.286***	-0.276***	-0.264***
	(0.046)	(0.049)	(0.045)	(0.043)	(0.046)
Ln population squared	0.017***	0.017***	0.017***	0.017***	0.016***
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Ln GDP per capita	0.198***	0.167***	0.193***	0.197***	0.164***
	(0.028)	(0.037)	(0.026)	(0.027)	(0.038)
Ln GDP per capita squared	-0.010***	-0.009***	-0.010***	-0.010***	-0.009***
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
Innovation input sub-index	0.004	0.048			0.065
	(0.017)	(0.040)			(0.040)
Innovation input sub-index squared		-0.049			-0.059
		(0.038)			(0.037)
Innovation output sub-index			-0.019***	-0.061***	-0.063***
			(0.007)	(0.015)	(0.015)
Innovation output sub-index squared				0.048***	0.051***
				(0.014)	(0.014)
Constant	0.297	0.372	0.364	0.293	0.324
	(0.270)	(0.254)	(0.255)	(0.253)	(0.241)
Observations	794	794	794	794	794
R-squared	0.961	0.961	0.961	0.962	0.962
Control Variables [a]	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y
Industrialization share turnover				0.112	0.111
Innovation Output sub-index turnover				0.629	0.619
P-value				0.000	0.000
t-test Nonlinearity Innovation Output sub-index [b]				2.15	2.39
P-value				0.016	0.008
Slope at Min				-0.060***	-0.063***
Slope at Max				0.035*	0.038**

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001.
[a] Control variable: manufacturing exports (imports) from (to) high-, medium- and low-income countries (% apparent consumption in manufacturing), unbalanced productivity growth and unemployment rate.
[b] Lind & Mehlum (2010) overall test of presence of an Inverse U shape. Test: H1: U shape vs. H0: Monotone or Inverse U shape.

Table F5: Real Manufacturing Value Added and Employment - Institutions Pillar and Sub-Pillars

VARIABLES	Realmva (1)	Realmva (2)	Manemp (3)	Manemp (4)
Institutions pillar	-0.107***		0.165***	
	(0.034)		(0.032)	
Institutions pillar squared	0.137***		-0.157***	
	(0.040)		(0.038)	
Political environment sub-pillar		-0.074***		0.074***
		(0.025)		(0.023)
Political environment sub-pillar squared		0.109***		-0.070**
		(0.037)		(0.035)
Regulatory environment sub-pillar		-0.018		0.064*
		(0.046)		(0.038)
Regulatory environment sub-pillar squared		0.023		-0.063
		(0.052)		(0.041)
Business environment sub-pillar		0.115**		0.004
		(0.046)		(0.043)
Business environment sub-pillar squared		-0.172***		0.008
		(0.065)		(0.062)
Observations	794	794	794	794
R-squared	0.969	0.970	0.962	0.962
Control Variables [a]	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Country FE	Y	Y	Y	Y
Region FE	Y	Y	Y	Y
Industrialization share turnover	0.154		0.125	
Institutions pillar turnover	0.388		0.527	
P-value	0.000		0.000	
t-test Nonlinearity Institutions pillar [b]	3.10		3.19	
P-value	0.001		0.000	
Slope at Min	-0.106***		0.165***	
Slope at Max	0.168***		-0.148***	
Political environment sub-pillar turnover		0.339		0.528
P-value		0.000		0.000
t-test Nonlinearity Political environment sub-pillar [b]		2.79		1.33
P-value		0.002		0.092
Slope at Min		-0.073**		0.074***
Slope at Max		0.143**		-0.066*
Business environment sub-pillar turnover			0.158	
P-value			0.000	
t-test Nonlinearity Business environment sub-pillar [b]			2.53	
P-value			0.005	
Slope at Min			0.115**	
Slope at Max			-0.229**	

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001.
[a] Control variables: Ln population, Ln population squared, Ln GDP per capita, Ln GDP per capita squared, manufacturing exports (imports) from (to) high-, medium- and low-income countries (% apparent consumption in manufacturing), unbalanced productivity growth and unemployment rate in the case of manufacturing employment share (Manemp) regressions.
[b] Lind & Mehlum (2010) overall test of presence of an Inverse U shape. Test: H1: U shape vs. H0: Monotone or Inverse U shape.

Table F6: Real Manufacturing Value Added and Employment – Human Capital and Research Pillar and Sub-Pillars

VARIABLES	Realmva (1)	Realmva (2)	Manemp (3)	Manemp (4)
Human capital and research pillar	-0.252***		-0.027	
	(0.031)		(0.027)	
Human capital and research pillar squared	0.276***		0.014	
	(0.032)		(0.026)	
Tertiary education sub-pillar		-0.255***		-0.042
		(0.034)		(0.029)
Tertiary education sub-pillar squared		0.191***		-0.019
		(0.033)		(0.029)
Research and development sub-pillar		-0.018		0.039*
		(0.020)		(0.023)
Research and development sub-pillar squared		0.081***		-0.011
		(0.023)		(0.023)
Observations	794	794	794	794
R-squared	0.973	0.974	0.961	0.963
Control Variables [a]	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Country FE	Y	Y	Y	Y
Region FE	Y	Y	Y	Y
Industrialization share turnover	0.143			
Human capital and research pillar turnover	0.457			
P-value	0.000			
t-test Nonlinearity Human capital and research pillar [b]	8.09			
P-value	0.000			
Slope at Min	-0.252***			
Slope at Max	0.299***			
Industrialization share turnover		0.142		
Tertiary education sub-pillar turnover		0.667		
P-value		0.000		
t-test Nonlinearity Tertiary education sub-pillar [b]		3.60		
P-value		0.000		
Slope at Min		-0.254***		
Slope at Max		0.126***		

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001.
[a] Control variables: Ln population, Ln population squared, Ln GDP per capita, Ln GDP per capita squared, manufacturing exports (imports) from (to) high-, medium- and low-income countries (% apparent consumption in manufacturing), unbalanced productivity growth and unemployment rate in the case of manufacturing employment share (Manemp) regressions.
[b] Lind & Mehlum (2010) overall test of presence of an Inverse U shape. Test: H1: U shape vs. H0: Monotone or Inverse U shape.

Table F7: Real Manufacturing Value Added and Employment – Infrastructure Pillar and Sub-Pillars

VARIABLES	Realmva (1)	Realmva (2)	Manemp (3)	Manemp (4)
Infrastructure pillar	-0.076***		0.081***	
	(0.022)		(0.029)	
Infrastructure pillar squared	0.067***		-0.086***	
	(0.020)		(0.026)	
ICT sub-pillar		-0.019		0.027**
		(0.013)		(0.012)
ICT sub-pillar squared		0.026*		-0.042***
		(0.013)		(0.012)
General infrastructure sub-pillar		0.050**		0.089***
		(0.021)		(0.026)
General infrastructure sub-pillar squared		-0.058***		-0.080***
		(0.018)		(0.020)
Observations	794	794	794	794
R-squared	0.969	0.970	0.962	0.962
Control Variables [a]	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Country FE	Y	Y	Y	Y
Region FE	Y	Y	Y	Y
Industrialization share turnover	0.155		0.124	
Infrastructure pillar turnover	0.566		0.472	
P-value	0.000		0.000	
t-test Nonlinearity Infrastructure pillar [b]	2.71		2.83	
P-value	0.003		0.002	
Slope at Min	-0.075***		0.081**	
Slope at Max	0.058**		-0.090***	
Industrialization share turnover				0.126
ICT sub-pillar turnover				0.326
P-value				0.000
t-test Nonlinearity ICT sub-pillar [b]				2.36
P-value				0.009
Slope at Min				0.027**
Slope at Max				-0.056***
Industrialization share turnover		0.161		0.126
General infrastructure sub-pillar turnover		0.427		0.558
P-value		0.000		0.000
t-test Nonlinearity General infrastructure sub-pillar [b]		2.43		3.46
P-value		0.007		0.000
Slope at Min		0.049**		0.089***
Slope at Max		-0.066***		-0.070***

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001.
[a] Control variables: Ln population, Ln population squared, Ln GDP per capita, Ln GDP per capita squared, manufacturing exports (imports) from (to) high-, medium- and low-income countries (% apparent consumption in manufacturing), unbalanced productivity growth and unemployment rate in the case of manufacturing employment share (Manemp) regressions.
[b] Lind & Mehlum (2010) overall test of presence of an Inverse U shape. Test: H1: U shape vs. H0: Monotone or Inverse U shape.

Table F8: Real Manufacturing Value Added and Employment – Market and Business Sophistication Pillars and Sub-Pillars

VARIABLES	Realmva (1)	Realmva (2)	Realmva (3)	Manemp (4)	Manemp (5)	Manemp (6)
Market sophistication pillar	0.192***			-0.240***		
	(0.055)			(0.045)		
Market sophistication pillar squared	-0.128**			0.287***		
	(0.062)			(0.048)		
Credit sub-pillar		0.018			-0.031**	
		(0.016)			(0.015)	
Credit sub-pillar squared		-0.022			0.033*	
		(0.015)			(0.017)	
Trade and competition sub-pillar		0.249***			-0.147***	
		(0.059)			(0.055)	
Trade and competition sub-pillar squared		-0.081			0.240***	
		(0.051)			(0.052)	
Business sophistication pillar			-0.043*			-0.033
			(0.023)			(0.024)
Business sophistication pillar squared			0.052**			0.020
			(0.026)			(0.026)
Observations	794	794	794	794	794	794
R-squared	0.970	0.971	0.969	0.963	0.963	0.961
Control Variables [a]	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y
Industrialization share turnover	0.175			0.115		
Market sophistication pillar turnover	0.749			0.419		
P-value	0.000			0.000		
t-test Nonlinearity Market sophistication pillar [b]	0.89			5.35		
P-value	0.186			0.000		
Slope at Min	0.191***			-0.240***		
Slope at Max	-0.064			0.333***		
Industrialization share turnover					0.116	
Credit sub-pillar turnover					0.472	
P-value					0.000	
t-test Nonlinearity Credit sub-pillar [b]					1.48	
P-value					0.070	
Slope at Min					-0.030*	
Slope at Max					0.034*	
Industrialization share turnover					0.115	
Trade and comp. sub-pillar turnover					0.305	
P-value					0.000	
t-test Nonlinearity Trade and comp. sub-pillar [b]					2.65	
P-value					0.004	
Slope at Min					-0.146**	
Slope at Max					0.333***	
Industrialization share turnover			0.157			
Business sophistication pillar turnover			0.416			
P-value			0.000			
t-test Nonlinearity Business sophistication pillar [b]			1.87			
P-value			0.030			
Slope at Min			-0.043*			
Slope at Max			0.060*			

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001.
[a] Control variable: Ln population, Ln population squared, Ln GDP per capita, Ln GDP per capita squared, manufacturing exports (imports) from (to) high-, medium- and low-income countries (% apparent consumption in manufacturing), unbalanced productivity growth and unemployment rate in the case of manufacturing employment share (Manemp) regressions.
[b] Lind & Mehlum (2010) overall test of presence of an Inverse U shape. Test: H1: U shape vs. H0: Monotone or Inverse U shape.

Table F9: Real Manufacturing Value Added and Employment – Scientific and Creative Pillars and Sub-Pillars

VARIABLES	Realmva (1)	Realmva (2)	Realmva (3)	Manemp (4)	Manemp (5)	Manemp (6)
Scientific output pillar	-0.085***			-0.095***		
	(0.019)			(0.023)		
Scientific output pillar squared	0.097***			0.070***		
	(0.019)			(0.021)		
Knowledge creation sub-pillar		0.009			-0.027	
		(0.018)			(0.017)	
Knowledge creation sub-pillar squared		-0.019			0.008	
		(0.019)			(0.018)	
Knowledge diffusion and impact sub-pillar		-0.063***			-0.076***	
		(0.018)			(0.021)	
Knowledge diffusion and impact sub-pillar squared		0.100***			0.063***	
		(0.018)			(0.020)	
Creative output pillar			0.001			-0.026***
			(0.010)			(0.009)
Creative output pillar squared			0.022**			0.029***
			(0.011)			(0.010)
Observations	794	794	794	794	794	794
R-squared	0.970	0.970	0.969	0.963	0.963	0.961
Control Variables [a]	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y
Industrialization share turnover	0.152			0.108		
Scientific output pillar turnover	0.440			0.679		
P-value	0.000			0.000		
t-test Nonlinearity Scientific output pillar [b]	4.60			2.00		
P-value	0.000			0.023		
Slope at Min	-0.085***			-0.095***		
Slope at Max	0.108***			0.045*		
Industrialization share turnover		0.155			0.111	
Know. Diff. sub-pillar turnover		0.315			0.607	
P-value		0.000			0.000	
t-test Nonlinearity Know. Diff. sub-pillar [b]		3.43			2.23	
P-value		0.000			0.013	
Slope at Min		-0.062***			-0.076***	
Slope at Max		0.136***			0.049*	
Industrialization share turnover						0.117
Creative output pillar turnover						0.448
P-value						0.000
t-test Nonlinearity Creative output pillar [b]						2.30
P-value						0.010
Slope at Min						-0.025**
Slope at Max						0.031*

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001.
[a] Control variables: Ln population, Ln population squared, Ln GDP per capita, Ln GDP per capita squared, manufacturing exports (imports) from (to) high-, medium- and low-income countries (% apparent consumption in manufacturing), unbalanced productivity growth and unemployment rate in the case of manufacturing employment share (Manemp) regressions.
[b] Lind & Mehlum (2010) overall test of presence of an Inverse U shape. Test: H1: U shape vs. H0: Monotone or Inverse U shape.

Table F10: Real Manufacturing Value Added – 2digit ISIC Rev.3

ISIC CODE	Innovation index	Innovation index2	Obs.	R2	IndexTurnover (p-value)	tTestNonlinear (p-value)	SlopeMin (p-value)	SlopeMax (p-value)
Food products (15)	-0.016**		747	0.797				
	(0.005)							
	0.025**	-0.040***	747	0.801	0.305	2.23	0.025	-0.056
	(0.011)	(0.008)			(0.000)	(0.013)	(0.012)	(0.000)
Tobacco products (16)	-0.003**		483	0.826				
	(0.001)							
	-0.001	-0.002	483	0.826	0.168	-	-	-
	(0.003)	(0.003)			(0.851)			
Textiles (17)	0.001		744	0.872				
	(0.002)							
	-0.005	0.006**	744	0.873	0.398	1.40	-0.004	0.007
	(0.004)	(0.003)			(0.022)	(0.089)	(0.080)	(0.021)
Wearing apparel (18)	0.001		673	0.968				
	(0.002)							
	-0.001	0.002	673	0.968	0.173	0.21	-0.000	0.003
	(0.003)	(0.003)			(0.784)	(0.416)	(0.416)	(0.135)
Leather products (19)	0.000		679	0.828				
	(0.000)							
	0.003***	-0.003***	679	0.830	0.571	2.27	0.002	-0.002
	(0.001)	(0.001)			(0.000)	(0.011)	(0.002)	(0.011)
Wood products (20)	0.017**		747	0.645				
	(0.007)							
	0.004	0.012*	747	0.647	0.167	-	-	-
	(0.012)	(0.006)			(0.762)			
Paper products (21)	-0.001*		731	0.814				
	(0.001)							
	-0.000	-0.001	731	0.814	0.017			
	(0.002)	(0.001)			(0.980)			
Printing (22)	-0.002***		706	0.707				
	(0.001)							
	0.006***	-0.009***	706	0.720	0.379	3.50	0.006	-0.010
	(0.002)	(0.002)			(0.000)	(0.000)	(0.000)	(0.000)
Petro. products (23)	-0.019***		619	0.754				
	(0.004)							
	0.006	-0.025***	619	0.758	0.129	0.71	0.006	-0.043
	(0.009)	(0.008)			(0.376)	(0.238)	(0.238)	(0.000)
Chemical products (24)	-0.005		700	0.830				
	(0.004)							
	-0.000	-0.005	700	0.830	0.028	-	-	-
	(0.007)	(0.006)			(0.970)			
Plastics products (25)	-0.003**		711	0.796				
	(0.001)							
	-0.002	-0.001	711	0.796	0.934	-	-	-
	(0.003)	(0.002)			(0.766)			
Mineral products (26)	0.005***		714	0.874				
	(0.002)							
	0.015***	-0.010***	714	0.877	0.760	1.60	0.015	-0.004
	(0.003)	(0.003)			(0.000)	(0.055)	(0.000)	(0.055)
Basic metals (27)	0.005**		733	0.810				
	(0.003)							
	0.008	-0.003	733	0.810	0.360	-	-	-
	(0.006)	(0.005)			(0.315)			
Fab.metal product (28)	0.002		808	0.828				
	(0.001)							
	-0.005	0.007**	808	0.831	0.338	1.55	-0.004	0.009
	(0.003)	(0.003)			(0.001)	(0.060)	(0.060)	(0.006)
Machinery (29)	0.001		687	0.831				
	(0.002)							
	-0.018***	0.019***	687	0.838	0.488	4.60	-0.018	0.019
	(0.004)	(0.003)			(0.000)	(0.000)	(0.000)	(0.000)
Computing machinery (30)	-0.012***		507	0.827				
	(0.004)							
	-0.011	-0.001	507	0.827	0.668	-	-	-
	(0.011)	(0.011)			(0.925)			
Elec.machinery (31)	0.008***		681	0.433				
	(0.002)							
	0.001	0.007**	681	0.434	0.049	-	-	-

Table F10: (continued) Real Manufacturing Value Added – 2digit ISIC Rev.3

ISIC CODE	Innovation index	Innovation index2	Obs.	R2	IndexTurnover (p-value)	tTestNonlinear (p-value)	SlopeMin (p-value)	SlopeMax (p-value)
	(0.003)	(0.004)			(0.844)			
Commu. equi.(32)	-0.000		257	0.950				
	(0.002)							
	-0.004	0.004	257	0.950	0.480	0.34	-0.003	0.004
	(0.010)	(0.011)			(0.105)	(0.366)	(0.345)	(0.366)
Medical instruments (33)	-0.000		330	0.954				
	(0.000)							
	-0.001	0.001	330	0.954	0.612	0.36	-0.001	0.000
	(0.001)	(0.002)			(0.149)	(0.358)	(0.216)	(0.358)
Motor vehicles (34)	-0.001		658	0.866				
	(0.001)							
	-0.001	-0.001	658	0.866	0.465	-	-	-
	(0.003)	(0.003)			(0.923)			
Other transport (35)	0.002**		579	0.900				
	(0.001)							
	0.004**	-0.003	579	0.901	0.831	0.48	0.004	-0.000
	(0.002)	(0.002)			(0.001)	(0.315)	(0.023)	(0.314)
Furniture (36)	0.000		740	0.737				
	(0.001)							
	0.004	-0.003	740	0.737	0.543	0.97	0.003	-0.003
	(0.004)	(0.003)			(0.006)	(0.166)	(0.165)	(0.112)

Source: Author's calculations.

Control variable: Ln population, Ln population squared, Ln GDP per capita, Ln GDP per capita squared, sectoral manufacturing exports (imports) (% apparent consumption in manufacturing), and unbalanced productivity growth.

Lind & Mehlum (2010) overall test of the presence of an Inverse U shape. Test: H1: U shape vs. H0: Monotone or Inverse U shape.

Table F11: Manufacturing Employment Share – 2digit ISIC Rev.3

ISIC CODE	Innovation index	Innovation index2	Obs.	R2	IndexTurnover (p-value)	tTestNonlinear (p-value)	SlopeMin (p-value)	SlopeMax (p-value)
Food products (15)	0.007***		712	0.927				
	(0.002)							
	0.020***	-0.013**	712	0.928	0.768	1.11	0.020	-0.006
	(0.005)	(0.005)		(0.000)	(0.133)	(0.000)	(0.133)	
Tobacco products (16)	-0.001***		480	0.933				
	(0.000)							
	0.002***	-0.002***	480	0.936	0.352	3.44	0.001	-0.003
	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	
Textiles (17)	0.006**		707	0.878				
	(0.002)							
	0.007	-0.001	707	0.878	0.173	-	-	-
	(0.006)	(0.004)		(0.893)				
Wearing apparel (18)	-0.007		655	0.909				
	(0.005)							
	-0.064***	0.055***	655	0.913	0.573	3.97	-0.063	0.047
	(0.016)	(0.013)		(0.000)	(0.000)	(0.000)	(0.000)	
Leather products (19)	0.001**		639	0.881				
	(0.000)							
	-0.000	0.001	639	0.881	0.030	0.04	-0.000	0.002
	(0.002)	(0.002)		(0.962)	(0.482)	(0.482)	(0.056)	
Wood products (20)	0.005***		710	0.974				
	(0.001)							
	0.004	0.001	710	0.974	0.753	-	-	-
	(0.003)	(0.002)			(0.708)			
Paper products (21)	0.001		703	0.923				
	(0.000)							
	0.001*	-0.001	703	0.923	0.868	0.30	0.001	-0.000
	(0.001)	(0.001)		(0.017)	(0.383)	(0.029)	(0.383)	
Printing (22)	-0.001		690	0.864				
	(0.001)							
	0.005***	-0.006***	690	0.868	0.442	2.85	0.005	-0.006
	(0.002)	(0.002)		(0.000)	(0.002)	(0.002)	(0.001)	
Petro. products (23)	-0.000		595	0.931				
	(0.000)							
	0.002**	-0.002**	595	0.933	0.456	2.07	0.002	-0.002
	(0.001)	(0.001)		(0.000)	(0.019)	(0.019)	(0.015)	
Chemical products (24)	0.003***		666	0.913				
	(0.001)							
	0.008***	-0.005***	666	0.915	0.783	2.32	0.008	-0.002
	(0.001)	(0.001)		(0.000)	(0.010)	(0.000)	(0.010)	
Plastics products (25)	0.001		691	0.926				
	(0.001)							
	-0.000	0.002	691	0.926	0.099	0.12	-0.000	0.002
	(0.002)	(0.002)		(0.887)	(0.451)	(0.451)	(0.152)	
Mineral products (26)	0.005***		685	0.917				
	(0.001)							
	0.004*	0.001	685	0.918	0.412	-	-	-
	(0.002)	(0.002)						
Basic metals (27)	0.006***		692	0.911				
	(0.001)							
	0.007***	-0.001	692	0.911	0.757	-	-	-
	(0.002)	(0.001)			(0.513)			
Fab.metal product (28)	0.006***		679	0.934				
	(0.001)							
	-0.007**	0.013***	679	0.939	0.289	2.39	-0.007	0.018
	(0.003)	(0.003)		(0.000)	(0.008)	(0.008)	(0.000)	
Machinery (29)	0.008***		677	0.936				
	(0.000)							
	0.006*	0.003	677	0.940	0.035	-	-	-
	(0.003)	(0.003)			(0.514)			
Computing machinery (30)	-0.004*		454	0.839				
	(0.002)							
	-0.007	0.003	454	0.839	0.355	-	-	-
	(0.006)	(0.005)			(0.452)			
Elec.machinery (31)	0.011***		663	0.578				
	(0.002)							
	0.002	0.009***	663	0.581	0.098	-	-	-

Table F11: (continued) Manufacturing Employment Share – 2digit ISIC Rev.3

ISIC CODE	Innovation index	Innovation index2	Obs.	R2	IndexTurnover (p-value)	tTestNonlinear (p-value)	SlopeMin (p-value)	SlopeMax (p-value)
	(0.003)	(0.003)			(0.550)			
Comm. equipment (32)	0.000		230	0.981				
	(0.002)							
	0.008	-0.008	230	0.981	0.463	1.09	0.007	-0.008
	(0.006)	(0.007)		(0.000)	(0.139)	(0.087)	(0.138)	
Medical instruments (33)	0.000		334	0.969				
	(0.000)							
	0.003**	-0.003*	334	0.970	0.517	1.43	0.002	-0.002
	(0.001)	(0.002)		(0.000)	(0.077)	(0.015)	(0.077)	
Motor vehicles (34)	0.004***		632	0.874				
	(0.001)							
	-0.002	0.006***	632	0.875	0.171	1.02	-0.001	0.009
	(0.002)	(0.002)		(0.170)	(0.154)	(0.154)	(0.000)	
Other transport (35)	0.001*		537	0.936				
	(0.001)							
	0.003	-0.001	537	0.936	0.971	-	-	-
	(0.002)	(0.002)		(0.239)				
Furniture (36)	-0.001		709	0.872				
	(0.002)							
	-0.002	0.001	709	0.872	0.882	0.04	-0.001	0.000
	(0.006)	(0.005)		(0.692)	(0.483)	(0.390)	(0.483)	

Source: Author's calculations.

