CEPAL REVIEW

ECONOMIC COMMISSION FOR LATIN AMERICA AND THE CARIBBEAN

UNITED NATIONS

ECLAC

N° 147 DECEMBER • 2025

Editorial note
Miguel Torres 7

Articles

Drivers of innovation and competitiveness in small and medium-sized enterprises: a comprehensive analysis of the Latin American and Caribbean region
Lemuel Kenneth David, Jianling Wang, Adama Theresa Lazarus and Vanessa Angel 9

Kaldor meets Dosi: an approach to the technological structure of regional production
Sérgio Felipe Melo da Silva, Douglas Alcântara Alencar, Wallace Marcelino Pereira and Camila de Moura Vogt. 33

Wages and productivity in Argentine manufacturing: a structuralist and distributional firm-level analysis
María Celeste Gómez and Maria Enrica Virgillito 55

Technological change and employment following the coronavirus disease (COVID-19) pandemic in Mexico
María Belén Conde, Agustín Filippo, Carlos Guaipatin and Lucas Navarro . . . 93

Determinants of pioneering technological innovations in the Brazilian manufacturing industry
Juliana Brito de Oliveira, Elaine Aparecida Fernandes and Jandresson Dias Pires 115

The winemaking sector in the province of La Rioja (Argentina): challenges, opportunities and policy guidelines in a context of structural heterogeneity
Manuel Gonzalo, Gabriela Starobinsky and Marilyn D'Alessandro 133

The Superintendency for the Development of the North-East (SUDENE) and the training of a generation of development planners in Brazil's north-east
Darlan Praxedes Barboza 153

Interview

Assumptions, history and rent: a conversation with Jayati Ghosh
Esteban Pérez Caldentey and Miguel Torres. 171

Book review

Towards inclusive development in Latin America: Leveraging the Global Green Transition, by Eva Paus and Rafael Domínguez
José Eduardo Alatorre and Santiago Lorenzo. 187

ISSN 0251-2920

Thank you for your interest in this ECLAC publication

UNITED NATIONS

ECLAC

Please register if you would like to receive information on our editorial products and activities. When you register, you may specify your particular areas of interest and you will gain access to our products in other formats.

Register

Click on the link below for our social networks and other channels for accessing our publications:

https://bit.ly/m/CEPAL

CEPAL

REVIEW

ECONOMIC
COMMISSION FOR
LATIN AMERICA AND
THE CARIBBEAN

UNITED NATIONS

ECLAC

Nº 147 DECEMBER • 2025

CEPAL REVIEW

ECONOMIC COMMISSION FOR LATIN AMERICA AND THE CARIBBEAN

UNITED NATIONS

ECLAC

ISSN 0251-2920

The *CEPAL Review* was founded in 1976, along with the corresponding Spanish version, *Revista CEPAL*, and it is published three times a year by the Economic Commission for Latin America and the Caribbean (ECLAC), which has its headquarters in Santiago. The *Review* has full editorial independence and follows the usual academic procedures and criteria, including the review of articles by independent external referees. The purpose of the *Review* is to contribute to the discussion of socioeconomic development issues in the region by offering analytical and policy approaches and articles by economists and other social scientists working both within and outside the United Nations. The *Review* is distributed to universities, research institutes and other international organizations, as well as to individual subscribers.

To subscribe, please visit the web page: https://mailchi.mp/cepal/suscripciones-cepal.

The complete text of the *Review* can also be downloaded free of charge from the ECLAC website (www.cepal.org/en).

This publication, entitled CEPAL Review, is covered in the
Social Sciences Citation Index (SSCI), published by Thomson Reuters,
and in the Journal of Economic Literature (JEL),
published by the American Economic Association

United Nations publication
ISSN: 0251-2920 (print version)
ISSN: 1684-0348 (electronic version)
ISBN: 978-92-1-003494-4 (print version)
ISBN: 978-92-1-107219-8 (pdf)
LC/PUB.2025/21-P
Sales No.: E.25.II.G.10
Distribution: G

Printed at United Nations, Santiago
S.2500597[E]

This publication should be cited as: Economic Commission for Latin America and the Caribbean. (2026). *CEPAL Review* (147) (LC/PUB.2025/21-P).

Contents

Editorial note
Miguel Torres 7

Articles

Drivers of innovation and competitiveness in small and medium-sized enterprises: a comprehensive analysis of the Latin American and Caribbean region
Lemuel Kenneth David, Jianling Wang, Adama Theresa Lazarus and Vanessa Angel 9

Kaldor meets Dosi: an approach to the technological structure of regional production
Sérgio Felipe Melo da Silva, Douglas Alcântara Alencar, Wallace Marcelino Pereira and Camila de Moura Vogt 33

Wages and productivity in Argentine manufacturing: a structuralist and distributional firm-level analysis
María Celeste Gómez and Maria Enrica Virgillito 55

Technological change and employment following the coronavirus disease (COVID-19) pandemic in Mexico
María Belén Conde, Agustín Filippo, Carlos Guaipatin and Lucas Navarro 93

Determinants of pioneering technological innovations in the Brazilian manufacturing industry
Juliana Brito de Oliveira, Elaine Aparecida Fernandes and Jandresson Dias Pires . . . 115

The winemaking sector in the province of La Rioja (Argentina): challenges, opportunities and policy guidelines in a context of structural heterogeneity
Manuel Gonzalo, Gabriela Starobinsky and Marilyn D'Alessandro 133

The Superintendency for the Development of the North-East (SUDENE) and the training of a generation of development planners in Brazil's north-east
Darlan Praxedes Barboza 153

Interview

Assumptions, history and rent: a conversation with Jayati Ghosh
Esteban Pérez Caldentey and Miguel Torres 171

Book review

Towards inclusive development in Latin America: Leveraging the Global Green Transition, by Eva Paus and Rafael Domínguez
José Eduardo Alatorre and Santiago Lorenzo 187

Guidelines for contributors to the *CEPAL Review* 193

ECLAC recent publications 194

Explanatory notes

The following symbols have been used in the tables in this publication:

… Three dots indicate that data are not available or are not separately reported.

— A dash indicates that the amount is nil or negligible.

A blank space indicates that the concept under consideration is not applicable or not comparable.

– A minus sign indicates a deficit or decrease, unless otherwise indicated.

. A full stop is used to indicate decimals.

/ A slash between years (e.g. 2025/2026) indicates a 12-month period falling between the two years.

- The use of an en dash between years (e.g. 2025–2026) indicates reference to the complete number of calendar years involved, including the beginning and end years.

Reference to "tons" indicates metric tons and the world "dollars" refers to United States dollars, unless otherwise specified.

Individual figures and percentages in graphs and tables may not always add up to the corresponding total because of rounding.

Editorial note

Miguel Torres
Editor of *CEPAL Review*

With its 147th issue, of December 2025, the *CEPAL Review* editorial team marks the end of a year of economic, social and geopolitical challenges unfolding on a global scale, with immediate and complex implications for the region.

According to the *Preliminary Overview of the Economies of Latin America and the Caribbean, 2025*, a flagship macroeconomic report of the Economic and Social Commission for Latin America and the Caribbean (ECLAC), our region continues to face a trap of low capacity for growth, with projected rates of just 2.4% for 2025 and 2.3% for 2026. This performance reflects an uncertain international climate, characterized by trade tensions and financial volatility, and by critical internal constraints, namely low investment, stagnant productivity and high public debt that is severely constricting fiscal space. Although a continued decline in inflation is allowing room for more flexible monetary policy, the region urgently requires a profound productive transformation and improved policy coordination to overcome labour informality and strengthen resilience to external shocks.

With regard to social development, meanwhile, the 2025 edition of the *Social Panorama of Latin America and the Caribbean* indicates that the region continues to experience significantly higher levels of inequality than the countries of the Organisation for Economic Co-operation and Development, with a Gini index score of 0.452 (compared to 0.315 in 2024). The wealthiest 10% of the population accounts for one third of regional income, while the poorest decile accounts for just 2%. Income distribution did improve slightly between 2021 and 2024 (the Gini index fell at an annual rate of 1.3%), but the improvement was primarily the result of labour dynamics and demographic changes, rather than effective redistributive policies. ECLAC has identified six structural causes of this trap of high inequality, low social mobility and weak social cohesion: segmented and highly informal labour markets, regressive tax systems, weak social protection, segmented education systems, gender inequality and urban segregation. To overcome this trap, ECLAC proposes an inclusive social development pact that would coordinate comprehensive policies, expand universal social protection systems and strengthen institutional capacities, supported by a robust multidimensional measurement of inequality to guide effective public policy design.

The traps of low growth capacity and of high inequality, low social mobility and weak social cohesion analysed in the above-mentioned reports are closely linked to other structural factors that play a significant role in the structural development delays that the region has historically faced, namely: the low level of productive development, weaknesses in institutional capacities aligned with an agenda that reconciles economic growth and social inclusion, and rising pressures concerning the environment and the political economy of managing the region's variety of natural resources. These aspects of the production, social and political-institutional structures point to an extremely complex outlook for the region, considering the extent to which its countries are affected by the global outlook. The weakening of international multilateralism, a fragmented geopolitical landscape, trade tensions exacerbated by tariff hikes, global financial volatility and accelerated technological disruptions are creating a climate of heightened uncertainty that is further limiting Latin American economies' room for manoeuvre.

Against this backdrop —the regional and global state of affairs at the end of 2025 and its potential intensification due to additional challenges in 2026— this issue of *CEPAL Review* presents seven articles offering empirical data, analytical frameworks and policy discussions on critical development obstacles facing Latin America and the Caribbean. The analyses, conducted from a variety of angles, address the links between technological change, innovation and competitiveness, the transformation of production structures, including from a territorial perspective, and how these factors affect employment, wages and productivity. In this regard, several of the articles address the themes that constitute the enduring focus of our editorial line, relating to cross-cutting issues, such as the persistence of structural heterogeneity, endogenous capacity gaps in technology and production and the need to strengthen institutional arrangements, that affect the ability to combine sustained growth strategies with greater social inclusion.

Rounding out this 147th issue is an interview with Jayati Ghosh, noted economist and member of International Development Economics Associates, conducted virtually by Esteban Pérez Caldentey and Miguel Torres in late July 2025, and a critical review by our ECLAC colleagues, José Eduardo Alatorre and Santiago Lorenzo, of the book *Toward Inclusive Development in Latin America: Leveraging the Global Green Transition*, by Eva Paus and Rafael Domínguez, published by Palgrave MacMillan in 2025.

We encourage our readership to explore and disseminate this issue of the *CEPAL Review* and those to come in 2026 as we continue to analyse the latest development problems facing Latin America and the Caribbean with the usual analytical rigour that our authors bring to our publication. These upcoming issues of *CEPAL Review* will also have the important distinction of marking its fiftieth anniversary.

Drivers of innovation and competitiveness in small and medium-sized enterprises: a comprehensive analysis of the Latin American and Caribbean region

Lemuel Kenneth David, Jianling Wang, Adama Theresa Lazarus and Vanessa Angel[1]

Received: 02/07/2024
Accepted: 21/07/2025

Abstract

This study analyses the key drivers of innovation and competitiveness in small and medium-sized enterprises (SMEs) in Latin America and the Caribbean between 2006 and 2023. Using panel data regression (fixed and random effects) and machine learning models, the authors identify the most significant enablers of SME innovation. In addition, they find that political stability plays a positive role, while inflation and corruption significantly constrain performance. The study integrates classical innovation theory with emerging insights from Asian economies and highlights the role of political culture in shaping SME resilience.

Keywords

Small and medium enterprises, technological innovations, competitiveness, measurement, data analysis, econometric models, economic statistics, economic development, Latin America and the Caribbean

JEL classification

O31, O32, L25, O54, C23

Authors

Lemuel Kenneth David is a PhD candidate in the Department of Accounting and Finance of the School of Management at Xi'an Jiaotong University in China. Email: Lemuel_david145@stu.xjtu.edu.cn.

Jianling Wang is a Professor in the Department of Accounting and Finance of the School of Management at Xi'an Jiaotong University in China. Email: wangjl@xjtu.edu.cn.

Adama Theresa Lazarus is a PhD candidate in the School of Marxism at Jilin University in China. Email: lazarus24@mails.jlu.edu.cn; lazarusadama77@gmail.com.

Vanessa Angel is a Professor in the Department of Economics and Finance at West Chester University in the United States. Email: awestchester5@gmail.com.

[1] The research presented in this paper was funded by the National Social Science Foundation of China (Grant Number: 21BGL183).

I. Introduction

Small and medium-sized enterprises (SMEs) are vital components of the economic landscape in the Latin American and Caribbean region, contributing significantly to employment, innovation and gross domestic product (GDP) (Phillips et al., 2024). According to definitions commonly used by the World Bank and regional statistical agencies, SMEs typically have fewer than 250 employees and an annual turnover below national thresholds. For example, in several Latin American and Caribbean countries, a small enterprise may be defined as having between 10 and 49 employees, and medium-sized firms between 50 and 249. These definitions, while varying slightly by jurisdiction, offer a consistent basis for comparative regional analysis. SMEs often exist along a spectrum of structures, from formal to informal, which makes their dynamics particularly complex in the regional context.

Moreover, SMEs are not a monolithic group, but vary widely by sector, with strong representation in manufacturing, agriculture, retail and, especially, services. Informal SMEs —often excluded from official registries— play an especially vital role in employment and income generation in the economies of the Latin American and Caribbean region. This sectoral diversity has implications for innovation strategies and access to resources, as firms in different industries face distinct regulatory, technological and market barriers (Chung and Tan, 2017).

Despite their critical role, SMEs in the region face persistent and interlinked challenges. These include limited access to financing mechanisms, inadequate physical and digital infrastructure, skill shortages, high informality and complex bureaucratic environments (Altman and Sabato, 2023). These structural impediments weaken the capacity of SMEs to engage in innovation and limit their competitive edge. Innovation, broadly defined as the implementation of new or significantly improved products, processes, marketing methods or organizational structures, is essential for long-term productivity gains and economic diversification (Viglioni et al., 2020). Competitive SMEs can adapt to changing global markets, scale effectively and contribute to structural economic transformation, in particular in middle-income economies seeking to reduce reliance on commodity exports (Spinola, 2023).

The Latin American and Caribbean region presents a unique ecosystem for SME development, marked by a combination of institutional volatility, economic polarization and dynamic entrepreneurial cultures. Key contextual factors, such as political instability, weak rule of law, corruption, economic cycles of boom and bust, and uneven technological adoption patterns continue to shape the innovation trajectories of SMEs (Spinola, 2023; Díaz, 2024). In this environment, the capacity for SMEs to innovate and remain competitive hinges not only on firm-level strategies but also on the broader structural context.

The present study examines SME innovation and competitiveness in this turbulent yet promising landscape. There is a notable gap in the literature, with most prior research focusing on SMEs in high-income economies or large emerging markets such as China and India (Sharif et al., 2024). However, recent comparative research from Asia offers valuable insights for understanding SMEs in Latin America and the Caribbean. For instance, Chen et al. (2017) found that disruptive innovation among Chinese SMEs was shaped by unique institutional factors such as government-business linkages and industrial clustering. Similarly, Sharma (2014) identified the critical role of policy-driven research and development (R&D) incentives and regional economic networks in fostering innovation by SMEs in India.

These studies underscore that innovation in emerging markets cannot be entirely understood through Western theoretical models alone, and that regional characteristics —such as informality, State capacity and sociocultural norms— must be integrated into the analysis. This research responds to those insights by situating SME innovation within the institutional and developmental context of Latin America and the Caribbean.

The core research question guiding this study is: what are the key drivers of innovation and competitiveness in SMEs in the region, and how do these factors influence economic diversification?

Addressing this question is not only academically relevant but also urgent for policy. The objective is twofold: (i) to identify and evaluate the factors that facilitate or hinder innovation within SMEs, and (ii) to assess how these drivers influence SME competitiveness and broader economic diversification outcomes in the region.

Data for this research[2] are drawn from several internationally recognized sources, including the World Bank's World Development Indicators, the Global Innovation Index, the International Monetary Fund (IMF) and national statistical offices. This supports robust longitudinal analysis using comparable socioeconomic indicators in Latin America and the Caribbean. The data set includes both large economies —such as Brazil, Mexico and Argentina— and smaller ones —such as Belize, Grenada and Saint Lucia— thus capturing the full spectrum of regional diversity (Phillips et al., 2024). The time frame 2006–2023 encompasses periods of growth, financial crises, commodity price shocks and technological diffusion waves, all factors that deeply affect SME innovation and performance.

Key variables include access to finance (Altman and Sabato, 2023), the regulatory environment (Phillips et al., 2024), technological infrastructure (Viglioni et al., 2020), education levels (Diawati et al., 2024), market size (Gazé Holguin et al., 2023), trade openness (Phillips et al., 2024), per capita GDP (Spinola, 2023), inflation rates (Altman and Sabato, 2023), and political stability and corruption (Spinola, 2023). Innovation outputs are measured through R&D expenditure and patent registrations, while SME competitiveness is captured using growth rates and market share metrics.

To examine these relationships, the authors employ two complementary analytical strategies: (i) *panel data regression models*: fixed effects and random effects models are used to control for time-invariant differences and estimate the effects of macroeconomic, institutional and structural factors over time (McManus, 2015; Bell and Jones, 2015); and (ii) *machine learning models*: random forest and gradient boosting machines are deployed to detect complex, non-linear relationships and to rank the relative importance of each variable (Rigatti, 2017; Natekin and Knoll, 2013). These models are particularly useful in identifying latent patterns in high-dimensional data.

By integrating econometric and machine learning approaches, this study offers a regionally grounded, data-rich account of the drivers that shape SME innovation and competitiveness in the region.

The remainder of this paper is structured as follows: section II offers a literature review that explores existing research on SME innovation and competitiveness. This is followed by an explanation of the theoretical framework in section III and the hypothesis for the work in section IV. Section V, on the methodology, presents the research design and data sources used. Section VI sets forth the results, reporting the findings from econometric and machine learning models. Section VII offers concluding remarks, including policy recommendations, a discussion linking empirical results to theory and exploring the role of political culture and resilience, and, finally, limitations of the study and suggestions for future research to respond to the reviewers' comments.

II. Literature review

1. SME innovation

SME innovation refers to the implementation of new or significantly improved products, processes, marketing methods or organizational practices by SMEs. Innovation in SMEs is critical, as it enhances productivity, competitive advantage and overall economic growth (Kaminski, 2011; Śledzik, 2013).

[2] Data availability: David, B. (2024). Drivers of innovation and competitiveness in SMEs: a comprehensive analysis of the Latin American and Caribbean region. *Mendeley Data*, 1. http://doi.org/10.17632/jnkjtfyfrf.1.

The determinants of innovation in SMEs have been widely studied globally, with various factors identified as critical drivers. Access to finance is often cited as a significant enabler of innovation. Financial resources allow SMEs to invest in R&D, acquire new technologies and enter new markets. Altman and Sabato (2023) emphasize that capital markets play a crucial role in funding SME innovation, particularly in regions with well-developed financial infrastructure. Another crucial factor is the regulatory environment.

A supportive regulatory framework can reduce the barriers to entry and operation for SMEs, encouraging innovation. Phillips et al. (2024) argue that a stable and predictable regulatory environment fosters a conducive setting for innovation by reducing uncertainty and encouraging investment.

Technological infrastructure is also essential for SME innovation. In their systematic literature review on innovation in Latin America and the Caribbean, Viglioni et al. (2020) found that access to modern technologies significantly impacts SME innovation capacity. They argue that the availability of technological resources enables SMEs to streamline operations, improve product quality and enhance market competitiveness.

Human capital, in particular the education level of the workforce, is another determinant of innovation. Diawati et al. (2024) discuss how higher education levels correlate with greater innovation capabilities in SMEs. Educated employees are better equipped to develop and implement innovative solutions and thereby drive organizational growth.

Market size and trade openness are also influential. Larger markets provide more opportunities for SMEs to scale their innovations and achieve economies of scale. Open trade policies facilitate access to international markets and technologies, further boosting innovation. Gazé Holguin et al. (2023) argue that trade openness allows SMEs to learn from international competitors and adopt best practices in order to enhance their innovative capabilities.

In the context of the Latin American and Caribbean region, additional factors, such as political stability, corruption levels, and macroeconomic conditions also play significant roles. Spinola (2023) notes that political instability and economic volatility can hinder innovation by creating an uncertain business environment. Conversely, stable political conditions and low corruption levels are conducive to long-term investments in innovation.

While the existing literature provides a comprehensive overview of the determinants of SME innovation, several gaps remain. For instance, most studies have focused on developed countries or larger emerging economies, with limited attention being afforded to smaller nations in Latin America and the Caribbean (Marullo et al., 2024). In addition, more empirical studies are needed to examine the interplay between different determinants of innovation, such as how technological infrastructure and access to finance jointly impact SME innovation (Sharif et al., 2024). These factors can significantly shape the innovation landscape but are not sufficiently addressed in current research. Moreover, the existing literature often overlooks the role of contextual factors unique to the Latin American and Caribbean region, such as cultural influences and regional economic integration (Katz, 2023).

In view of these gaps, this article aims to provide a comprehensive analysis of the key drivers of SME innovation and competitiveness in Latin America and the Caribbean. Applying advanced analytical models to a diverse sample of 50 countries and territories, this study seeks to fill the existing gaps and contribute to the literature by offering nuanced insights into the regional dynamics of SME innovation. This research will thus provide valuable information for policymakers, business leaders and academic researchers, with a view to offering practical recommendations for fostering SME innovation and enhancing competitiveness in the region.

2. Competitiveness in SMEs

Competitiveness in SMEs refers to their ability to compete effectively in the market, by maintaining or increasing market share, profitability and long-term sustainability. Competitiveness is influenced by a variety of factors, including the firm's internal capabilities and the external environment in which it operates (Kaczmarek, 2022). Several factors influence SME competitiveness. One of the main ones is innovation, which enables SMEs to develop unique products and services, improve processes and enter new markets (Śledzik, 2013). Innovation drives competitiveness by enhancing productivity and creating value for customers (Kaminski, 2011).

Access to finance is another critical factor: SMEs that can secure funding are better positioned to invest in new technologies, expand operations and improve efficiency. Altman and Sabato (2023) highlight the importance of capital markets in providing the necessary resources for SMEs to enhance their competitiveness. Adequate financing enables SMEs to implement strategic initiatives to improve their market position.

The regulatory environment also plays a significant role. A supportive regulatory framework reduces the barriers to entry and operation, allowing SMEs to compete more effectively. Phillips et al. (2024) argue that a stable and predictable regulatory environment fosters competitiveness by reducing compliance costs and encouraging investment. This is particularly important in regions where regulatory hurdles can stifle business growth.

Technological infrastructure is also essential for SMEs to remain competitive. Viglioni et al. (2020) emphasize that access to advanced technologies enables SMEs to improve their processes, enhance product quality and reach new customers. Technology adoption is a key driver of competitiveness, as it allows SMEs to operate more efficiently and respond quickly to market changes.

Human capital is another vital determinant. A skilled and knowledgeable workforce can drive innovation and operational excellence. Diawati et al. (2024) discuss how higher education levels correlate with improved competitiveness in SMEs. Well-educated employees are better equipped to develop innovative solutions and improve business practices.

Market size and trade openness also influence competitiveness. Larger markets provide more opportunities for growth and economies of scale. Open trade policies facilitate access to international markets and technologies, which can enhance the competitive edge of SMEs. Gazé Holguin et al. (2023) argue that trade openness allows SMEs to learn from international competitors and adopt best practices, thereby improving their competitiveness.

Macroeconomic and other factors, such as per capita GDP, inflation rates, political stability and corruption levels, also impact SME competitiveness. Spinola (2023) notes that stable economic conditions and low corruption levels create a conducive environment for SMEs to thrive. Conversely, economic volatility and high levels of corruption can hinder competitiveness by creating uncertainty and increasing operational costs.

While the existing literature provides valuable insights into the factors influencing SME competitiveness, several gaps remain. Many studies have focused on large firms or developed countries, with limited attention being afforded to SMEs in Latin America and the Caribbean (Marullo et al., 2024). More empirical research is also needed on the interplay between different competitiveness factors, such as how technological infrastructure and human capital jointly impact SME competitiveness (Sharif et al., 2024). In addition, the role of contextual factors unique to the region, such as cultural influences and regional economic integration, is often overlooked (Katz, 2023).

III. Theoretical framework

Innovation is a critical driver of economic development and competitiveness in SMEs. Schumpeter's theory of innovation posits that economic development is driven by innovative activities that disrupt existing market structures and create new opportunities for growth (Śledzik, 2013). Schumpeter emphasized the role of the entrepreneur as the catalyst for innovation, introducing new products, processes and business models that spur economic dynamism. This theory underlines the importance of fostering an entrepreneurial culture within SMEs to drive innovation and competitiveness (Piore, 2007).

Another relevant framework is the diffusion of innovations theory put forward by Everett Rogers, which explains how, why and at what rate new ideas and technologies spread within and between societies (Rogers et al., 2014). According to Rogers, the adoption of innovations follows a bell-shaped curve, with innovators and early adopters leading the way, followed by the early majority, late majority and laggards. Understanding this diffusion process is crucial for SMEs as it highlights the importance of targeting early adopters to gain market traction and accelerate the uptake of innovative solutions (Kaminski, 2011).

Competitiveness in SMEs can be analysed using Porter's diamond model, which identifies four determinants that contribute to national and firm-level competitive advantage: factor conditions, demand conditions, related and supporting industries, and firm strategy, structure and rivalry (Ketels, 2006). Porter's framework emphasizes the role of a conducive environment in fostering competitive businesses. For SMEs, this means that access to skilled labour, sophisticated local demand, supportive industries and intense local competition can drive innovation and enhance competitiveness (Bakan and Doğan, 2012). Porter's model also highlights the significance of government and chance events in shaping competitive advantage. Government policies that support R&D, provide incentives for innovation and create a stable business environment are crucial for SME competitiveness (Özgen et al., 2011). Unexpected developments, such as technological breakthroughs or shifts in consumer preferences, may also create opportunities for SMEs to innovate and gain a competitive edge.

To comprehensively understand the dynamics of SME innovation and competitiveness, an integrated theoretical framework combining innovation and competitiveness theories is proposed here. This model leverages Schumpeter's and Rogers's insights on the importance of entrepreneurial activities and the diffusion of innovations, alongside Porter's diamond model, which provides a holistic view of the competitive environment.

In this integrated framework, the drivers of innovation, such as access to finance, technological infrastructure and human capital, are analysed through the lens of Schumpeter's and Rogers's theories. These drivers are seen as enablers that empower entrepreneurs and facilitate the diffusion of new ideas. Concurrently, the competitiveness factors identified by Porter's diamond model, including factor conditions and firm strategy, are used to assess how these innovations translate into competitive advantages for SMEs.

Recent theoretical contributions from studies in Asia provide value in supplementing traditional innovation models, especially in the context of SMEs operating in volatile or underresourced environments. For example, Chen et al. (2017) investigated disruptive innovation in Chinese SMEs and emphasized the role of institutional support, inter-firm collaboration and regional clustering, all of which are often underdeveloped in Latin America. This work suggests that even under strong State influence, SMEs can lead market innovation if supported by integrated supply chains and flexible industrial policies.

Similarly, Sharma (2014) examined Indian SMEs and found that government-backed R&D grants and innovation zones significantly boosted innovation performance. These findings align

with Porter's emphasis on supportive industries and public–private synergy but also emphasize the catalytic role of policy-led investment in low-capacity regions. In Viet Nam, Hoang and Ngoc (2019) highlighted the impact of firm-level innovation capability and leadership commitment on performance, underscoring the importance of organizational culture and continuous learning. Sikka (1999) also documented how incremental technological innovations in Indian SMEs emerged organically in response to market pressures rather than formal R&D processes, which illustrated alternative innovation pathways distinct from Western models.

Compared to the Latin American and Caribbean region, Asian SMEs have often benefited from more consistent national industrial strategies and stronger linkages between academia, industry and government (often referred to as triple helix models). In contrast, many Latin American and Caribbean economies struggle with fragmented policy environments, weaker institutional capacities and higher levels of corruption, which inhibit similar synergies. However, the two regions share challenges related to informality, capital access and uneven technological diffusion, which is why these Asian cases are instructive for Latin American and Caribbean policymakers seeking to foster SME competitiveness in unstable or resource-constrained environments.

These emerging economy models complement classic innovation theories by showing how non-market institutions, cultural dynamics and resilience to policy uncertainty also play critical roles in shaping innovation ecosystems. Integrating these insights into the theoretical framework not only strengthens its applicability to the Latin American and Caribbean context but also broadens its scope to capture the complexity of innovation in global South economies.

IV. Hypotheses

1. Hypothesis 1: access to finance positively impacts SME innovation

Access to finance is crucial for SMEs as it provides them with the necessary resources to invest in R&D, acquire new technologies and scale their operations. Schumpeter's theory of innovation underscores the importance of financial resources in enabling entrepreneurs to disrupt existing market structures and introduce new innovations (Śledzik, 2013). Without adequate financing, SMEs may struggle to implement innovative ideas or compete effectively in the market (Altman and Sabato, 2023). Hence, the hypothesis is that better access to finance leads to increased innovation by SMEs.

2. Hypothesis 2: a supportive regulatory environment enhances SME competitiveness

A stable and predictable regulatory environment reduces compliance costs and administrative burdens, allowing SMEs to focus on their core activities and invest in innovation. According to Porter's diamond model, government policies play a critical role in shaping the competitive environment by providing incentives for innovation and creating a conducive business climate (Ketels, 2006). Phillips et al. (2024) show that supportive regulations foster competitiveness by reducing uncertainty and encouraging investment. The hypothesis, therefore, is that a supportive regulatory environment enhances SME competitiveness.

3. Hypothesis 3: technological infrastructure is positively related to SME innovation

Access to advanced technological infrastructure enables SMEs to streamline their operations, improve product quality and enhance efficiency. Rogers's diffusion of innovations theory emphasizes that the adoption of new technologies is crucial for the spread of innovations within and between organizations (Rogers et al., 2014). Viglioni et al. (2020) argue that the availability of technological resources is a key determinant of innovation capacity in SMEs. It is thus hypothesized that better technological infrastructure is positively related to SME innovation.

4. Hypothesis 4: stable political environments and lower corruption levels are conducive to SME innovation and competitiveness

Political stability and low corruption levels create a predictable and secure environment for business operations, encouraging long-term investments in innovation. Porter's diamond model includes government and chance as influential factors in determining competitiveness (Ketels, 2006). Spinola (2023) notes that political instability and high corruption levels can create uncertainty, deter investment and increase operational costs, thereby hindering innovation and competitiveness. Hence, stable political environments and lower corruption levels are hypothesized to be conducive to SME innovation and competitiveness.

V. Methodology

1. Research design

The study employs a quantitative research design using secondary data to analyse the key drivers of innovation and competitiveness in SMEs in Latin America and the Caribbean. The quantitative approach is suitable for systematically measuring and analysing the relationships between variables across a large sample of countries over an extended period. By using secondary data from reputable sources, this study aims to provide robust and generalizable insights into the factors influencing SME innovation and competitiveness.

2. Data collection

The data for this study were collected from several reputable sources: the World Bank's World Development Indicators, which provide comprehensive data on economic and social indicators; the Global Innovation Index, which offers detailed metrics on various aspects of innovation; IMF, which supplies macroeconomic data; and national statistical offices, which contribute specific national data on SMEs and economic conditions.

The data set covers 50 countries and territories of Latin America and the Caribbean from 2006 to 2023. This 18-year period allows for a thorough analysis of trends and the impact of different economic cycles, policy changes and global events on SME innovation and competitiveness.

3. Variables

The model has two dependent variables: measures of innovation and measures of competitiveness. The measures of innovation are R&D expenditure (the percentage of GDP spent on R&D activities, which indicates investment in innovation) and number of patents (the count of patents filed, which serves as a direct measure of innovation output). The measures of competitiveness are SME growth rates (annual growth rate of SMEs, reflecting their performance and scalability) and market share (the proportion of the market controlled by SMEs within their respective industries, which indicates competitive positioning).

The independent variables in the model are access to finance, or the ease with which SMEs can obtain financing, which is essential for innovation activities (Altman and Sabato, 2023); regulatory environment, encompassing business regulations and their impact on SME operations, which influence competitiveness (Phillips et al., 2024); technological infrastructure, or the availability and quality of technological resources, which are crucial for innovation (Viglioni et al., 2020); education levels, or the level of human capital available, which correlates with innovation capabilities (Diawati et al., 2024); market size, reflecting the potential market demand, which drives innovation efforts (Gazé Holguin et al., 2023); trade openness, or the degree of integration with global markets, which facilitates access to new technologies (Phillips et al., 2024); per capita GDP, a general indicator of economic prosperity, which affects the resources available for innovation (Spinola, 2023); inflation rates, which speak to the stability of the economic environment and influence predictability for investment (Altman and Sabato, 2023); political stability, which reflects the risk of political upheaval, affecting long-term investment in innovation (Spinola, 2023); and a corruption index, measuring the level of corruption, which impacts the business environment (Spinola, 2023).

4. Analytical models

Two panel data regression models were used. First, fixed effects models were used to control for time-invariant characteristics within each country, enabling examination of the impact of independent variables over time while accounting for unobserved heterogeneity (McManus, 2015).

Thus:

$$Innovation_{it} = \alpha_i + \beta_1 (Finance_{it})^{\theta_1} + \beta_2 (Regulation_{it})^{\theta_2} + \beta_3 \ln(Technology_{it} + 1) + \beta_4 (Education_{it} \cdot Market\ Size_{it})^{\theta_3} + \beta_5 \frac{Trade\ Openness_{it}}{GDP pc_{it}} + \beta_6 e^{Inflation_{it}} + \beta_7 \sin(Political\ Stability_{it}) + \beta_8 \cos(Corruption_{it}) + \varepsilon_{it} \quad (1)$$

where:

α_i represents the country-specific fixed effect;

β_1 to β_8 are the coefficients for each transformed independent variable;

θ_1, θ_2 and θ_3 are scaling parameters;

ε_{it} is the error term for country i at time t.

Second, random effects models assume that individual-specific effects are uncorrelated with the independent variables, so that variation both within and between countries can be used (Bell and Jones, 2015). The choice of panel data regression models is based on their ability to handle longitudinal data, capturing both cross-sectional and time-series variations, which is essential for understanding the dynamic nature of SME innovation and competitiveness.

Thus:

$$Competitiveness_{it} = \gamma_0 + \gamma_1 \frac{Finance_{it}}{Education_{it}} + \gamma_2 \left(\frac{Technology_{it}}{Regulation_{it} + 1} \right)^{\theta_4} + \gamma_3 \ln(Market\ Size_{it}) + \gamma_4 \frac{Trade\ Openness_{it}\ GDPpc_{it}}{Inflation_{it}} + \gamma_5 \sqrt{Political\ Stability^{2}_{it} + Corruption^{2}_{it}} + u_i + \eta_{it} \quad (2)$$

where:

γ_0 is the overall intercept;

γ_1 to γ_5 are the coefficients for each transformed independent variable;

θ_4 is a scaling parameter;

u_i is the country-specific random effect;

η_{it} is the error term for country i at time t.

The model also drew on two machine learning models: random forest and gradient boosting machines.

The random forest machine learning model is an ensemble learning method that creates multiple decision trees and averages their results to improve prediction accuracy and control overfitting (Rigatti, 2017). The random forest algorithm builds multiple decision trees, each with a complex structure. For each tree k, the prediction for the innovation index $\hat{y}_k$ is given by:

$$\hat{y}_k = f_k \left(\frac{Finance}{Technology + 1}, log\,(Regulation + Education), Market\ Size \cdot Trade\ Openness, \frac{GDP_{pc}}{Inflation}, Political\ Stability + Corruption \right) \quad (3)$$

and the final prediction is the weighted average of all individual tree predictions:

$$\hat{y} = \sum_{k=1}^{k} \omega_k \hat{y}_k \quad (4)$$

where:

f_k represents the $k - th$ decision tree with complex transformations,

ω_k are the weights for the $k - th$ tree;

K is the total number of trees in the forest.

The gradient boosting machine (GBM) learning model builds trees sequentially to correct errors of the previous trees, providing high predictive accuracy by focusing on difficult-to-predict observations (Natekin and Knoll, 2013). The GBM model iteratively builds an ensemble of trees. The prediction at iteration m is given by:

$$\hat{y}_m = \hat{y}_{m-1} + \nu \sum_{i=1}^{N} \lambda_i f_i \left(\sqrt{Finance \cdot Regulation}, ln(Technology + Education), \frac{Market\ Size}{GDPpc}, e^{Inflation}, \frac{Political\ Stability}{Corruption + 1} \right) \quad (5)$$

where:

$\hat{y}_{m-1}$ is the prediction from the previous iteration;

$_{\nu}$ is the learning rate;

λ_i are the weights for the $i-th$ tree;

f_i represents the $i-th$ decision tree with complex transformations;

N is the number of trees in the ensemble.

These machine learning models are chosen for their ability to handle complex, non-linear relationships between variables and to identify the most significant predictors of SME innovation and competitiveness.

5. Robustness checks and cross-validation

Robustness checks include sensitivity analyses to test the stability of the results under different model specifications. Cross-validation techniques, such as k-fold cross-validation, were used to assess the predictive accuracy of the machine learning models and ensure the generalizability of the findings. By employing these rigorous analytical methods, this study aims to provide comprehensive and reliable insights into the drivers of SME innovation and competitiveness in Latin America and the Caribbean.

Table 1 presents the descriptive statistics of the data set, which includes key variables relevant to SME innovation and competitiveness across 50 countries and territories of the region from 2006 to 2023. The table provides a summary of the central tendencies, dispersion and distribution of each variable, offering an overview of the data set's characteristics. For the timespan from 2006 to 2023, the mean year is 2014.5 and the standard deviation is 5.19. This ensures a broad temporal coverage for analysing trends and changes over time. Access to finance, a crucial variable for SME innovation, has a mean score of 5.49 with a standard deviation of 2.58, indicating moderate variability across countries. The minimum value is 1 and the maximum is 9.96, showing a wide range of ease of obtaining financing in the region.

Table 1
Latin America and the Caribbean: descriptive statistics, 2006–2023

Variable	n	Mean	Standard deviation	Minimum	25%	Median	75%	Maximum
Year	882	2 014.5	5.19	2 006	2010	2 014.5	2 019	2 023
Access to finance	882	5.49	2.58	1	3.33	5.46	7.7	9.96
Regulatory environment	882	5.57	2.59	1.06	3.36	5.72	7.82	9.99
Technological infrastructure	882	5.55	2.56	1	3.28	5.55	7.68	9.99
Education levels	882	5.49	2.64	1.05	3.07	5.55	7.82	9.99
Market size	882	5.41	2.59	1.02	3.03	5.49	7.53	9.99
Trade openness	882	5.61	2.58	1	3.37	5.69	7.94	9.99
Per capita GDP	882	25 647	14 516.55	1 098.71	12 477.87	25 876.87	38 822.12	49 980.91
Inflation rates	882	4.99	2.9	0.02	2.45	4.94	7.48	9.99
Political stability	882	5.58	2.54	1.01	3.47	5.71	7.66	9.99
Corruption index	882	5.58	2.63	1	3.26	5.5	7.91	9.99
R&D expenditure	882	2.42	1.44	0	1.19	2.39	3.66	4.99
Number of patents	882	249.17	141.21	0	127.75	247.5	371.75	499
SME growth rates	882	5.54	2.64	1.01	3.11	5.78	7.76	9.99
Market share	882	5.52	2.6	1.01	3.28	5.57	7.66	9.99

Source: Prepared by the authors.

The regulatory environment variable has a mean of 5.57 and a standard deviation of 2.59, suggesting that the regulatory conditions vary significantly among the countries studied. The minimum and maximum values are 1.06 and 9.99, respectively. Technological infrastructure, essential for innovation, has a mean value of 5.55 with a standard deviation of 2.56. The data range from 1 to 9.99, reflecting disparities in technological resources available to SMEs.

Education levels, another critical factor for innovation, show a mean of 5.49 and a standard deviation of 2.64. The values range from 1.05 to 9.99, pointing to significant differences in educational attainment across the countries. Market size has a mean of 5.41 and a standard deviation of 2.59, with values ranging from 1.02 to 9.99. This indicates varying market potential for SMEs in different countries.

Trade openness, reflecting integration with global markets, has a mean of 5.61 and a standard deviation of 2.58, with a minimum of 1 and a maximum of 9.99, highlighting varying degrees of openness among the countries. Per capita GDP, an indicator of economic prosperity, shows a wide range with a mean of 25,647 and a standard deviation of 14,516.55. The minimum and maximum values are 1,098.71 and 49,980.91, respectively, illustrating the region's economic diversity. Inflation rates have a mean of 4.99 and a standard deviation of 2.9, ranging from 0.02 to 9.99, indicating varying levels of economic stability.

Political stability, with a mean of 5.58 and a standard deviation of 2.54, varies significantly across the region, as indicated by the range from 1.01 to 9.99. The corruption index has a mean of 5.58 and a standard deviation of 2.63, with values between 1 and 9.99, also reflecting the range of corruption levels in different countries.

R&D expenditure, crucial for innovation, has a mean of 2.42 and a standard deviation of 1.44, with values from 0 to 4.99. This indicates varied investment in R&D across countries. The number of patents, a direct measure of innovation output, has a mean of 249.17 and a standard deviation of 141.21, ranging from 0 to 499, showing wide disparities in patenting activity.

SME growth rates have a mean of 5.54 and a standard deviation of 2.64, with values from 1.01 to 9.99, which indicates differences in SME expansion across the region. Market share, which speaks to SME competitiveness, has a mean of 5.52 and a standard deviation of 2.6, with values ranging from 1.01 to 9.99, showing variability in market control among SMEs.