Control variables: Ln population, Ln population squared, Ln GDP per capita, Ln GDP per capita squared, sectoral manufacturing exports (imports) (% apparent consumption in manufacturing), unbalanced productivity growth and unemployment rate in the case of manufacturing employment share (Manemp) regressions.

Lind & Mehlum (2010) overall test of the presence of an Inverse U shape. Test: H1: U shape vs. H0: Monotone or Inverse U shape.

Chapter 2
Manufacturing Employment Effects of Innovation and Trade: Evidence from Firm-Level Colombian Data

Abstract
This paper employs a structural model to examine how product innovations impact employment growth in Colombian manufacturing firms, while accounting for the differing effects of Chinese import competition based on firms' innovation levels. The findings suggest that innovation generally supports firms in expanding their market share and boosting employment, particularly for highly educated workers. However, rising competition from Chinese imports leads highly innovative firms to reduce employment. Although product innovation serves as a defensive tactic, it does not fully mitigate the adverse effects of foreign competition on employment.

Keywords: Innovation · Employment Growth · Import Competition · Colombian Manufacturing · Firms · China.

JEL Codes: C26, D22, F16, J23, O14, O3.

1 Introduction

The connection between innovation, trade, and manufacturing employment growth is vital for developing economies. According to Carranza et al. (2022), stimulating manufacturing employment in Colombia requires increased investment in science, technology, and innovation. These efforts would help firms adopt new technologies, improve productivity, and create jobs, while also fostering economic diversification. Additionally, enhancing international competitiveness is critical as Colombian firms face mounting pressure from imports. Griffin (2015) and Molina (2020) show that Chinese

import competition has contributed to the country's declining manufacturing output and employment. However, these studies did not differentiate the impact of Chinese competition based on firms' innovation levels.

To fill this gap, the current paper examines how innovation influences employment growth at the Colombian manufacturing firm level and how Chinese competition affects employment outcomes differently, depending on a firm's level of innovation. To explore these issues, the paper provides empirical evidence of the causal relationship between innovation and job creation or loss at the firm level using the "Development and Technological Innovation Industrial Survey (EDIT)" data from 2007-2018. The main contribution of the paper lies in extending the structural model by Harrison et al. (2014) to examine how Chinese competition affects employment growth differently, depending on the firm's levels of innovative activity.

The paper focuses on two key literature strands. First, innovation's impact on manufacturing employment shows that process innovations, which boost productivity, often reduce jobs, while product innovations increase demand and employment (Pianta, 2005; Harrison, 2014). In Colombia, innovation enhances firm productivity and employment, particularly for firms close to the technological frontier (Mejia & Arias, 2014). However, these effects are shaped by sectoral factors like trade (Calvino & Virgillito, 2018). Second, trade's role is examined, highlighting that product innovation can raise labour demand, but international competition, especially from China, challenges firms to improve productivity or exit the market, often leading to labour reallocation (Rodrik, 2016; McMillan et al., 2014). This highlights the importance of evaluating how Colombian firms handle import competition while sustaining employment growth (Griffin, 2015).

The empirical analysis presents three key findings. First, consistent with existing literature, sales growth driven by new products has a positive and significant effect on firm employment growth across all manufacturing sectors during the study period. In contrast, process and organizational innovations generally show no significant impact on employment at the firm level. Second, product innovation has a stronger influence on employment growth among highly educated workers compared to those with lower education. This effect is similar across both high-tech and low-tech sectors. Lastly, Chinese import competition exerts a greater negative impact on highly innovative firms, especially in low-tech sectors and for highly educated workers. This result means that while innovative firms tend to adopt product innovation as a defensive response to competition, this strategy proves largely ineffective.

The structure of this paper is as follows. Section 2 presents the literature review of the two strands of literature used in this article's analytical framework. It offers an overview of the process and product innovation effects on firm employment growth, and how these effects change in the presence of Chinese import competition. Section 3 presents the description of the theoretical structural model of Harrison et al. (2014). Section 4 gives an overview of the Colombian data and the descriptive statistics of the variables used. Section 5 shows the econometric specification, which is extended to consider the heterogeneous effects of Chinese import competition. Sections 6 and 7 present the results and conclusions.

2 Literature Review

The research of this paper draws on two strands of literature: the first strand investigates employment impacts of innovation, and the second one is related to the heterogeneity of the employment effects in the context of increasing Chinese import competition.

2.1 General Employment Effects of Product and Process Innovations

The link between employment and innovation at the firm level is complex and difficult to discern. There have been prolific theoretical and empirical contributions on the subject, which have been collected and analysed by Pianta (2005), Vivarelli (2014), Calvino and Virgillito (2018) and Calvino (2019). According to all contributions, technological innovations theoretically can entail two opposite effects on employment[1]. First, process innovations that increase production efficiency and factor productivity are related to labour-destruction. And second, product innovations that introduce new or modified products to the market and increase the firm's market participation, are related to a labour-creation outcome (Pianta, 2005). In the literature, the first effect is known as the "productivity effect of process innovation" while the second effect is known as the "direct demand effect of product innovation," respectively (Dachs et al., 2017).

However, the outcome of innovation activities depends on various indirect channels and compensation or displacement mechanisms that influence the adjustment processes of labour demand after the firm introduces an innovation (Calvino et al., 2018). For instance, the increase in efficiency and productivity that entail process innovations can also cause a decrease in the marginal cost of production, that, depending on the competitive structure in which the firm operates, can generate price reductions, and hence stimulate the firm's product demand and labour-creation. This compensation of the initial labour-destruction of the productivity effect is known as the "price effect of process innovation" (Vivarelli, 2014).

In the case of product innovation, the initial labour-creation that follows the introduction of new products to the market can be displaced by other mechanisms. In this respect, at least two mechanisms are at work: i) new products can replace or cannibalize the existing old products of the firm, destructing the labour used to produce this last kind of products, nonetheless, if new and old products are complements, the labour demand of the firm tends to increase, this process in the literature is known as "indirect demand effect of product innovation"; and, ii) new products can be produced less (more) efficiently than old products, which increase (reduce) firm's needs for labour, which is known in the literature as the "productivity effect of product innovation" (Dachs et al.,

[1] Other analysis, such as Coad and Rao (2011) and Bogliacino et al. (2012), use R&D expenditures and patents as proxies of innovation activities. Their results show a positive relationship between innovation and firm employment in developed economies. In the analysis presented in the present paper, the proxies used as innovation activities at firm level are product and process innovations, due to two reasons. First, as state by Calvino et al. (2018), the analysis with patents and R&D expenditures are not able to disentangle the effects of the compensation or displacement effects over employment growth. Second, in the case of a developing countries such as Colombia, the innovative activities at firm level are concentrated mainly in imitation or adaptation of existing innovations, hence the level of patents and R&D expenditure is low (Gorodnichenko et al., 2010).

2017).

The firm-level empirical evidence that analyses the operation of the above compensation mechanisms is extensive. Nonetheless, the conclusion about the employment effects of process innovation has been inconclusive, whereas most studies have found a positive relationship between employment and product innovation (Calvino et al., 2018).

The work of Harrison et al. (2014) is, for instance, one of the most relevant recent studies. Its importance lies in the development of a theoretical structural model that disentangles the compensation mechanisms that work on the relation between firm-level employment growth and product and process innovations. In particular, the model is able to quantitatively measure the efficiency gains in the production of old products (productivity effects of process innovations), the demand growth due to new products, and the productivity effect related to product innovations.

The empirical application of this structural model uses the Community Innovation Survey (CIS) firm-level data from 1998 to 2000 for a set of European countries. Results show that process innovation tends to displace employment, although price reduction compensation mechanism is prevalent, and confirms that positive employment growth is strongly related to product innovation, "that is, no evidence of productivity gains and employment displacement effects associated with product innovation" (Harrison et al., 2014, pp. 36).

This structural model has been applied by a bundle of empirical exercises (Calvino et al., 2018). In the case of developed countries, the works of Peters (2005)[2], Hall et al. (2008), Dachs et al. (2014, 2017), and Arenas-Diaz et al. (2020) find similar results to those primarily set up by Harrison. The results for developing countries are heterogeneous. Process innovations have ambiguous effects, with labour-displacement, labour-creation or not effect depending on the country. Regarding product innovation, the effect is always positive, that is, there is evidence of creation of employment after product innovation, due to firm's product demand enlargement, firms' market expansion, or no productivity gains on the production of new products relative to old ones.

For instance, Crespi, Tacsir and Pereira (2019) examine the case of Argentina, Chile, Costa Rica, and Uruguay using micro data from innovation surveys from the 1990s to 2000s. The study confirms the mixed results of process innovation, with no significant effect on employment in Argentina and Costa Rica, but with a negative one for Chile and Uruguay, especially in the case of large and high technology firms, which represents labour- displacement due to productivity increase in the production of old products. On the other hand, there is evidence of a labour-creation effect due to demand enlargement related to product innovations. This positive effect is lower for Argentina, where the results suggest a production efficiency gain of new products relative to old ones. With respect to skill composition effects, the authors concluded that there is a skill-biased product and process innovation in Argentina and Uruguay.

[2]Peters (2005) presents a multi-product analysis by distinguish product innovation according to their novelty degree, that is new products for the market and new products only for the firm (imitation strategies). The results demonstrate that in Germany's manufacturing sector, employment effects do not significantly vary with product novelty.

These results were previously confirmed by Benavente and Lauterbach (2008) for the Chilean case after controlling for investment and sectoral patterns, although without the skill composition analysis. Alvarez et al. (2011)[3] found a positive association between product innovation and labour expansion for the Chilean case during the 1990s and 2000s, but, unlike Crespi et al. (2019), process innovation is not relevant for employment growth, regardless of firm's technology intensity and size.

For the Argentinian case, during the period 1998 to 2001, De Elejalde et al. (2015) concluded that there are heterogenous effects on employment quality. Product innovations are skill-biased only for low-tech firms, and there is no evidence of process innovations' effects on employment growth or composition. Aboal et al. (2015) arrived at comparable results to Crespi et al. (2019) for the Uruguayan case, with evidence that there is no complementarity between product innovation and labour skill composition after controlling for foreign ownership of firms and wage bill growth rate. Fajnzylber and Fernandes (2009) found that in the case of Brazilian firms, from 2001 to 2003, process innovation had no significant effect on employment, while the positive compensation effects of product innovation is higher than the productivity gains, entailing a positive employment growth.

Mejia and Arias (2014) confirm that in Colombian manufacturing firms, the sales of new products had a positive and significant effect on employment growth from 2007 to 2010, especially on employees with higher education. In low-tech firms, old products are produced more efficiently than new products, which means that the introduction of product innovations increases the firm's need for labour. On the contrary, the results in high-tech firms demonstrate that the creation of employment due to product innovation is lower. In all cases, process innovations present a displacement effect on employment growth, although it is not significant.

Finally, a recent strand of empirical literature provides more fine-grained insights into the relationship between innovation and employment growth at the firm level. Using linked employer-employee datasets for the Norwegian case from 2004 to 2010, Herstad and Sandven (2020) demonstrate that different aspects of innovation (products, processes, patents, combinations) and employment growth (employment upscaling or downscaling) are interlaced with each other in virtuous or vicious circles over time. The results show that employment upscaling persists over time, and increases the probability that product and process innovations are introduced and strengthen employment further. Employment downscaling also persists and reduces the probability that complementarity innovations are introduced to change the negative employment trend. On the other hand, Ciarli et al. (2018) combine different data sets to generate variables on employment status and R&D investment at the firm level. The results show that growth in firm R&D investment does not affect the ratio of employed and unemployed in a local UK labour

[3]The authors also extended the Harrison structural model to consider the impact of different types of business innovation strategies on firms' employment growth. These innovation strategies are "make" (in-house developed innovation) and "buy" (externally acquired innovation). The results show that in-house innovation is positively related with employment growth, but not for the case of small firms, and particularly with the growth of skilled and unskilled workers in low-tech industries. Zuniga and Crespi (2013) arrived at similar conclusions for the cases of Argentina, Chile, Costa Rica, and Uruguay, as well as Aboal et al. (2015) for the Uruguayan case.

market. However, there is a positive effect of R&D in areas with a high share of workers in routinised occupations and a share of highly educated workers.

These empirical shreds of evidence show heterogeneous process innovation effects across countries and time, whereas the positive employment effect of product innovation is pervasive. Vivarelli (2014) stated that this "positive bias" between employment and product innovation is a limitation of the empirical studies with firm-level data, since this kind of "approach cannot fully account for the indirect compensation effects which operate not only at the firm level but also through intersectoral linkages and aggregate dynamics" (Vivarelli, 2014, pp. 133). The author highlighted that the final impact of firm innovation over employment depends on the indirect compensation and displacement mechanisms related to foreign competition.

2.2 Employment Effects of Firm Innovation in the Presence of Increasing Foreign Competition

The effects of innovation activities on firm employment dynamics depend on the indirect compensation and displacement mechanisms related to competition. Following the literature, product innovation that allures new consumers and expands the market share of the firm is the strongest force behind employment creation. Nevertheless, direct demand effect of innovation can be outweighed by the competition degree in the sector in which the firm performs its activities (Harrison et al., 2014

Damijan et al. (2014), using the structural model of Harrison et al. (2014), conclude that the average employment growth of European firms is not affected by competition from abroad in the second half of the 2000s, but the share of high-skill labour at firm level increases by 2 per cent as a result of a 10 per cent increase of Chinese import share in the industry. However, the study does not show the heterogeneity of employment effects of Chinese competition, meaning that there is no evidence that more innovative firms are better armed to face higher sectoral competition from abroad.

Concerning this point, Bloom et al. (2016) demonstrated that for the European case after the year 2000, the sectoral Chinese competition had a substantial effect on firm innovation (that is, increases in R&D, patents, and productivity growth) and employment reallocation toward more technological advanced firms. These results suggest two conclusions: first, Chinese competition at the sectoral level induces technological upgrading at the firm level, which in turn leads to skill-biased employment growth; and second, high-tech firms are more protected from the negative employment effects of Chinese import competition.

The following studies have reached similar results. According to Bernard et al. (2006), import competition from low-wage countries harmed employment growth in US manufacturing plants from 1977 to 1997, but this negative effect is lower for capital-intensive plants. Autor et al. (2013) present evidence that over the period 2000 to 2007, US employment declined in manufacturing plants located in local economies that specialized in industries with higher competition from China, and this negative impact is stronger in labour-intensive industries, in which China's comparative advantage is pronounced. These results are extended by Autor et al. (2021) showing that in

more trade-exposed local economies, the negative effect of Chinese competition on manufacturing employment persists nearly a decade after the culmination of the trade shock. Finally, Mion and Zhu (2013) conclude that sectoral Chinese import competition reduces firm employment growth, especially in low-tech firms, and induces skill upgrading in manufacturing industries in the Belgian case during the period 1996 to 2007.

The evidence for developing countries, particularly Latin America, is broad and indicates that those firms that operate in sectors with higher competition from China experienced a decline in employment, but an increase in productivity, skill upgrading and average years of schooling. At the sectoral level, the share of labour informality among unskilled workers increases in those manufacturing sectors that are most affected by competition. The principal studies in this respect are Utar and Torres (2013), Iacovone et al. (2013), Mendez (2015), Blyde and Fentanes (2019) for Mexico[4]; Mercado et al. (2019) for Peru; Li and Mesquita (2019) for El Salvador; Costa et al. (2016), Mesquita-Moreira et al. (2020, 2023) and Paz (2018) for Brazil; Alvarez and Claro (2009), Fernandes and Paunov (2009) and Cesar et al. (2021) for Chile[5].

In Colombia, numerous studies have proved that the "China effect" has been one of the factors that explain the reverse in the process of industrialization (Cardenas & Kugler, 2011; Griffin, 2015; Molina, 2020). Griffin (2015) states that after the year 2008 the greater competition from China have contributed to the contraction of the Colombian manufacturing sector, reducing the profitability of those firms located in high Chinese competition sectors, such as textiles, chemicals, plastics, basic metals machinery and transport equipment. Molina (2020) demonstrates that 1-percentage point increase in Chinese manufacturing import competition growth decreases current and future growth rates of firm productivity, domestic sales, and employment in 0.6, 1.6 and 0.4 percentage points respectively. Although, there is labour skill upgrading represented by an increase of 0.12 percentage points in nonproduction workers at firm level.

Summarizing, the results for developed countries presented by Bloom et al. (2016), Bernard et al. (2006), Autor et al. (2013) and Mion and Zhu (2013) show that import competition from China hurts manufacturing employment growth but induces positive effects on skill upgrading and firm innovation. The results from the studies of Latin

[4]Utar and Torres (2013) present a study of the effect of Chinese competition on the participation of Mexican maquiladoras in the US market during the period from 1990 to 2006. The Chinese competition measure is interacted with productivity, capital-labor ratio, and skill-intensity variables to access the heterogeneity effect of Chinese competition over different types of Mexican maquiladoras. The results show that Chinese competition explains the slowdown of the participation of Mexican firms in the US markets, although, there is evidence of skill-upgrading, productivity-enhancing, and product development in Mexican maquiladoras in response to competition from China. Similar results are shown by Iacovone et al. (2013). Finally, Blyde and Fentanes (2017) find that the trade shock has been productivity-enhancing, mainly in Mexican sector that have experienced large- scale import penetration from China.

[5]The results of Paz (2018) indicates that the Chinese import penetration have a negative effect on employment level in Brazil during the period from 2000 to 2012. This effect is stronger on firms located in labor-intensive industries such as textiles, footwear, nonmetallic products, and furniture. The same type of results is presented in Li and Mesquita (2019) in El Salvador, where Chinese import competition has a negative impact on production employment at low capital intensity and low skill firms. On the other hand, Fernandes and Paunov (2009) find that Chinese competition raises product innovation and quality upgrading in Chilean firms. Although Álvarez and Claro (2009) do not find these results, arguing that Chilean companies are characterized by low capital and skills that limit their ability to compete with more sophisticated products.

American countries confirm the negative China shock over employment growth but are more ambiguous concerning the effects on innovation.

In the case of Colombia, Molina (2020) finds that Chinese competition negatively impacts employment, innovation, and productivity across the manufacturing sector. However, this analysis does not account for the differences in how these effects vary by firms' levels of innovation. To address this gap, the current paper investigates the impact of innovation on employment growth at the firm level in Colombia and explores how Chinese competition influences employment outcomes differently, depending on the firm's level of innovative activity.

3 Harrison Structural Model

3.1 Theoretical Approach

To accomplish the goal of this paper, it is adopted the structural model developed by Harrison et al. (2014) that establishes the link between process and product innovation with firm employment growth, considering the different compensation and displacement effects of the employment-innovation nexus.

According to this model, each firm can be observed during two periods, *t=1* and *t=2*, and produce two types of products: old and new (or significantly improved) products, denoted as *i=1* and *i=2*, respectively. The firm's production function is defined as:

$$Y_{it} = \theta_{it} F\left(K_{it}, L_{it}, M_{it}\right) e^{\eta+\omega_{it}} \tag{1}$$

Where K stands for capital, L for labour, M for intermediate inputs, and θ for the Hicks-neutral technology (efficiency) parameter. Furthermore, η captures the constant unobserved factors that explain a firm's productivity (or firm fixed effects) and ω captures the time-varying (unanticipated) non-technological productivity shocks, where $E(\omega_{it}) = 0$.

All production in the first period corresponds to old products (Y_{11}). Between the two periods, the firm can invest in R&D generating processes and product innovation. Hence, in the second period of analysis, there are at least two outcomes: first, the firm can produce either new (Y_{22}) and old (Y_{12}) products, and second, there is a shift in the efficiency of producing old products θ_{12}/θ_{11} , as well as in the efficiency of producing new products relative to old products θ_{22}/θ_{11}.

These changes in production efficiency and introduction of a new or improved product affect the firm's labour use in the production of each type of product. The equations of labour demand to produce old and new products are:

$$L_{1t} = c_{wL}(w_{1t}) \frac{Y_{1t}}{\theta_{1t} e^{\eta+\omega_{it}}} \quad \text{for } t = 1, 2 \tag{2}$$

$$L_{22} = c_{wL}(w_{22}) \frac{Y_{22}}{\theta_{22} e^{\eta + \omega_{22}}} \tag{3}$$

The expression $c_{wL}(.)$ represents the derivative of production cost with respect to wage, where the assumption is that the cost of labour does not change significantly across periods, therefore it is supposed that $c_{wL}(w_{11}) = c_{wL}(w_{12}) = c_{wL}(w_{22})$.

The employment growth rate between the two periods can be broken down into the growth of employment due to the production of old products $ln\frac{L_{12}}{L_{11}}$ and the growth of employment due to the production of new products $ln\frac{L_{22}}{L_{11}}$. The equation is the following:

$$\frac{\Delta L}{L} = \frac{L_{12} + L_{22} - L_{11}}{L_{11}} = \frac{L_{12} - L_{11}}{L_{11}} + \frac{L_{22}}{L_{11}} \approx \ln \frac{L_{12}}{L_{11}} + \ln \frac{L_{22}}{L_{11}} \tag{4}$$

Then, replacing equations (2) and (3) in (4) and applying logarithms, the employment growth equation at the firm level can be written as:

$$\frac{\Delta L}{L} \approx -(\ln \theta_{12} - \ln \theta_{11}) + (\ln Y_{12} - \ln Y_{11}) + \frac{\theta_{11}}{\theta_{22}} \frac{Y_{22}}{Y_{11}} - (\omega_{12} - \omega_{11}) \tag{5}$$

In equation (5) the firm fixed effect η is differentiated out and the employment growth at the firm level is explained by the following terms: the first term $-(\ln \theta_{12} - \ln \theta_{11})$ represents the efficiency change in the production of old products from process innovations, that would lead to a labour-displacement effect; the second term $(\ln Y_{12} - \ln Y_{11})$ represents the growth rate of production of old products, that can be provoked by the introduction of new products that are complements or substitutes of the old products, that could be a labour-creation or labour- displacement on employment growth, respectively (Peters, 2005); the third term $\frac{\theta_{11}}{\theta_{22}} \frac{Y_{22}}{Y_{11}}$ represents two effects, that is the efficiency of producing old products relative to new ones, and the growth rate of the production of new products, that is related to product innovations; and finally, the last term $-(\omega_{12} - \omega_{11})$ represents the impact of non-technological productivity shocks.

3.2 Empirical Approach

The empirical specification of the employment growth from the theoretical approach, is represented in the following equation:

$$l = \alpha_0 + \alpha_1 d + y_1 + \beta y_2 + u \tag{6}$$

Where l stands for the firm growth rate of employment between two periods (*t=1* and *t=2*), y_1 represents the growth rate of the production (sales) due to old products between *t=1* and *t=2*.