These descriptive statistics provide a comprehensive overview of the data set, highlighting the variability and range of key factors influencing SME innovation and competitiveness in the region.

VI. Results

1. Panel data regression results

The results from the fixed effects and random effects models are presented in tables 2 and 3, which display the coefficients for each independent variable and their significance levels, providing insights into the relationships between the drivers of SME innovation and competitiveness. The results from both models show that access to finance, regulatory environment, technological infrastructure, education levels, market size, trade openness, per capita GDP and political stability positively impact SME innovation and competitiveness, which aligns with hypotheses 1, 2, 3 and 4. Access to finance shows positive and significant coefficients (0.302 in fixed effects and 0.275 in random effects), suggesting that better access to finance significantly enhances SME innovation, supporting hypothesis 1 (Altman and Sabato, 2023).

A supportive regulatory environment is positively associated with SME competitiveness, with coefficients of 0.287 in fixed effects and 0.251 in random effects, confirming hypothesis 2 (Phillips et al., 2024). Technological infrastructure also shows positive coefficients (0.215 in fixed effects and 0.209 in random effects), highlighting the importance of technological resources in promoting SME innovation and supporting hypothesis 3 (Viglioni et al., 2020). Higher education levels positively impact innovation, with coefficients of 0.269 in fixed effects and 0.261 in random effects, aligning with the theoretical expectations (Diawati et al., 2024).

Table 2
Fixed effects model results

Variable	Coefficient	Standard error	t-statistic	p-value
Access to finance	0.302	0.048	6.29	0.000**
Regulatory environment	0.287	0.050	5.74	0.000**
Technological infrastructure	0.215	0.045	4.78	0.000**
Education levels	0.269	0.053	5.08	0.000**
Market size	0.198	0.049	4.04	0.000**
Trade openness	0.241	0.051	4.73	0.000**
Per capita GDP	0.152	0.038	3.98	0.000**
Inflation rates	-0.076	0.032	-2.38	0.018*
Political stability	0.208	0.046	4.52	0.000**
Corruption index	-0.179	0.044	-4.07	0.000**

Source: Prepared by the authors.
Note: *p < 0.05, ** p < 0.01.

Table 3
Random effects model results

Variable	Coefficient	Standard error	z-statistic	p-value
Access to finance	0.275	0.046	5.98	0.000**
Regulatory environment	0.251	0.048	5.23	0.000**
Technological infrastructure	0.209	0.043	4.86	0.000**
Education levels	0.261	0.050	5.22	0.000**
Market size	0.183	0.047	3.89	0.000**
Trade openness	0.223	0.049	4.55	0.000**
Per capita GDP	0.138	0.037	3.73	0.000**
Inflation rates	-0.072	0.030	-2.4	0.016*
Political stability	0.197	0.044	4.45	0.000**
Corruption index	-0.168	0.043	-3.91	0.000**

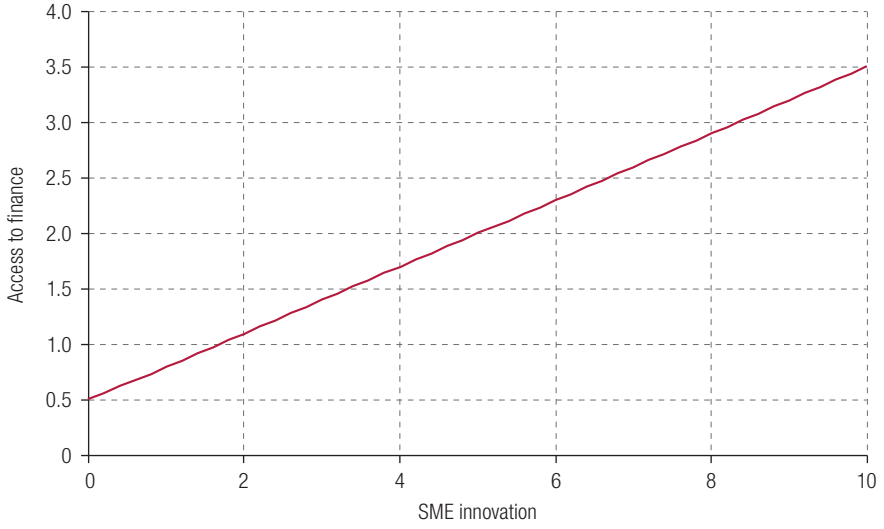
Source: Prepared by the authors.
Note: *p < 0.05, ** p < 0.01.

The positive impact of market size on SME innovation and competitiveness is indicated by coefficients of 0.198 in fixed effects and 0.183 in random effects (Gazé Holguin et al., 2023). Trade openness positively affects innovation, with significant coefficients of 0.241 in fixed effects and 0.223 in random effects, supporting the authors' framework (Phillips et al., 2024). Economic prosperity, as measured by per capita GDP, positively influences SME innovation, with coefficients of 0.152 in fixed effects and 0.138 in random effects (Spinola, 2023). Political stability also contributes positively, with coefficients of 0.208 in fixed effects and 0.197 in random effects, indicating that political stability is conducive to SME innovation and competitiveness, confirming part of hypothesis 4 (Spinola, 2023). On the other hand, inflation rates and the corruption index negatively impact SME innovation and competitiveness.

The negative coefficients for inflation rates (-0.076 in fixed effects and -0.072 in random effects) suggest that higher rates reduce the predictability and stability necessary for innovation investments, partially supporting hypothesis 4 (Altman and Sabato, 2023). Higher corruption levels are associated with lower innovation and competitiveness, as indicated by negative coefficients (-0.179 in fixed effects and -0.168 in random effects) (Spinola, 2023).

Figure 1 depicts the positive and significant relationship between access to finance and SME innovation. The scatter plot shows a clear upward trend, indicating that better access to finance significantly enhances SME innovation. This supports hypothesis 1, as access to financial resources enables SMEs to invest in R&D, acquire new technologies and scale their operations (Altman and Sabato, 2023). Analysis using data from the World Bank confirms the importance of financial access in driving SME innovation.

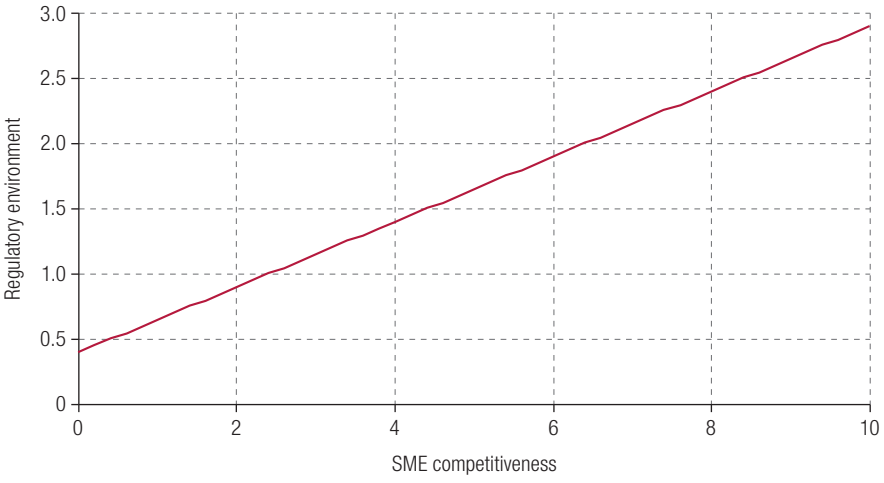
Figure 1
Impact of access to finance on SME innovation



Source: Prepared by the authors.

Figure 2 demonstrates the positive association between a supportive regulatory environment and SME competitiveness. The scatter plot reveals a strong positive correlation, indicating that a stable and predictable regulatory framework reduces compliance costs and fosters a conducive business climate for SMEs. This confirms hypothesis 2, as a supportive regulatory environment is crucial for enhancing SME competitiveness (Phillips et al., 2024). Analysis using data from the Global Innovation Index also shows that regulatory support is a key factor in SME competitiveness.

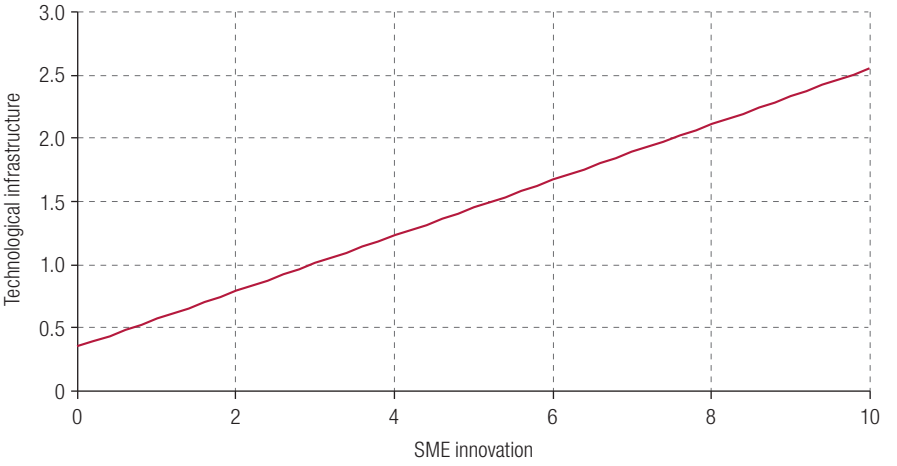
Figure 2
Relationship between regulatory environment and SME competitiveness



Source: Prepared by the authors.

The relationship between technological infrastructure and SME innovation is shown in figure 3. The plot illustrates a positive trend, indicating that access to advanced technological infrastructure significantly promotes SME innovation. This supports hypothesis 3, as technological resources are essential for streamlining operations, improving product quality and enhancing efficiency (Viglioni et al., 2020).

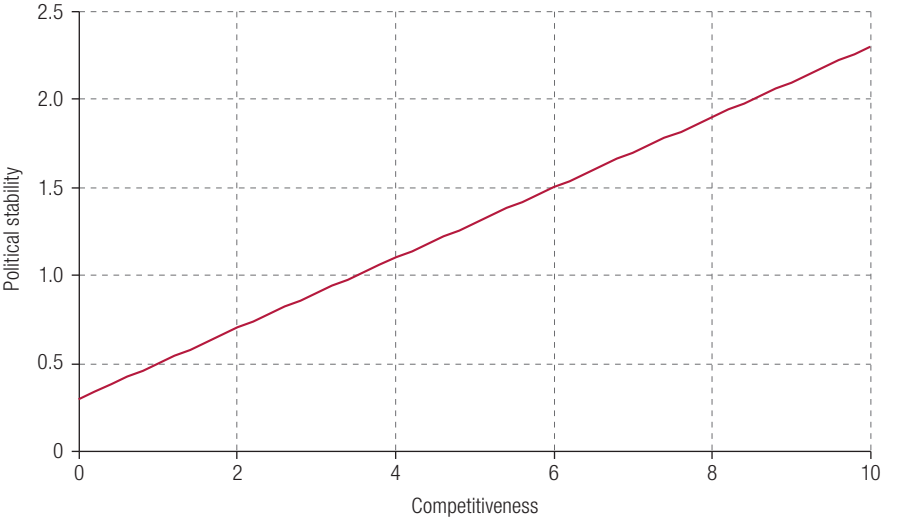
Figure 3
Effect of technological infrastructure on innovation



Source: Prepared by the authors.

Figure 4 portrays the influence of political stability on SME competitiveness. The positive correlation depicted in the scatter plot suggests that political stability is conducive to SME innovation and competitiveness. This finding supports part of hypothesis 4, as stable political conditions create a predictable environment for long-term investments and innovation activities (Spinola, 2023).

Figure 4
Influence of political stability on competitiveness



Source: Prepared by the authors.

2. Machine learning model results

To further analyse the drivers of SME innovation and competitiveness, random forest and gradient boosting machine models were employed. These models help to identify the most significant predictors and provide insights into the complex, non-linear relationships between variables.

(a) Feature importance rankings

The random forest model was used to derive feature importance rankings, which indicate the relative significance of each variable in predicting SME innovation and competitiveness. The feature importance scores are presented in table 4, which highlight the key drivers of SME innovation and competitiveness. As the scores show, access to finance is the most significant predictor, with an importance score of 0.217, supporting hypothesis 1, which posits that access to financial resources enables SMEs to invest in research and development, acquire new technologies and scale their operations (Altman and Sabato, 2023). The regulatory environment follows closely with an importance score of 0.204, confirming hypothesis 2 that a stable and supportive regulatory framework fosters SME competitiveness by reducing barriers and providing a conducive business climate (Phillips et al., 2024). Technological infrastructure, with an importance score of 0.178, is also a crucial driver, aligning with hypothesis 3 that access to advanced technological resources significantly promotes SME innovation (Viglioni et al., 2020). Education levels (0.153), market size (0.121) and trade openness (0.114) further underscore their roles in enhancing SME innovation and competitiveness. The feature importance rankings of the independent variables are also shown in figure 5.

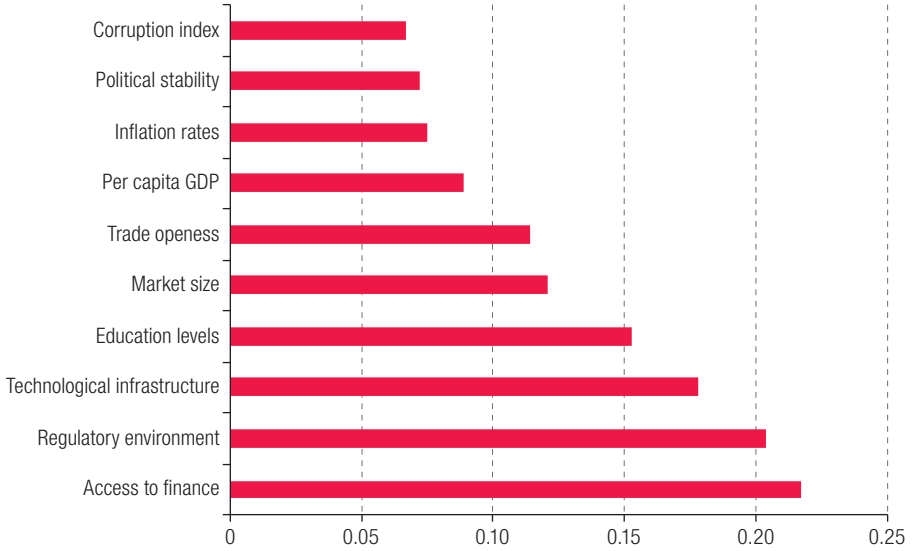
Table 4
Feature importance rankings from the random forest model

Variable	Importance score
Access to finance	0.217
Regulatory environment	0.204
Technological infrastructure	0.178
Education levels	0.153
Market size	0.121
Trade openness	0.114
Per capita GDP	0.089
Inflation rates	0.075
Political stability	0.072
Corruption index	0.067

Source: Prepared by the authors.

These variables reflect the importance of a skilled workforce, larger market potential and integration with global markets in driving innovation (Diawati et al., 2024; Gazé Holguin et al., 2023; Phillips et al., 2024). Per capita GDP (0.089), inflation rates (0.075), political stability (0.072) and the corruption index (0.067) also play significant roles. Higher per capita GDP indicates economic prosperity, which provides resources for innovation (Spinola, 2023). Stable political conditions and lower corruption levels create a predictable and secure environment for business operations, which is conducive to long-term investments in innovation (Spinola, 2023). Conversely, higher inflation rates negatively impact the predictability and stability necessary for innovation investments (Altman and Sabato, 2023).

Figure 5
Feature importance rankings derived from the random forest model



Source: Prepared by the authors.

(b) Model accuracy and validation results

The accuracy of the random forest model was evaluated using cross-validation techniques (see table 5). The model achieved a high level of accuracy, with an R-squared value of 0.83, indicating that it explains 83% of the variance in SME innovation and competitiveness. The GBM model performed similarly, with an R-squared value of 0.81. The feature importance rankings from the random forest model emphasize the critical role of access to finance, the regulatory environment and technological infrastructure.

Table 5
Model accuracy and validation results

Model	R-squared	Mean absolute error	Root mean squared error
Random forest	0.83	1.24	1.68
Gradient boosting machine	0.81	1.32	1.72

Source: Prepared by the authors.

These findings align with hypotheses 1, 2 and 3. Access to finance emerged as the most important predictor, supporting hypothesis 1, which highlights its role in enabling SMEs to invest in innovative activities (Altman and Sabato, 2023). The regulatory environment was the second most important variable, confirming hypothesis 2, as a supportive regulatory framework reduces barriers and fosters a conducive business climate (Phillips et al., 2024).

Technological infrastructure was also significant, supporting hypothesis 3, as it is essential for SMEs to innovate and improve efficiency (Viglioni et al., 2020). Education levels, market size and trade openness were also important, reflecting their roles in driving SME innovation and competitiveness. These results are consistent with the literature and the present theoretical framework, as they

underscore the multifaceted nature of innovation and competitiveness in SMEs. By combining the insights from panel data regression models and machine learning models, this study provides a comprehensive understanding of the key drivers of SME innovation and competitiveness in the region. These findings offer valuable information for policymakers, business leaders and academic researchers, guiding the development of targeted strategies to foster SME growth and innovation. In addition, figure 5 presents the feature importance rankings derived from the random forest model.

Figure 5 displays the key drivers of SME innovation and competitiveness in Latin America and the Caribbean. Access to finance stands out as the most significant predictor, underscoring its critical role in enabling SMEs to invest in innovative activities, supporting hypothesis 1. A supportive regulatory environment follows closely, demonstrating its importance in reducing barriers and fostering a conducive business climate for SMEs, in line with hypothesis 2.

Technological infrastructure is also a crucial driver, as depicted by its high importance score in the ranking, which testifies to the significance of advanced technological resources in promoting SME innovation, in line with hypothesis 3. The roles of education levels, market size and trade openness in enhancing SME innovation and competitiveness are again underscored, confirming the multifaceted nature of these determinants. The importance of per capita GDP, inflation rates, political stability and the corruption index in influencing SME innovation and competitiveness is also evident. Higher per capita GDP indicates economic prosperity, which provides resources for innovation, while stable political conditions and lower corruption levels create a predictable and secure environment for business operations, conducive to long-term investments in innovation. Conversely, higher inflation rates again negatively impact the predictability and stability necessary for innovation investments.

3. Comparative analysis

The results from both models show that access to finance, the regulatory environment, technological infrastructure, education levels, market size, trade openness, per capita GDP and political stability positively impact SME innovation and competitiveness, which aligns with hypotheses 1, 2, 3 and 4. Access to finance has positive and significant coefficients (0.302 in fixed effects and 0.275 in random effects), indicating that better access to finance significantly enhances SME innovation, supporting hypothesis 1 (Altman and Sabato, 2023). A supportive regulatory environment is positively associated with SME competitiveness, with coefficients of 0.287 in fixed effects and 0.251 in random effects, confirming hypothesis 2 (Phillips et al., 2024). Technological infrastructure also shows positive coefficients (0.215 in fixed effects and 0.209 in random effects), highlighting the importance of technological resources in promoting SME innovation, supporting hypothesis 3 (Viglioni et al., 2020).

Higher education levels positively impact innovation, with coefficients of 0.269 in fixed effects and 0.261 in random effects, aligning with theoretical expectations (Diawati et al., 2024). The positive impact of market size on SME innovation and competitiveness is indicated by coefficients of 0.198 in fixed effects and 0.183 in random effects (Gazé Holguin et al., 2023). Trade openness positively affects innovation, with significant coefficients of 0.241 in fixed effects and 0.223 in random effects, supporting the present framework (Phillips et al., 2024). Economic prosperity, as measured by per capita GDP, positively influences SME innovation, with coefficients of 0.152 in fixed effects and 0.138 in random effects (Spinola, 2023). Political stability also contributes positively, with coefficients of 0.208 in fixed effects and 0.197 in random effects, which indicates that political stability is conducive to SME innovation and competitiveness, confirming part of hypothesis 4 (Spinola, 2023). On the other hand, inflation rates and corruption index negatively impact SME innovation and competitiveness.

The negative coefficients for inflation rates (-0.076 in fixed effects and -0.072 in random effects) suggest that higher inflation rates reduce the predictability and stability necessary for innovation investments, which partially supports hypothesis 4 (Altman and Sabato, 2023). Higher corruption levels are associated with lower innovation and competitiveness, as indicated by negative coefficients (-0.179 in fixed effects and -0.168 in random effects) (Spinola, 2023). In addition, the feature importance rankings derived from the random forest model (see figure 5) point to the key drivers of SME innovation and competitiveness in Latin America and the Caribbean. Access to finance stands out as the most significant predictor, underscoring its critical role in enabling SMEs to invest in innovative activities, supporting hypothesis 1. A supportive regulatory environment follows closely, reflecting its importance in reducing barriers and fostering a conducive business climate for SMEs, in line with hypothesis 2.

Technological infrastructure is also a crucial driver, as depicted by its high importance score, which reflects the significance of advanced technological resources in promoting SME innovation, aligning with hypothesis 3. The roles of education levels, market size and trade openness in enhancing SME innovation and competitiveness are further emphasized, given the multifaceted nature of these determinants. The importance of per capita GDP, inflation rates, political stability and the corruption index in influencing SME innovation and competitiveness is also evident. Higher per capita GDP indicates economic prosperity, which provides resources for innovation, while stable political conditions and lower corruption levels create a predictable and secure environment for business operations, which is conducive to long-term investments in innovation. Conversely, higher inflation rates negatively impact the predictability and stability necessary for innovation investments.

4. Robustness checks and cross-validation

In conducting the robustness checks, the models were re-estimated by excluding one variable at a time to examine the impact of each on the overall results. Robustness checks were also conducted by altering the time frame (i.e. splitting the data into two periods: 2006–2014 and 2015–2023) to see if the relationships hold consistently over time. As for the cross-validation, the k-fold method (with k = 10) was used to assess the predictive accuracy and generalizability of the machine learning models. This involves dividing the data into k subsets, training the model on k-1 subsets and validating it on the remaining subset. This process is repeated k times, and the results are averaged to provide an overall measure of model performance. Table 6 presents the robustness test results, specifically the sensitivity analysis conducted by excluding one variable at a time.

This analysis examines the impact of each variable on the overall results, ensuring the stability and reliability of the findings. The sensitivity analysis portrayed in table 6 shows that excluding any single variable does not substantially alter the coefficients of the remaining variables. This consistency suggests that the results are robust and not overly dependent on any specific variable.

The results of cross-validation (see table 7) confirm the high predictive accuracy of the machine learning models. The random forest model achieved a mean R-squared value of 0.81, and the boosting machine model performed similarly, with a mean R-squared value of 0.79. Both models demonstrated low mean absolute errors and root mean squared errors, further validating their reliability. The robustness checks and cross-validation results align with the entirety of the work presented in this article, which speaks to the validity of the findings.

Table 6
Sensitivity analysis results (excluding one variable at a time)

Variable excluded	Access to finance	Regulatory environment	Technological infrastructure	Education levels	Market size	Trade openness	Per capita GDP	Inflation rates	Political stability	Corruption index
None (original model)	0.302	0.287	0.215	0.269	0.198	0.241	0.152	-0.076	0.208	-0.179
Access to finance	…	0.292	0.218	0.271	0.199	0.243	0.156	-0.074	0.209	-0.178
Regulatory environment	0.298	…	0.22	0.267	0.2	0.24	0.149	-0.078	0.207	-0.177
Technological infrastructure	0.304	0.285	…	0.265	0.195	0.238	0.154	-0.077	0.206	-0.176
Education levels	0.305	0.29	0.217	…	0.197	0.239	0.153	-0.075	0.205	-0.175
Market size	0.3	0.283	0.216	0.268	…	0.242	0.15	-0.073	0.204	-0.174
Trade openness	0.301	0.288	0.214	0.266	0.194	…	0.151	-0.079	0.203	-0.173
Per capita GDP	0.299	0.284	0.213	0.263	0.196	0.237	…	-0.074	0.202	-0.172
Inflation rates	0.306	0.286	0.212	0.262	0.195	0.236	0.157	…	0.201	-0.171
Political stability	0.308	0.289	0.211	0.26	0.193	0.235	0.155	-0.07	…	-0.17
Corruption index	0.307	0.288	0.21	0.259	0.191	0.234	0.153	-0.068	0.2	…

Source: Prepared by the authors.

Table 7
Cross-validation results

Model	Mean R-squared	Mean absolute error	Root mean squared error
Random forest	0.81	1.26	1.70
Gradient boosting machine	0.79	1.30	1.74

Source: Prepared by the authors.

The sensitivity analysis indicates that the key drivers of SME innovation and competitiveness, such as access to finance, the regulatory environment and technological infrastructure, remain significant even when other variables are excluded. The high predictive accuracy of the random forest and gradient boosting machine models, demonstrated through cross-validation, confirms the robustness of the machine learning approach taken. The model's ability to explain a substantial portion of the variance in SME innovation and competitiveness underscores the importance of the key drivers identified.

VII. Concluding remarks

The findings of this study have significant implications for both theory and practice, providing valuable insights into the key drivers of SME innovation and competitiveness in Latin America and the Caribbean. The positive and significant impact of access to finance on SME innovation, as supported by hypothesis 1, reinforces Schumpeter's theory of innovation, which emphasizes the critical role of financial resources in enabling entrepreneurial activities and market disruptions (Śledzik, 2013; Altman and Sabato, 2023). This finding aligns with existing literature that underscores the importance of financial markets in fostering innovation within SMEs.

The confirmation of hypothesis 2 —that a supportive regulatory environment enhances SME competitiveness— supports Porter's diamond model, which highlights the importance of government policies in creating a conducive business environment (Ketels, 2006). This result is consistent with the work of Phillips et al. (2024), who argue that stable and predictable regulations reduce barriers and encourage investment in innovation.

The positive relationship between technological infrastructure and SME innovation, as validated by hypothesis 3, resonates with Rogers's diffusion of innovations theory and emphasizes the role of technological resources in facilitating the spread of new ideas and practices (Rogers et al., 2014; Viglioni et al., 2020). The availability of advanced digital tools, broadband penetration and cloud services has emerged as one of the top three predictors in the random forest model (variable importance score = 0.178), which reflects its central role in enabling innovation diffusion.

The significant influence of political stability and low corruption levels on SME innovation and competitiveness, supporting hypothesis 4, further extends Porter's framework by demonstrating the importance of a transparent, predictable and secure institutional setting. Countries with lower corruption and stable governance showed significantly higher innovation outputs ($\beta = 0.208$), while corruption had a strong negative coefficient ($\beta = -0.179$), pointing to its systemic drag on competitiveness.

1. Policy recommendations

Expand SME access to tailored financial instruments.[3] Governments and financial institutions should collaborate to design credit mechanisms, innovation funds and loan guarantees specifically

[3] Rooted in fixed effects model: $\beta = 0.302$; random forest top predictor: 0.217.

targeting SMEs. Public-private innovation grants and simplified collateral processes can address one of the most consistent barriers to SME innovation across Latin America and the Caribbean. These financial reforms must also prioritize inclusivity by supporting both formal and informal enterprises.

Institutionalize regulatory simplification with innovation incentives.[4]Rather than focusing on broad deregulation, reforms should focus on predictable timelines, digital filing systems and sector-specific licensing relief schemes. Linking regulatory compliance with tax credits for R&D or digital transformation initiatives can transform bureaucratic bottlenecks into channels for structured innovation.

Invest strategically in technological infrastructure for SMEs.[5] Broadband access, cloud computing subsidies and national SME digitalization platforms are critical enablers. Public investment in information and communications technologies hubs and data centres in secondary cities can decentralize innovation beyond metropolitan capitals and foster inclusive technology adoption across sectors.

Design resilience-building programmes in high-volatility economies.[6] SMEs in countries such as Argentina, the Bolivarian Republic of Venezuela and Honduras face systemic uncertainty. Policies must account for this by offering adaptive toolkits including, for example, mobile financing, regional market entry assistance or informal sector bridges. Future policy should also support knowledge-sharing networks wherein SMEs can exchange successful resilience strategies.

Prioritize anti-corruption mechanisms in innovation programmes.[7] Innovation grants, procurement incentives and public R&D investments should include transparency benchmarks. Anti-corruption audits tied to public funding eligibility can help to channel support towards high-potential SMEs while reinforcing institutional trust.

Build national SME innovation observatories. Establishing centralized platforms to monitor SME innovation metrics, collect real-time data and track the effectiveness of measures would allow governments to continuously improve SME policy results and reduce information asymmetry between the State and entrepreneurs, by supporting continuous feedback and dynamic policy adjustment.

2. Discussion

A critical contextual factor influencing SME innovation in Latin America and the Caribbean is the political culture, which includes the degree of institutional trust, bureaucratic rigidity and the prevalence of informal governance practices. In countries experiencing prolonged political instability —such as the Bolivarian Republic of Venezuela or Nicaragua— SMEs often operate under highly unpredictable regulatory conditions. Frequent policy reversals, limited rule of law and politicized access to public services can deter long-term investments in innovation.

Similarly, in Argentina, macroeconomic volatility and recurring debt crises have produced a culture of short-termism in business, in which SMEs tend to prioritize survival over strategic innovation. In these environments, innovation is less about formal R&D and more about adaptive practices —what some scholars term "resilience innovation"— with firms continuously adjusting their operations to unstable conditions.

SMEs in politically unstable environments develop resilience through informal networks, diversification strategies and regional partnerships. For instance, Honduran SMEs in the agri-export sector have increasingly relied on cross-border collaboration to offset domestic governance failures, while others shift towards informal employment or mobile capital to avoid local risks.

[4] Rooted in fixed effects model: $\beta = 0.287$; importance score: 0.204.

[5] Machine learning score = 0.178; aligns with Rogers's theory.

[6] This recommendation is linked to qualitative insights on resilience and innovation under instability.

[7] Corruption index: negative $\beta = -0.179$.

3. Limitations and future research

While this study provides valuable insights, it has several limitations. The reliance on secondary data limits the ability to capture all nuanced factors influencing SME innovation and competitiveness. In addition, its focus on the Latin American and Caribbean region means that it may not be possible to generalize the findings to other regions.

A notable limitation is the absence of qualitative data —such as interviews or case studies— that could reveal firm-level resilience strategies, innovation cultures or governance workarounds that are not visible in macrolevel data. Including in-depth case studies from countries like Argentina or Honduras could enhance understanding of how SMEs navigate volatility and institutional fragility.

Future research should also examine how political and cultural factors mediate innovation capacity. For example, informality, trust in institutions and leadership norms likely influence how innovation unfolds at the enterprise level across the subregions of Latin America and the Caribbean.

Longitudinal studies incorporating primary data collection could provide deeper insights into the dynamic nature of SME innovation and competitiveness. Combining quantitative and qualitative methods would yield a more holistic view of the mechanisms driving innovation under complex political and economic conditions.

Bibliography

Altman, E. I. and Sabato, G. (2023). *The Role of capital Markets in Funding MSMEs in Latin America and the Caribbean*. Inter-American Development Bank. http://dx.doi.org/10.18235/0005188

Bakan, I. and Doğan, İ. F. (2012). Competitiveness of the industries based on the Porter's diamond model: an empirical study. *International Journal of Research and Reviews in Applied Sciences, 11*(3). Academic Research Publishing Agency.

Bell, A. and Jones, K. (2015). Explaining fixed effects: random effects modeling of time-series cross-sectional and panel data. *Political Science Research and Methods, 3*(1). https://doi.org/10.1017/psrm.2014.7

Chen, J., Zhu, Z. and Zhang, Y. (2017). A study of factors influencing disruptive innovation in Chinese SMEs. *Asian Journal of Technology Innovation, 25*(1). https://doi.org/10.1080/19761597.2017.1302552

Chung, L. and Tan, K. H. (2017). The unique Chinese innovation pathways: lessons from Chinese small and medium sized manufacturing firms. *International Journal of Production Economics, 190*. https://doi.org/10.1016/j.ijpe.2016.09.004

Diawati, P., Muhamad, L. F., Permana, R. M. and Suparwata, D. O. (2024). Innovative strategies of SMEs in alignment with community needs. *Jurnal Terobosan Peduli Masyarakat (TIRAKAT), 1*(1). https://doi.org/10.61100/j.tirakat.v1i1.103

Díaz, J. (2024). Monitoring May 2024 solar and geomagnetic storm using broadband seismometers. *Scientific Reports, 14*. https://doi.org/10.1038/s41598-024-81079-6

Gazé Holguin, T., Miguez, T., Hasenclever, L. and Freitas, F. (2023). Gross fixed capital formation in the Brazilian health sector: methodology and results for 2010–2019. *CEPAL Review* (140) (LC/PUB.2023/15-P). Economic Commission for Latin America and the Caribbean.

Hoang, C. C. and Ngoc, B. H. (2019). The relationship between innovation capability and firm's performance in electronic companies, Vietnam. *Journal of Asian Finance, Economics and Business, 6*(3). https://doi.org/10.13106/jafeb.2019.vol6.no3.295

Kaczmarek, J. (2022). The stance, factors, and composition of competitiveness of SMEs in Poland. *Sustainability, 14*(3). https://doi.org/10.3390/su14031788

Kaminski, J. (2011). Diffusion of innovation theory. *Canadian Journal of Nursing Informatics, 6*(2). https://cjni.net/journal/?p=1444

Katz, J. (2023). Where next for Latin America? The two faces of the new Latin American capitalism. *CEPAL Review* (140) (LC/PUB.2023/15-P). Economic Commission for Latin America and the Caribbean.

Ketels, C. H. M. (2006). Michael Porter's competitiveness framework—recent learnings and new research priorities. *Journal of Industry, Competition and Trade, 6*. https://doi.org/10.1007/s10842-006-9474-7

Marullo, C., Shapira, P. and Di Minin, A. (2024). Enhancing SME innovation across European regions: success factors in EU-funded open innovation networks. *Technological Forecasting and Social Change, 201*. https://doi.org/10.1016/j.techfore.2024.123207

McManus, P. (2015). *Introduction to regression models for panel data analysis* [Presentation]. Indiana University Workshop in Methods, Bloomington. https://scholarworks.iu.edu/iuswrrest/api/core/bitstreams/336d2421-ec53-4c7c-b629-3376978be2cd/content

Natekin, A. and Knoll, A. (2013). Gradient boosting machines, a tutorial. *Frontiers in Neurorobotics, 7*. https://doi.org/10.3389/fnbot.2013.00021

Özgen, A., Tuzkaya, G., Tuzkaya, U. R. and Özgen, D. (2011). A multi-criteria decision making approach for machine tool selection problem in a fuzzy environment. *International Journal of Computational Intelligence Systems, 4*. https://doi.org/10.2991/ijcis.2011.4.4.3

Phillips, P. A., Bianchi, C., Brenes, E. R., Mountinho, L. and Salhi, S. (2024). Latin America and the Caribbean economy: a growth agenda. *Journal of Business Research, 175*. https://doi.org/10.1016/j.jbusres.2024.114571

Piore, M. J. (2007). *A Critical View of Schumpeter's 'Theory' of Innovation* [Presentation]. Conference on Capitalism and Entrepreneurship, Ithaca. https://economics.mit.edu/sites/default/files/inline-files/Critical-View-of-Schumpeters-Theory-of-Innovation-.pdf

Rigatti, S. J. (2017). Random forest. *Journal of Insurance Medicine, 47*(1). https://doi.org/10.17849/insm-47-01-31-39.1

Rogers, E. M., Singhal, A. and Quinlan, M. M. (2014). Diffusion of innovations. In D. W. Stacks and M. B. Salwen (Eds.), *An Integrated Approach to Communication Theory and Research*. https://doi.org/10.4324/9780203887011

Sharif, S. M. F., Wang, W., Yang, N., Alghamdi, O., Kanwal, F. and Gebremariam, M. G. (2024). Sustaining SME agility through knowledge coupling, business process digitization, and innovation during crisis. *Journal of Engineering and Technology Management, 71*. https://doi.org/10.1016/j.jengtecman.2024.101802

Sharma, N. (2014). Determinants of innovation: a study of SMEs in India. *World SME News*. http://dx.doi.org/10.2139/ssrn.2391929

Sikka, P. (1999). Technological innovations by SME's in India. *Technovation, 19*(5). https://doi.org/10.1016/S0166-4972(98)00126-6

Śledzik, K. (2013). Schumpeter's view on innovation and entrepreneurship. In S. Hittmár (Ed.), *Management Trends in Theory and Practice: Scientific Papers*. University of Zilina.

Spinola, D. (2023). Instability constraints and development traps: an empirical analysis of growth cycles and economic volatility in Latin America. *CEPAL Review* (139) (LC/PUB.2023/4-P). Economic Commission for Latin America and the Caribbean.

Viglioni, M. T. D., de Brito, M. J. and Calegario, C. L. L. (2020). Innovation and R&D in Latin America and the Caribbean countries: a systematic literature review. *Scientometrics, 125*. https://doi.org/10.1007/s11192-020-03714-z

Kaldor meets Dosi: an approach to the technological structure of regional production

Sérgio Felipe Melo da Silva, Douglas Alcântara Alencar, Wallace Marcelino Pereira and Camila de Moura Vogt

Received: 16/10/2023
Accepted: 19/03/2025

Abstract

This paper proposes a theoretical connection between the ideas of economists Nicholas Kaldor and Giovanni Dosi, based on an analysis of the technological structure of regional output using the input-output methodology created by Wassily Leontief, and applies this connection to the economy of the Brazilian Legal Amazon, specifically the state of Pará. Illustratively, the focus is placed on the mining sector, which accounts for a large share of output in the state. To summarize the findings, applying the Kaldor-Dosi approach made it possible to identify the importance of intersectoral technological diffusion at the international level through global value chains and the effects of these on local economic dynamics. This preliminary application of the Kaldor-Dosi perspective with the aid of the input-output matrix shows that mining is export-oriented and therefore linked to the trajectories of global technologies in the sectors for which it produces inputs.

Keywords

Economists, industrialization, mining industry, industrial development, technological change, input-output analysis, regional economics, Brazil

JEL classification

O14, O33, R11, C67

Authors

Sérgio Felipe Melo da Silva holds a Ph.D. in Economics from the Graduate Programme in Economics of the Institute of Applied Social Sciences at the Federal University of Pará, Brazil. ORCID: 0000-0002-9917-8858. E-mail: sergiofelipems@gmail.com.

Douglas Alcântara Alencar is a full professor on the Graduate Programme in Economics of the Institute of Applied Social Sciences at the Federal University of Pará, Brazil. ORCID: 0000-0002-6077-998X. E-mail: dalencar@ufpa.br.

Wallace Marcelino Pereira is a full professor on the Graduate Programme in Economics of the Institute of Applied Social Sciences at the Federal University of Pará, Brazil. ORCID: 0000-0003-1817-3332. E-mail: wmpereirabr@gmail.com.

Camila de Moura Vogt is a full professor on the Graduate Programme in Economics of the Institute of Applied Social Sciences at the Federal University of Pará, Brazil. ORCID: 0000-0002-5693-9637. E-mail: camilavogt@ufpa.br.

I. Introduction

This study seeks to establish a theoretical connection between the formulations proposed by Kaldor (1966) and Dosi (1984), analysing the technological structure of regional output in the state of Pará in Brazil with the input-output methodology created by Leontief (1936). Illustratively, it focuses on the mining sector, which accounts for a large share of economic output in the state.

According to Santos (2017), the mining economy in Pará has generated processes that have accelerated population growth and urbanization, with the creation of new municipalities and the installation of road, energy and communications infrastructure. The economic dynamics of south-eastern Pará exerted a strong influence on the state's economic performance both in the period from the 1960s to the 1980s, with the implementation of major agribusiness projects and a large wave of migration into the mesoregion, and again from the 1980s, when mining became strongly established. In 2022, according to data from the Brazilian Mining Institute (IBRAM), mining companies in Pará recorded revenues of 92.4 billion reais, second only to Minas Gerais with 100.5 billion reais.

The objective of this paper is to estimate changes in multiplier effects in the Pará industrial sector between 2011 and 2015 by examining the set of industrial activities operating in the state in the first and last year of the period, and to identify indicators for the share of economic output attributable to the iron ore extractive industry in 2015 from a Kaldorian perspective. Thus, the guiding research question of the paper can be expressed as follows: "How did the relative importance and multiplier effects of Pará's industrial sector evolve between 2011 and 2015?"

Observing Brazil's export-oriented vocation, Ferreira and Schneider (2015) point out that the Organisation for Economic Co-operation and Development (OECD) and the World Trade Organization (WTO) began to measure countries' participation in global value chains in 2013, distinguishing between forward and backward linkages. Among the authors' conclusions is that large exporters of mineral products, such as Australia and Brazil, tend to have less foreign content in their exports. Furthermore, in Brazil, the most strongly forward-linked sectors are mining, agriculture, chemicals, and basic minerals and metals.

Araújo, Perobelli and Faria (2021) show that Brazil's participation in global value chains increased between 1990 and 2015 and became more internationally fragmented, with most activity taking place at the global level, although regional integration (with South America) increased by more than global integration. Other developments have included a process of deindustrialization in Brazil over recent decades and the implementation of reindustrialization policies in different countries (Guisan et al., 2017; Przywara, 2017; Maldonado Atencio, 2019; Moczadlo, 2020).

With the approach taken in this paper, economic growth can be understood as a phenomenon that originates in a large but specific sector of the economy. In the case dealt with here, that sector is industry, as conceived by Nicholas Kaldor (and expressed in Kaldor's laws) and subsequent economists. Many later theoretical and empirical developments have been considered in relation to Brazil, for example in Lamonica et al. (2007), Oreiro, Nakabashi and Souza (2010) and Morceiro (2012).

The approach of this paper is similar to that of Romero (2019), who related the Kaldorian and Schumpeterian literatures to create a multisectoral growth model which proved more complete than the Kaldor-Dixon-Thirlwall model, highlighting the importance of demand and supply factors for economic growth. Romero (2021) also summarizes the main ideas of the Schumpeterian macroeconomic approach to economic growth. Similar theoretical or methodological approaches can be found in various studies such as Pan (2006), Grodzicki and Skrzypek (2020), Borghi (2017) and Silva and Hasenclever (2010).