The parameter α_0 stands for the average growth of the efficiency in the production of old products not related to innovations, while the parameter α_1 represents the efficiency of the production of old products related to the introduction of process innovation, that is the *gross effect of process innovations*, which in turn is represented

by the dummy variable d that takes the value of 1 if the firm introduces only process innovations (not associated with product innovations), and 0 otherwise.

The term βy_2 represent the employment growth induced by new products. According to Harrison (2014) and Dachs et al. (2017), this term consists of two channels: y_2, the gross effect of demand growth due to new products (which represent the introduction of product innovation at *t=2*) and β, defined as $\beta = \frac{\theta_{11}}{\theta_{22}}$, is the *gross productivity effects of old products relative to new products.* This last element states that new products will generate less employment growth if they are produced more efficiently than old product, which is represented by a parameter β less than the unity ($\beta < 1$). Finally, the error term u represents the unobservable non-technological productivity shocks $-(\omega_{12}-\omega_{11})$ and random disturbances ξ.

From the structural model assumptions, the coefficient of y_1 is equal to one, therefore, the empirical specification can be written as:

$$l - y_1 = \alpha_0 + \alpha_1 d + \beta y_2 + u \tag{7}$$

However, empirically y_1 and y_2, that stand for the real output growth rate of old and new product respectively, cannot been observed with firm level data. Instead, they are replaced by observable data of the nominal sales growth rates of old products, $g_1 = y_1 + \pi_1$, and nominal sales growth rates of new (or significantly improve) products, $g_2 = (1 + \pi_2)\, y_2$, as it is showed in equation (8):

$$l - (g_1 - \ \pi_1) = \alpha_0 + \alpha_1 d + \beta \frac{g_2}{(1 + \pi_2)} + u \tag{8}$$

Where π_1 and π_2 represent the price growth rates of old and new products at the firm level, respectively. However, this price information is not observable in the firm-level data, therefore it is replaced by the price growth rates at the 2-digit industry level ($\widetilde{\pi}$). It may exist the risk that $\widetilde{\pi}$ is not a good proxy of the prices at the firm level leading to a measurement error in the estimation of the model, which creates a new error term ε that incorporates these potential sources of endogeneity, where $\varepsilon = -E\,(\pi_1 - \widetilde{\pi}_1) - \beta \pi_2 y_2 + u$, as state in the equation (9):

$$l - (g_1 - \ \widetilde{\pi}_1) = \alpha_0 + \alpha_1 d + \beta g_2 + \varepsilon \tag{9}$$

There is another source of endogeneity bias when estimating the coefficient β. Innovations are the result of technological investments, such as R&D expenditures, which depend on firm's technological productivity η, that is differentiated out in the model, and on unobserved non-technological productivity shocks ω that are presented in the error term ε of equation (9). In that case, the variable g_2 is correlated with the error term leading to a downward bias in the estimation.

As state by Harrison et al.(2014), an instrumental variable approach is necessary to solve the possible two identification problems described above. In particular, the chosen IV must be correlated with the production of new or improved products, and hence

affecting employment growth throughout product innovation, but must be uncorrelated with the error term, that is, with the price differences of old and new products, and with unobservable non-technological productivity shocks. In sections 4 and 5 it is described the definition of the variables used, the estimation strategy and the chosen IV for the endogenous variable g_2 of product innovation.

Finally, the structural model from Harrison et al. (2014) is extended in this analysis to examine how the impact of Chinese import competition on employment growth varies with a firm's level of product innovation. This extension aims to test whether more innovative firms are better equipped to handle increased foreign competition.

4 Data and Descriptive Statistics

The empirical analysis uses three sources of data. As mentioned in the first section, the employment–innovation data is drawn from The Development and Technological Innovation Industrial Survey (EDIT) collected by the Colombian Department of Statistics DANE. The second source is the UN COMTRADE via World Integrated Trade Solution (WITS), from which Chinese manufacturing imports are collected at a 4-digit industrial level and classified according to the International Standard Industrial Classification ISIC Rev. 3. The trade data is converted into the ISIC Rev. 4 classification adapted for Colombia using official DANE correspondence tables. This information is combined with the firm-level data according to the 4-digit sector in which each firm is classified. Finally, as mentioned in section 3, producer price indices at the 2-digit industry level are collected from DANE.

The EDIT is a census that is carried out on all Colombian manufacturing firms with 10 or more employees (DANE, 2015). For the present analysis, it is used the EDIT from 2007 to 2018, for a total of 49,794 firm-year observations. The panel data comes from six waves of the EDIT from the following periods: 2007-2008 (EDIT IV – 7,854 firms), 2009-2010 (EDIT V – 8,814 firms), 2011-2012 (EDIT VI – 8,304 firms), 2013-2014 (EDIT VII – 9,006 firms), 2015-2016 (EDIT VIII – 8,118 firms), and 2017-2018 (EDIT IX – 7,700 firms).

For each EDIT wave, the available data gives information about firm characteristics during the period of observation (years t and $t + 1$) and the factors that influence the innovative behaviour of the firms (strategies, incentives, and barriers to innovation) as well as the results and impacts of these innovation activities. In particular, the EDIT includes quantitative data on sales, number of employees, level of education of employees, type of innovations introduced during the period, etc. Therefore, the growth rates of employment and sales are calculated between year t and $t + 1$ within each EDIT wave. This data is collected at the firm level following the Oslo Manual for the universe of firms that are classified according to their manufacturing activity in 55 sectors following the classification ISIC Rev. 4 adapted for Colombia.

Firms are classified according to their innovative behaviour in the year t in each wave or period of analysis: (i) process innovators only: firms that introduced only new or significantly improved processes of production; (ii) product innovators: firms that introduced new or significantly improved goods for the enterprise or the market

(domestic or international); (iii) Organizational innovators: firms that introduced a new or significantly improved organizational method or marketing technique; and, (iv) non-innovators: firms that did not introduce any process, product or organizational innovations.

Table 1 shows that for the whole sample, 85.7% of the firms are classified as non-innovators, 5.6% as product innovators only, 7.3% as process innovators only and 1.4% as organizational innovators only. On the other hand, 12.6% are product innovators and 8.2% are organizational innovators, that is, those firms that include new or improved products or organizational methods, respectively, along with other types of innovations.

The average employment growth for the whole sample is negative during the period of analysis. In general, the deindustrialization process in Colombia is evident in terms of manufacturing employment. This result is driven by non-innovative firms. In comparison, all innovative firms show average positive employment growth, with the highest values of growth in product innovators where the gap to non-innovators is about 6.3 percentage points.

These results would confirm that the compensation effect of innovation is higher than the displacement effect, leading to employment growth in firms with all kinds of innovations. Notice that innovative firms have higher employment growth rates despite gains in labour productivity, as shown in Table 1. This result could mean that the positive employment effects of sales growth and the compensation effect (represented by new products, for example) dominate the employment displacement effects of innovation.

Finally, the average increase in sales over the whole sample is relatively small (0.9%), with negative sales growth in non-innovative firms (-2.5%). All kinds of innovative firms present increasing sales growth rates, with the highest for product innovators (16.5%) followed by organizational innovators (9.8%) and process-only innovators (6.8%).

It is important to notice that firms classified as product innovators present negative sales growth of old products, which is compensated by a strong increase in sales growth due to new products. These figures could be explained either by the fact that sales of new products cannibalize sales of old products, or by the fact that the demand for old products is declining and therefore firms must increase their product range with new products to gain new market demand.

Table A1 in the Appendix presents the complete descriptive statistics for the whole sample.

Table 1: Descriptive Statistics

Variables	
Number of Firms	49,794
Distribution of Firms (%)	
Non-Innovators	85.7
Product Innovators Only	5.6
Process Innovators Only	7.3
Organizational Innovators Only	1.4
Product Innovators	12.6
Organizational Innovators	8.2
Employment Growth (Average Rate %)	
All Firms	-1.8
Non-Innovators	-3.3
Product Innovators	3.0
Process Innovators Only	2.4
Organizational Innovators	2.9
Sales Growth (Average Rate %)	
All Firms	0.9
Non-Innovators	-2.5
Product Innovators	16.5
Of Which:	
Old Products	-10.7
New Products	27.2
Process Innovators Only	6.8
Organizational Innovators	9.8
Labour Productivity Growth (Average Rate %)	
All Firms	2.6
Non-Innovators	0.6
Product Innovators	13.5
Process Innovators Only	4.3
Organizational Innovators	6.9
Chinese Import Competition (Average Rate %)	
All Firms	7.92
Non-Innovators	8.30
Product Innovators	6.32
Process Innovators Only	7.63
Organizational Innovators	6.17
Price Growth (Average Rate %)	
All Firms	2.5
Non-Innovators	2.4
Product Innovators	3.1
Process Innovators Only	2.5
Organizational Innovators	2.9

Source: Author's calculations using DANE and UN Comtrade data (2023).
Average growth rates of total employment (full time, permanent, and temporary) between year t and t+1.
Sales growth rates correspond to variable g, and old and new products sales growth rates correspond to variables g1 and g2, respectively.
Labour productivity is measured as total sales per worker.
Chinese Import Competition is calculated according to equation (14): the share of Colombian imports from China with respect to Colombian apparent consumption (Colombian total imports plus production) at time t and 4-digit industrial sector.
Industrial price growth (2-digit sector) is assigned to firms according to their activity in the EDIT.

5 Identification Strategy

5.1 Innovation Effects on Firm Employment Growth

Following the empirical approach of Harrison et al. (2014) presented in equation (9) of section 3.2, the econometric specification for the case of the Colombian manufacturing firms is as follows:

$$\begin{aligned} EMP_{i,j,t|t+1} = \alpha_0 + \alpha_1 PC_{i,j,t|t+1} + \beta NEWPR_{i,j,t|t+1} \\ + \mathbf{X}'_{it}\gamma + \varphi HHI_{j,t} \\ + \delta_i + \delta_t + \delta_{jt} + \varepsilon_{i,j,t} \end{aligned} \tag{10}$$

Where $EMP_{i,j,t|t+1}$ represents the dependent variable of the model, that is the employment growth rate of the firm t, in the manufacturing sector j (4-digit ISIC Rev. 4 adapted for Colombia), and during the period t to $t + 1$ of each EDIT wave. This variable corresponds to the element in the theoretical model $l - (g_1 - \widetilde{\pi_1})$. Hence, *EMP* is constructed within each EDIT wave between t and $t+1$ as the difference between three elements: l, that measures the growth rate in the total number of employees; g_1, the nominal sales growth rate due to old products; and $\widetilde{\pi_1}$, the producer prices indices at the 2-digit industry level, published by DANE. As it is described in section 4, equation (10) is estimated using panel data from six waves of the EDIT, where each wave represents the data for year t to year $t + 1$.

The vector $\mathbf{X}'_{it}$ represents the set of firm-level controls in year t, among which are: i) firm size dummies defined as small (10 to 50 employees), medium (51 to 200 employees) and large (more than 200 employees); ii) firm export status dummy, that takes the value of one if the firm reports exports in period t or $t+1$; iii) public cooperation dummy, that takes the value of one if the firm reports having public cooperation to perform science, technology and innovation activities; iv) non-technological innovation such as organizational innovations dummy, equal to one if the firm performs changes in the workplace, in management and in external relations; and v) the logarithm of labour productivity defines as sales over total employment.

In this paper, it was not possible to use the Annual Manufacturing Survey from DANE (Kugler & Verhooghen, 2012) since it does not disaggregate the quantities and prices for new and/or old products. Therefore, prices at the sector level had to be used to estimate the model as explained in Section 3. In this case, I introduce as a control variable a competition index (HHI: Herfindahl Index) at the industry level (4-digit ISIC Rev. 4 adapted for Colombia) to correct for the market power (prices) of firms. I also include the parameter δ_i to control for firm fixed effects, δ_t period fixed effect, and δ_{jt} industry-period fixed effects to take into account for industry trends (2-digit ISIC Rev. 4 adapted for Colombia).

The dummy variable *PC* takes the value of one if the firm introduces only process innovation (but no product innovation), and zero otherwise, then the coefficient α_1 denotes the *gross effect of process innovations*. $NEWPR_{i,j,t|t+1}$, which is the principal explicative variable g_2, corresponding to the nominal sales growth rate due to new products, representing the gross effect of demand growth due to new products, and the

coefficient β the *gross productivity effects of old products relative to new products.* New products are those products that appear in year *t+1* (and are not produced in year t), therefore, following Harrison et al. (2014) the nominal sales growth rate due to new products is constructed as the proportion of sales of new products in the year *t+1* (s) multiplied by the total sales growth between *t+1* and t (denoted as *(1+g)*):

$$\begin{aligned} NEWPR_{i,j,t|t+1} = g_2 = \frac{new\ products\ sales_{t+1}}{old\ products\ sales_t} = s(1+g), \\ \text{where} \quad s = \frac{new\ products\ sales_{t+1}}{old\ products\ sales_{t+1} + new\ products\ sales_{t+1}}, \\ \text{and} \quad g = \frac{old\ products\ sales_{t+1} + new\ products\ sales_{t+1} - old\ products\ sales_t}{old\ products\ sales_t}. \end{aligned} \tag{11}$$

As explained in section 3.2, the main explicative variable g_2 (or $NEWPR_{i,j,t|t+1}$) is an endogenous variable, due to unobserved firm prices and correlation with the non-technological productivity shocks in the error term (Harrison et al., 2014), that is $Cov(g_2, \varepsilon_{i,t}) \neq 0$. Following the literature, particularly Harrison et al. (2014) and Mejia et al. (2014) for the case of Colombia, I use the dummy variable *Range* as the instrumental variable (IV), which takes the value of 1 if the firm answers that the introduced product innovation has been relevant for getting an increased range of products.

According to Harrison et al. (2014), the theoretical reasons that support the use of this IV are the following: "On the one hand, the degree by which product innovation is aimed to increase the range of products is likely to be correlated with planning (R&D, design, marketing exploration...) and the expectations of sales. On the other, enlarging the range of products does not imply any particular direction of the changes in prices (increased market share is likely to be correlated with lower prices and improved quality with possibly higher prices). It also seems unlikely that the range of products is correlated with unanticipated productivity shocks" (Harrison et al., 2014, p. 36). Equation (12) presents the first stage estimation:

$$\begin{aligned} \widehat{NEWPR}_{i,j,t|t+1} = \rho_0 + \rho_1 Range_{i,t} + \rho_2 PC_{i,j,t|t+1} \\ + \mathbf{X}'_{it}\rho_3 + \rho_4 HHI_{j,t} + \delta_i + \delta_t + \delta_{jt} + \varepsilon_{i,j,t}. \end{aligned} \tag{12}$$

Therefore, it is expected that the IV and the endogenous variable (sales growth rate of new products) are positively correlated $Cov(g_2, IV_i,) \neq 0$, that is IV is relevant, and the IV satisfies the exclusion restriction, since it is not related to the elements within the error term, in this case, prices π and unexpected productivity shocks ω, $Cov(\varepsilon, IV_i,) = 0$. Section 6 presents the tests for the IV strength in the estimation. It is verified that the IV is positively and significantly correlated with the endogenous variable in the first stage regression.

5.2 Heterogenous Innovation Effects: Chinese Import Competition

In addition to examining the innovation effect on employment growth at the firm level, the structural model of Harrison et al. (2014) presented in equation (10) is extended to consider the employment effects of firm innovation in the presence of an increasing Chinese import competition at the sectoral level. Consequently, the firm employment growth structural equation is estimated as follows:

$$\begin{aligned} EMP_{i,j,t|t+1} = \alpha_0 &+ \alpha_1 PC_{i,j,t|t+1} + \beta_0 \widehat{NEWPR}_{i,j,t|t+1} \\ &+ \beta_1 \widehat{IMP^{CHINA}_{j,t}} + \mathbf{X}'_{it}\gamma \\ &+ \varphi HHI_{j,t} + \delta_i + \delta_t + \delta_{jt} + \varepsilon_{i,j,t}. \end{aligned} \tag{13}$$

The explicative variable $\widehat{IMP^{CHINA}_{j,t}}$ represents the Chinese import competition in the manufacturing sector j (4-digit ISIC Rev. 4 adapted for Colombia) at time t. Following Mion and Zhu (2013), this variable is calculated as the share of Colombian imports from China with respect to Colombian apparent consumption (Colombian total imports plus production) following the expression:

$$\widehat{IMP^{CHINA}_{j,t}} = \frac{M^{CHINA}_{j,t}}{Q^{TOTAL}_{j,t} + M^{TOTAL}_{j,t}}. \tag{14}$$

Where $M^{CHINA}_{j,t}$, $M^{TOTAL}_{j,t}$, and $Q^{TOTAL}_{j,t}$ represent the Colombian import from China, imports from the World, and the Colombian total production of manufacturing sector j and year t. Then, the term $\widehat{IMP^{CHINA}_{j,t}}$ represents the impact of the Chinese import competition share in the manufacturing sector j and year t on the employment growth between year t and $t+1$ of the firms that belongs to the manufacturing sector j.

One concern about the estimation of structural equation (13) is the potential endogeneity problems when using the observed Chinese import competition measure of equation (14) due to possible omitted variables and simultaneity biases. Throughout the analysis period, Colombian trade and product development policies influenced both the demand for Chinese goods and industrial employment levels[6]. On the other hand, the increase of Chinese import competition at the sectoral level is correlated with a higher Colombian demand for Chinese products, including the firms' demand for Chinese goods used as inputs in the production process, affecting firms' employment.

To overcome these problems, due mainly to Colombian demand shocks for Chinese products correlated with the error term, an instrumental variable is used to capture only the supply-driven shocks and exogenous components that explain the presence of Chinese imports in Colombia. In particular, the instrument must capture the more aggressive export-led policy followed by the Chinese government since the 2000s, leading to productivity increases and price declines in the manufacturing production of China.

[6]See, for example, Ocampo and Porcile (2020) and Abreo et al. (2021) for an overview of industrial and trade policies in Colombia.

Following Autor et al. (2013), the Chinese import competition in equation (14) is instrumented using the Chinese imports in other comparable developing countries. Specifically, the instrumental variable is constructed as the ratio of the contemporaneous sectoral Chinese imports in Latin America (excluding Colombia) in year t, $M^{CHINA}_{o,j,t}$, over the Colombian sectoral apparent consumption in the year 2002, that is five years before the period of analysis presented here (from 2007 to 2018) to prevent the endogeneity risk between current apparent consumption and employment growth:

$$IV^{CHINA}_{o,j,t} = \sum_{o=Latin\ \ America \neq Colombia} \frac{M^{CHINA}_{o,j,t}}{Q^{COLOMBIA\ TOTAL}_{j,2002} + M^{COLOMBIA\ TOTAL}_{j,2002}}. \tag{15}$$

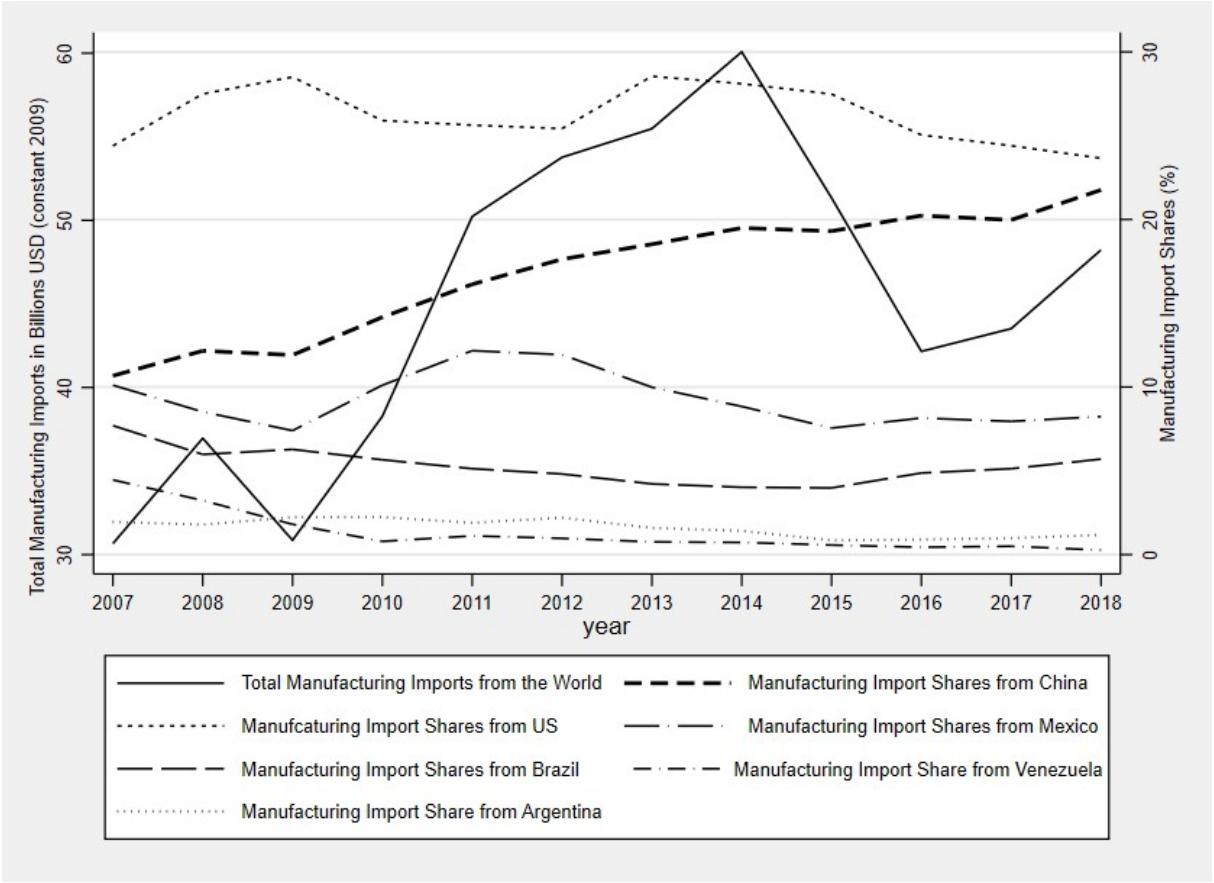
The first stage of the model, for the second endogenous variable related to the sectoral Chinese import competition, can be written as follows:

$$\begin{aligned} \widehat{IMP^{CHINA}_{j,t}} = \rho_0 + \rho_1 IV^{CHINA}_{o,j,t} + \rho_2 Range_{i,t} + \rho_3 PC_{i,j,t|t+1} \\ + \mathbf{X}'_{it}\rho_4 + \rho_5 HHI_{j,t} + \delta_i + \delta_t + \delta_{jt} + \varepsilon_{i,j,t}. \end{aligned} \tag{16}$$

The identification strategy requires that $\rho_1 \neq 0$. In fact, in Section 6 is demonstrated that $IV^{CHINA}_{o,j,t}$ is positively and significantly correlated with the endogenous variable $IMP^{CHINA}_{j,t}$, existing a positive relation between sectoral Chinese import competition in Latin America and in Colombia. The F-test also confirms the relevance of the instrument.

On the other hand, the choice of Latin American countries for the construction of the instrument responds to the fact that those countries are comparable to Colombia in terms of development and comparative advantage, and the trade relationship between Colombia and Latin America in terms of manufacturing was modest during the period of analysis. As is shown in Figure 1, the manufacturing import shares from the principal Latin American countries have been stable and lower to the 10%, whereas the same measure from China has been steadily increasing.

Figure 1: Colombia Manufacturing Import Shares 2007 – 2018



Source: Author's calculations using UN Comtrade - WITS (2023).
Import shares from each country are calculated according to equation (14).