This paper seeks to apply the Kaldorian framework to Brazil, and especially Pará, in respect of the importance of the industrial sector. To this end, it conducts an input-output analysis based on the Pará input-output matrices for 2011 and 2015. The input-output model will serve both to characterize Pará's economy through an analysis of its production structure and, using the techniques that form part of the model, to present evidence of relationships that combine the theories of Kaldor (1966) and Dosi (1984).

The information sources for this paper are the Pará interregional input-output matrices for 2011, prepared by Haddad, Gonçalves Júnior and Oliveira Nascimento (2017), and for 2015, published by the Amazon Development Superintendence (SUDAM). Data from the Brazilian Institute of Geography and Statistics (IBGE), the Annual Industrial Survey (PIA) and the regional accounts are also used, as are the OECD Trade in Value-Added (TiVA) indicators.

The main contribution of this paper is to connect and draw conclusions from elements of distinct theoretical frameworks and to carry out an application using a specific methodological benchmark. Specifically, it connects Kaldor's and Dosi's theories to input-output analysis for the economy of Brazil, a country considered to be undergoing deindustrialization, with a focus on Pará, a state that is outside the dynamic core of that economy, emphasizing an activity of global importance, the iron ore extractive industry.

Following this introduction, section II discusses the theoretical issues surrounding Kaldor's laws and Dosi's paradigms and technological trajectories, connecting them to the importance of industry and technological change within this framework. Section III presents the methodology and the data sources and input-output techniques used. Section IV contains the results and discussions, and section V concludes.

II. Theoretical considerations

1. The Kaldorian approach to economic growth

Kaldor's Keynesian background heavily influenced his work, and in this connection, at least two major phases of his intellectual output can be identified. In the first, Kaldor was concerned with solving problems strictly related to Keynes' ideas, stating (Kaldor, 1957) that the ultimate objective of economic growth theory should be to show the nature of the non-economic variables associated with economic growth.

The start of the second major phase of Kaldor's thinking can be dated to his inaugural lecture at Cambridge in 1966 on the causes of the United Kingdom's slow growth rate. As Thirlwall (1983) shows, Kaldor (1966) presented a series of "laws" to explain the differences in growth rates between advanced capitalist countries. He later elaborated on these laws in a lecture at Cornell University (1967). These laws, and their interpretation and validity, have been the subject of considerable scrutiny and debate, and Kaldor himself clarified and modified his position after his initial statement of them.

Kaldor's first law states that there is a strong relationship between manufacturing output growth and GDP growth. Kaldor argued that a rapid rate of economic growth was associated with a rapid rate of growth in the manufacturing sector, which in turn was a feature of the transition from "immaturity" to "maturity". "Immaturity" is defined as a situation in which productivity is lower outside industry (particularly in agriculture), so that labour is available for use in industry in practically unlimited quantities (Thirlwall, 1983).

Kaldor's second law states that there is a strong positive relationship between the growth rate of manufacturing productivity and the growth of manufacturing output. A Verdoorn-type relationship is also found in construction and utilities.

The primary sector, and specifically agriculture and mining, does not display the same relationship as manufacturing. In both agriculture and mining, productivity growth reflects a large trend component that is independent of total output growth, and the regression coefficient is not significantly different from unity, as Thirlwall's (1983) calculations showed.

In long-run average terms, productivity growth was the dominant contributor to output growth across countries. In the case of transport and communications, Kaldor did not find a correlation between productivity growth and output growth. In trade, there is a high correlation, but the constant term in the equation given by Thirlwall (1983) is negative.

Kaldor's third law states that the stronger the growth of manufacturing output, the higher the rate of transfer of labour from non-manufacturing to manufacturing sectors, so that overall productivity growth is positively related to growth in manufacturing output and employment and negatively associated with the growth of employment outside manufacturing. The implications of this law can be developed into a fourth law, which is that the long-run growth of the economy is constrained not by supply, but by demand.

There are clear affinities between Kaldor's ideas and those of Albert Hirschman, who criticized balanced development theorists and advocated a development strategy driven by a sequence of imbalances initiated in specific sectors of the economy, given the effects of existing forms of intersectoral interdependence (Hirschman, 1961).

Along the same lines, Dixon and Thirlwall (1975) argued that differences in regional growth rates could be explained by a Kaldorian model, with demand growth driving productivity and so creating virtuous or vicious circles that reinforced regional inequalities. This argument was advanced by Kaldor (1970), who advocated regional policies to correct structural disparities, since more developed regions tended to grow faster because of accumulated learning advantages and economies of scale created by the process of cumulative circular causation.

McCombie (1988) complements this view by contrasting the neoclassical and post-Keynesian theories of regional growth, highlighting the way the neoclassical approach, based on long-term convergence, ignores dynamic constraints associated with effective demand and structural imbalances. Conversely, the post-Keynesian perspective suggests that productive specialization and balance-of-payments constraints are determining factors in the growth trajectory of a region, aligning with Thirlwall (2007), who argues that regional problems are essentially balance-of-payments problems. This means that the growth of a region depends on its export capacity and the income elasticity of its imports, suggesting that industrial and innovation policies are essential to reverse low-growth trajectories and promote structural changes favourable to regional development.

2. Paradigms and technological trajectories in Giovanni Dosi

Giovanni Dosi approaches Kaldor's conception by a different path. For Dosi (1984), the economic system constitutes a complex environment in which change and transformation arise from the interaction of its constituent parts and partially exogenous variables, with two variables being of paramount importance: the evolution of the technological system and the system of social relations in a broad sense. From a Schumpeterian perspective, Dosi devotes his theoretical efforts to the former and develops a theoretical framework that is widely recognized for highlighting the role of technical change in the economy.

Thus, Dosi (1984) proposes the concept of a technological paradigm, defined as a model or pattern for solving selected technological problems on the basis of certain principles derived from the natural sciences and specific material technologies. The notion of a technological paradigm is Dosi's analogy to Thomas Kuhn's concept of a scientific paradigm, found in his work *The Structure of Scientific Revolutions* (Kuhn, 1962).

Dosi also discusses the transmission mechanisms for technical change and the relationship with macroeconomic transformation, which occurs through diffusion. He notes that the effects of technical change spread across economic sectors (and especially industries) because of the input-output relationships between them, with the discussion being tantamount to an analysis of technological and economic variables that lead to a specific configuration of inputs and outputs (Dosi, 1984, p. 395).

Input-output analysis represents the bridge linking the microeconomic level at which research is conducted to macroeconomic trends (Dosi, 1984, p. 396). In other words, the spread of technological innovations is intrinsically linked to interindustrial relationships, which can be analysed through input-output matrices.

According to Dosi (1984), diffusion may result from the expansion of innovative firms or imitation by competitors, and may be driven by production, when associated with innovations and incremental improvements, or by demand, when minor or major modifications occur in processes or products. For this author, if the interrelationships between producers and users are important in stimulating fresh innovations, then there is a clear "dynamic circle" of positive feedback. Thus, it can be seen that there is a mechanism which determines the degree of sophistication and innovation of industrial production in the economy.

Many aspects of Dosi's thinking were discussed by the economist Carlota Pérez. For Pérez (2010), a technological paradigm, in Dosi's sense, is a collectively shared logic in which technological potential, relative costs, market acceptance, functional coherence and other factors converge. The techno-economic paradigm, a concept introduced by Pérez (1985), is a model of best practices that guides the direction of innovation over time, emerging from experience with new technologies and establishing the most efficient and profitable way to use them. This paradigm identifies a predictable pattern of relative costs and productive organization, functioning as a "golden rule" for investments and technological development. According to Pérez (2001), it combines technical and organizational models to maximize the potential of technological revolutions and provides a new set of "common-sense" principles that guide the decision-making of economic agents. Furthermore, as Pérez (1992) explains, technical change is a continuous process in the economic system, occurring both through incremental innovations that improve products and processes and through radical innovations that create new industries and revolutionize entire technological systems.

3. The Kaldor-Dosi approach

An analytical approach that consists in connecting the theoretical frameworks of Kaldor (Kaldor's laws) and Dosi (technological paradigms and trajectories) will now be proposed as a way to create a single perspective capable of explaining a greater number of phenomena than if each approach were applied individually. In this proposed Kaldor-Dosi approach, the elements cited by Kaldor, especially the Kaldor-Verdoorn effect and the idea of cumulative circular causation generated by manufacturing, are conjoined with Dosi's ideas about market direction, whereby technological paradigms create technological trajectories. Table 1 synthesizes the main parameters of this approach.

Table 1
The Kaldor-Dosi approach: analytical uses

1.	Identifies whether an economic activity is capable of generating circular causation in the local economy.
2.	Identifies whether the most dynamic economic activity is a sector of manufacturing industry.
3.	Identifies which technological paradigm drives economic activity.
4.	Identifies whether the technological paradigm around which economic activity is oriented is able to foster diffusion of innovations internally.

Source: Prepared by the authors.

As shown in table 1, it is possible to combine Kaldor's and Dosi's perspectives to create a unified approach that can explain the level of economic growth in a country or region. By combining analysis from the macro- and microeconomic perspectives, this approach serves to identify distinct economic forces acting on the same environment that either reinforce one another or cancel out.

Table 2 identifies transmission channels that reflect the combined effects of Kaldor's laws and Dosi's paradigms and technological trajectories. The intersectoral supply and demand pattern illustrates the type of product bundle that needs to be consumed for an activity to operate, and thus the extent to which it can foster new production technologies and internalize the effects of cumulative circular causation, where the origin of the products allows. This is the link to the second transmission channel: the level of connection between the activity and the local economy, which depends on where its multiplier effects are distributed. The level of connection with the international economy determines how much the demand for and supply of activities influence and are influenced by the world economy.

Table 2
The Kaldor-Dosi approach: transmission channels

1.	Level of intersectoral supply of and demand for an activity.
2.	Level of intersectoral connection with the local economy.
3.	Level of intersectoral connection with the international economy.
4.	Level of productive density.
5.	Changes in multiplier effects.

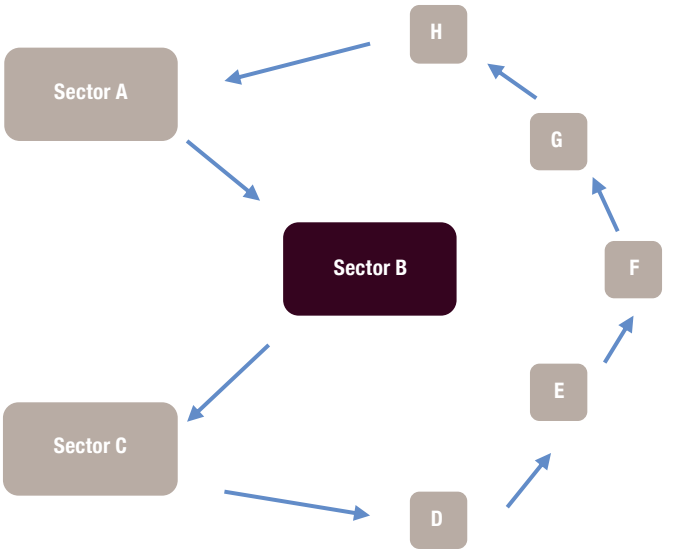
Source: Prepared by the authors.

The level of productive densification of an activity shows the extent to which it has been able to contribute to the creation of new links in production chains. Lastly, changes in the activity's multiplier effects over time show how effectively it has improved its capacity to generate cumulative circular causation.

In this context, there are three distinct transmission pathways for the effects of diffusion and cumulative circular causation, considering input-output relationships: local, national and international production chains. Even when all these intersectoral transmission pathways exist, the potential to internalize new technologies and activate new productive activities in the location of interest is ultimately reduced when international and national pathways predominate.

Diagram 1 illustrates how technology is propagated along the different sectoral pathways of the economy. The technology introduction sector (B) is the starting point where technological innovation is first introduced. The arrows connecting this sector with other adjacent sectors indicate the relationship between the sale of goods and services and the direct propagation of technology immediately affecting these sectors. The arrows connecting the directly affected sectors (A and C) with other sectors (D, E, F, G, and H) represent the indirect propagation of technology. This demonstrates how innovation spreads through economic interconnections, influencing multiple sectors along the way.

Diagram 1
Propagation of technology through sectoral linkages



Source: Prepared by the authors.

Input-output matrices capture relationships of interdependence between economic sectors, such that when a sector incorporates a new technology, there is an increase in demand for related inputs. This additional demand, in turn, stimulates production in other sectors, creating a multiplier effect that spreads throughout the economy. Furthermore, input-output matrices make it possible to distinguish between direct and indirect effects. The direct effect occurs in the sector that adopted the technology, while the indirect effects are transmitted to other sectors through production chains. This reflects the complex nature of technological diffusion and propagation in the economy.

The global fragmentation of production works in just this way, distributing technological and productive advances worldwide, but favouring the locations where technologies are developed (since it is there that externalities linked to the production of applied technological knowledge are concentrated) and where the most complex phases of industrial production are sited.

The approach described brings out the importance of having local technological paradigms strong enough to accelerate the effects of cumulative circular causation and thence structural change. The mobilization of institutional forces, including local production sectors, can be decisive in ensuring that the paradigms implemented have a configuration consistent with the economic, environmental, demographic, cultural and other characteristics of the location of interest.

Dosi, Roventini and Russo (2019) corroborate the argument for a theoretical relationship between the Kaldor and Dosi approaches when discussing endogenous growth and global divergence in an agent-based multi-country model. The authors argue that each of the countries they analyse has a Schumpeterian engine of endogenous technical change that interacts with mechanisms of Keynesian or Kaldorian demand generation, so that it undergoes a structural transformation of its production system during the development process.

III. Methodology

Miller and Blair (2009) show that, in its most basic form, an input-output model consists of a system of linear equations, each of which describes the distribution of an industry's output throughout the economy. Leontief's basic input-output model is generally constructed from observed economic data for a specific geographical region (country, state, county, etc.). The present analysis aims to examine the activity of a group of industries that both produce goods (outputs) and consume goods from other industries (inputs) in the process of producing their own outputs.

In the model, the economy is categorized into n sectors. Let x_i denote the total output of sector i and f_i the total final demand for sector i's output. A simple equation can then be written to explain how sector i distributes its products, which are divided between sales to other sectors and final demand, as equation (1) shows:

$$x_i = z_{ij} + ... + z_{ij} + ... + z_{in} + f_i = \sum_{j=1}^{n} z_{ij} \quad (1)$$

Selling sectors supply inputs for the output of buying sectors. Sellers also supply goods and services for final demand, represented by household and government consumption, investment and exports. Buying sectors, for their part, pay taxes and add value through wages and profits in the process of producing goods and services, while also importing.

The input-output matrix allows us to establish the technical coefficients of production, calculated as the ratio of each sector's total intermediate input purchases to its gross output. Knowledge of these coefficients makes it possible to ascertain the origin of each sector's inputs and thence its cost structure.

The matrix of direct and indirect technical coefficients or total requirements matrix, also known as the Leontief inverse matrix, is represented by $(I–A)^{-1}$ and captures all effects on the entire production process of the economy from a quantitative change in any component of final demand.

Two important analytical tools of the input-output model originate from intermediate demand:

(i) The matrix of direct coefficients (matrix A): this shows each sector's relationship with total output. Mathematically, each element of the matrix is given by equation (2):

$$a_{ij} = \frac{x_{ij}}{X_{ij}} \quad (2)$$

where each element a_{ij} represents the relationship of each sector (x_{ij}) with total output (X_{ij}). In matrix form, equation 3 is obtained.

$$A = [a_{ij}] \quad (3)$$

(ii) The matrix of direct and indirect technical coefficients, also called the total requirements matrix: this indicates the total repercussions in all economic sectors of a change in any component of final demand. It is obtained by inverting the matrix resulting from the difference between an identity matrix I and matrix A. It may be denoted matrix B and represented by equation 4.

$$B = [I - A]^{-1} \quad (4)$$

From matrix B it is possible to capture the direct and indirect effects on output X of a change in final demand Y, leading to equation 5.

$$\Delta X = [I - A]^{-1} \Delta Y \quad (5)$$

In addition, the output multiplier for each economic activity is defined as the total value of output in all activities of the economy that is required to satisfy one monetary unit of final demand for that activity. The initial output effect on the economy is defined as only the initial monetary value of that activity's output necessary to meet that additional unit of final demand. Thus, formally, the output multiplier is the ratio between the total (direct and indirect) effect and the initial effect. Income and employment multipliers capture the wider economic impacts of new final demand, such as jobs created and increases in household income and value added. Multipliers can be calculated according to equation (6):

$$GV_j = \sum_{i=1}^{n} b_{ij} v_i \tag{6}$$

in which GVj is the total (direct and indirect) impact on the variable concerned, b_{ij} is the ij-th element of the Leontief inverse matrix and v_i is the direct coefficient of the variable concerned.

Leontief's classic approach assumes a fixed production structure in which the relationships between sectors are described by constant technical coefficients. This means that the multipliers reflect the economy's response to a demand shock, but take no account of dynamic adjustments over time. In this article, however, two points in time are taken to increase the explanatory power of multiplier effects in temporally distinct production structures.

The output multiplier in the input-output model is based on assumptions such as fixed proportionality between inputs and output, constant prices and the absence of financial or productive constraints in the short term. The matrix of technical coefficients is treated as stable, implying that an increase in final demand generates a proportional increase in output. In practice, however, demand expansion may face constraints such as limited production capacity, input and labour shortages, inflationary impacts and external constraints.

This study applies an interregional model, in which transactions are distributed across more than one region, following the procedure used by Guilhoto (2011) and Miller and Blair (2009). Table 3 presents this configuration with a two-region model in which the block of intersectoral transactions and the vectors of final demand are subdivided to reflect interregional flows.

Table 3
Basic model of the interregional input-output matrix

Destination →		Intermediate demand (endogenous)		Final demand (exogenous)		Total demand
Origin ↓		Sectors in region M	Sectors in region E			
Agents	Sectors in region M	Intermediate inputs MM	Intermediate inputs ME	Final demand MM	Final demand ME	M
	Sectors in region E	Intermediate inputs EM	Intermediate inputs EE	Final demand EM	Final demand EE	E
Total demand		(M)	(M)	(M)		(M)
Net indirect taxes (NIT)		(NIT)	(NIT)	(NIT)		(NIT)
Value added (VA)		VA	VA			
Gross value of total output		Region M	Region E			

Source: Prepared by the authors, on the basis of Guilhoto, J. J. M. (2011). *Análise de insumo-produto: teoria e fundamentos*. https://mpra.ub.uni-muenchen.de/32566/.

For this purpose, participation indicators derived from the intraregional output block for Pará are used to assess the contribution of the sector of interest to total output. The following indicators are calculated:

- Intermediate purchase coefficient: the ratio between the total intersectoral purchases of each economic activity in the input-output matrix and its gross output;
- Intermediate sales coefficient: the ratio between the total intersectoral sales of each economic activity in the input-output matrix and its total demand;
- Import coefficient: the ratio between the total imports of each economic activity in the input-output matrix and its gross output;
- Export coefficient: the ratio between the total exports of each economic activity in the input-output matrix and its total demand.

The first part of the results section that follows looks at the participation indicators for the 67 economic activities in Pará as of 2015, while the second section analyses the multiplier effects of the same activities, comparing the years 2011 and 2015.

IV. Results and discussion

1. Analysis of mining industry participation in 2015

This section presents the results of applying the input-output methodology to support the theoretical discussion in section II. Table 4 synthesizes Pará's 2015 interregional input-output matrix with aggregate values for intra- and interregional output, imports and exports.

Table 4
Pará: summary interregional input-output matrix, 2015
(Millions of reais)

		Destination			Total
		Pará	Rest of Brazil	Rest of world	
Origin	Pará	135 900.61	34 249.44	28 515.41	198 665.47
	Rest of Brazil	74 453.72	9 235 326.83	738 516.58	10 048 297.13
	Rest of world	15 292.44	826 327.04	0.00	841 619.48
Total		**225 646.76**	**10 095 903.32**	**767 032.00**	**11 088 582.07**

Source: Amazon Development Superintendence. (2022). Matriz interestadual de insumo-produto para o Estado do Pará 2015. In E. A. Haddad (Coord.), *Matrizes de Insumo-Produto da Amazônia Legal, 2019*. Institute of Economic Research Foundation. https://www.gov.br/sudam/pt-br/central-de-conteudo/mip.

The data in the table show that Pará's economy has a strong trading relationship with the rest of Brazil when it comes to purchases of goods and services, and with the rest of the world when it comes to exports. Even so, the state's internal trade outweighs its trade with both combined.

The following charts use intermediate and foreign trade ratios to detail these flows. Figure 1, based on matrix A, presents the ratios of intermediate purchases by the different sectors in Pará, meaning the extent to which they purchase goods and services from one another. It can be seen that sectors 8, 10 and 20 have the highest demand for goods and services from the state's own economy.