It could be argued that the presence of Chinese imports in Latin American countries during the period of analysis appears to be related to factors specific to China, not to Colombian demand shocks for manufacturing imports[7]. The exclusion restriction of the IV holds since the presence of Chinese manufacturing imports in Latin American countries affects Colombian manufacturing employment growth only through its correlation with the Chinese manufacturing imports in Colombia, which in turn is related to the supply-driven and exogenous component of the Chinese competition such as rising productivity, manufacturing comparative advantages and globalization policies.

Finally, and according to the empirical evidence presented in section 2, it is expected that in the estimation of the structural equation (13) the effect of nominal sales growth due to new products (product innovation) has a positive effect on the firm's employment growth ($\beta_0 > 0$), whereas the sectoral Chinese import competition has a negative effect ($\beta_1 < 0$).

This analysis is extended to investigate the heterogeneous effect of Chinese import

[7]Using Latin American countries in the instrumental variable strategy has been widely used in the related literature. For instance, Molina (2020) used to study the causal effect of manufacturing Chinese imports on Colombia's employment growth, Iacovone et al. (2013) and Blyde et al. (2017) for Mexico, Paz (2018) for Brazil, and Li and Mesquita (2019) for El Salvador.

competition on employment growth depending on the firm's level of product innovation. Then, I introduce interactions between the Chinese import competition variable and the dummy variables $Q^p_{i,t}$ that represent the quantiles (p) of the firm's (i) nominal sales growth due to new products (product innovation). For each EDIT wave, firms are divided into three product innovation quantiles with the first one representing the least innovative firms (product innovation lower than the 33rd percentile), the second group covering middle-range innovative firms (between the 33rd and 66th percentile), and the last group covering the highly innovative firms (higher than the 66th percentile). Equation (17) represents this new specification:

$$\begin{aligned} EMP_{i,j,t|t+1} = \alpha_0 + \alpha_1 PC_{i,j,t|t+1} + \beta_0 Q^p_{i,t} \\ + \beta_1 \widehat{IMP^{CHINA}_{j,t}} + \sum_{p=1}^{3} \chi^p \left(\widehat{IMP^{CHINA}_{j,t}} \times Q^p_{i,t} \right) \\ + \mathbf{X}'_{it}\gamma + \varphi HHI_{j,t} + \delta_i + \delta_t + \delta_{jt} + \varepsilon_{i,j,t}. \end{aligned} \tag{17}$$

$$\begin{aligned} \widehat{IMP^{CHINA}_{j,t}} \times Q^p_{i,j,t|t+1} = \rho_0 + \sum_{p=1}^{3} \sigma^p \left(IV^{CHINA}_{o,j,t} \times Range_{i,t}{}^p \right) \\ + \rho_1 IV^{CHINA}_{o,j,t} + \rho_2 Range_{i,t}{}^p + \rho_3 PC_{i,j,t|t+1} \\ + \mathbf{X}'_{it}\rho_4 + \rho_5 HHI_{j,t} + \delta_i + \delta_t + \delta_{jt} + \varepsilon_{i,j,t}. \end{aligned} \tag{18}$$

Since this new term is the interaction of two endogenous variables, the identification strategy for this case is to include the interaction of the instrumental variables for product innovation and Chinese import competition as described in the first stage equation (18). Section 6 demonstrates the relevance of the new instrument.

6 Econometric Results and Discussion

Table 2 presents the basic specification of the structural model of Harrison et al. (2014) for the Colombian case during the period 2007 to 2018. The first two columns present the Panel and IV regression results of equation (13). In general, and following the results in the empirical literature, the sales growth due to new products ($NEWPR_{i,j,t|t+1}$) has a positive and significant effect on firm employment growth ($EMP_{i,j,t|t+1}$) in all manufacturing sectors (high- and low-tech sectors, Columns (5) and (6)) and type of workers (high- and low- educated workers, Columns (3) and (4)) during the period of analysis.

Table 2: Employment Effects of Innovation and Chinese Import Competition

VARIABLES	(1) Panel All	(2) IV All	(3) IV HighEdu	(4) IV LowEdu	(5) IV HighTech	(6) IV LowTech
NewPr	0.693***	0.820***	0.872***	0.847***	0.887***	0.864***
	(0.0266)	(0.0841)	(0.0899)	(0.0861)	(0.159)	(0.0962)
IMPchina	-0.0779*	-0.343**	-0.341**	-0.282*	-0.618	-0.287**
	(0.0426)	(0.155)	(0.174)	(0.158)	(0.412)	(0.121)
Process Inn	0.00498	-0.000160	0.000314	0.00719	-0.0136	0.0162
	(0.00882)	(0.00933)	(0.00994)	(0.00975)	(0.0188)	(0.0106)
Organiza Inn	0.00371	-0.00220	0.0194	-0.00855	-0.000695	-0.00209
	(0.0119)	(0.0127)	(0.0135)	(0.0130)	(0.0238)	(0.0147)
Public coop	0.00509	-0.00117	0.0118	-0.00500	0.0372*	-0.0152
	(0.0110)	(0.0119)	(0.0126)	(0.0122)	(0.0217)	(0.0139)
Exporter Firm	0.134***	0.137***	0.156***	0.150***	0.257***	0.132***
	(0.0148)	(0.0149)	(0.0149)	(0.0153)	(0.0300)	(0.0168)
HHI	-0.148*	-0.141*	-0.0795	-0.127	-0.0663	-0.160*
	(0.0859)	(0.0823)	(0.0884)	(0.0840)	(0.166)	(0.0860)
Labour prod (ln)	-0.542***	-0.543***	-0.536***	-0.559***	-0.583***	-0.548***
	(0.0125)	(0.0125)	(0.0132)	(0.0130)	(0.0259)	(0.0141)
Small Size	0.509***	0.502***	0.503***	0.608***	0.641***	0.512***
	(0.0368)	(0.0372)	(0.0332)	(0.0334)	(0.0667)	(0.0372)
Medium Size	0.337***	0.328***	0.359***	0.343***	0.410***	0.336***
	(0.0278)	(0.0281)	(0.0246)	(0.0247)	(0.0472)	(0.0280)
Observations	41,996	41,996	39,277	40,328	9,157	32,682
R-squared	0.479	0.288	0.262	0.288	0.325	0.297
Firm FE	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Ind(2-digit) x Time FE	Y	Y	Y	Y	Y	Y
Wald Test NEWPr=1 (p-value)	0.0000	0.0213	0.1092	0.0484	0.4332	0.1040
RANGE		0.138***	0.306*	0.286*	0.235*	0.202**
		(0.005)	(0.171)	(0.161)	(0.128)	(0.942)
F-test		272.57	102.95	143.54	92.18	184.01
IV IMPchina		0.007***	0.005***	0.004***	0.004***	0.002***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
F-test		74.08	37.95	103.05	110.56	70.46

Note: Standard errors robust to heteroskedasticity in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Chinese Import Competition (IMPchina) is calculated according to equation (13): the share of Colombian imports from China with respect to Colombian apparent consumption (Colombian total imports plus production) at time t and 4-digit industrial sector.

In Column (2), the Wald test confirms that in the case of the IV estimates, the coefficient of sales growth due to new products is significantly different from one. A 1-percentage point increase in sales growth due to new products leads to a 0.820-percentage points increase in employment growth in firms. According to the definition of this coefficient presented in Section 3.2, $\beta = \frac{\theta_{11}}{\theta_{22}}$, this result means that although there is a labour-creation effect from the product innovation, new products generate less employment growth because they are produced more efficiently than old products ($\theta_{11} < \theta_{22}$).

On the other hand, the IV estimates of Column (2) are higher than the Panel estimates of Column (1), validating the presence of a downward bias because of endogeneity issues from the variable sales growth due to new products. The IV Range is not a weak instrument, since is always positively and significantly correlated with the endogenous variable in the first-stage reduced form regression. Additionally, the F-test is higher than the threshold level of 10, confirming that the IV is strong.

As a robustness check, a new IV is included in Table A3 of the Appendix. The new IV variable is the Manufacturing tariff change (4-digit) in Colombia from the UNCTAD Trade Analysis Information System via WITS. However, the empirical results show product innovation coefficients are not significant in all cases. On the other hand, the new IV is not significantly correlated with the endogenous product innovation variable, and the F-test is lower than the threshold of 10, meaning a weak IV. Hence, it is decided to use the *Range* variable as the preferred IV.

Columns (3) and (4) in Table 2 present the analysis of employment growth by the level of education of employees. High-educated labour is defined as workers with professional or technical education, whereas low-educated labour are those workers with no, primary or secondary education. In line with the results from Mejia et al. (2014), the effect of product innovation is higher on employees with higher qualifications. In this case, the coefficient for highly educated workers is not statistically different from 1, hence a 1-percentage point increase in sales growth due to new products leads to a 1-percentage point increase in high-educated employment growth, and to a 0.847-percentage points increase in low-educated employment growth. On average, there is no difference in the size of the effect of product innovation on employment growth for firms in the high-tech sectors and the low-tech sectors. In both cases, a 1-percentage point increase in sales growth due to new products leads to a 1-percentage point increase in employment growth Columns (5) and (6).

Chinese import competition has a negative effect on employment growth in all cases (Columns (2) to (6)), although the effect is harder for the employment growth of highly-educated labour with a decrease of 0.341 percentage points when Chinese competition increases in 1-percentage point. On the other hand, the Chinese import competition has a negative but non-significant effect on employment growth in high-tech sectors. In all cases, the first-stage estimation shows that the IV is positively and statistically correlated with the endogenous Chinese competition variable, and the F-test shows that the IV is strong.

The control variables show that neither process nor organizational innovations have any effect on employment growth in any of the cases. Innovation cooperation with public institutions is positive and significant for employment growth in high-tech firms, which means that cooperation of firms with governments (R&D subsidies) and with public universities and laboratories (R&D projects, interchanges of researchers, training of labour, PhD students, etc.) is a good source of labour-creation in firms that belong in sectors of chemicals, medical instruments, pharmaceutical, and machinery and equipment. On the other hand, labour productivity is negatively correlated with labour-creation, especially employment in low-tech firms and low-educated labour. Market power (HHI) or competition concentration is detrimental to employment growth in low-tech firms.

Exporter firms have a higher employment growth than non-exporter firms, particularly in the case of employment growth of highly-educated workers. In all cases, small and medium firms present a higher employment growth than larger firms, especially in the cases of low-educated workers and firms in high-tech sectors.

Table 3: Heterogenous Employment Effects of Innovation and Chinese Import Competition

VARIABLES	(1) IV All	(2) IV HighEdu	(3) IV LowEdu	(4) IV HighTech	(5) IV LowTech
LowNewPr x IMPchina	0.194	0.166	0.329	0.944	0.0104
	(0.224)	(0.257)	(0.232)	(1.343)	(0.154)
MedNewPr x IMPchina	0.0785	0.0342	0.249	0.374	0.120
	(0.257)	(0.292)	(0.265)	(1.388)	(0.196)
HighNewPr x IMPchina	-0.799**	-0.754*	-0.602*	0.266	-1.084***
	(0.341)	(0.386)	(0.354)	(1.408)	(0.355)
Med NewPr	0.0539***	0.0466***	0.0521***	0.0569*	0.0463**
	(0.0167)	(0.0180)	(0.0175)	(0.0321)	(0.0190)
High NewPr	0.499***	0.474***	0.502***	0.422***	0.527***
	(0.0242)	(0.0256)	(0.0255)	(0.0473)	(0.0284)
Process Inn	0.0127	0.00697	0.0107	-0.000115	0.0175*
	(0.00902)	(0.00967)	(0.00951)	(0.0185)	(0.0104)
Organiza Inn	0.0147	0.0369***	0.00461	0.0154	0.0154
	(0.0122)	(0.0130)	(0.0129)	(0.0242)	(0.0142)
Public coop	0.0110	0.0222*	0.00339	0.0557***	-0.00735
	(0.0112)	(0.0122)	(0.0117)	(0.0215)	(0.0132)
Exporter Firm	0.156***	0.149***	0.142***	0.254***	0.123***
	(0.0147)	(0.0153)	(0.0150)	(0.0304)	(0.0168)
HHI	-0.0820	-0.0426	-0.0505	-0.0166	-0.137
	(0.106)	(0.114)	(0.109)	(0.237)	(0.103)
Labour prod (ln)	-0.549***	-0.531***	-0.555***	-0.577***	-0.543***
	(0.0124)	(0.0132)	(0.0130)	(0.0263)	(0.0140)
Small Size	0.534***	0.601***	0.495***	0.651***	0.497***
	(0.0326)	(0.0336)	(0.0334)	(0.0688)	(0.0370)
Medium Size	0.351***	0.356***	0.341***	0.404***	0.332***
	(0.0246)	(0.0251)	(0.0252)	(0.0496)	(0.0282)
Observations	41,996	39,277	40,328	9,151	32,676
R-squared	0.282	0.245	0.266	0.294	0.280
FirmFE	Y	Y	Y	Y	Y
TimeFE	Y	Y	Y	Y	Y
Ind(2digit)xTimeFE	Y	Y	Y	Y	Y
F-Test					
LowNewPr x IV IMP	103.47	97.82	98.12	236.68	86.16
MedNewPr x IV IMP	46.90	46.88	45.40	102.33	33.07
HighNewPr x IV IMP	91.54	90.03	88.06	82.48	114.49

Note: Standard errors robust to heteroskedasticity in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Chinese Import Competition (IMPchina) is calculated according to equation (13): the share of Colombian imports from China with respect to Colombian apparent consumption (Colombian total imports plus production) at time t and 4-digit industrial sector.

Table 3 presents the estimation results for equation (17). The coefficients of the interac-

tion variable show the heterogenous effect of Chinese competition on employment growth depending on the firm's innovation level. Firms are categorized by their nominal sales growth from new products, representing their degree of product innovation. *LowNewPR* is a dummy equal to 1 if the firm is classified as a low innovative firm, which are those firms with product innovations lower than the 33rd percentile, medium innovative firms (*MedNEwPR* equal to 1) that have product innovations between the 33rd and 66th percentile, and high innovative firms (*HighNewPR* equal to 1) with product innovations higher than the 66th percentile. The impact of Chinese import competition on firm employment growth is only significant and negative for highly innovative firms, but not in the case of firms belonging to high-tech sectors. The estimation results show that the negative effect of Chinese import competition on employment growth is higher for highly innovative firms that belong to the low-tech sector and in the case of highly-educated workers.

In conclusion, Table 2 indicates that firms introducing product innovations tend to expand their market shares, primarily generating employment for highly educated workers. This suggests that innovation activities complement high-skilled labour. While Chinese import competition has an overall negative impact on employment across the sample, a more nuanced analysis that accounts for innovation heterogeneity reveals a different outcome. Specifically, Table 3 shows that highly innovative firms when faced with Chinese sectoral competition, respond by innovating and launching new products. However, this is often accompanied by downsizing, particularly among highly educated workers and in low-tech sectors. Therefore, while product innovation serves as a defensive response to foreign competition, it does not appear to be effective in sustaining or increasing employment.

7 Concluding Remarks

This paper examines the causal link between product innovation on employment growth at the firm level using the structural model of Harrison et al. (2014) for the case of Colombian manufacturing firms over the period of 2007 to 2018. This analysis is extended to take into account the heterogeneous effect of Chinese import competition on employment growth depending on the firm's level of product innovation.

The empirical analysis reveals three major findings. First, and following the literature, sales growth due to new products has a positive and significant effect on firm employment growth in all manufacturing sectors and during the period of analysis. In general, process innovations and organizational innovations appear to have no significant effects on employment growth at the firm level. Second, product innovation has a stronger impact on the employment growth of highly-educated workers than on low-educated ones. Innovation effects on employment growth are similar across high-tech and low-tech sectors. Third, Chinese import competition has a significant negative impact on highly innovative firms, particularly in low-tech sectors and for highly educated workers. Innovative firms seem to use product innovation as a defensive strategy against competition, but this approach is not very effective.

The policy implications of this paper suggest several key actions. First, there is a clear link between the development of new products and growth in manufacturing

employment, indicating the need for public policies that promote innovation, encourage exports, and invest in human capital. Since the data shows that firms primarily increase employment among highly educated workers, human capital development is essential.

Second, the government should provide support to highly innovative firms through measures such as subsidies or tax incentives. These measures would not only encourage ongoing innovation in response to trade competition but also ensure that employment, particularly among highly educated workers, continues to grow.

The paper concludes by outlining several avenues for future research. It suggests examining the long-term relationship between innovation and employment growth, particularly to explore whether these factors form a self-reinforcing cycle over time, as discussed by Herstad and Sandven (2020). Moreover, future studies should delve into firm survival strategies in competitive markets, with a focus on understanding the mechanisms that explain why highly innovative firms tend to reduce employment when faced with foreign sectoral competition. Expanding the scope of this analysis to include other developing countries could also prove insightful, enabling cross-country comparisons and a more comprehensive understanding of these dynamics.

8 References

Aboal, D., Garda, P., Lanzilotta, B., & Perera, M. (2015). Innovation, firm size, technology intensity, and employment generation: evidence from the Uruguayan manufacturing sector. *Emerging Markets Finance and Trade*, 51(1), 3 – 26.

Abreo, C., Bustillo, R., & Rodriguez, C. (2021). The role of institutional quality in the international trade of a Latin American country: evidence from Colombian export performance. *Journal of Economic Structures*. Springer. Pan-Pacific Association of Input- Output Studies (PAPAIOS), 10(1), 1 – 21.

Aghion, P., & Howitt, P. (1992). A model of growth through creative destruction. *Econometrica*, 60, 323–354.

Aghion, P., Bloom, N., Blundell, R., Griffith, R., & Howitt, P. (2005). Competition and innovation: an inverted U relationship. *Quarterly Journal of Economics*, 20(2), 701 – 728.

Avila, O., & Alessandria, G. (2020). Trade integration in Colombia: a dynamic general equilibrium study with new exporter dynamics. *Journal of Economic Dynamics and Control*, 115, issue C.

Alvarez, R., & Claro, S. (2009). David versus Goliath: the impact of Chinese competition on developing countries. *World Development*, 37(3), 560 – 571.

Alvarez, R., Benavente, J.M., Campusano, R., & Cuevas, C. (2011). Employment generation, firm size, and innovation in Chile. *Inter-American Development Bank. Technical Notes No. IDB-TN-319*.

Arango, L., Castellani, F., & Obando, N. (2019). Heterogeneous labour demand

in the Colombian manufacturing sector. *Journal for Labour Market Research*, 53(1), 1 – 19.

Arenas-Diaz, G., Barge-Gil, A., & Heijs, J. (2020). The effect of innovation on skilled and unskilled workers during bad times. *Structural Change and Economic Dynamics*, 52, 141 – 158.

Attanasio, O., Goldberg, P.K., & Pavcnik, N. (2004). Trade reforms and wage inequality in Colombia. *Journal of Development Economics*, 74(2), 331 – 366.

Autor, D., Dorn, D., & Hanson, G. (2013). The China syndrome: local labor market effects of import competition in the United States. *American Economic Review*, 103(6), 2121 – 2168.

Benavente, J.M., & Lauterbach, R. (2008). Technological innovation and employment: complements or substitutes? *The European Journal of Development Research*, 20(2), 318 – 329.

Bernard, A.B., Bradford Jensen, J., & Schott, P.K. (2006). Survival of the best fit: exposure to low-wage countries and the (uneven) growth of the U.S. manufacturing plants. *Journal of International Economics*, 68, 219 – 237.

Bloom, N., Draca, M., & Van Reenen, J. (2016). Trade induced technical change? the impact of Chinese imports on innovation, IT, and productivity. *Review of Economic Studies*, 83, 87 – 117.

Blyde, J.S., & Fentanes, O. (2019). The heterogeneous impacts of import competition on Mexican manufacturing plants. *Inter-American Development Bank*. IDB Working Papers Series No. IDB-WP-01087.

Bogliacino, F., Piva, M., & Vivarelli, M. (2012). R&D and employment: an application of the LSDVC estimator using European microdata. *Economics Letters*, 116(1), 56 – 59.

Busom, I., & Velez-Ospina, J.A. (2017). Innovation, public support, and productivity in Colombia. A cross-industry comparison. *World Development*, 99, 75 – 94.

Calvino, F., & Virgillito, M.E. (2018). The innovation-employment nexus: a critical survey of theory and empirics. *Journal of Economic Surveys*, 32(1), 83 – 117.

Calvino, F. (2019). Technological innovation and the distribution of employment growth: a firm-level analysis. *Industrial and Corporate Change*, 28(1), 177 – 202.

Cardenas, M., & Kugler, A. (2011). The reversal of the structural transformation in Latin America after China's emergence. *Brookings Working Paper*, Washington, D.C.

Carranza, E., Wiseman, W., Eberhard-Ruiz, A., & Cardenas, A.L. (2022). Colombia jobs diagnostic: structural challenges for the creation of more and better jobs. *World*

Bank Group, Jobs Series, Issue No. 30.

Ciarli, T., Marzucchi, A., Salgado, E., & Savona, M. (2018). The effect of R&D growth on employment and self-employment in local labour markets. *SPRU Working Paper Series, 2018-08*. SPRU - Science Policy Research Unit, University of Sussex Business School.

Cesar, A. Falcone, G., & Gasparini, L. (2021). Costs and benefits of trade shocks: evidence from Chilean local labor markets. *Labour Economics*, 73, 1 - 35.

Coad, A., & Rao, R. (2011). The firm-level employment effects of innovations in high-tech US manufacturing industries. *Journal of Evolutionary Economics*, 21 (2), 255–283.

Costa, F., Garred, J., & Pessoa, J.P. (2016). Winners and losers from a commodities-for-manufactures trade boom. *Journal of International Economics*, 102, 50 – 69.

Crespi, G., Figal-Garone, L., Maffioli, A., & Melendez, M. (2015). Long-term productivity effects of public support to innovation in Colombia. *Emerging Markets Finance and Trade*, 51, 48 – 64.

Crespi, G., Tacsir, E., & Pereira, M. (2019). Effects of innovation on employment in Latin America. *Industrial and Corporate Change*, 28(1), 139 – 159.

Dachs, B., & Bettina, P. (2014). Innovation, employment growth, and foreign ownership of firms. *Research Policy*, 43(1), 214 – 232.

Dachs, B., Had, M., Koehler, C., & Peters, B. (2017). Innovation, creative destruction, and structural change: firm-level evidence from European countries. *Industry and Innovation*, 24(4), 346 – 381.

Damijan, J., Kostevc, C., & Stare, M. (2014). Impact of innovation on employment and skill upgrading. *Working Papers of VIVES* - Research Centre for Regional Economics 627713, KU Leuven, Faculty of Economics and Business (FEB), VIVES - Research Centre for Regional Economics.

DANE (2015). Technical Development and Innovation in the Manufacturing Industry – EDIT. General Methodology. *Statistical Methodology and Production Division* – DIMPE.

De Elejalde, R., Giuliodori, D., & Stucchi, R. (2015). Employment and Innovation: Firm- Level Evidence from Argentina. *Emerging Markets Finance & Trade*, 51(1), 27–47.

Eslava, M., Haltiwanger, J., Kugler, A., & Kugler, M. (2013). Trade and market selection: evidence from manufacturing plants in Colombia. *Review of Economic Dynamics*, 16(1), 135– 158.

Fajnzylber, P., & Fernandes, A. M. (2009). International economic activities and the demand for skilled labour: evidence from Brazil and China. *Applied Economics*, 41(5), 563–577.

Fernandes, A., & Paunov, C. (2009). Does tougher import competition foster product quality upgrading? *World Bank Policy Research Working Paper No. 4894*.

Fernandes, A. (2007). Trade policy, trade volumes and plant level productivity in Colombian manufacturing industries. *Journal of International Economics*, 71(1), 52–71.