An understanding of the matrix elements helps confirm that, as Dosi (1984) discusses, the effects of technical change are not restricted to a single industrial branch. The dynamics of each branch influence and are influenced by patterns of change in other branches through the interindustrial spread of innovations. Figure 1 shows that the iron ore mining industry (sector 6) has an intermediate purchase ratio of 20.2%, compared to the cross-sector average of 21.6%: a relatively low value for an industrial sector that acquires a considerable range of inputs in order to produce.

Figure 2 follows the same logic as figure 1, but this time measuring the ratio between each sector's imports and its gross output and so showing which sectors' final products have the largest import shares. In this case, the average is 6.1% for all sectors and 5.3% for the mining industry, which thus falls below the state average. Combining these indicators with the first set provides evidence that there is considerable demand for goods and services from the rest of Brazil in the case of the iron ore extractive industry.

Figure 3 presents intermediate sales ratios for Pará, showing the proportion of sales that takes place between sectors within the state relative to total demand. This makes it possible to identify which sectors are being directly activated by the local economy.

The average intermediate sales ratio is 28.8%, while the iron ore mining industry has a ratio of only 1.3%, showing that its production is not geared toward the local economy. This indicates that technological diffusion effects have not been sufficient to generate dynamic local activities capable of acquiring a significant portion of mining output.

Figure 4 follows the same logic as figure 3, but shows the ratio of Pará's exports to total demand. The average across sectors is 12.8%, while the value observed for the iron ore extractive industry is 87.6%. Kaldor highlights the importance of increasing the technological intensity of the industrial export basket as a means of boosting output and productivity growth, something that is not observed at the local level in the case of iron ore mining, as products are exported in the early phases of industrial processing.

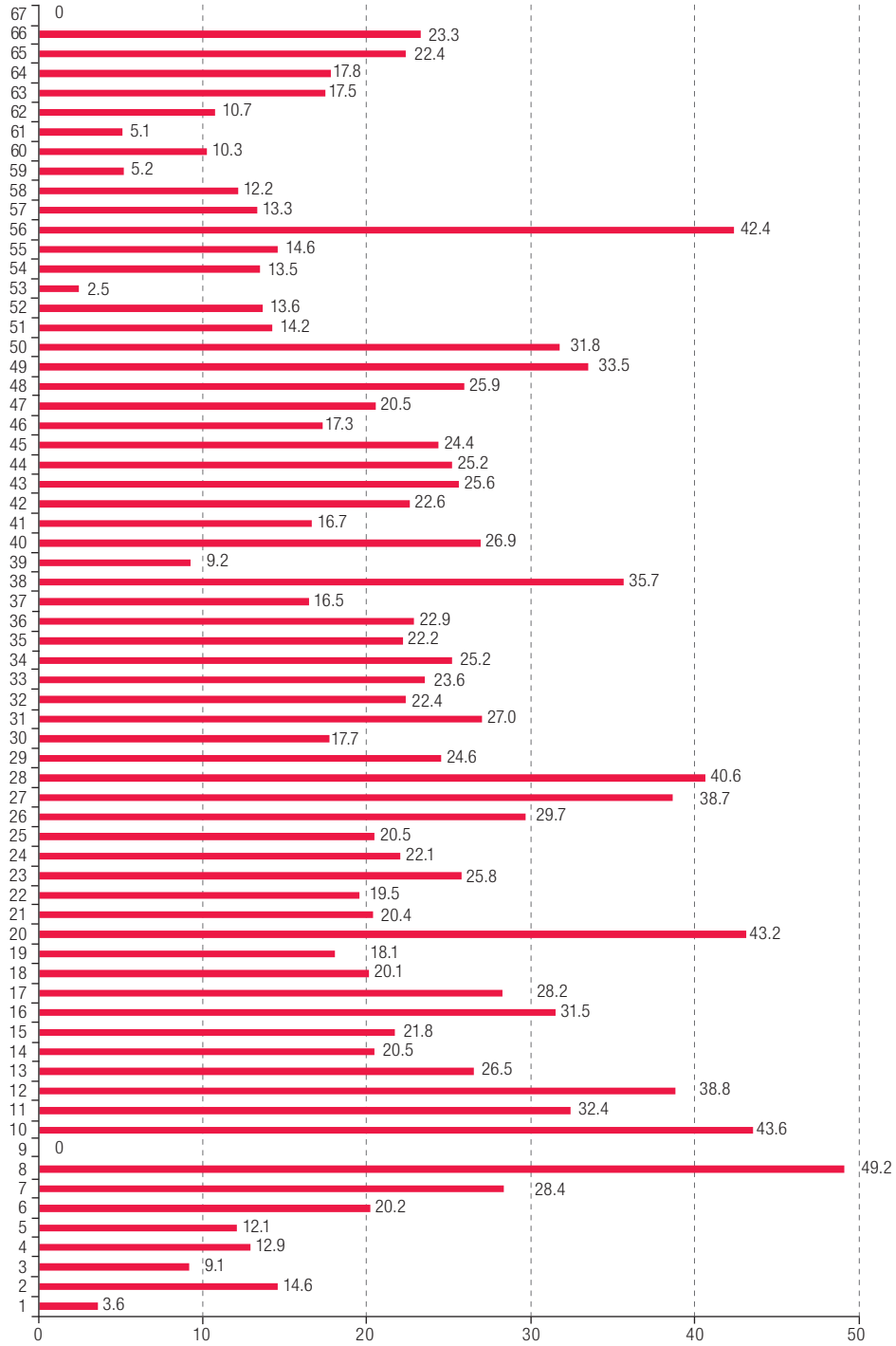
Following Hirschman (1961), it is also evident that the limited activation of intersectoral linkages in the state hampers the formation of new ventures, contributing to lower production density and, consequently, a slower pace of economic activity compared to what the situation would be if mining production were more directly linked to local economic activities.

These results suggest that the technological trajectory and paradigm of mining in Pará are oriented towards global production. Exports are from extractive sectors, and there is thus a lack of local productive-technological densification. Although they are a link in the global industrial chain, the implementation of additional stages within the state would increase the multiplier power of output via the gains identified in Kaldor's laws.

Pérez-Oviedo, Cajas-Guijarro and Vallejo (2018) show that the international trade network underwent significant changes from 1992 to 2014, especially with the consolidation of the United States and China as "global centres". Over the course of those years, conversely, no South American country joined the "core" of the global trade network.

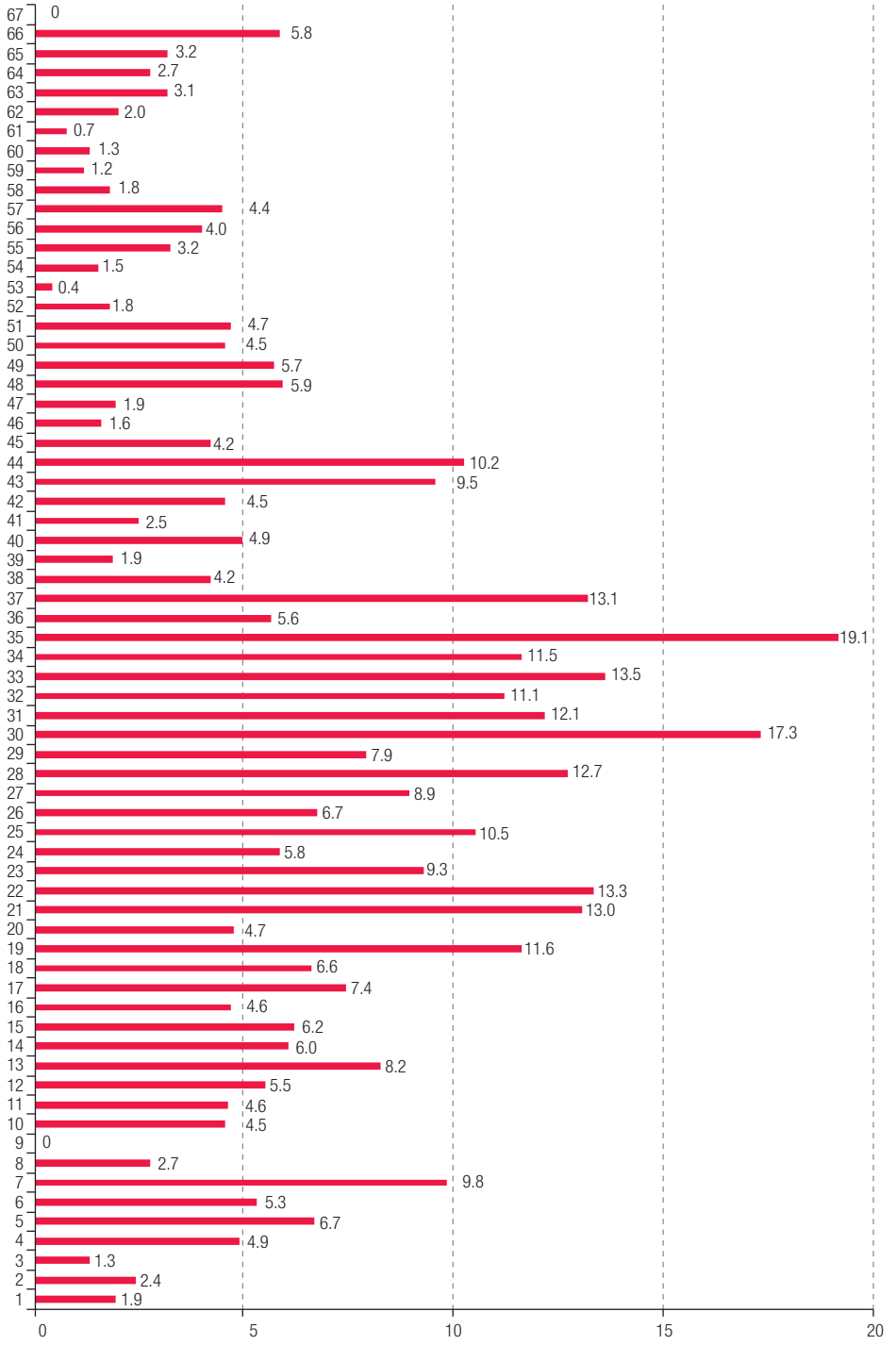
Callegari, Melo and Carvalho (2018) show that Brazil's participation in global value chains is characterized by strong forward linkages, since it is a primary supplier of products, and limited backward linkages, with limited use of imports in exports. The Brazilian economy leverages exports to the rest of the world, especially developed countries, as it is a supplier of low value added, highly competitive goods. The country is not able to use imports to promote the competitive advantage of its own exports.

Figure 1
Pará: intermediate purchase ratios, 2015
(Sectors and percentages)



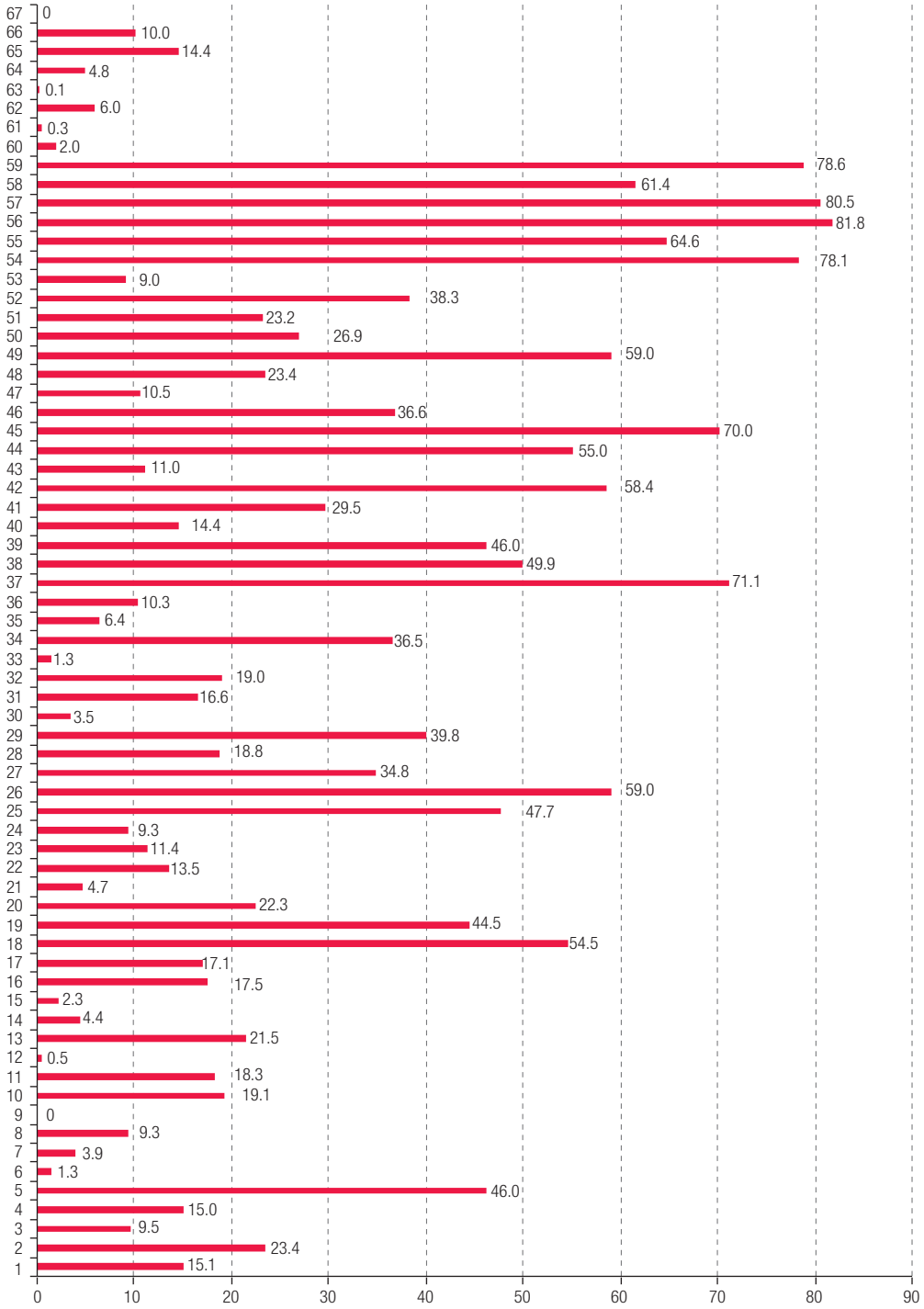
Source: Prepared by the authors, on the basis of Amazon Development Superintendence. (2022). Matriz interestadual de insumo-produto para o Estado do Pará 2015. In E. A. Haddad (Coord.), *Matrizes de Insumo-Produto da Amazônia Legal, 2019*. Institute of Economic Research Foundation. https://www.gov.br/sudam/pt-br/central-de-conteudo/mip.

Figure 2
Pará: import ratios, 2015
(Sectors and percentages)



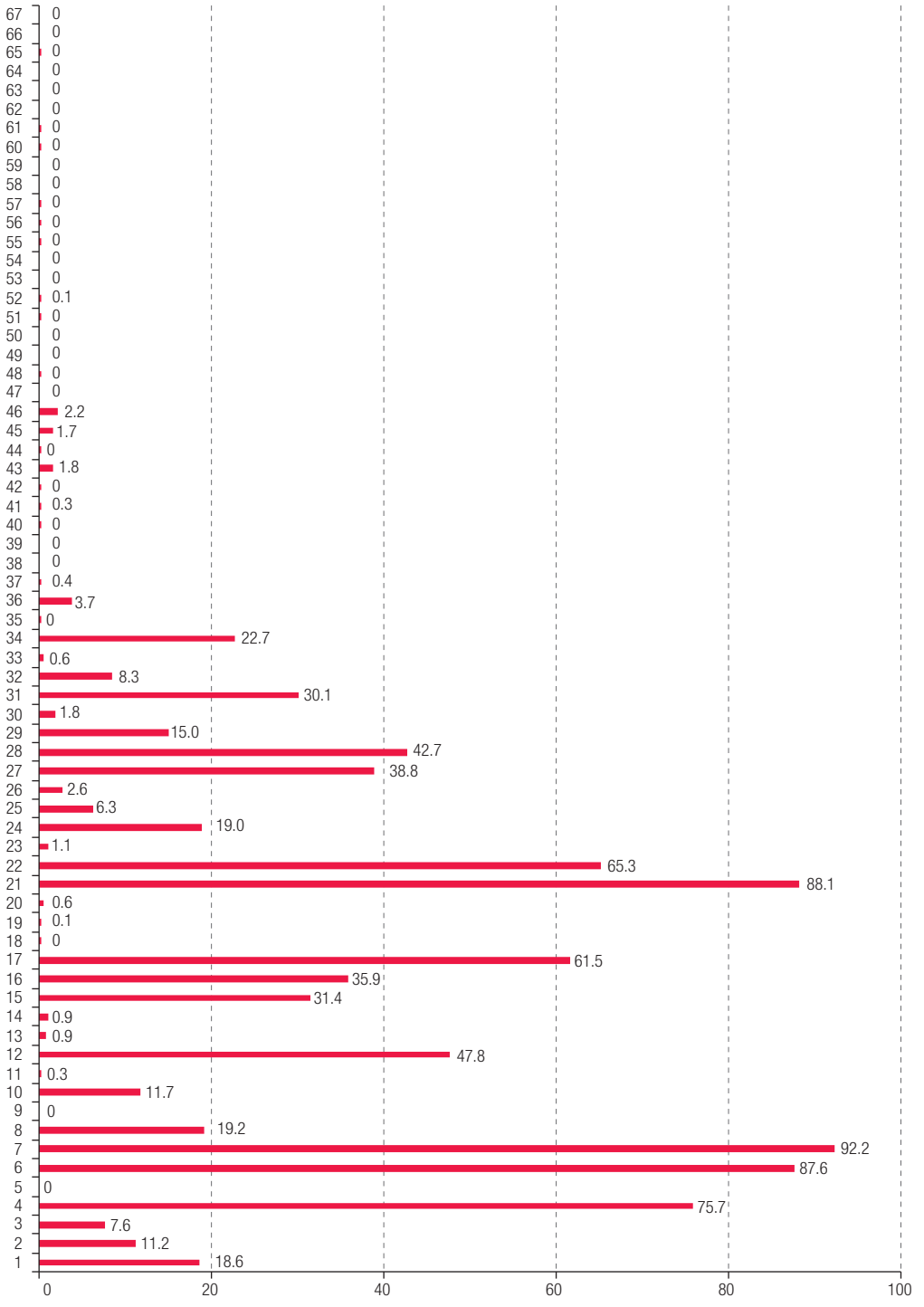
Source: Prepared by the authors, on the basis of Amazon Development Superintendence. (2022). Matriz interestadual de insumo-produto para o Estado do Pará 2015. In E. A. Haddad (Coord.), *Matrizes de Insumo-Produto da Amazônia Legal, 2019*. Institute of Economic Research Foundation. https://www.gov.br/sudam/pt-br/central-de-conteudo/mip.

Figure 3
Pará: intermediate sales ratios, 2015
(Sectors and percentages)



Source: Prepared by the authors, on the basis of Amazon Development Superintendence. (2022). Matriz interestadual de insumo-produto para o Estado do Pará 2015. In E. A. Haddad (Coord.), *Matrizes de Insumo-Produto da Amazônia Legal, 2019*. Institute of Economic Research Foundation. https://www.gov.br/sudam/pt-br/central-de-conteudo/mip.

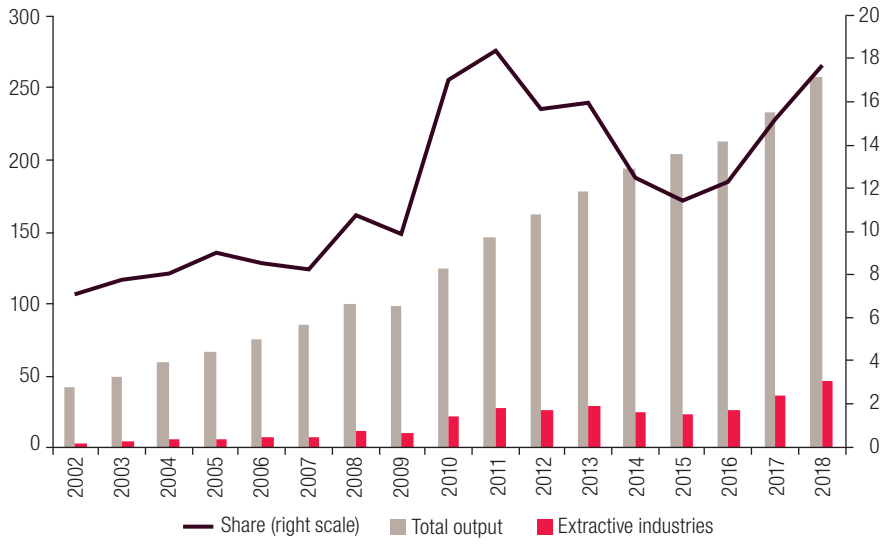
Figure 4
Pará: export ratios, 2015
(Sectors and percentages)



Source: Prepared by the authors, on the basis of Amazon Development Superintendence. (2022). Matriz interestadual de insumo-produto para o Estado do Pará 2015. In E. A. Haddad (Coord.), *Matrizes de Insumo-Produto da Amazônia Legal, 2019*. Institute of Economic Research Foundation. https://www.gov.br/sudam/pt-br/central-de-conteudo/mip.