Fieler, A.C., Marcela, E., & Yi-Xu, D. (2018). Trade, quality upgrading, and input linkages: theory and evidence from Colombia. *American Economic Review*, 108 (1), 109-46.

Gallego, J.M., Gutierrez, L.H., & Taborda, R. (2015). Innovation and productivity in the Colombian service and manufacturing industries. *Emerging Markets Finance and Trade*, 51, Issue 3.

Garcia, A., Jaumandreu, J., & Rodriguez, C. (2004). Innovation and Jobs: evidence from manufacturing firms. *MPRA Paper 1204*, University Library of Munich, Germany.

Gorodnichenko, Y., Svejnar, J., & Terrell, K. (2010). Globalization and innovation in emerging markets. *American Economic Journal: Macroeconomics*, 2 (2), 194-226.

Griffin, N. (2015). Determinants of firm profitability in Colombia's manufacturing sector: exchange rate or structural? *IMF Working Papers 2015/097*, International Monetary Fund.

Hall, B.H., Lotti, F., & Mairesse, J. (2008). Employment, innovation, and productivity: evidence from Italian microdata. *Industrial and Corporate Change*, 17 (4), 813–839.

Harrison, R., Jaumandreu, J., Mairesse, J., & Peters, B. (2014). Does innovation stimulate employment? A firm-level analysis using comparable micro-data from four European countries. *International Journal of Industrial Organization*, 35, 29–43.

Hatzichronoglou, T. (1997). Revision of the high-technology sector and product classification. *OECD. Sci., Technology, and Industry Working Paper*.

Herstad, S. J., & Sandven, T. (2020). A closer look at the relationship between innovation and employment growth at the firm level. *Journal of Evolutionary Economics*, 30(2), 375-399.

Iacovone, L., Rauch, F., & Winters, L.A. (2013). Trade as an engine of creative destruction: mexican experience with Chinese competition. *Journal of International Economics*, 89(2), 379–392.

Jenkins, R., Peters, E., & Mesquita-Moreria, M. (2008). The impact of China on Latin America and the Caribbean. *World Development*, 36(2), 235 – 253.

Kugler, M., & Verhoogen, E. (2009). Plants and imported inputs: new facts and interpretation. *American Economic Review*, 99(2), 501-507.

Kugler, M., & Verhoogen, E. (2012). Price, plant size, and product quality. *Review of Economic Studies*, 79(1), 307-339.

Li, K., & Mesquita-Moreira, M. (2019). China import competition and El Salvador manufacturing firm performance. *IDB Working Paper Series IDB-WP-01082*, IDB, Washington, DC.

Lucchese, M., & Pianta, M. (2012). Innovation and employment in economic cycles. *Comparative Economic Studies*, Palgrave Macmillan. Association for Comparative Economic Studies, 54(2), 341 - 359.

McMillan, M., Rodrik, D. & Verduzco-Gallo, I. (2014). Globalization, structural change, and productivity growth, with an update on Africa. *World Development*, 63, 11 – 32.

Mejia, J.F., & Arias-Granada, Y. (2014). Innovation and its effects on employment composition: microeconomic evidence from Colombian firms. *Documentos de Trabajo CIEF 012338*, Universidad EAFIT.

Mendez, O. (2015). The effect of Chinese import competition on Mexican local labour markets. *North American Journal of Economics and Finance*, 34, 364 – 380.

Mercado, E., Pierola, M.D., Sanchez-Navarro, D. (2019). The impact of import competition from China on firm performance in the Peruvian Manufacturing sector. *IDB Working Paper Series IDB-WP-01092*, IDB, Washington, DC.

Mesquita-Moreira, M., Rodriguez-Chatruc, M., Lage, F., & Merchan, F. (2020). Trade, productivity, innovation, and employment: lessons from the impact of Chinese competition on manufacturing in Brazil. *IDB Working Paper Series IDB-WP-01141*, IDB, Washington, DC.

Mesquita-Moreira, M., Rodriguez-Chatruc, M., Lage, F., & Merchan, F. (2023). The China shock on manufacturing in Brazil: lessons on productivity, innovation, and jobs. *The International Trade Journal*, 37(3), 1 – 24.

Mion, G., & Zhu, L. (2013). Import competition from and offshoring to China: a curse or blessing for firms? *Journal of International Economics*, 89, 202–215.

Molina, D. (2020). The China effect on Colombia's manufacturing labor market. *IDB Working Paper Series IDB-WP-01101*, IDB, Washington, DC.

Ocampo, J.A., & Porciel, G. (2020). American industrial policies: a comparative

perspective. In Oqubay, A., Cramer, C., Chang, H., & Kozul-Wright, R. (Eds.), *The Oxford Handbook of Industrial Policy* (pp. 811 – 841). Oxford, UK, Oxford University Press.

Palma, G. (2005). Four sources of "de-industrialization" and a new concept of the Dutch disease. In Ocampo, J. (Eds.), *Beyond Reforms: Structural Dynamics and Macroeconomic Vulnerability*. Palo Alto, Stanford University Press.

Paus, E. (2020). Innovation strategies matter: Latin America's middle-income trap meets China and globalization. *The Journal of Development Studies*, 56(4), 657 – 679.

Paus, E., Robinso, M. & Tregenna, F. (2022). Firm innovation in Africa and Latin America: Heterogeneity and country context. *Industrial and Corporate Change*, 31(2), 338 – 357.

Pavcnik, N., & Goldberg, P. (2005). Short term consequences of trade reform for industry employment and wages: survey of evidence from Colombia. *The World Economy*, 28(7), 923 – 939.

Paz, L. (2018). The effect of import competition on Brazil's manufacturing labor market in the 2000s: are imports from China different? *The International Trade Journal*, 32(1), 76 – 99.

Peters, B. (2005). Employment effects of different innovation activities: microeconometric evidence. *ZEW Discussion Papers*, No. 04 - 73, Zentrum für Europäische Wirtschaftsforschung (ZEW), Mannheim

Peters, B., Dachs, B., Dünser, M., Hud, M., Köhler, C., & Rammer, C. (2014). Firm growth, innovation, and the business cycle. *Background Report for the 2014 Competitiveness Report*. ZEW Gutachten/Forschungsberichte.

Pianta, M. (2005). Innovation and employment. In Fagerberg, J., Movery, D.C., & Nelson, R.R. (Eds.), *The Oxford Handbook of Innovation* (pp. 568 – 598). Oxford, UK, Oxford University Press.

Rafique, A. (2013). Competition and innovation: the inverted-U relationship revisited. *The Review of Economics and Statistics*, 95(5), 1653 – 1668.

Ramirez, S., Gallego, J., & Tamayo, M. (2020). Human capital, innovation, and productivity in Colombia enterprises: a structural approach using instrumental variables. *Economics of Innovation and New Technology*, 29(6), 625 – 642.

Rodrik, D. (2016). Premature deindustrialization. *Journal of Economic Growth*, 21(1), 1 – 33.

Utar, H., & Torres Ruiz, L.B. (2013). International competition and industrial evolution: evidence from the impact of Chinese competition on Mexican maquiladoras. *Journal of Development Economics*, 105, 267–287.

Vivarelli, M. (2014). Innovation, employment, and skills in advanced and developing countries: a survey of economic literature. *Journal of Economic Issues*, 48(1), 123 – 154.

Zuniga, P., & Crespi, G. (2013). Innovation strategies and employment in Latin American firms. *Structural Change and Economic Dynamics*, 24, Issue C, 1 – 17.

Appendix A

Additional Results

Table A1: Descriptive Statistics (Continuation)

Variable	Obs	Mean	Std. dev.	Min	Max
Employment Growth[1]	49,254	-0.018	0.286	-5.654	5.298
High-Skilled Employment Growth[2]	46,053	0.032	0.266	-5.869	3.258
Low-Skilled Employment Growth[3]	47,284	-0.029	0.315	-5.379	4.189
Sales Growth (New Prod)[4]	47,167	0.035	0.186	-2.360	5.027
Process Innovation Only[5]	49,794	0.178	0.382	0	1
Chinese Import Competition[6]	47,781	0.079	0.101	0.000	0.737
Organizational Innovation[7]	49,794	0.085	0.279	0	1
Foreign Ownership[8]	747	0.015	0.121	0	1
Public Cooperation[9]	5,643	0.113	0.316	0	1
Exporter Firm[10]	17,478	0.351	0.477	0	1
Small Size[11]	33,222	0.667	0.471	0	1
Medium Size[11]	11,475	0.230	0.421	0	1
Large Size[11]	5,096	0.102	0.303	0	1
Price Growth[12]	49,794	0.025	0.034	-0.102	0.161
Labor Productivity Growth[13]	47,129	0.026	0.643	-9.996	9.297

Source: Author's calculations using DANE and UN Comtrade data (2023).

[1] Average growth rates of total employment (full-time, permanent and temporary) between year t and t+1.

[2] High-skilled labor is defined as workers with professional or technical education.

[3] Low-skilled labor refers to workers with none, primary, or secondary education.

[4] Nominal sales growth due to new or significantly improved products.

[5] Process innovation only dummy, equal to one if the firm introduces only new or significantly improved processes of production.

[6] Chinese Import Competition is calculated as the share of Colombian imports from China with respect to Colombian apparent consumption (Colombian total imports plus production) at time t and 4-digit industrial sector.

[7] Organizational innovations dummy, equal to one if the firm performs changes in the workplace, management, or external relations.

[8] Foreign ownership dummy, which takes the value of one if the firm reports in the EDIT survey that during the period t to t+1 it is owned by a foreign parent company.

[9] Public cooperation dummy, equal to one if the firm reports having public cooperation to perform science, technology, and innovation activities.

[10] Firm export status dummy, equal to one if the firm reports exports in period t or t+1.

[11] Firm size dummies are defined as small (10 to 50 employees), medium (51 to 200 employees), and large (more than 200 employees).

[12] Industrial price growth (2-digit sector) assigned to firms according to their activity in the EDIT.

[13] Labor productivity is measured as total sales per worker.

Table A2: High-tech and Low-tech Sectors

High-tech sectors	**Low-tech sectors**
Manufacture of chemical substances and products (20), pharmaceuticals, medicinal chemicals, and pharmaceutical botanicals (21), computer, electronic and optical products (26), electrical appliances and equipment (27), machinery and equipment (28), motor vehicles, trailers and semi-trailers (29), other types of transport equipment (30).	Manufacture of food products (10), beverage manufacturing (11), tobacco products (12), textile products (13), clothing (14), tanning and dressing of leather (15), wood and of products of wood and cork (16), paper and paper products (17), printing and reproduction of recorded media (18), coke, refined petroleum products (19), rubber and plastics products (22), other non-metallic mineral products (23), basic metals (24), fabricated metal products (25), furniture (31), other manufacturing industries (32), installation, maintenance and specialized repair of machinery and equipment (33).

Source: Sectors are grouped by technological categories according to the R&D intensity of each sector as proposed by Hatzichronoglou (1997), considering the ISIC Rev. 4 classification adapted for Colombia (2-digit industrial level).

Table A3: Robustness Check - Employment Effects of Innovation and Chinese Import Competition

VARIABLES	(1)		**(2)**		**(3)**	
	Panel	**IV**	**Panel**	**IV**	**Panel**	**IV**
NewPr	-1.848	0.315	-1.448	0.288	-0.962	0.750
	(1.792)	(0.831)	(2.172)	(0.827)	(1.845)	(0.798)
IMPchina			-0.271	-0.153	-0.207	0.146
			(0.321)	(0.256)	(0.279)	(0.241)
Process Inn	0.176	0.0388	0.158	0.0449	0.0687	0.00316
	(0.114)	(0.0535)	(0.142)	(0.0545)	(0.0722)	(0.0320)
Organiza Inn					0.103	0.000126
					(0.110)	(0.0481)
Public coop					0.0994	0.00160
					(0.105)	(0.0467)
Exporter Firm					0.119***	0.135***
					(0.0248)	(0.0165)
HHI					-0.165*	-0.0821
					(0.0894)	(0.105)
Labour prod (ln)					-0.529***	-0.542***
					(0.0198)	(0.0142)
Observations	45,237	45,237	45,237	45,237	45,237	45,237
R-squared	0.464	0.026	0.335	0.026	0.063	0.289
Firm FE	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Industry(2-digit) x Time FE	N	Y	N	Y	N	Y
Wald Test B=1 (p-value)	0.1120	0.4095	0.2599	0.3894	0.2878	0.7535
Manufacturing tariff changes	0.178**	3.230	0.394***	-0.0746	0.412***	-0.0497
	(0.0794)	(2.302)	(0.0184)	(0.0712)	(0.0194)	(0.0553)
F-Test	5.02	1.97	3.07	2.76	3.10	2.13
IV Chinese Import Competition			0.007***	0.009***	0.006***	0.008***
			(0.000)	(0.000)	(0.000)	(0.000)
F-Test			337.13	76.98	351.62	73.88

Note: Standard errors robust to heteroskedasticity in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Chinese Import Competition (IMPchina) is calculated according to equation (13): the share of Colombian imports from China with respect to Colombian apparent consumption (Colombian total imports plus production) at time t and 4-digit industrial sector. Manufacturing tariff changes (4-digit) in Colombia come from the UNCTAD Trade Analysis Information System via WITS.

Chapter 3
Patterns of Structural Change in the Manufacturing Sector: A Firm Size Analysis

Abstract[1]
This paper uses a shift-share decomposition method to access the between and within components that explain the manufacturing labour productivity growth in developing countries. Using the data from the World Bank Enterprise Surveys (WBES) from 2006 to 2019, the results conclude that: (i) on average, the shift-share decomposition analysis indicates that the majority of labour productivity growth in the manufacturing sector across regions is driven by the between component, reflecting employment allocation among firms of different sizes; (ii) small and medium firms in the Africa, South Asia, and Europe and Central Asia regions show positive between components but low within components, while large firms in Africa experience the highest productivity growth despite reducing their workforce, confirming the findings of the literature; (iii) in Latin America, large firms demonstrate both productivity growth and increased labour absorption, whereas firms in Middle East and North Africa exhibit low or negative values in both components; (iv) finally, it is shown that export of output (proxy of forward linkages in GVCs) primarily benefit small firms, while imported inputs (proxy of backward linkages in GVCs) favour large firms. Further analysis identifies skilled workers, innovation status, and capital stock as key mechanisms. Skilled workers improve productivity in medium and large firms but decrease their employment share, with small firms absorbing this surplus labour. Innovation and capital stock enhance productivity, especially in large firms, but do not affect employment share. On the other hand, stronger regulations diminish the positive impacts of imported inputs on productivity and employment shares.

Keywords: Structural change · Labour Productivity Growth · Manufacturing Firms · Global Value Chains.

JEL Codes: F60, J24, O14, O40.

[1]This chapter is the product of joint work with professors Lorenzo Cassi and Rémi Bazillier.

1 Introduction

Historically, economic literature has shown that economic development and improved living standards are strongly linked to growth in manufacturing labour productivity (Szirmai & Verspagen, 2015), which can be achieved in two main ways. First, labour productivity growth depends on the performance of firms and their ability to adopt new technologies and innovate. Second, it relies on the efficient allocation of resources and employment across firms (Brown et al., 2018, p. 1571). In this regard, Hsieh et al. (2009), Bartelsman et al. (2013), and McMillan et al. (2014) highlight that manufacturing industries are composed of a mix of small, low-productivity firms competing with larger firms that operate with highly productive technologies.

This paper aims to explore the factors driving labour productivity growth in the manufacturing sector of developing countries. Specifically, it investigates whether this growth stems from productivity improvements within different firm size categories or from shifts in employment shares between these groups—such as labour moving from small firms to larger ones, or vice versa. The study contributes to the literature by analyzing how firm size dynamics affect overall productivity in the manufacturing sector. To achieve this objective, this paper exploits firm-level data from the World Bank's Enterprise Survey program collected between 2006 and 2019. Firms are categorized into three groups based on size: small firms (1 to 19 employees), medium firms (20 to 99 employees), and large firms (100 or more employees).

The motivation for this research stems from evidence found in the African manufacturing sector. Kruse et al. (2023) observed a manufacturing resurgence in many sub-Saharan African countries since the 2000s, characterized by an expansion of employment, primarily in small unregistered firms, to meet local demand for basic manufactured goods. This pattern is confirmed for Ethiopia and Tanzania by Diao et al. (2018, 2021), and for Ghana, Kenya, Nigeria, and Senegal by McMillan and Zeufack (2022), where small firms absorb much of the employment but show little to no productivity growth, while larger firms demonstrate higher productivity but contribute minimally to employment expansion. This shift in employment toward smaller, less productive firms results in a decline in overall labour productivity in the manufacturing sector.

This paper is composed of two parts of analysis. In the first part, the paper employs the shift-share decomposition method proposed by McMillan and Rodrik (2011) and de Vries et al. (2015) to break down labour productivity growth in the manufacturing sector into two components: (i) the within component, which captures productivity growth within each firm size group, and (ii) the between component, which reflects productivity gains or losses due to the reallocation of labour toward more productive or less productive groups of firms, also referred to as growth-enhancing or growth-reducing structural change, respectively.

Results show that small and medium firms in the countries of Africa (AFR), South Asia (SAR), and Europe and Central Asia (ECA) have positive between components but low within components, while large firms in AFR experience the highest productivity growth despite reducing their workforce, confirming the findings of the literature. In Latin American countries (LAC), large firms demonstrate both productivity growth

and increased labour absorption, whereas firms in the Middle East and North African countries (MNA) exhibit low or negative values in both components. By industrial taxonomy, most sectors in AFR have negative results, except for Supplier Dominated sectors, which show increased productivity and labour reallocation. In LAC, productivity growth is noted in the Scale-Intensive and Supplier-Dominated sectors, but with labour moving to less productive firms. In the Science-Based sectors, only the ECA and SAR regions show positive labour productivity growth, mainly due to the reallocation of labour toward the most productive firms.

The second part of this paper explores the factors that explain differences in labour productivity and employment levels across small, medium, and large firms. The analysis reveals that capital-intensive technologies generally boost labour productivity across the sample of firms. Large firms see a 0.030% productivity increase for every 1% rise in imported inputs, while small firms benefit more from exports, with a 0.049% productivity increase for every 1% increase in exported output. Both exported output and imported inputs positively influence employment share in large firms. These results indicate that exports of output (a proxy for forward linkages in global value chains GVCs) primarily support small firms, whereas imports of inputs (a proxy for backward linkages) benefit large firms. Key factors such as skilled workers, innovation, and capital stock drive productivity improvements, especially in larger firms, although they may reduce employment share. Lastly, stronger labour and financial regulations diminish the positive impacts of imported inputs on productivity and employment shares.

The remainder of the paper is structured as follows: Section 2 reviews the relevant literature. Sections 3 and 4 provide summary statistics of the data and detail the methodology for assessing labour productivity growth in the manufacturing sector of developing countries. Section 5 introduces a simple econometric model to evaluate the impact of foreign technologies embedded in imported inputs (proxy of backward GVC participation) and the export of output (proxy of forward GVC participation) on labour productivity and employment shares across firms. Finally, Section 6 offers concluding remarks.

2 Literature Review

Several studies have explored the differences in job creation between small and large firms within the manufacturing sectors of developing countries. Ayyagari et al. (2014), using data from the World Bank Enterprise Surveys, found that small firms exhibit the highest rates of job creation, while large firms tend to show stronger productivity growth. The authors also investigated the role of firm age, revealing that the highest job creation occurs in small, young firms—those with 20 or fewer employees and less than five years old. This inverse relationship between job creation and a firm's size and age is further supported by findings from Lawless (2014), Aga et al. (2015), and Atwine et al. (2023).

Other factors also explain differences in labour productivity and employment growth across firms. According to Diao et al. (2021), limited employment growth in the most productive larger firms can be attributed to the adoption of capital- and skill-intensive technologies imported from advanced economies or through participation in global value chains (GVCs). Additional factors include sector-specific challenges such as financing

constraints, high labour costs, and an unfavourable business environment.

Regarding the effects of trade, Shu and Steinwender (2019) review empirical studies on how trade liberalization influences firm productivity. On one hand, research shows that import competition can boost productivity in emerging economies, with the strongest impacts seen in firms that were already larger and more productive (Pavcnik, 2002; Eslava et al., 2012; Fernandes & Paunov, 2013; Iacovone, 2012). On the other hand, expanded export opportunities increase market potential for domestic firms, driving innovation and productivity gains. The most productive firms are generally the ones that benefit the most from increased access to export markets. For example, Bas and Ledezma (2010) found that in Chile, a reduction in export barriers positively correlated with firm productivity, while reductions in import barriers led to productivity gains mainly in export-oriented sectors. McCaig and Pavcnik (2018) also found that a positive export shock in Vietnam increased the share of formal manufacturing employment by 5 percentage points.

Trade openness not only encourages competition but also allows domestic firms to acquire foreign technology at lower costs. These imported inputs, often capital- and skill-intensive, improve production efficiency, leading to the development of new products or enhanced product quality, which in turn boosts productivity and competitiveness (Shu & Steinwender, 2019). Amiti and Konings (2007) demonstrated that in the Indonesian manufacturing sector, lower output tariffs increased productivity by fostering import competition, while cheaper imported inputs contributed to productivity growth through learning and quality improvements. Similarly, Bas and Paunov (2019, 2021) found in Ecuador that input tariff reductions primarily benefited more productive firms, allowing them to expand their product range, improve quality, and capture greater market shares. Skilled workers also experienced higher wage growth compared to less skilled workers. In Mexico, Bas and Bombarda (2023) showed that input trade liberalization prompted a shift of workers from informal to formal firms, although this effect was largely concentrated among high-skilled workers.

Moreover, globalization, particularly through participation in global value chains (GVCs), plays a pivotal role in influencing firm productivity and labour dynamics. Integration into global production networks boosts productivity in developing countries by providing access to foreign markets and facilitating the adoption of new technologies. As highlighted by Farole (2016), Rodrik (2018), and Pahl & Timmer (2020), manufacturing exports through GVCs (forward GVC participation) are key drivers of job creation. However, the introduction of capital- and skill-intensive technologies via imported inputs (backward GVC participation) has contributed to declining employment shares in manufacturing industries. Nevertheless, the overall impact on employment depends on market compensation mechanisms. For example, technological progress leading to the introduction of new products or lower output prices can stimulate higher demand, ultimately resulting in increased employment (Dosi et al., 2021).

Finally, the literature emphasizes the role of institutions in shaping productivity and labour reallocation across firms. Berthou et al. (2020) observe that both export and import growth contribute to increased average firm productivity, but strong institutions (such as a strong rule of law, low corruption, efficient factors and product markets)

amplify the productivity gains from import competition and dampen the productivity gains from export expansion. Moreover, Brown et al. (2018) highlight that stringent labour regulations may imply lower productivity growth, by making it more costly to take risks and innovate. On the other hand, low financial development at the country level can produce misallocation of resources across firms, reducing their productivity growth. Hence, labour and financial policy reforms play a crucial role in the allocative efficiency and productivity across firms.

In Section 4, this paper applies the shift-share decomposition method introduced by McMillan and Rodrik (2011) and de Vries et al. (2015) to analyse labour productivity growth in the manufacturing sector across various regions of developing countries. Section 5 then examines the factors discussed in the literature review to account for the differences in labour productivity and employment levels among small, medium, and large firms.

3 Data and Summary Statistics

The data comes from the World Bank Enterprise Surveys (WBES) and covers 58,163 firms across 78 developing countries during the period from 2006 to 2019. These countries are located in 6 regions: Africa (AFR), East Asia and Pacific (EAP), Europe and Central Asia (ECA), Latin America and The Caribbean (LCR), Middle East and North Africa (MNA), and South Asia (SAR). The list of countries and the period of each one is presented in Table A1 in the appendix.

Firms are grouped by size within each country. There are three groups: small firms (1 to 19 employees), medium firms (20 to 99 employees), and large firms (100 or more employees). The variables used are those related to the number of permanent, full-time workers and total sales (in LCU) at the end of the last fiscal year. Sampling or probability weights available in the survey are applied to these variables to make a cross-country statistical analysis.

Two new variables are calculated for each group of firms by country and year. First, employment share is defined as the total employment within each firm group over the total manufacturing employment in the country[2]. Second, a measure of labour productivity share is defined as the ratio of total sales in 2009 US dollars (in ten thousand) over total employment within each firm group. Table 1 presents the summary statistics for these variables according to region and firm group.

Summary statistics indicate that small and medium-sized firms outnumber large firms across all regions. However, it is the large firms that exhibit the highest average labour productivity and employment shares, except for the ECA, MNA, and SAR regions, where small and medium-sized firms show higher average labour productivity relative to large firms. Additionally, the coefficient of variation (CV, that is the ratio of the standard deviation to the mean) reveals a greater dispersion of labour productivity and employment shares within each firm group across all regions, except for ECA,

[2]The total manufacturing employment is defined as the sum of total employment of the whole set of manufacturing firms for a country in a given year.

which represents the more advanced economies in the sample. This finding aligns with McMillan et al. (2014), who highlighted that larger productivity gaps are characteristic of developing countries.

Table 1: Employment Shares and Labour Productivity (LP) Shares – Summary Statistics

Region	Firm Group	Share of Firms	Employment Shares				Average LP relative to large firms	LP
			Mean	CV	Min	Max		CV
AFR	Small Firms	0.608	0.197	0.882	0.019	0.672	0.619	2.070
	Medium Firms	0.286	0.306	0.477	0.048	0.896	0.981	2.536
	Large Firms	0.104	0.546	0.410	0.054	0.924		6.700
EAP	Small Firms	0.539	0.137	0.983	0.014	0.526	0.723	0.889
	Medium Firms	0.321	0.260	0.479	0.039	0.573	0.888	0.823
	Large Firms	0.138	0.603	0.374	0.088	0.899		1.080
ECA	Small Firms	0.513	0.123	0.586	0.008	0.401	1.023	0.560
	Medium Firms	0.363	0.319	0.349	0.060	0.667	1.021	0.880
	Large Firms	0.123	0.564	0.274	0.152	0.928		0.857
LAC	Small Firms	0.537	0.136	0.675	0.020	0.510	0.691	2.599
	Medium Firms	0.346	0.310	0.463	0.124	0.682	0.710	1.130
	Large Firms	0.116	0.563	0.364	0.091	0.805		1.083
MNA	Small Firms	0.592	0.227	0.809	0.039	0.563	1.022	1.184
	Medium Firms	0.312	0.328	0.443	0.128	0.609	1.224	1.005
	Large Firms	0.095	0.495	0.524	0.033	0.833		0.743
SAR	Small Firms	0.532	0.177	0.916	0.013	0.464	0.943	1.087
	Medium Firms	0.321	0.269	0.598	0.055	0.587	2.036	2.241
	Large Firms	0.146	0.555	0.458	0.197	0.932		0.653

Source: Author's calculations using data from the World Bank Enterprise Surveys (ES). Employment shares are presented for each region and group of firms according to their size: group of small firms (1 to 19 employees), group of medium firms (20 to 99 employees), and group of large firms (100 or more employees). Countries are classified in 6 regions: Africa (AFR), East Asia and Pacific (EAP), Europe and Central Asia (ECA), Latin America and The Caribbean (LCR), Middle East and North Africa (MNA), South Asia (SAR). The results take into account the sampling weights from the survey.

4 Measuring the Patterns of Structural Change and Labour Productivity Growth

Labour productivity growth in the manufacturing sector can be decomposed into two components. First, the within component, which measures the productivity growth in each group of firms, and second, the between component or structural change, which measures the productivity growth that comes from the reallocation of labour from low- to high-productive group of firms. Following the methods of shift-share decomposition presented by McMillan and Rodrik (2011) and de Vries et al., (2015) the labour productivity growth can be expressed as:

$$\Delta P = \sum_i (P_i^T - P_i^O) S_i^O + \sum_i (S_i^T - S_i^O) P_i^O \quad (1)$$

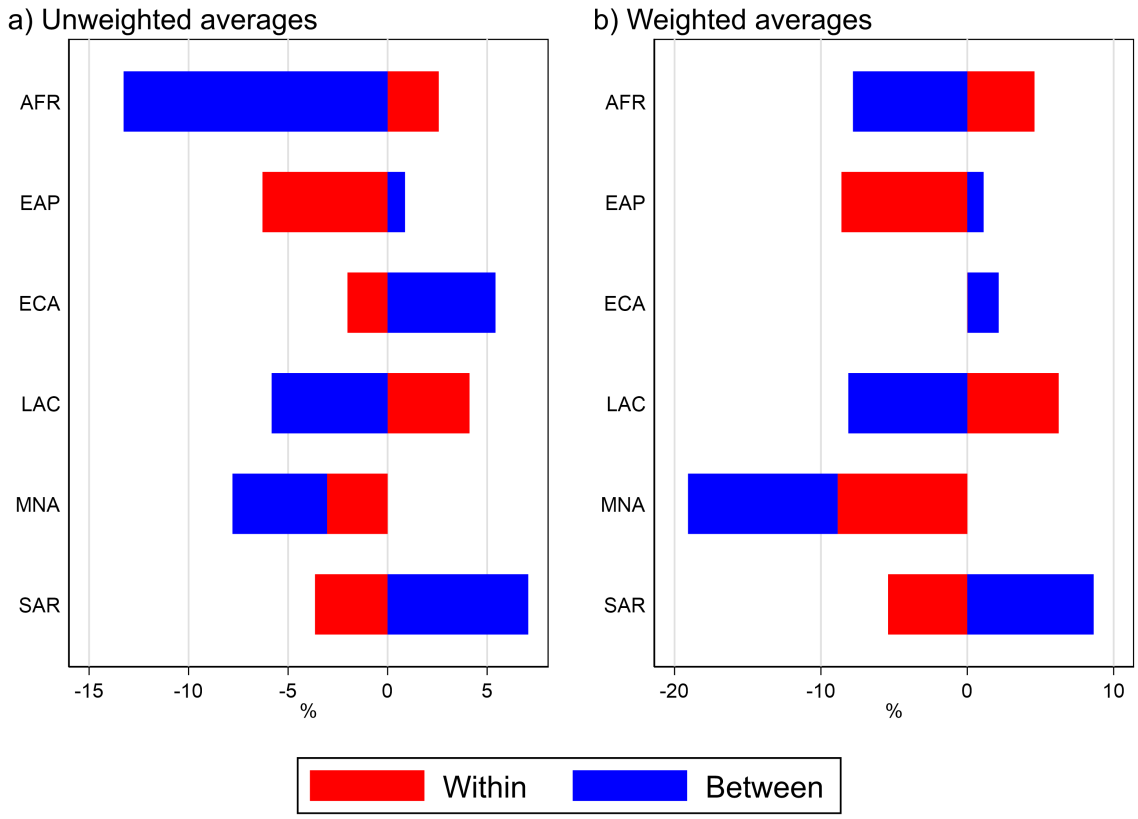
Where i represents the group of firms according to their size that can be the group

of small firms (1 to 19 employees), group of medium firms (20 to 99 employees), and group of large firms (100 or more employees). P_i and S_i are the labour productivity and employment share of group i, respectively. The superscripts O and T refer to the initial and final period of observation for each country in each region. However, since the period of observations is different for each country due to data availability, expression (1) is transformed to account for compound annual growth rates as follows:

$$\Delta P = \sum_i \left(\sqrt[n]{\frac{P_i^T}{P_i^O}} - 1 \right) S_i^O + \sum_i \left(\sqrt[n]{\frac{S_i^T}{S_i^O}} - 1 \right) P_i^O \tag{2}$$

Where n corresponds to the number of years between O and T. The first term of the expression (2) corresponds to the within component of the decomposition, that is the productivity growth within firm group i weighted by its initial employment share. The second term of expression (2) corresponds to the between component that shows the employment share growth of the firm group i weighted by its initial labour productivity level. Therefore, this last term represents the structural change of the manufacturing sector related to the reallocation of labour from one group to another according to their productivity.

Figure 1: Decomposition of Labor Productivity Growth by Region

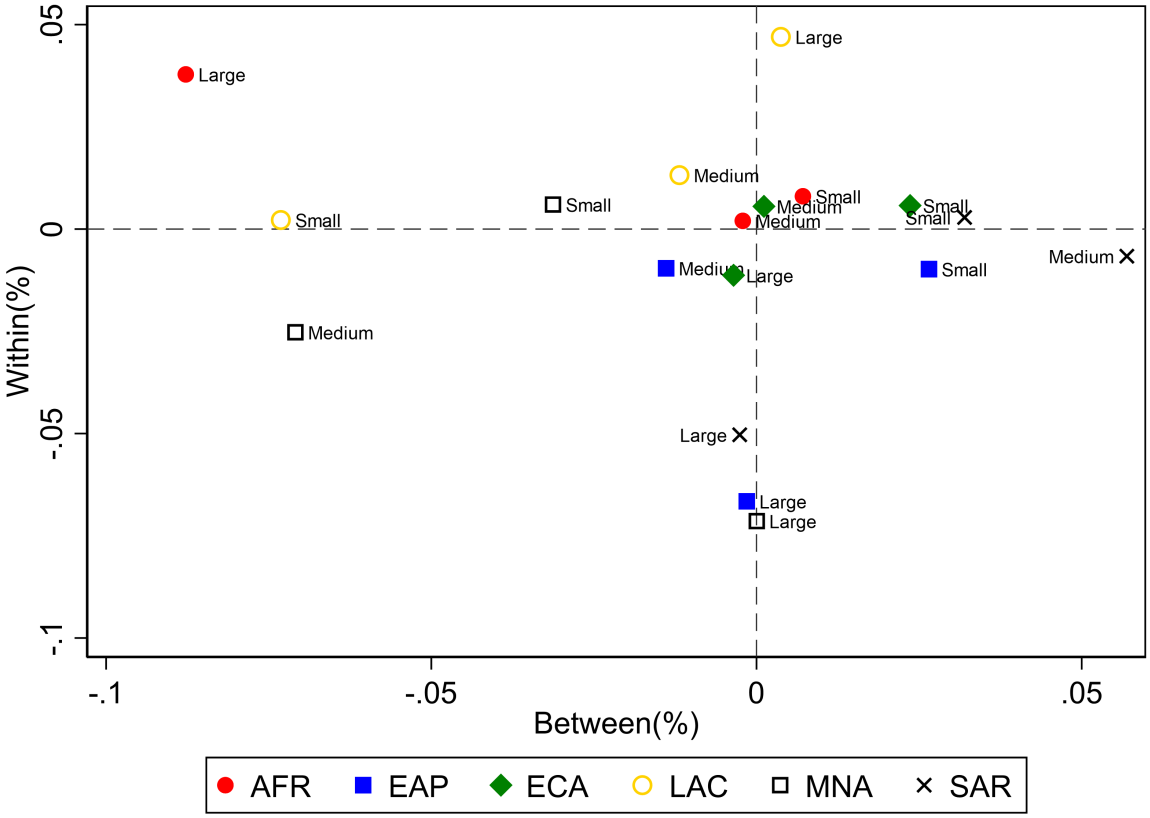


Source: Author's calculations using data from the World Bank Enterprise Surveys (ES). Countries are classified in 6 regions: Africa (AFR), East Asia and Pacific (EAP), Europe and Central Asia (ECA), Latin America and The Caribbean (LCR), Middle East and North Africa (MNA), and South Asia (SAR). Weighted averages are calculated using country sizes in terms of total manufacturing employment as weights.

Table A1 in the appendix shows the results of the labour productivity growth decomposition of expression (2) for each country. Figure 1 presents the regional results as a simple average and weighted average (using country size in terms of total manufacturing employment as weights) of each component. The unweighted and weighted results are closer in terms of sign and magnitude, although the weighted averages are higher than the unweighted averages for the regions of LCR, MNA and SAR suggesting the effect of larger countries in the samples.

Overall, the between component largely explains the differences in labour productivity growth across regions. In the AFR and LAC regions, the within component is positive, indicating that all groups of firms have improved their labour productivity. However, the negative between component suggests a reallocation of labour from high-productivity firms to lower-productivity ones. In contrast, the EAP, ECA, and SAR regions exhibit the opposite pattern. The MNA region shows, on average, negative values for both the within and between components.

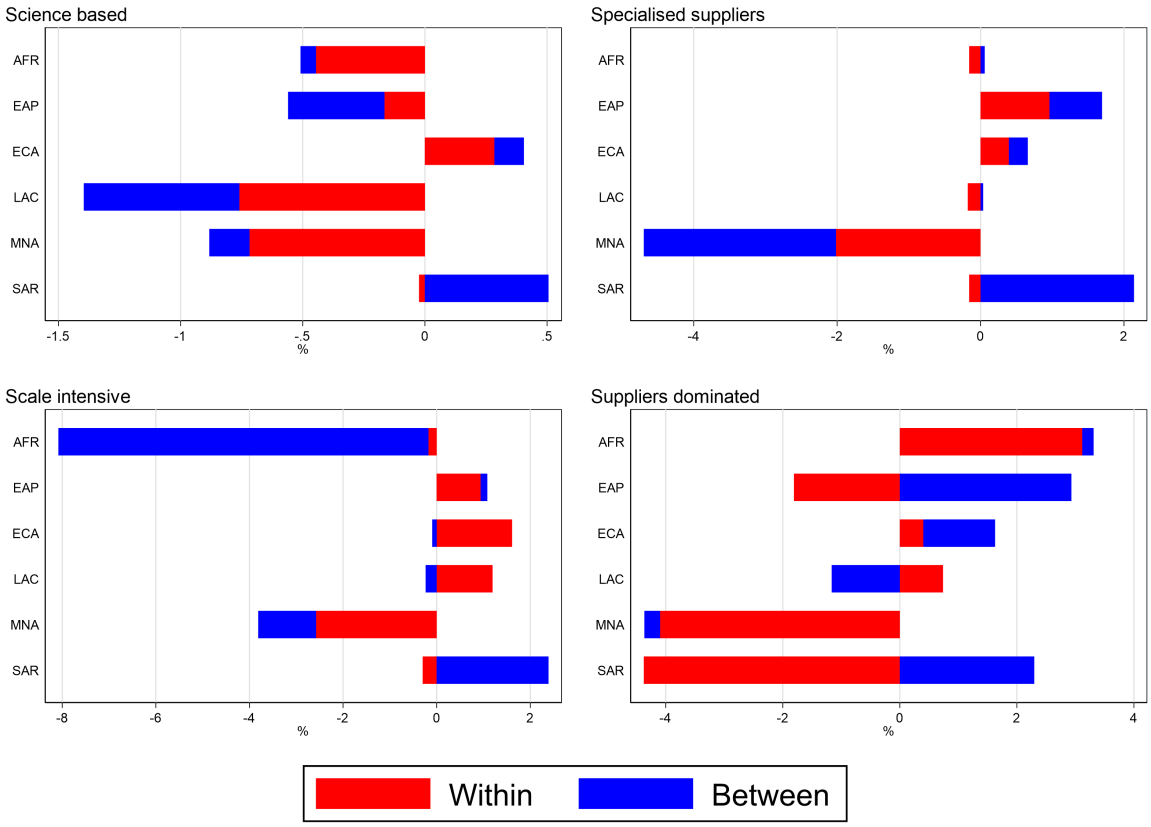
Figure 2: Decomposition of Labor Productivity Growth by Region and Firm Size Group



Source: Author's calculations using data from the World Bank Enterprise Surveys (ES). Countries are classified in 6 regions: Africa (AFR), East Asia and Pacific (EAP), Europe and Central Asia (ECA), Latin America and The Caribbean (LCR), Middle East and North Africa (MNA), South Asia (SAR). Weighted averages are calculated using country sizes in terms of total manufacturing employment as weights.

Figure 2 further analyzes the decomposition exercise by firm type. Generally, small and medium firms in the AFR, SAR, and ECA regions exhibit a positive between component and a positive, though low, within component. Large firms in AFR show the largest increase in labour productivity (within component), but a negative between component, indicating a reallocation of labour to less productive small and medium firms. In the LAC region, large firms demonstrate both labour productivity growth and increased labour absorption. In contrast, all types of firms in the MNA region display either low or negative within components, along with a negative between component.

Figure 3: Decomposition of Labor Productivity Growth by Region and Industrial Sector (Pavitt)



Source: Author's calculations using data from the World Bank Enterprise Surveys (ES). Countries are classified in 6 regions: Africa (AFR), East Asia and Pacific (EAP), Europe and Central Asia (ECA), Latin America and The Caribbean (LCR), Middle East and North Africa (MNA), South Asia (SAR). Weighted averages are calculated using country sizes in terms of total manufacturing employment as weights.

Figure 3 illustrates the decomposition exercise based on Pavitt's industrial taxonomy, as defined in Table A2 in the Appendix. In the AFR region, all sectors show negative within and between components, except for the Supplier Dominated sectors, which exhibit an increase in labour productivity across all firm types and a reallocation of labour toward the most productive firms. In the LAC region, labour productivity growth is observed within group of firms in the Scale-Intensive and Supplier Dominated sectors; however, there is a reallocation of labour toward less productive firms.

Finally, in the Science-Based sectors, only the ECA and SAR regions show positive labour productivity growth, mainly due to the reallocation of labour toward the most productive firms.

5 Trade, GVC, Patterns of Structural Change, and Labour Productivity Growth

The objective of this section is to provide a basic explanation of the patterns of structural change in the manufacturing sector as measured by the shift-share decomposition method seen in the previous section.

According to the literature, participation in trade and GVCs can increase labour productivity through the imports of capital inputs, technology, and knowledge. However, this could have a negative impact on manufacturing unskilled employment as the technologies available in the market are mainly capital-intensive. These results are found by Diao et al. (2021) for the case of the African countries of Tanzania and Ethiopia, where the rise of capital shares has increased productivity in large firms but without any employment generation.

To test these outcomes for the whole sample of countries analysed in this paper, I follow the model proposed by Farole (2016) to estimate the impact of a domestic firm's output export share and imported inputs share (as proxies for GVC participation) on labour productivity and employment levels. The following model is estimated with the panel data of firms from the World Bank Enterprise Survey:

$$\begin{aligned} \ln Y_{i,s,c,t} = \alpha + \beta_1 \ln \mathrm{EXP}_{i,s,c,t} + \beta_2 \ln \mathrm{IMP}_{i,s,c,t} + \mathbf{Z}'_{i,s,c,t}\gamma_1 + \mathbf{X}'_{s,c,t}\gamma_2 + \mathbf{W}'_{c,t}\gamma_3 \\ + \delta_i + \delta_t + \varepsilon_{i,s,c,t} \end{aligned} \tag{3}$$

Where $lnY_{i,s,c,t}$ is the logarithm of labour productivity or employment share of firm i, in sector s (4-digit ISIC Rev. 3.1), country c, and time t. As presented in previous sections, the labour productivity of each firm is defined as the ratio of total sales in 2009 US dollars (in ten thousand) over total employment, and employment share as the ratio of firm employment over total manufacturing employment in the country. The main explanatory variables are $lnEXP_{i,s,c,t}$ and $lnIMP_{i,s,c,t}$ that represent the two alternative measures proposed by Farole (2016) of GVC integration. $lnEXP_{i,s,c,t}$ is the logarithm of a firm's total export share in output (proxy of the *forward linkages* in GVCs as an exporter on the selling side), and $lnIMP_{i,s,c,t}$ is the logarithm of a firm's share of imported inputs in total inputs (proxy of the *backward linkages* in GVCs as an importer of intermediate inputs on the buying side).

The vector $\mathbf{Z}'_{i,s,c,t}$ represent the time-varying control variables at the firm level. For example, the logarithm of the share of the total annual cost of labour relative to productivity (*Labour cost*). The logarithm of firm's labour productivity relative to the maximum labour productivity in the sector and country, where a higher number indicates a lower productivity gap of the firm (*Gap*), following Bas and Ledezma (2010). The firm age and its square term (Age, Age^2), following Bas and Berthou (2012). The dummy *Foreign*, if the firm is owned by private foreign individuals. And, the dummy *Public*, if the firm is owned by the Government.

The vector $\mathbf{X}'_{s,c,t}$ represents the time-varying control variables at the sector level (4-digit ISIC Rev. 3.1). For example, the logarithm of sectoral exports as a share of

total exports (*Exp-Demand*), and the logarithm of sectoral imports as a share of total imports (*Imp-Competition*). Since a revenue-based labour productivity measure (sales over employment) is used, the analysis can capture variations in prices (markups) and not in physical quantity (or efficiency), then it is not possible to discern the exact channel that increases productivity. Following Amiti and Konings (2007), a *Herfindhal Index* is included to control for the mark-ups and is defined as the sum of the squared market shares in each 4-digit sector. The vector $\mathbf{W}'_{c,t}$ represents the time-varying control variables at the country level, such as the logarithm of GDP per capita (*GDPpc*) at constant 2015 US Dollars. Finally, δ_i and δ_t represent the firm and time-fixed effects. In some specifications, I include δ_s sector fixed effects (2-digit ISIC Rev. 3.1) and δ_c country fixed effects.

Table 2: Determinants of Firm Labor Productivity by Size

VARIABLES	(1) All Firms	(2) All Firms	(3) All Firms	(4) Small Firms	(5) Medium Firms	(6) Large Firms
Exp-output(i)(Ln)	0.051**	0.057***	0.060***	0.049***	0.036***	0.027***
	(0.023)	(0.017)	(0.002)	(0.005)	(0.004)	(0.004)
Imp-inputs(i)(Ln)	0.082***	0.039***	0.032***	0.021***	0.018***	0.030***
	(0.016)	(0.012)	(0.002)	(0.003)	(0.003)	(0.005)
Labor-cost(i)(Ln)		-0.197***	-0.103***	-0.293***	-0.262***	-0.190***
		(0.022)	(0.003)	(0.007)	(0.008)	(0.008)
Gap(i)(Ln)		0.510***	0.622***	0.534***	0.564***	0.615***
		(0.018)	(0.003)	(0.006)	(0.006)	(0.008)
Herfindhal(s)		-0.562***	-0.406***	-0.281***	-0.450***	-0.421***
		(0.136)	(0.031)	(0.046)	(0.048)	(0.062)
Foreign(i)			0.226***	0.202***	0.181***	0.158***
			(0.013)	(0.032)	(0.020)	(0.017)
Public(i)			0.035	-0.471***	-0.032	0.009
			(0.036)	(0.127)	(0.071)	(0.042)
Age(i)(Ln)			-0.301**	-1.100***	-1.166***	0.159
			(0.146)	(0.223)	(0.242)	(0.322)
Age^2(i)(Ln)			0.167**	0.506***	0.558***	-0.044
			(0.068)	(0.102)	(0.113)	(0.152)
GDPpc(c)(Ln)			0.127*	0.356***	0.215*	0.126
			(0.072)	(0.110)	(0.114)	(0.148)
Exp-Demand(s)(Ln)			0.044***	0.042*	0.021	0.082***
			(0.014)	(0.024)	(0.016)	(0.027)
Imp-Competition(s)(Ln)			0.013	0.000	0.020	0.028
			(0.031)	(0.044)	(0.043)	(0.055)
Constant	9.771***	11.599***	11.607***	9.593***	14.715***	11.991***
	(0.115)	(0.105)	(0.566)	(0.861)	(0.886)	(1.302)
Observations	52,477	48,389	45,651	18,038	16,870	10,743
R-squared	0.915	0.961	0.758	0.780	0.763	0.782
Firm FE	Y	Y	N	N	N	N
Year FE	Y	Y	Y	Y	Y	Y
Sector(2-digit) FE	N	N	Y	Y	Y	Y
Country FE	N	N	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001. The regression results take into account the sampling weights from the survey.