Figure 5 shows the evolution of the extractive industries' share of Pará's gross output from 2008 to 2018, in current values.

Figure 5
Pará: gross output share of extractive industries, 2002–2018
(Billions of current reais and percentages)



Source: Prepared by the authors, on the basis of Brazilian Institute of Geography and Statistics. (2021). *Sistema de Contas Regionais 2019*. https://www.ibge.gov.br/estatisticas/economicas/contas-nacionais/9054-contas-regionais-do-brasil.html?=&t=publicacoes.

Kaldor's third law refers to the well-known "export-led growth" model; however, the exports concerned are those of manufacturing industry, which benefits from intersectoral linkages and increasing returns to scale. The mining economy, conversely, is a sector that forms part of a global value chain and does not interact in a significant way with others in the local economy.

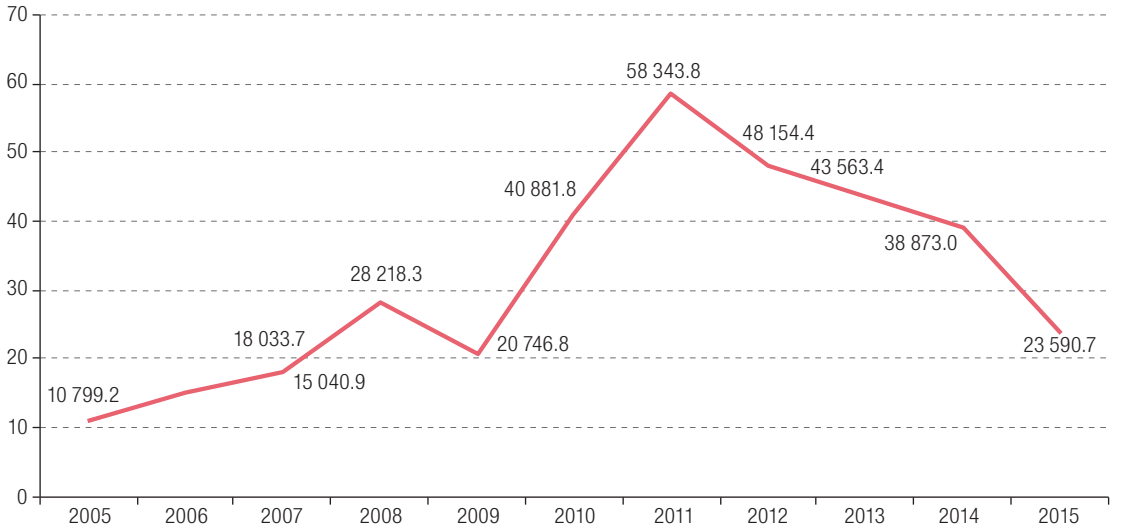
This result is consistent with the analysis of Sanguinet, Alvim and Atienza (2022), who examined the effect of regional trade agreements on the participation of Latin American countries in global value chains between 1995 and 2015. To summarize, they found that, for Latin American exporters, the elasticities of regional trade agreements were more significant for trade that was less intensive in research and development.

This pattern suggests that trade policy might be encouraging the export of inputs with lower technological content and lower levels of value added. Low-complexity industries incorporate little knowledge and technology into global value chains, reducing the opportunities for upgrading and development in the region's countries.

The data in figure 6 come from international input-output matrices and can be taken as indicating the extent of Pará's participation in global value chains, with the OECD TiVA indicators being the main source. Dosi (1984) points out that changes in the economic environment are a permanent feature of the system, and these changes often stimulate straightforward technical progress along a technological trajectory.

Thus, figures 5 and 6 show that mining is subject to its own dynamics and to the economic fluctuations stemming from global developments in the sector, since the state's total gross output value increased throughout the period, whereas there were fluctuations in the gross output of the mining industry. Again, the value added of Brazil's mining industry decreased during the same period in which the gross output of the mining industry in Pará likewise declined.

Figure 6
Brazil: domestic content of value added in mining exports, 2005–2015
(Billions of current reais)



Source: Prepared by the authors on the basis of figures from the Organisation for Economic Co-operation and Development (OECD).

Dosi (1984) explains that certain fundamental forces in capitalist economies (such as liquidity criteria, profitability, efforts to reduce production costs and the search for new markets) act as selection mechanisms between different technological developments. In the production structure of Pará, mining is export-oriented and therefore tied to global technological trajectories in the sectors for which it produces its inputs.

2. Comparative analysis of the multiplier effects of industrial sectors in Pará (2011–2015)

The data for this section are presented in the annex and are simple output multipliers for Pará's industrial sectors, showing the multiplier effect on the sector of interest from final demand shocks that generate direct and indirect repercussions in the economy.

Annex figure A1.1 shows output multipliers for Pará industry in 2011. It can be seen that oil refining and coke (2.578), manufacture of organic and inorganic chemicals (2.422) and slaughter and meat products (2.412) were the sectors that showed the highest output multiplier effects, with indicators close to 2.500. The iron ore extractive sector had the lowest multiplier effects in 2011, with an indicator of 1.206. This is consistent with Kaldor's laws, which do not treat the mining sector as one that generates cumulative circular causation, unlike manufacturing industry.

Annex figure A1.2 presents the output multipliers for Pará's industrial sector in 2015. The results show the oil refining and coke sector (2.471) again topping the ranking. Slaughter and meat products (2.383) and manufacture of organic and inorganic chemicals (2.331) also reappeared.

Although the multipliers for these three sectors were still among the highest, they were lower than formerly. The largest decrease was in the sugar manufacturing and refining sector, whose multiplier fell from 2.066 in 2011 to 1.000 in 2015, meaning that it no longer generated additional effects from an increase in final demand.

In the iron ore extraction sector, the 2015 figure of 2.050 represented a jump of some 70% from 2011. This result indicates a sectoral evolution contrary to what would be expected from Kaldor's laws, with the mining sector apparently increasing its intersectoral linkages with the economy of which it forms part.

Consideration should also be given here to the evidence found by Florensa et al. (2015) that regional and global production networks are present in Latin America. The positive effect of intermediate goods imports from China on trade flows between members of the Latin American Integration Association (LAIA) can be explained by Latin America's trade policy strategy of facilitating access to intermediate goods.

Banacloche et al. (2020) show that the high level of value added embodied in South American exports is not matched by a comparable level of domestic content in imported intermediates, reflecting limited integration into global value chains, with the exception of Uruguay. Although import penetration in South American exports is greater than in the rest of the world, it is still low, suggesting that the region is not fully leveraging imported inputs to improve the quality and variety of its exports.

As seen in the previous point, the intermediate purchase ratio of the mining industry was below the average for other sectors of Pará's economy in 2015 (20.2%), showing that, despite its leading role in output, the sector is not a leader in the diffusion and multiplication of effects in Pará's production structure. Moreover, the intermediate sales ratio of the iron ore extractive sector was considerably below the average in 2015 (1.3%).

The jump in the sector's multiplier effects is explained, then, by rising values for the intermediate purchases indicator in sectors that have a greater multiplier effect in the economy, boosting the indirect effects of the iron ore extractive industry. Thus, it was other sectors that had spread productive multiplication effects through Pará's economy by 2015, as shown in table A1.2.

It should be noted that large-scale mining activity generates major related effects. One example is the impact on municipal revenues, particularly in the areas where projects are located, via contributions from the Financial Compensation for the Exploitation of Mineral Resources (CFEM) fund and the municipalities' share of the tax on the circulation of goods and services (ICMS). According to the National Mining Agency (ANM, 2022), CFEM, established by art. 20, paragraph 1 of Brazil's 1988 constitution, is allocated to states, the Federal District, municipalities and federal government agencies as compensation for the economic use of mineral resources within their jurisdictions.

Through CFEM, part of the impact of mining activities is transferred to public budgets, contributing to broader aspects of economic development. However, these effects are not transmitted to other activities through intersectoral linkages involving purchases and sales. By way of example, in 2022, municipalities in Pará received just over 2 billion reais in CFEM transfers.

V. Conclusions

This paper set out to analyse Pará's economy by making a theoretical connection between the ideas of Nicholas Kaldor and Giovanni Dosi and examining the technological structure of regional output using the input-output methodology created by Wassily Leontief. For illustrative purposes, the focus was placed on the mining sector, which accounts for a large share of the state's economy.

A preliminary application of the Kaldor-Dosi perspective, with the aid of the Leontief input-output matrix, allowed specific conclusions to be drawn about the dynamics of the mining industry in relation to Pará's production structure. The analysis indicates that mining is export-oriented and therefore linked to global technological trajectories in the sectors for which it produces inputs.

The evidence shows that the mining sector is part of a global value chain and does not interact in a substantial way with other sectors in the local economy. In other words, technological diffusion effects are not sufficient to generate dynamic local activities capable of absorbing a significant portion of mining output.

In short, applying the Kaldor-Dosi approach made it possible to identify the importance of intersectoral technological diffusion at the international level, specifically through global value chains and their effects on local economic dynamics and technological trajectories. Given global trade patterns, dynamic activities may lack links to local activities and thus may fail to transfer technology through the diffusion mechanisms described by Dosi (1984). Similarly, they may fail to contribute to the formation of a dynamic local industrial base capable of attaining high levels of productivity and technological sophistication in the Kaldorian sense.

It is important to note that the paradigm and technological trajectory approach aligns with the input-output framework in the sense that both are tools for understanding the structure of an economy. However, the two approaches differ in their methods and purpose.

The paradigm and trajectory approach focuses on the role of technological innovation as a central driver of economic growth and describes how economies evolve over time in response to technological change. Conversely, the input-output framework is a tool for analysing the structure of an economy at a specific point in time. Thus, the findings from the analysis in this study highlight temporal and spatial points in the production structure that arise from a productive dynamic shaped by technological paradigms and trajectories.

Bibliography

Amazon Development Superintendence. (2022). Matriz interestadual de insumo-produto para o Estado do Pará 2015. In E. A. Haddad (Coord.), *Matrizes de Insumo-Produto da Amazônia Legal, 2019*. Institute of Economic Research Foundation. https://www.gov.br/sudam/pt-br/central-de-conteudo/mip

Araújo, I. F., Perobelli, F. S. and Faria, W. R. (2021). Regional and global patterns of participation in value chains: evidence from Brazil. *International Economics, 165*.

Banacloche, S., Cadarso, M. Á. and Monsalve, F. (2020). Implications of measuring value added in exports with a regional input-output table: a case of study in South America. *Structural Change and Economic Dynamics*, *52*.

Borghi, R. A. Z. (2017). The Brazilian productive structure and policy responses in the face of the international economic crisis: an assessment based on input-output analysis. *Structural Change and Economic Dynamics*, *43*.

Brazilian Mining Institute. (2022). *Datos IBRAM setor Mineral 2022.* https://ibram.org.br/publicacoes/

Callegari, J., Melo, T. M. and Carvalho, C. E. (2018). The peculiar insertion of Brazil into global value chains. *Review of Development Economics*, *22*(3).

Dixon, R. and Thirlwall, A. P. (1975). A model of regional growth-rate differences on Kaldorian lines. *Oxford Economic Papers*, *27*(2), 201–214.

Dosi, G. (1984). *Technical change and industrial transformation: The theory and an application to the semiconductor industry*. Springer.

Dosi, G., Roventini, A. and Russo, E. (2019). Endogenous growth and global divergence in a multi-country agent-based model. *Journal of Economic Dynamics and Control*, *101*.

Ferreira, J. D. and Schneider, M. B. (2015). As cadeias globais de valor e a inserção da indústria brasileira. *Revista Tecnologia e Sociedade*, *11*(23).

Florensa, L. M., Márquez-Ramos, L., Martínez-Zarzoso, I., and Recalde, M. L. (2015). Regional versus global production networks: where does Latin America stand? *Applied Economics*, *47*(37), 3938–3956. https://doi.org/10.1080/00036846.2015.1023938

Grodzicki, M. J. and Skrzypek, J. (2020). Cost-competitiveness and structural change in value chains: vertically-integrated analysis of the European automotive sector. *Structural Change and Economic Dynamics*, *55*.

Guilhoto, J. J. M. (2011). *Análise de insumo-produto: teoria e fundamentos*. https://mpra.ub.uni-muenchen.de/32566/

Guisan, M. C., et al. (2017). Manufacturing and development in countries and areas of Europe and Eurasia, 2000–2010. *Regional and Sectoral Economic Studies*, *17*(1).

Haddad, E. A., Gonçalves Júnior, C. A. and Oliveira Nascimento, T. (2017). Matriz interestadual de insumo-produto para o Brasil: uma aplicação do método IIOAS. *Revista Brasileira de Estudos Regionais e Urbanos*, *11*(4). http://www.revistaaber.org.br

Hirschman, A. O. (1961). *Estratégia do desenvolvimento econômico*. Fundo de Cultura.

Kaldor, N. (1957). *A model of economic growth*. *The Economic Journal*, *67*(268), 591–624.

Kaldor, N. (1966). Marginal productivity and the macro-economic theories of distribution: Comment on Samuelson and Modigliani. *The Review of Economic Studies*, *33*(4).

Kaldor, N. (1970). The case for regional policies. *Scottish Journal of Political Economy*, *17*(3), 337–348.

Kuhn, T. S. (1962), *The Structure of Scientific Revolutions*, University of Chicago Press.

Lamonica, M. T., et al. (2007). Crescimento e industrialização no Brasil: As lições das Leis de Kaldor. *Anais do 35º Encontro Nacional de Economia*, *35*. https://en.anpec.org.br/previous-editions.php?r=encontro-2007

Leontief, W. (1936). Quantitative input-output relations in the economic systems of the United States. *Review of Economics and Statistics*, *18*(3).

Maldonado Atencio, A. A. (2019). *El patrón estructural de desindustrialización prematura de América Latina 1970-2015: evidencias y determinantes* [Doctoral thesis, University of Granada].

McCombie, J. S. L. (1988). A synoptic view of regional growth and unemployment: I – The neoclassical theory. *Urban Studies*, *25*(4), 267–281.

Miller, R. E. and Blair, P. D. (2009). *Input-output analysis: Foundations and extensions*. Cambridge University Press.

Moczadlo, R. (2020). Re-industrialization to foster growth and employment in the European Union. *Ekonomski Vjesnik*, *33*(1).

Morceiro, P. C. (2012). *Desindustrialização na economia brasileira no período 2000–2011: Abordagens e indicadores*. Cultura Acadêmica.

National Mining Agency. (2022). *Compensação Financeira pela Exploração Mineral – CFEM*. https://www.gov.br/anm/pt-br/acesso-a-informacao/perguntas-frequentes/contribuicao-financeira-pela-exploracao-mineral-2013-cfem

Oreiro, J. L., Nakabashi, L. and Souza, G. J. G. (2010). A economia brasileira puxada pela demanda agregada. *Brazilian Journal of Political Economy*, *30*.

Pan, H. (2006). Dynamic and endogenous change of input-output structure with specific layers of technology. *Structural Change and Economic Dynamics*, *17*(2).

Pérez, C. (1985). Microelectronics, long waves and world structural change: New perspectives for developing countries. *World Development*, *13*(3).

Pérez, C. (1992). Cambio técnico, reestructuración competitiva y reforma institucional en los países en desarrollo. *El Trimestre Económico*, *59*(233).

Pérez, C. (2001). Cambio tecnológico y oportunidades de desarrollo como blanco móvil. *Revista de la CEPAL* (75) (LC/G.2150-P). Comisión Económica para América Latina y el Caribe.

Pérez, C. (2010). Technological revolutions and techno-economic paradigms. *Cambridge Journal of Economics*, *34*(1).

Pérez-Oviedo, W., Cajas-Guijarro, J. and Vallejo, M. C. (2018). South America: Trade and integration in the new global trade network. *Regionalism, Development and the Post-Commodities Boom in South America*.

Przywara, R. (2017). Deindustrialization – Opportunity or threat? *Athens Journal of Business and Economics*, *5*.

Romero, J. P. (2019). A Kaldor–Schumpeter model of cumulative growth. *Cambridge Journal of Economics*, *43*(6).

Romero, J. P. (2021). Aggregate growth models from a Schumpeterian perspective: A review. *Revista Brasileira de Inovação*, *19*.

Sanguinet, E. R., Alvim, A. M. and Atienza, M. (2022). Trade agreements and participation in global value chains: Empirical evidence from Latin America. *The World Economy*, *45*(3).

Santos, V. M. (2017). *A economia do Sudeste paraense: Evidências das transformações estruturais*. Institute of Applied Economic Research.

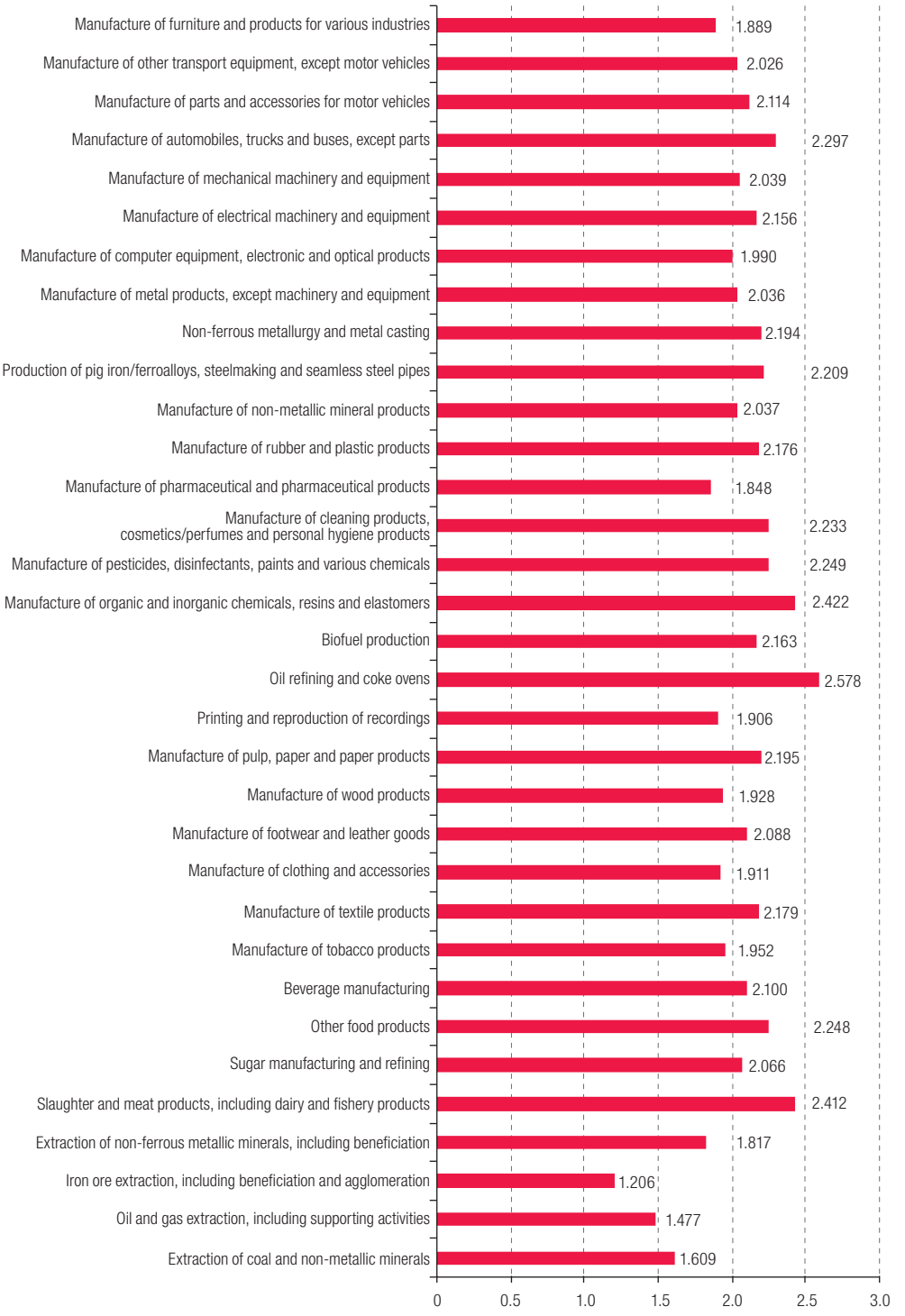
Silva, E. H. and Hasenclever, L. (2010). Simulação da dinâmica do crescimento econômico em um modelo kaldoriano-evolucionário no contexto da economia brasileira. *Economia*, *11*(3).

Thirlwall, A. P. (1983). A plain man's guide to Kaldor's growth laws. *Journal of Post Keynesian Economics*, *5*(3). https://doi.org/10.1080/01603477.1983.114893757

Thirlwall, A. P. (2007). Regional problems are "balance-of-payments" problems. *Regional Studies*, *41*(S1), S89–S95.