Table 2 presents the estimation results of equation (3) for the labour productivity for the whole sample and differentiated by firm size. On one hand, the import of inputs has a

higher effect on the labour productivity of large firms than of small and medium ones. On average, a 1% increase in the share of imported input increases the labour productivity of large firms by 0.030%. This trend is reverted for the case of the total export share in output, which has a higher effect on the labour productivity of small firms. On average, a 1% increase in the share of exported output increases the labour productivity of small firms by 0.049%, which is 0.022 percentage points higher than the increase of labour productivity in large firms. On the other hand, Table 3 shows that both the share of exported output and the share of imported input have a higher effect on the employment share of large firms. On average, a 1% increase in the share of exported output or in the share of imported input increases the employment share of large firms by 0.012% and 0.006% respectively.

Table 3: Determinants of Firm Employment Share by Size

VARIABLES	(1) All Firms	(2) All Firms	(3) All Firms	(4) Small Firms	(5) Medium Firms	(6) Large Firms
Exp-output(i)(Ln)	0.024***	0.015***	0.016***	0.001***	0.004***	0.012***
	(0.006)	(0.005)	(0.001)	(0.000)	(0.001)	(0.002)
Imp-inputs(i)(Ln)	0.013***	0.009***	0.004***	0.000**	0.002***	0.006***
	(0.003)	(0.003)	(0.001)	(0.000)	(0.000)	(0.002)
Labor-cost(i)(Ln)		0.078***	0.103***	0.010***	0.030***	0.137***
		(0.007)	(0.001)	(0.000)	(0.001)	(0.003)
Gap(i)(Ln)		0.027***	0.036***	0.004***	0.013***	0.040***
		(0.005)	(0.001)	(0.000)	(0.001)	(0.002)
Herfindhal(s)(Ln)		0.157***	0.071***	0.010***	0.038***	0.185***
		(0.040)	(0.010)	(0.002)	(0.007)	(0.025)
Foreign(i)			0.087***	0.006***	0.012***	0.061***
			(0.005)	(0.002)	(0.003)	(0.008)
Public(i)			0.090***	0.008	0.017	0.038**
			(0.016)	(0.006)	(0.011)	(0.019)
Age(i)(Ln)			0.437***	-0.039***	0.005	0.368***
			(0.050)	(0.012)	(0.035)	(0.137)
Age^2(i)(Ln)			-0.191***	0.019***	0.002	-0.161**
			(0.023)	(0.005)	(0.016)	(0.064)
GDPpc(c)(Ln)			-0.296***	-0.138***	-0.441***	-0.754***
			(0.026)	(0.007)	(0.021)	(0.071)
Exp-Demand(s)(Ln)			0.001	0.001	0.003	0.014
			(0.004)	(0.002)	(0.004)	(0.012)
Imp-Competition(s)(Ln)			-0.003	-0.007*	-0.007	-0.011
			(0.009)	(0.004)	(0.011)	(0.030)
Constant	0.187***	0.116***	2.639***	1.269***	4.345***	7.332***
	(0.028)	(0.031)	(0.211)	(0.058)	(0.171)	(0.532)
Observations	52,477	48,389	45,651	18,038	16,870	10,743
R-squared	0.937	0.949	0.562	0.774	0.774	0.713
Firm FE	Y	Y	N	N	N	N
Year FE	Y	Y	Y	Y	Y	Y
Sector(2-digit) FE	N	N	Y	Y	Y	Y
Country FE	N	N	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001. The regression results take into account the sampling weights from the survey.

These results hold when firms are categorized as non-exporters, non-foreign-owned, and non-licensed, as shown in Tables A3 and A4 of the Appendix. Following Amiti and

Konings (2007), foreign-owned firms are excluded because they may have higher shares of imported inputs. Similarly, exporter firms and firms with technology licenses are excluded to avoid any spurious correlation between these firms and the productivity measures. The robustness of the results indicates that the proxy for forward linkages in global value chains (GVCs) has a more significant impact on labour productivity growth for small firms, whereas the proxy for backward linkages in GVCs has a greater effect on the labour productivity growth of large firms. Furthermore, both proxies for forward and backward linkages in GVCs contribute more substantially to employment growth in large firms.

Table 4 shows the mediating factors or mechanisms driving the above-mentioned results. Following Farole (2016), the mechanisms through which the exports of output and imports of inputs operate are the share of skilled workers at the firm level (defined as the share of non-production workers relative to total employment in logarithms), the innovative status of the firm (dummy variable equal to 1 if the firm introduced new or improved products and processes), and firm's capital stock (that is the share of capital relative to labour, in logarithms).

Table 4: Mechanisms of Firm Labor Productivity and Employment Share by Size

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	**Prod-SmallF.**	**Prod-MediumF.**	**Prod-LargeF.**	**Empl-SmallF.**	**Empl-MediumF.**	**Empl-LargeF.**
Exp-output(i)(Ln)	0.041***	0.037***	0.026***	0.001***	0.004***	0.013***
	(0.005)	(0.004)	(0.005)	(0.000)	(0.001)	(0.002)
Imp-inputs(i)(Ln)	0.017***	0.007**	0.020***	0.000**	0.002***	0.009***
	(0.003)	(0.003)	(0.005)	(0.000)	(0.001)	(0.002)
Skills(i)(Ln)	0.039***	0.064***	0.050***	0.003***	-0.003**	-0.027***
	(0.006)	(0.009)	(0.011)	(0.000)	(0.001)	(0.005)
Innovation(i)	0.041***	0.035**	0.061***	0.001	0.001	0.000
	(0.014)	(0.014)	(0.018)	(0.001)	(0.001)	(0.008)
Cap-stock(i)(Ln)	0.114***	0.110***	0.109***	0.000	0.001	0.001
	(0.004)	(0.004)	(0.005)	(0.000)	(0.001)	(0.002)
Constant	8.256***	12.920***	11.777***	1.199***	4.060***	7.378***
	(0.954)	(1.028)	(1.286)	(0.062)	(0.206)	(0.655)
Observations	14,398	12,906	8,011	14,398	12,906	8,011
R-squared	0.802	0.790	0.810	0.765	0.764	0.716
Controls	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001. The regression results take into account the sampling weights from the survey.

The estimation results for exports of output and imports of inputs remain robust even with the inclusion of the mediation factors. With this respect, the share of skilled workers has a higher effect on labour productivity growth in medium and large firms. However, a 1% increase in the share of skilled labour decreases by 0.027% and 0.003% in the employment share in large and medium firms respectively, but there is an increase of 0.003% in the employment share of small firms. This means that the excess labour from large and medium firms is absorbed by small firms, which decreases their productivity. On the other hand, the innovation status and capital stock of firms do not impact employment share, but only labour productivity. In this case, innovation status affects more the labour productivity growth of large firms, and the effect of capital stock is

similar across firm sizes.

Finally, following Berthou et al.(2020), institutional measures are incorporated by interacting them with the main explanatory variables. Two dummy variables are included: labour regulations and financial regulations. Each dummy is assigned a value of 1 if the firm perceives the respective regulation as an obstacle to its current operations. The results are presented in the Appendix. Table A5 shows that stricter labour regulations weaken the positive effect of imported inputs on employment share in smaller firms. Table A6 indicates that stronger financial regulations reduce the positive effect of imported inputs on job creation in large firms and diminish the positive impact of exported output on labour productivity across all firm types.

6 Conclusions

Understanding the drivers of labour productivity growth of the manufacturing sector is a first-order topic for developing countries, as the process of industrialization gives rise to several opportunities for economic growth and poverty reduction. Hence, the objective of the present paper is to study if developing countries have experienced growth-enhancing or growth-reducing structural change in the manufacturing sector, by the allocation of employment from small and low-productivity firms to larger and highly productive ones.

From a shift-share decomposition method, the results suggest that the bulk of labour productivity growth of the manufacturing sector across regions is explained by the between component or structural change, that is the allocation of employment across groups of firms according to their size (small, medium, or large firms). Results indicate that small and medium firms in AFR, SAR, and ECA exhibit positive between and low within components, while large firms in AFR have the highest productivity growth but shed labour to smaller firms. In LAC, large firms show both productivity growth and labour absorption. MNA firms display low or negative results in both components. By industrial taxonomy, in AFR, most sectors have negative results except for Supplier Dominated sectors, which show increased productivity and labour reallocation toward more productive firms. In LAC, productivity grows in Scale-Intensive and Supplier Dominated sectors, but labour shifts to less productive firms. Finally, in the Science-Based sectors, only the ECA and SAR regions show positive labour productivity growth, mainly due to the reallocation of labour toward the most productive firms.

The analysis is extended by means of a simple econometric model to establish the effect of the use of foreign technologies embedded in imported inputs (backward GCV participation) and the export of output (forward GVC participation) on labour productivity and employment share across firm size. In general, the use of capital-intensive technologies increases labour productivity growth for the entire sample. Imports of inputs enhance labour productivity in large firms, with a 1% increase leading to a 0.030% rise. In contrast, small firms gain more from exports, as a 1% increase in exported output boosts their productivity by 0.049%. Both exported output and imported input also positively impact employment share in large firms. The results indicate a need for trade and industrial policies that support import- and export-led initiatives (Vivarelli, 2014). Reducing input tariffs to facilitate access to foreign capital goods is essential (Bas & Berthou, 2012, among others), alongside public policies that promote "learning by

exporting," especially for small firms to enhance productivity through learning, variety, quality, and market-size effects (Amiti & Konings, 2007; Shu & Steinwender, 2019). These policies should be complemented by stronger efforts to improve human capital and expand skills and training to counter the labour-saving effects of innovation, particularly in small firms, which are the primary job creators in most developing countries included in the analysis.

These trends persist across various firm categories, highlighting that forward linkages in GVCs primarily benefit small firms, while backward linkages favour large firms. Further analysis identifies skilled workers, innovation status, and capital stock as key mechanisms. Skilled workers improve productivity in medium and large firms but decrease their employment share, with small firms absorbing this surplus labour. Innovation and capital stock enhance productivity, especially in large firms, but do not affect employment share. Finally, stronger labour and financial regulations dampen the positive effects of imported inputs in both labour productivity and employment shares.

This analysis could be enhanced in future studies by addressing the risk of endogeneity present in this paper. Specifically, there may be bias due to reverse causality between firm productivity, employment, and trade. As noted by Amiti and Konings (2007), firms in low-productivity firms and industries may lobby for protection, or governments may choose to protect "winners" against foreign competition or promote the use of foreign inputs. Additionally, this paper uses sales per employee as a measure of labour productivity, as the TFPR measure in the WBES dataset is a residual from a production function and could introduce estimation bias. However, future studies could utilize TFPR and TFPQ measures as robustness checks for the results presented here. Furthermore, alternative decomposition techniques for labour productivity growth, such as the method proposed by Brown et al. (2018), could also be employed as a robustness check.

7 References

Aga, G., Francis, D., & Rodriguez, J. 2015. SMEs, age, and jobs: a review of the literature, metrics, and evidence. *Policy Research Working Paper Series*, 7493, The World Bank.

Amiti, M., & Konings, J. (2007). Trade liberalization, intermediate inputs, and productivity: evidence from Indonesia. *American Economic Review*, 97(5), 1611 - 1638.

Atwine, B., & Mike, I., & Bosco, J. (2023). What drives the dynamics of employment growth in firms? Evidence from East Africa. *Journal of Innovation and Entrepreneurship*, 12(1), 1 - 25.

Ayyagari, M., Demirguc-Kunt, A. & Maksimovic, V. (2014). Who creates jobs in developing countries? *Small Business Economics*, 43(1), 75 - 99.

Bartelsman, E., Haltiwanger, J., & Scarpetta, S. (2013). Cross country differences in productivity: The role of allocative and selection. *American Economic Review*, 103(1), 305 – 334.

Bas, M., & Berthou, A. (2012). The decision to import capital goods in India: firms' financial factors matter. *The World Bank Economic Review*, 26(3), 486 - 513.

Bas, M., & Ledezma, I. (2010). Trade integration and within-plant productivity evolution in Chile. *Review of World Economics*, 146(1), 113 - 146.

Bas, M., & Paunov, C. (2019). What gains and distributional implications result from trade liberalization? *MERIT Working Papers 2019-003*, United Nations University - Maastricht Economic and Social Research Institute on Innovation and Technology (MERIT).

Bas, M., & Paunov, C. (2021). Input quality and skills are complementary and increase output quality: Causal evidence from Ecuador's trade liberalization. *Journal of Development Economics*, 151(C).

Bogliacino, F., & Pianta, M. (2010). Innovation and employment: A reinvestigation using revised Pavitt classes. *Research Policy*, 39, 799 – 809.

Bombarda, P., & Bas, M. (2023). Foreign technology and informal employment: Evidence from Mexico. *THEMA Working Papers 2023-02*, THEMA (THéorie Economique, Modélisation et Applications), Université de Cergy-Pontoise.

Brown D., Crespi, G., Iacovone, L., & Marcolin, L. (2018). Decomposing firm-level productivity growth and assessing its determinants: evidence from the Americas. *The Journal of Technology Transfer*, 43(6), 1571 – 1606.

de Vries, G.J., Timmer, M.P., & de Vries, K. (2015). Structural Transformation in Africa: Static Gains, Dynamic Losses. *The Journal of Development Studies*, 51 (6), 674–88.

Diao, X., Kweka, J., & McMillan, M. (2018). Small firms, structural change and labor productivity growth in Africa: evidence from Tanzania. *World Development*, 105, 400 – 415.

Diao, X., Ellis, M., McMillan, M., & Rodrik, D. (2021). Africa's Manufacturing Puzzle: Evidence from Tanzanian and Ethiopian Firms. *NBER Working Papers 28344*, National Bureau of Economic Research, Inc.

Dosi, G., Piva, M., Virgillito, M., & Vivarelli, M. (2021). Embodied and disembodied technological change: The sectoral patterns of job-creation and job-destruction. *Research Policy*, 50(4), 1 - 13.

Eslava, M., Haltiwanger, J., Kugler, A., & Kugler, M. (2013). Trade and market selection: evidence from manufacturing plants in Colombia. *Review of Economic Dynamics*, 16(1), 135–158.

Farole, T. (2016). Factory Southern Africa? SACU in global value chains. *Sum-*

mary report (No. 102850, pp. 1-110). The World Bank.

Fernandes, A., & Paunov, C. (2013). Does trade stimulate product quality upgrading? *Canadian Journal of Economics*, 46(4), 1232 - 1264.

Iacovone, L. (2012). The better you are the stronger it makes you: evidence on the asymmetric impact of liberalization. *Journal of Development Economics*, 99(2), 474 - 485.

Hsieh, C.T., & Klenow, P. J. (2009). Misallocation and manufacturing TFP in China and India. *Quarterly Journal of Economics*, 124(4),1403–1448.

Lawless, M. (2014). Age or size? Contributions to job creation. *Small Business Economics*, 42(4), 815 - 830.

McCaig, B., & Pavcnik, N. (2018). Export markets and labour allocation in a low-income country. *American Economic Review*, 108(7), 1899 - 1941.

McMillan, M., & Rodrik, D. (2011). Globalization, Structural Change, and Productivity Growth. In M. Bachetta and M. Jansen, eds. *Making Globalization Socially Sustainable*. Geneva: International Labour Organization and World Trade Organization.

McMillan, M., Rodrik, D., & Verduzco-Gallo, I. (2014). Globalization, structural change, and productivity growth with an update on Africa. *World Development*, 63, 11 – 32.

McMillan, M., & Zeufack, A. (2022). Labour productivity growth and industrialization in Africa. *Journal of Economic Perspectives*, 36(1), 3 – 32.

Pahl, S., & Timmer, M. (2020). Do global value chains enhance economic upgrading? A long view. *The Journal of Development Studies*, 56(9), 1683 – 1705.

Pavcnik, N. (2002). Trade liberalization, exit, and productivity improvements: evidence from Chilean plants. *Review of Economic Studies*, 69(1), 245 - 276.

Rodrik, D. (2018). New technologies, global value chains, and developing economies. *National Bureau of Economic Research. Working Paper No. 25164.* Cambridge, MA: National Bureau of Economic Research.

Shu, P., & Steinwender, C. (2019). the impact of trade liberalization on firm productivity and innovation. *Innovation Policy and the Economy*, 19(1), 39 - 68.

Szirmai, A., & Verspagen, B. (2015). Manufacturing and economic growth in developing countries, 1950–2005. *Structural Change and Economic Dynamics*, 34(C), 46–59.

Vivarelli, M. (2014). Structural change and innovation as exit strategies from the middle-income trap. *IZA Discussion Papers*, 8148, Institute of Labor Economics (IZA).

Appendix A

Additional Results

Table A1: Shift-share decomposition results by country and firm size.

			Total Manufacturing			Small Firms		Medium Firms		Large Firms	
Country	Code	Time Period	Labour produc. growth	Within	Between	Within	Between	Within	Between	Within	Between
REGION : AFRICA (AFR)											
Burundi	BDI	2006-2014	-0.0134	-0.0024	-0.0110	-0.0216	-0.0120	0.0796	0.0051	-0.0603	-0.0041
Botswana	BWA	2006-2010	0.1421	0.1183	0.0238	-0.0228	0.0218	0.0289	0.0026	0.1122	-0.0006
Congo. Dem. Rep.	COD	2006-2013	-0.5792	0.9731	-1.5523	0.0798	0.1589	0.0556	0.0191	0.8377	-1.7303
Ethiopia	ETH	2011-2015	0.0105	0.0346	-0.0241	-0.0133	-0.0239	0.0330	-0.0013	0.0150	0.0011
Ghana	GHA	2007-2013	0.1717	0.1668	0.0049	0.0443	0.0036	0.0286	0.0026	0.0938	-0.0013
Gambia. The	GMB	2006-2018	-0.0025	-0.0048	0.0024	0.0134	0.0047	-0.0182	-0.0023		
Kenya	KEN	2007-2018	0.0330	-0.0078	0.0408	-0.0022	0.0218	-0.0017	0.0335	-0.0038	-0.0145
Madagascar	MDG	2009-2013	-0.2158	-0.2178	0.0020	-0.0091	0.0047	-0.0103	-0.0023	-0.1983	-0.0004
Namibia	NAM	2006-2014	-0.1293	-0.1475	0.0182	-0.0060	0.0200	-0.0543	0.0020	-0.0872	-0.0038
Nigeria	NGA	2007-2014	-0.1309	-0.1375	0.0066	0.0298	0.0130	-0.1149	-0.0063	-0.0524	-0.0001
Rwanda	RWA	2006-2019	-0.0394	-0.0796	0.0402	0.0079	0.0414	-0.0072	0.0041	-0.0804	-0.0053
Senegal	SEN	2007-2014	-0.0155	0.0319	-0.0474	-0.0228	-0.0446	-0.0039	-0.0138	0.0586	0.0110
Eswatini	SWZ	2006-2016	-0.0763	-0.1018	0.0255	-0.0017	0.0126	-0.0047	0.0160	-0.0954	-0.0031
Tanzania	TZA	2006-2013	-0.2121	-0.2083	-0.0038	-0.0223	0.0091	-0.0770	-0.0148	-0.1091	0.0018
Uganda	UGA	2006-2013	-0.1201	-0.1299	0.0098	-0.0160	0.0112	-0.0649	0.0003	-0.0490	-0.0017
South Africa	ZAF	2007-2020	-0.2040	-0.1549	-0.0491	-0.0050	-0.0010	-0.0459	-0.0636	-0.1040	0.0156
Zambia	ZMB	2007-2019	-0.0852	-0.1070	0.0218	-0.0196	0.0177	-0.0182	0.0120	-0.0691	-0.0080
			Total Manufacturing			Small Firms		Medium Firms		Large Firms	
Country	Code	Time Period	Labour produc. growth	Within	Between	Within	Between	Within	Between	Within	Between

Table A1 continued from previous page

			Total Manufacturing			Small Firms		Medium Firms		Large Firms	
REGION: EAST ASIA AND PACIFIC (EAP)											
Indonesia	IDN	2009-2015	-0.0390	-0.0083	-0.0307	-0.0528	-0.0367	0.0354	0.0032	0.0091	0.0028
Lao PDR	LAO	2009-2018	0.0192	-0.0004	0.0196	-0.0230	0.0168	-0.0032	0.0038	0.0258	-0.0009
Myanmar	MMR	2014-2016	-0.5816	-0.5460	-0.0355	-0.0281	0.0671	-0.1201	-0.1081	-0.3979	0.0055
Mongolia	MNG	2009-2019	-0.0256	-0.0267	0.0012	0.0135	0.0081	-0.0237	-0.0049	-0.0166	-0.0021
Philippines	PHL	2009-2015	0.1400	0.1043	0.0356	0.0078	0.0358	0.0513	0.0032	0.0453	-0.0034
Timor-Leste	TLS	2009-2021	-0.2902	-0.2674	-0.0228	-0.1760	-0.0252	-0.0980	0.0022	0.0066	0.0001
Vietnam	VNM	2009-2015	-0.0707	-0.1194	0.0487	0.0032	0.0589	-0.0068	-0.0080	-0.1158	-0.0022

			Total Manufacturing			Small Firms		Medium Firms		Large Firms	
Country	Code	Time Period	Labour produc. growth	Within	Between	Within	Between	Within	Between	Within	Between
REGION: EUROPE AND CENTRAL ASIA (ECA)											
Albania	ALB	2007-2013	-0.0795	-0.0445	-0.0350	-0.0073	-0.0191	-0.0336	-0.0168	-0.0036	0.0009
Armenia	ARM	2009-2020	-0.0842	-0.0899	0.0058	0.0024	0.0038	-0.0130	0.0054	-0.0793	-0.0035
Azerbaijan	AZE	2009-2019	-0.1708	-0.1638	-0.0070	-0.0071	-0.0010	-0.0703	0.0009	-0.0863	-0.0069
Bulgaria	BGR	2007-2019	0.0466	0.0571	-0.0105	-0.0004	-0.0176	0.0117	0.0033	0.0458	0.0038
Bosnia and Herzegovina	BIH	2009-2019	0.0042	0.0431	-0.0389	0.0011	0.0012	-0.0134	-0.0431	0.0553	0.0030
Belarus	BLR	2008-2018	0.0190	-0.0001	0.0192	0.0024	0.0105	0.0064	0.0105	-0.0090	-0.0019
Czechia	CZE	2009-2019	0.0045	0.0855	-0.0810	0.0043	0.0441	0.0457	-0.1249	0.0355	-0.0003
Estonia	EST	2009-2019	0.0314	0.0182	0.0132	-0.0104	0.0157	0.0121	-0.0031	0.0166	0.0006
Georgia	GEO	2008-2019	0.1113	0.1184	-0.0070	0.0082	-0.0062	0.0640	-0.0018	0.0462	0.0010
Croatia	HRV	2007-2019	-0.0160	-0.0212	0.0052	-0.0021	0.0137	-0.0133	-0.0054	-0.0058	-0.0031
Hungary	HUN	2009-2019	-0.0114	-0.1756	0.1642	-0.0020	0.1587	-0.0297	0.0262	-0.1439	-0.0206
Kazakhstan	KAZ	2009-2019	-0.0641	-0.1285	0.0645	0.0117	0.0563	-0.0233	0.0203	-0.1169	-0.0121
Kyrgyz Republic	KGZ	2009-2019	0.0475	0.0394	0.0080	0.0037	0.0089	-0.0171	0.0012	0.0528	-0.0021

Table A1 continued from previous page

			Total Manufacturing			Small Firms		Medium Firms		Large Firms	
Lithuania	LTU	2009-2019	-0.0397	-0.0686	0.0289	0.0042	0.0205	-0.0452	0.0139	-0.0276	-0.0055
Latvia	LVA	2009-2019	0.0288	0.0425	-0.0137	0.0120	-0.0152	0.0165	0.0032	0.0140	-0.0016
Moldova	MDA	2009-2019	0.0413	0.0068	0.0345	0.0122	0.0315	0.0116	0.0052	-0.0170	-0.0022
North Macedonia	MKD	2009-2019	-0.0267	-0.0886	0.0619	-0.0067	0.0474	-0.0334	0.0215	-0.0485	-0.0069
Montenegro	MNE	2013-2019	-0.0349	-0.0454	0.0105	0.0356	0.0136	-0.0395	-0.0012	-0.0414	-0.0019
Romania	ROU	2009-2019	-0.0203	-0.0177	-0.0025	0.0050	0.0054	-0.0167	-0.0078	-0.0061	-0.0002
Serbia	SRB	2009-2019	-0.0420	-0.1131	0.0711	-0.0017	0.0639	-0.0121	0.0318	-0.0993	-0.0247
Slovenia	SVN	2009-2019	0.1429	-0.0705	0.2134	-0.0024	0.2112	-0.0140	0.0131	-0.0541	-0.0109
Tajikistan	TJK	2008-2019	-0.0136	-0.0372	0.0236	0.0014	0.0199	0.0228	0.0062	-0.0614	-0.0025
Turkiye	TUR	2008-2019	0.0368	-0.1112	0.1480	0.0043	0.0796	-0.0182	0.0772	-0.0973	-0.0088
Ukraine	UKR	2008-2019	0.0156	0.0020	0.0136	0.0032	0.0085	-0.0084	0.0065	0.0072	-0.0014
Uzbekistan	UZB	2008-2019	0.0466	0.0420	0.0047	0.0004	0.0047	0.0483	0.0004	-0.0068	-0.0004
Kosovo	XKX	2009-2019	0.2384	0.2363	0.0021	0.0911	0.0068	0.1618	-0.0027	-0.0332	-0.0039

			Total Manufacturing			Small Firms		Medium Firms		Large Firms	
Country	Code	Time Period	Labour produc. growth	Within	Between	Within	Between	Within	Between	Within	Between
REGION: LATIN AMERICA AND THE CARIBBEAN (LCR)											
Argentina	ARG	2006-2017	0.0698	-0.0700	0.1398	-0.0003	0.0724	-0.0086	0.1028	-0.0612	-0.0354
Bolivia	BOL	2006-2017	-0.0209	0.0210	-0.0419	0.0003	-0.0397	-0.0340	-0.0140	0.0546	0.0117
Chile	CHL	2006-2010	-0.0445	0.0833	-0.1278	-0.0044	-0.0652	-0.0127	-0.0856	0.1004	0.0230
Colombia	COL	2006-2017	0.1034	0.1342	-0.0308	0.0084	-0.0173	0.0936	-0.0179	0.0322	0.0044
Dominican Republic	DOM	2010-2016	-0.0119	-0.0109	-0.0010	-0.0159	-0.0095	-0.0203	0.0091	0.0252	-0.0006
Ecuador	ECU	2006-2017	-0.1176	-0.0476	-0.0699	-0.0108	-0.0644	-0.0167	-0.0109	-0.0202	0.0054
Guatemala	GTM	2006-2017	-0.0380	0.0165	-0.0545	-0.0345	-0.0525	-0.0018	-0.0032	0.0528	0.0011
Honduras	HND	2006-2016	0.3169	0.2349	0.0819	0.0858	0.0829	0.0346	0.0000	0.1145	-0.0009
Mexico	MEX	2006-2010	0.0662	0.0858	-0.0196	0.0184	0.0364	-0.0296	-0.0637	0.0970	0.0077

Table A1 continued from previous page

			Total Manufacturing			Small Firms		Medium Firms		Large Firms	
Nicaragua	NIC	2006-2016	-0.0567	-0.0470	-0.0097	-0.0174	-0.0117	0.0531	0.0025	-0.0826	-0.0006
Panama	PAN	2006-2010	0.2420	0.2430	-0.0010	-0.0183	0.0323	0.1401	-0.0396	0.1211	0.0063
Peru	PER	2006-2017	0.1034	0.0739	0.0295	0.0028	0.0291	0.0051	0.0029	0.0659	-0.0025
Paraguay	PRY	2006-2017	-0.0661	0.0080	-0.0741	0.0105	-0.0321	-0.0171	-0.0601	0.0146	0.0181
El Salvador	SLV	2006-2016	-0.3575	0.0576	-0.4151	-0.0140	-0.4136	0.0137	-0.0015	0.0579	0.0001
Suriname	SUR	2010-2018	-0.1631	-0.1427	-0.0204	-0.0582	-0.0288	-0.0894	0.0082	0.0048	0.0002
Uruguay	URY	2006-2017	-0.0425	0.0361	-0.0787	0.0126	-0.0634	0.0044	-0.0414	0.0191	0.0262

			Total Manufacturing			Small Firms		Medium Firms		Large Firms	
Country	Code	Time Period	Labour produc. growth	Within	Between	Within	Between	Within	Between	Within	Between
REGION: MIDDLE EAST AND NORTH AFRICA (MNA)											
Egypt. Arab Rep.	EGY	2013-2016	-0.1390	-0.1077	-0.0313	-0.0116	-0.0014	-0.0160	-0.0306	-0.0800	0.0007
Jordan	JOR	2013-2019	-0.0362	-0.1385	0.1023	-0.0059	0.0458	-0.0043	0.0768	-0.1283	-0.0203
Lebanon	LBN	2013-2019	0.0182	-0.0696	0.0877	0.0116	0.0763	0.0229	0.0449	-0.1041	-0.0334
Tunisia	TUN	2013-2020	-0.1739	-0.0978	-0.0762	-0.0083	-0.0707	-0.0158	-0.0084	-0.0736	0.0029
Yemen. Rep.	YEM	2010-2013	0.3724	0.3836	-0.0112	0.3261	-0.0145	0.0386	0.0016	0.0190	0.0017

			Total Manufacturing			Small Firms		Medium Firms		Large Firms	
Country	Code	Time Period	Labour produc. growth	Within	Between	Within	Between	Within	Between	Within	Between
REGION: SOUTH ASIA (SAR)											
Afghanistan	AFG	2008-2014	-0.1393	-0.1183	-0.0210	-0.0226	-0.0183	-0.0391	-0.0094	-0.0565	0.0066
Bangladesh	BGD	2007-2013	-0.0446	-0.0695	0.0249	0.0007	0.0140	0.0006	0.0123	-0.0709	-0.0014
Nepal	NPL	2009-2013	0.1517	0.1487	0.0030	0.0704	0.0009	0.0464	0.0051	0.0319	-0.0030

Table A1 continued from previous page

			Total Manufacturing			Small Firms		Medium Firms		Large Firms	
Pakistan	PAK	2007-2013	0.2736	-0.0077	0.2813	0.0027	0.0666	-0.0134	0.2199	0.0030	-0.0052

Notes: Figures are calculated as the weighted averages across countries using the re-scale probability weights provided by the Enterprise Surveys of each year. Small firms: 0 to 19 full- time employees. Medium firms: 20 to 99 full-time employees. Large firms: 100 or more full-time employees. Within and Between terms are calculated as the Compound Annual Growth Rate (CAGR) during the survey period by country.

Table A2: Pavitt Taxonomy for Manufacturing Industries (2-digit code ISIC Rev.3)

Pavitt Class	Industry	ISIC
Supplier Dominated	Food products and beverages	15
	Tobacco products	16
	Textiles	17
	Wearing apparel	18
	Leather products	19
	Wood products	20
	Fabricated metal products	28
	Furniture	36
	Recycling	37
Scale Intensive	Paper products	21
	Publishing, printing and reproduction of data	22
	Coke, refined petroleum and nuclear fuel	23
	Rubber and plastic products	25
	Other non-metallic mineral products	26
	Basic metals	27
	Motor vehicles	34
Specialised Suppliers	Machinery and equipment	29
	Electrical machinery and apparatus	31
	Other transport equipment	35
Science-Based	Chemicals and chemical products	24
	Office, accounting and computing machinery	30
	Radio, television and communication equipment	32
	Medical, precision and optical instruments	33

Source: Bogliacino & Pianta (2010)

Table A3: Determinants of Firm Labour Productivity by Size

VARIABLES	(1) All Firms	(2) Small Firms	(3) Medium Firms	(4) Large Firms
NON-EXPORTER FIRMS				
Imp-inputs(i)(Ln)	0.038***	0.027***	0.023***	0.042***
	(0.002)	(0.003)	(0.004)	(0.007)
Observations	30,331	15,300	11,089	3,942
R-squared	0.744	0.773	0.753	0.779
NON-FOREIGN FIRMS				
Exp-output(i)(Ln)	0.064***	0.050***	0.038***	0.031***
	(0.003)	(0.005)	(0.004)	(0.005)
Imp-inputs(i)(Ln)	0.032***	0.022***	0.018***	0.030***
	(0.002)	(0.003)	(0.003)	(0.005)
Observations	40,923	17,405	15,250	8,268
R-squared	0.755	0.782	0.760	0.780
NON-LICENSED FIRMS				
Exp-output(i)(Ln)	0.063***	0.050***	0.038***	0.028***
	(0.003)	(0.005)	(0.004)	(0.005)
Imp-inputs(i)(Ln)	0.031***	0.020***	0.016***	0.030***
	(0.002)	(0.003)	(0.003)	(0.005)
Observations	38,877	16,667	14,316	7,894
R-squared	0.757	0.780	0.764	0.784
Control Variables	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y
Country FE	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001. The regression results take into account the sampling weights from the survey.

Table A4: Determinants of Firm Employment Share by Size

VARIABLES	(1) All Firms	(2) Small Firms	(3) Medium Firms	(4) Large Firms
NON-EXPORTER FIRMS				
Imp-inputs(i)(Ln)	0.005***	0.000***	0.001**	0.010***
	(0.001)	(0.000)	(0.001)	(0.002)
Observations	30,331	15,300	11,089	3,942
R-squared	0.513	0.776	0.793	0.751
NON-FOREIGN FIRMS				
Exp-output(i)(Ln)	0.016***	0.001***	0.004***	0.012***
	(0.001)	(0.000)	(0.001)	(0.002)
Imp-inputs(i)(Ln)	0.005***	0.000**	0.001***	0.008***
	(0.001)	(0.000)	(0.000)	(0.002)
Observations	40,923	17,405	15,250	8,268
R-squared	0.541	0.773	0.775	0.718
NON-LICENSED FIRMS				
Exp-output(i)(Ln)	0.016***	0.001***	0.003***	0.013***
	(0.001)	(0.000)	(0.001)	(0.002)
Imp-inputs(i)(Ln)	0.004***	0.000**	0.002***	0.006***
	(0.001)	(0.000)	(0.000)	(0.002)
Observations	38,877	16,667	14,316	7,894
R-squared	0.548	0.776	0.776	0.714
Control Variables	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y
Country FE	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001. The regression results take into account the sampling weights from the survey.

Table A5: Labour Regulations

VARIABLES	(1) Prod-SmallF.	(2) Prod-MediumF.	(3) Prod-LargeF.	(4) Empl-SmallF.	(5) Empl-MediumF.	(6) Empl-LargeF.
(1)Exp-output(i)(Ln)	0.041***	0.035***	0.025***	0.001***	0.004***	0.013***
	(0.005)	(0.004)	(0.005)	(0.000)	(0.001)	(0.002)
(2)Imp-inputs(i)(Ln)	0.018***	0.009**	0.020***	0.001***	0.002***	0.010***
	(0.003)	(0.004)	(0.005)	(0.000)	(0.001)	(0.002)
(1) * Labor Reg(i)	0.001	0.025	0.010	0.001	0.002	-0.002
	(0.013)	(0.023)	(0.011)	(0.001)	(0.001)	(0.005)
(2) * Labor Reg(i)	-0.011	-0.013	-0.000	-0.001**	-0.000	-0.006
	(0.008)	(0.008)	(0.012)	(0.000)	(0.001)	(0.005)
Constant	8.234***	12.894***	11.785***	1.191***	4.042***	7.406***
	(0.955)	(1.027)	(1.285)	(0.062)	(0.206)	(0.656)
Observations	14,398	12,906	8,011	14,398	12,906	8,011
R-squared	0.802	0.790	0.810	0.766	0.765	0.716
Controls	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001. The regression results take into account the sampling weights from the survey.

Table A6: Financial Regulations

VARIABLES	(1) Prod-SmallF.	(2) Prod-MediumF.	(3) Prod-LargeF.	(4) Empl-SmallF.	(5) Empl-MediumF.	(6) Empl-LargeF.
(1)Exp-output(i)(Ln)	0.041***	0.036***	0.027***	0.000	0.004***	0.012***
	(0.006)	(0.004)	(0.005)	(0.000)	(0.001)	(0.002)
(2)Imp-inputs(i)(Ln)	0.017***	0.008**	0.018***	0.001***	0.002***	0.010***
	(0.004)	(0.004)	(0.005)	(0.000)	(0.001)	(0.002)
(1) * Finc. Reg(i)	0.001	0.008	-0.007	-0.001	-0.008	0.005
	(0.010)	(0.008)	(0.010)	(0.001)	(0.013)	(0.004)
(2) * Finc. Reg(i)	-0.070*	-0.068***	-0.036**	-0.000	0.001	-0.008**
	(0.040)	(0.023)	(0.017)	(0.000)	(0.001)	(0.004)
Constant	8.261***	13.037***	11.851***	1.194***	4.059***	7.422***
	(0.954)	(1.029)	(1.285)	(0.062)	(0.206)	(0.655)
Observations	14,398	12,906	8,011	14,398	12,906	8,011
R-squared	0.802	0.790	0.810	0.766	0.765	0.717
Controls	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y

Notes: Robust standard errors in parentheses *p<.05; **p<.01; ***p<.001. The regression results take into account the sampling weights from the survey.

General Conclusions

General Conclusions

This thesis emphasises innovation and technology upgrading as essential drivers of industrialization. Nevertheless, the relationship between innovation and industrialization in developing countries comes with complexities. Specifically, by constructing an innovation index for 53 developing countries from 1996 to 2018, the results from Chapter 1 show that in the context of deeper globalization and foreign competition, developing countries that used to have an ISI-based development model must surpass a certain national innovation index threshold to have a positive correlation between innovation and manufacturing value-added. If the national innovation index is lower than the threshold, developing countries present a process of premature deindustrialization in output. On the other hand, there is a labour-saving effect as innovation correlates negatively with overall manufacturing employment. Sectoral analysis shows that innovation fosters value-added and employment in Supplier-Dominated, Scale-Intensive, and Specialized Supplier sectors, where labour-saving effects are offset by market compensation mechanisms, for instance, a higher consumer demand. However, in Science-Based sectors, only high-innovation countries see value-added growth, and the correlation with employment remains negative, highlighting the need for human capital development and skill training.

These results are extended in the remaining two chapters by analysing the effect of innovation on manufacturing employment at the firm level. In Chapter 2, I study the impact of innovation activities (such as product and process innovations) on employment growth at the firm level in Colombian manufacturing firms from 2007 to 2018, using Harrison et al. (2014) structural model. It also explores how Chinese import competition affects employment growth, particularly among firms with varying levels of product innovation. The study identifies three main findings. First, growth in sales from new products significantly boosts firm employment across all manufacturing sectors, while process and organizational innovations do not show a substantial effect on employment growth. Second, product innovations primarily benefit employment growth among highly educated workers, with similar effects across both high-tech and low-tech sectors. Third, Chinese import competition at the sectoral level has a more substantial negative impact on highly innovative firms, particularly in low-tech sectors and among highly educated workers, suggesting that product innovation serves as a defensive strategy, albeit with limited success.

Finally, in Chapter 3 the results show that labour productivity growth in manufacturing is largely driven by structural reallocation of employment across firms of different sizes. In regions like AFR, SAR, and ECA, small and medium firms show moderate productivity gains, while large firms in AFR exhibit the highest productivity growth but lose workers to smaller firms. LAC's large firms display both productivity and labour absorption, whereas MNA firms show low or negative performance in both metrics. An econometric analysis further reveals that foreign technologies embedded in imported inputs (backward GVC participation) enhance productivity in large firms, while exports (forward GVC participation) boost productivity mainly in small firms. Exports and imports also increase employment share in large firms, with small firms benefiting more from forward linkages and large firms from backward linkages. Additionally, skilled labour and innovation positively impact productivity in medium and large firms but reduce their employment share, with surplus labour absorbed by smaller firms. Capital-intensive technologies boost productivity, especially in large firms, though they do not affect employment shares. Strict labour and financial regulations limit the productivity and employment benefits of imported inputs across all types of firms.

Concerning policy recommendations that follow the implications from the chapters, in general, it is recommended that developing countries should enhance innovation capacities through investments

in human capital, R&D, and technological infrastructure to sustain industrial growth, increase global competitiveness, and support economic development. Suggested policy instruments include public research funding, postgraduate scholarships, and tax incentives for R&D and to support highly innovative firms, helping them to sustain employment in the face of trade competition. The findings highlight the importance of trade and industrial policies that support import- and export-led growth, such as reducing tariffs on foreign capital goods and fostering "learning by exporting". These policies should be paired with efforts to strengthen human capital, skills, and training to mitigate the labour-saving effects of innovation, particularly in small firms, which are key job creators in many developing countries.

Kergroach (2019) considers a mix of innovation policies to accelerate industrial and technological upgrading and the country's participation in foreign markets. Among this mix of policies are the following: "(i) policies to attract FDI in S&T and to increase location attractiveness for international research centres; (ii) policies to encourage innovative entrepreneurship, in particular, ease access to capital and skills for start-ups; (iii) policies to reinforce linkages and potential spillovers between GVC participants and the local knowledge base, such as research and education institutions; (iv) policies to encourage internationalization of domestic innovation actors, including universities and small-and-medium-sized enterprises; (v) policies to encourage international mobility of talent; and (vi) policies to develop the right skills mix for innovation, by mobilizing education and training system capacity" (Kergroach, 2019, p. 260).

However, the literature highlights specific policy instruments and recommendations for developing countries, based on best practices from advanced economies and developing countries with comparative advantages in manufacturing. Braude et al. (2021) emphasize the need to raise awareness about the potential and applications of advanced technologies. They cite India as an example, where public research infrastructure demonstrates these technologies' practical applications, aligns them with firm needs, and fosters collaboration with higher education institutions to support training and skill development. With this respect, Schot and Steinmueller (2018) point to the need for a strong education in research careers and practical training of the workforce to support absorptive capacities. A robust connectivity agenda is also crucial to accelerate technological progress, particularly for small firms and those in rural areas. Additionally, policies should focus on improving small firms' access to financial resources, such as subsidized credit and demand-driven subsidies, to enable technology adoption and innovation. Moreover, governments should enhance support for start-ups and entrepreneurship to boost job creation and expand technological capabilities (Naudé, 2017). A robust set of innovation and industrial policies should be countercyclical to withstand challenges posed by abrupt external and internal financing cycles and sharp fluctuations in commodity prices and terms of trade. Such policies can support the accumulation of technological capabilities over time and ensure a strategy for diversifying production structures, and establishing enduring domestic and foreign production linkages (Ocampo, 2011).

This thesis highlights the need to pursue certain directions in a future research agenda. As outlined in each chapter, several conceptual, methodological, and empirical issues require attention to test the robustness of the results. For example, in Chapter 1 it is necessary to refine the national innovation index by adding more country data or using alternative methods to address potential endogeneity and reverse causality between innovation and industrialization measures. Chapter 2 recommends exploring the long-term dynamics between innovation and employment growth, examining firm survival in competitive markets, and expanding the analysis to other developing countries for comparative insights. And, Chapter 3 suggests future improvements by addressing endogeneity concerns (e.g., reverse causality between productivity and trade) and testing alternative measures of productivity, such as TFPR and TFPQ, as well as other decomposition techniques for labour productivity growth.

The relationship between innovation and industrialization is a broad area of research, given the rapid changes and advancements in global technology and innovation. Specifically, the rise of automation, the Fourth Industrial Revolution, the emergence of Artificial Intelligence (AI), and the adoption of green production technologies may complicate innovation-led industrialization and the shift toward service-oriented strategies in developing countries. Therefore, the findings of this thesis could be extended to examine the primary threats and opportunities that the latest technological advancements present for developing countries. Shu and Steinwender (2019) provide a literature review on this topic. For instance, the authors highlight the works of Ernst et al. (2018) and Acemoglu and Restrepo (2019)

who state that AI is shifting focus from automating physical tasks to mental ones, challenging the generation of new labour-intensive tasks in developed countries.

Naudé (2017) analyzes the major risks and potential opportunities for African manufacturing industries in light of technological advancement. Key findings include the significant likelihood that automation and advanced technologies will replace many low-skilled jobs, which make up a large share of African manufacturing. Furthermore, there is a risk that such advancements in developed countries could reduce their reliance on offshoring manufacturing to low-cost labour markets in developing countries. These developments could negatively impact the production processes and employment generation in developing countries, especially for low-skilled workers, exacerbating inequality and inequity issues (see, e.g., the analyses of Naude & Nagler, 2015; Saha & Ciarli, 2018). The results from the present thesis may be extended in the discussions on the impacts of recent technological advancements on industrialization in developing countries.

References

Acemoglu, D. & Restrepo, P. (2018). The race between man and machine: Implications of technology for growth, factor shares, and employment. *American Economic Review*, 108(6), 1488–1542.

Braude, H., Grosman, N., Patiño, A., & Rovira, S. (2021). Made in Latam: How smart manufacturing can give Latin America new hope for industrialization. *Documentos de Proyectos*, 47439, Naciones Unidas Comisión Económica para América Latina y el Caribe (CEPAL).

Ernst, E., Merola, R., & Samaan, D. (2018). The economics of artificial intelligence: Implications for the future of work. *ILO Future of Work Research Paper Series*, No. 5.

Harrison, R., Jaumandreu, J., Mairesse, J., & Peters, B. (2014). Does innovation stimulate employment? A firm-level analysis using comparable micro-data from four European countries. *International Journal of Industrial Organization*, 35, 29–43.

Kergroach, S. (2019). National innovation policies for technology upgrading through GVCs: A cross-country comparison. *Technological Forecasting and Social Change*, 145(C), 258 - 272.

Naudé, W., & Nagler, P. (2015). Industrialisation, innovation, inclusion. *MERIT Working Papers*, 2015-043, United Nations University - Maastricht Economic and Social Research Institute on Innovation and Technology (MERIT).

Naudé, W. (2017). Entrepreneurship, education and the Fourth Industrial Revolution in Africa. *IZA Discussion Papers*, 10855, Institute of Labor Economics (IZA).

Ocampo, J.A. (2011). Macroeconomy for development: countercyclical policies and production sector transformation. *Revista CEPAL*, Naciones Unidas Comisión Económica para América Latina y el Caribe (CEPAL).

Saha, A., & Ciarli, T. (2018). Innovation, structural change, and inclusion. A cross country PVAR analysis. *SPRU Working Paper Series*, 2018-01, SPRU - Science Policy Research Unit, University of Sussex Business School.

Schot, J., & Steinmueller, W. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. *Research Policy*, 47(9), 1554 - 1567.

Shu, P., & Steinwender, C. (2019). The impact of trade liberalization on firm productivity and innovation. *Innovation Policy and the Economy*, 19(1), 39 - 68.