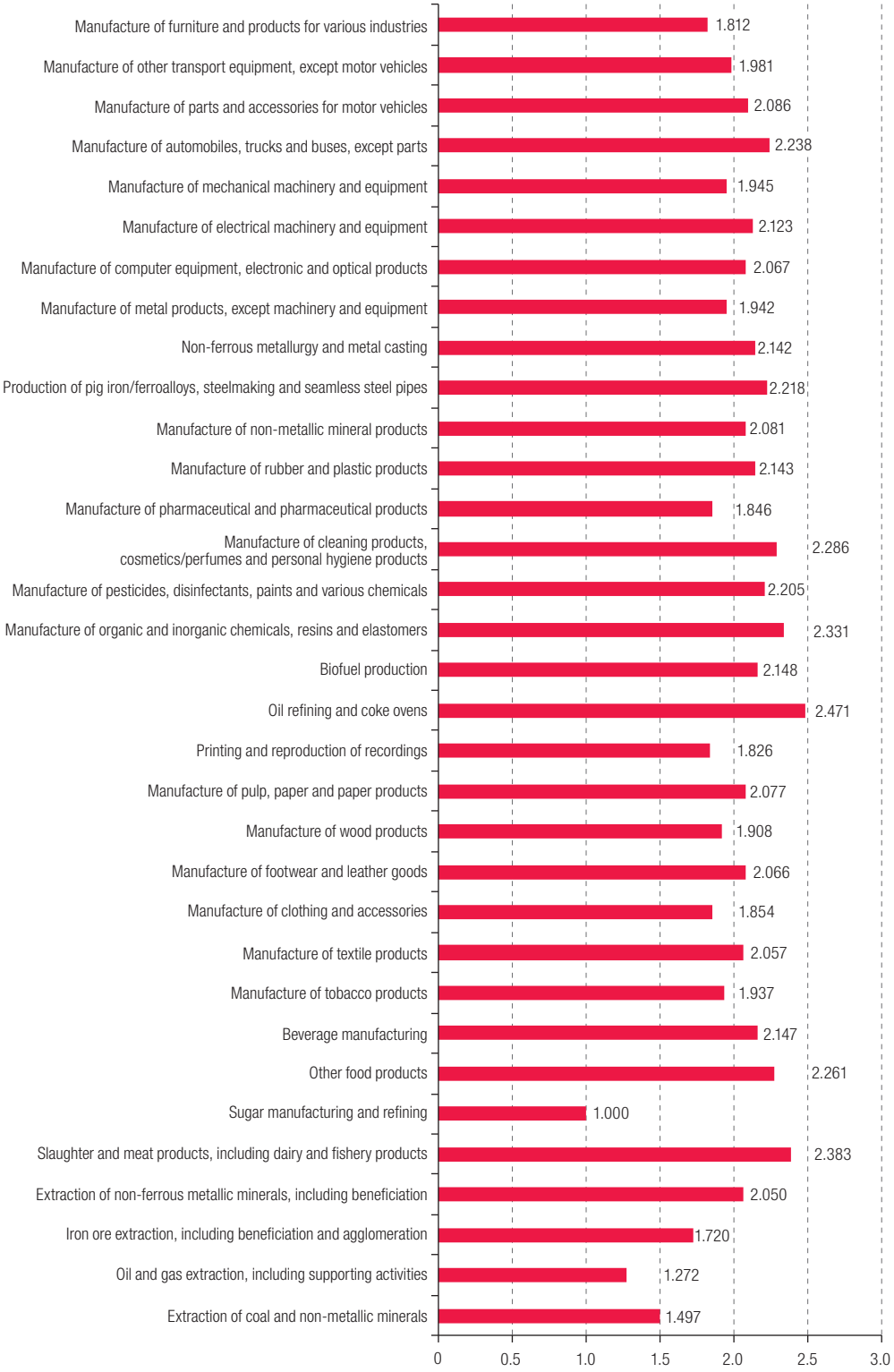
Annex A1
Output multipliers in Pará industry

Figure A1.1
Gross output multiplier effects in Pará's industrial sector, 2011



Source: Prepared by the authors on the basis of figures from the Organisation for Economic Co-operation and Development (OECD).

Figure A1.2
Gross output multiplier effects in Pará's industrial sector, 2015



Source: Prepared by the authors on the basis of figures from the Organisation for Economic Co-operation and Development (OECD).

Wages and productivity in Argentine manufacturing: a structuralist and distributional firm-level analysis[1]

María Celeste Gómez and Maria Enrica Virgillito

Received: 15/01/2024
Accepted: 19/03/2025

Abstract

Is there a link between labour productivity and wages in Argentine manufacturing? Does it vary between different technical and productive categories and wage levels? What factors affect this relationship, in the light of the country's premature deindustrialization? Employing a firm-level dataset for 2010–2021 from the National Survey on Employment and Innovation Dynamics (ENDEI) database, we estimate the link between productivity and wages across the conditional wage distribution among manufacturing firms. Our results confirm a positive but extremely low wage-productivity pass-through that differs between sectors according to their technical and productive capabilities and is robust to alternative estimation strategies. These asymmetrical firm-level distribution patterns carry substantial implications for the macroeconomic trajectory of the country, as they are perpetuating the underdevelopment trap.

Keywords

Industrial enterprises, manufacturing enterprises, employment, labour productivity, wages, economic analysis, econometric models, Argentina

JEL classification

J31, D24, O14

Authors

María Celeste Gómez is a National Scientific and Technical Research Council (CONICET) postdoctoral fellow with the Centre for Research in Economic Sciences (CICE) of the National University of Córdoba (Argentina). Email: mcelestegomez@unc.edu.ar.

Maria Enrica Virgillito is an associate professor at the Institute of Economics of the Scuola Superiore Sant'Anna (Italy). E-mail: mariaenrica.virgillito@santannapisa.it.

[1] This research was conducted under the Global Labor Organization (GLO) 2021–2022 Virtual Young Scholars Program (GLO VirtYS). We are extremely grateful to Klaus Zimmermann, Marco Vivarelli and Olena Nizalova for their guidance and support. We also wish to thank participants in the VirtYS third cohort progress meetings, the 2022 workshop at the Institute of Economics and Finance (National University of Córdoba) and the Third International Conference in Heterodox Economics (National University of Colombia) for their helpful discussions and comments. We are likewise grateful to staff at the National Bureau for Scientific Information of Argentina's Secretariat of Innovation, Science and Technology for sharing firm-level data.

I. Introduction

Wages and productivity are two of the most important variables in the development process. The extent to which they are coupled or decoupled has substantial implications for the macroeconomic trajectory of a country. In fact, productivity is the ultimate growth engine in the global economy and a challenge for countries that are catching up, as it is a precondition for breaking out of the middle-income trap (Organisation for Economic Co-operation and Development [OECD], 2015; Paus, 2018). In addition, the pass-through of productivity gains to wages represents a crucial dimension for workers' welfare and distributive justice.

However, wage and productivity heterogeneities both between and within production sectors are substantial and growing. Firm-level heterogeneity in productivity means that the aggregate macroeconomic growth path is substantially influenced by the shape of the micro-level productivity distribution, while sector-level heterogeneity means that alternative specialization paths will affect aggregate macroeconomic performance. From the distributive perspective, wage heterogeneity, both between firms and across sectors, produces unjustifiable economic and social disparities between similar workers and weakens internal macroeconomic demand and autonomous growth potential.

The literature has identified a positive relationship between these two dispersions, known as the "great divergence(s)" (Berlingieri et al., 2024), both in advanced economies (Barth et al., 2016) and in emerging countries (Barrera Insua and Fernández Massi, 2017). One issue in these divergences is the extent to which wage dispersion mirrors productivity dispersion, whenever there is a link between the two variables (Card et al., 2018; Dosi et al., 2020; Stansbury and Summers, 2017). So far, little effort has been made to study these relationships in relation to the development stage of a given country. This is one research gap that the present paper helps to fill.

A development obstacle that Argentina faces is the "middle-income trap", whereby middle-income nations are unable to trade internationally in standardized goods, labour-intensive products or both because of their relatively high wage levels, while their poor productivity and limited technological capabilities leave them unable to compete on a large enough scale in higher-value added sectors (Paus, 2017). In a globalized world, developing economies have few options for reducing productivity disparities and improving employment conditions (Dosi, Riccio and Virgillito, 2021; Graña, 2018). Comparative advantages in natural resources in Latin American countries do not appear to favour these processes (McMillan and Rodrik, 2011). Therefore, a country's structural international positioning and dependency relationships influence wage-productivity coupling or decoupling.

Besides the issues of a country's development stage and international positioning, the wage-productivity literature suffers from another limitation. Most studies focusing on wage-productivity pass-through analyse elasticity via the conditional mean (Card et al., 2018; Stansbury and Summers, 2017), but it is essential to explore this link throughout the wage distribution and across sectors with different technological regimes, especially when examining a country such as Argentina that displays persistent productive heterogeneity and large wage disparities, in a structural context of rapid deindustrialization.

Given the research gaps described, this paper addresses three interconnected questions: What is the link between wages and productivity in Argentine manufacturing? Does it vary along the wage distribution and across industries or technology classes? What factors influence this relationship, given that Argentina is a late-industrializing and prematurely deindustrializing middle-income country?

To try and solve this puzzle, we employ a firm-level dataset from the National Survey on Employment and Innovation Dynamics (ENDEI) covering the period 2010–2021. This firm-level dataset is a solid representation of Argentine manufacturing production. Using conditional quantile

regression methodologies, we examine wage-productivity pass-through patterns across production sectors and technological classes (Pavitt, 1984). According to our estimates, which are robust to different specifications, the Argentine manufacturing sector is characterized overall by a very low degree of pass-through of productivity gains to wages, which highlights the unequal appropriation of total value generated between profits and wages. As further evidence, we show that low-technology industries that are heavily dependent on external demand are even less likely than others to redistribute productivity gains. Such industries, which are intensively resource-dependent, draw greatly upon informal labour. Lastly, from a sectoral composition perspective, our findings depict a self-defeating cumulative cycle in which the specialization pattern followed until recently has created a dual development trap, impeding both productivity upgrading and wage growth.

The paper is organized as follows. Section II after this Introduction summarizes the theoretical underpinnings of the structuralist and evolutionary literature. Section III focuses on the political and institutional context in Argentina since the late industrialization phase. Section IV gives a picture of the manufacturing sector's development. Section V discusses the database and empirical strategy, section VI sets out our findings, and section VII presents a discussion of their implications and concluding remarks.

II. Theoretical background

To study the wage-productivity relationship in Argentina, we adopt the evolutionary and structuralist perspectives, which link the composition of countries' production to development and growth opportunities (Lewis, 1984; Syrquin, 1988). The approach taken to the relationship between technological progress and economic growth differs from that of neoclassical theory, as it focuses on technology accumulation resulting from endogenously generated capabilities that are influenced by the nature and strength of opportunities for technological progress and the ability of firms to appropriate the returns to scientific research and development (R&D) (Dosi, 1988). These mechanisms highlight the dynamic nature of capitalism (Schumpeter, 1934). This is the context in which firms decide whether or not to bring innovations to market, and microeconomic behaviours are highlighted as fundamental to innovative outcomes (Nelson and Winter, 1982).

Given how idiosyncratically countries move along the trajectories of technological progress, then, there is not one but a variety of highly path-dependent routes to development (Adelman, 2001). In the structuralist view, sectors and products represent heterogeneous learning opportunities and different income elasticities of demand, and choosing which to promote is critical (Dosi, Riccio and Virgillito, 2021), for "today's specializations influence tomorrow's productivity growth, chances to innovate and demand potential" (Cimoli et al., 2009, p.3). In the global context, having proper "bridging institutions" to link science and technology creates the conditions for local, national and regional technological development (Dosi, 1982; Freeman, 1974). Technological progress is thus about interaction between firms, organizations and institutions endogenously determining the path of innovation as a collective process, as an innovation system (Lundvall, 2010; Malerba, 2002) or, if there is a structural break, as the emergence of a new technical and economic paradigm (Dosi et al., 2025).

The long-run process of structural transformation (Syrquin, 1988) involves five dimensions: science, technology, economics, politics and culture, which intermingle through positive or negative interactions (Dosi et al., 2025; Freeman, 2019). Countries' growth does not have a single cause, but is the outcome of the specific conditions under which these dimensions interact. Institutions and policies determine countries' development trajectories and boundaries, both geographically

and temporally. Consequently, policies that worked well in igniting economic growth for early industrializers (Britain, Germany, the United States) were generally not appropriate for countries with abundant natural resources that expanded commodity exports at an early stage in their development (Adelman, 2001), in part because of colonial path dependence.

Historically, major technological developments and their impacts on productivity growth have occurred in manufacturing, with a significant link between productivity and wages (Hirschman, 1968; Pavitt, 1984; Prebisch, 1959). Nowadays, although new technologies have blurred the boundaries between manufacturing and services, with all the challenges entailed by automation and digitalization, "manufacturing is still an important contributor to labor productivity and GDP growth" (Palma and Pincus, 2024, p. 333). In short, manufacturing drives growth and knowledge absorption, strengthens the wage-productivity relationship and acts as an economy-wide employment multiplier (Berlingieri et al., 2024; Bogliacino and Pianta, 2011; Cresti and Virgillito, 2025).

The experience of developed countries shows that, in any virtuous industrialization process, the production structure needs to be regarded as critical for the development strategy. Unfavourable production structures, which are typical of underdeveloped countries, reduce development opportunities (Pagés, 2010) and can be understood as part of the middle-income trap framework (Kang and Paus, 2020; Paus, 2018). A seeming paradox arises: natural resource intensity does not improve productive performance because it contributes to a bad strategy of specialization in products that are not demand-elastic (Dosi et al., 2022; Reinert, 1995). Something that is supposedly positive for the country actually impedes any genuine structural change that might improve productivity.

Thus, more complex production processes are associated with greater learning potential and ability to cope with expansions in demand (Dosi et al., 2022). To classify industry composition and inherent complexity, Pavitt (1984) develops a taxonomy that groups sectors and firms into four distinct classes according to their technological content, the quality of their specialization and their position within value chains (Dosi, Riccio and Virgillito, 2021). Taking them from least to most complex, the supplier-dominated class includes firms where innovation is driven by exogenous changes in capital inputs and the process of learning by using (food and beverages, textiles, leather and wood products). The scale-intensive class includes firms which rely on capital-intensive production technologies and where learning is cumulative and reinforced by economies of scale (paper, rubber, plastics and their derivatives, basic metals, trailers and semi-trailers). In the specialized supplier class, firms act as suppliers of capital equipment, instruments and components, and innovation arises from endogenous learning and in-house R&D investment (machinery and equipment, other transport equipment). In the science-based class, lastly, the innovation process is strongly associated with applied and basic research and networking with scientific and technological systems (basic chemicals and pharmaceuticals, medical and optical instruments).

Using the Pavitt taxonomy, Dosi, Riccio and Virgillito (2021) highlight the opportunities deriving from specialization in knowledge-disseminating and specialized supplier sectors and point out the barriers facing developing countries, given the tight appropriability conditions, enforced by intellectual property rights, that have prevailed since the Washington Consensus phase. While developing countries specialize in non-core productive activities, developed countries concentrate on core ones, often relying massively on sectors protected by property rights (Aguiar de Medeiros and Trebat, 2017), such as digital and communication technologies and pharmaceuticals.

Lastly, to foster the generation of crucial technological capabilities, industrialization needs to be coordinated with macroeconomic policies (Syrquin, 1988; Cimoli et al., 2009). National policymakers inevitably apply or forego industrial policies when making decisions about distributive, production and trade patterns or even when accepting their position in the international division of labour and learning opportunities (Hausmann and Rodrik, 2006).

III. The regional background

The industrialization of the Latin American countries represents a major and still under-researched case study, as the process was interrupted in the 1970s, with reindustrialization efforts taking place in the early 2000s. In this context, some economists have developed variants on the concept of deindustrialization (Dasgupta and Singh, 2007; Rodrik, 2016; Tregenna, 2014), speaking of "premature deindustrialization" and emphasizing the economic drivers behind it. The literature focuses on institutional and political factors and the long-term variability of industrial policies vis-à-vis their macroeconomic and fiscal objectives (Cimoli et al., 2019; Peres and Primi, 2009). Contributions from international political economy focus on production structures, firm heterogeneity and exposure to globalization since the neoliberal turn (Graña and Terranova, 2020; Triador and Pinazo, 2021), while other strands concentrate on the factors underlying natural resource dependence and the role of comparative advantage (Castillo and Martins Neto, 2016; Hirschman, 1968; McMillan and Rodrik, 2011; Palma, 2019). In a nutshell, the factors influencing the manufacturing experience of Latin America and the Caribbean can be summarized as: (i) delays and inertia in technological upgrading investment; (ii) excessive specialization in low-value added activities with weak backward linkages; (iii) increasing reliance on the export of resource-intensive manufactured goods; (iv) rising dependence on natural resources; (v) lack of a systematic industrial policy framework; and (vi) growing macroeconomic and social instability.

Thus, the Latin American countries have failed to undertake significant structural transformations in the most recent decades and have missed out on the benefits of technological upgrading and long-term development. The major constraints have been an inability to climb the structural upgrading ladder and overcome their technological and financial dependence on the developed economies (Ormaechea and Fernández, 2020; Santarcángelo, 2019). By contrast with the successful catching-up processes in China and the Asian tigers (Yu et al., 2015), they have remained trapped in a specialization centred on natural resources and low-complexity manufacturing production and export (Chena and Pérez Caldentey, 2020), which has held back productivity growth (Paus, 2018).

This weak productivity performance has been manifested both in productivity gaps relative to international competitors and in domestic heterogeneity (Graña, 2018). Argentine manufacturing now exhibits a clear neo-dualism between firms in the production structure (Dosi et al., 2021). While a limited number of firms in a few manufacturing sectors engage in sustained innovation and attain international productivity frontiers as technological leaders (Raffo et al., 2008), a majority of small and medium-sized enterprises (SMEs) operate in low-productivity, low-technology sectors, remaining competitive by holding down wages and downgrading employment conditions (Graña, 2018).

Against this multifaceted backdrop to deindustrialization in Latin America and the Caribbean, we shall now briefly review some of the key historical and institutional developments that have shaped the current production structure of the Argentine economy. These macroeconomic and institutional factors will inform and guide the microeconomic and industry-level empirical analysis that follows.

1. Incomplete catch-up in Argentine manufacturing

Industrial policies can be defined as a set of instruments that States apply to promote the development of specific industries, technologies or groups of activities in line with national development priorities (Peres and Primi, 2009; Dosi et al., 2025). In Latin America, these policies have not always been formalized, designed or evaluated with long-term considerations in mind. Industrialization "was fact before it was policy, and policy before it was theory" (Love, 1995, p. 395). An explanation for

this pattern might be the recurrent macroeconomic and policy swings that many of these countries have experienced for decades. Nevertheless, there is an industrial policy tradition in the larger countries of the region, with Argentina a leading example.

Until the Second World War, Argentina had a highly natural resource-intensive economy and depended on international trade in commodities. In this context, the industrialization process that began in the 1940s was designed to foster traditional manufacturing activities through import substitution (Santarcángelo, 2019). The first industrial promotion regime was implemented in 1944 by the Ministry of Industry and Commerce. An industrial credit bank was also created to strengthen the financial structure of industry and diversify the production structure of the economy. Labour-intensive industries were promoted throughout this decade and the next, with a focus on the domestic market. Employment conditions and wages improved, reducing inequality and urban poverty.

Between 1950 and 1970, with an industry-supporting legal framework in place, the State nurtured a set of development planning and research institutions, and a number of vertical industrial policy instruments were applied (tariffs and import quotas, production, export and financing subsidies, and the creation of public companies) (Bascur and Coviello, 2021). The State played an active role in developing the production fabric, which included the implementation of multi-year industrial plans, in line with the prevailing political consensus about the importance of manufacturing to the economy (Santarcángelo et al., 2018).

As a result, having specialized in textiles, food and beverages and tobacco (the supplier-dominated Pavitt class), Argentina became a manufacturer of consumer durables, machinery and equipment, while more dynamic and complex sectors with greater value added took off over the following decades.[2] Although the foreign trade effects of commodity price and foreign currency movements hampered the country's industrialization (Graña, 2018), the post-Second World War period represented a first successful phase in this national policy-led process.

Under Argentina's last military dictatorship (1976–1983), economic policy was radically reoriented towards a model centred on financialization, deregulation and privatization. This led to a structural breakdown in manufacturing, undermining labour conditions and compressing wages (see figures 1 and 3) (Rougier, 2021). Natural resource-intensive manufacturing had been on the increase for two decades (Santarcángelo, 2019), and the situation did not change significantly in the 1980s where industrial policy was concerned, as economic policy focused on resolving inflationary, fiscal and balance-of-payments crises. In Argentina and Latin America more generally, the urgency of these concerns left no space to engage either in debates about long-term strategies or in discussions about intervention and industrialization (Odisio and Rougier, 2021).

A decade later, the Convertibility Plan, a neoliberal stabilization model implemented in the wake of a hyperinflation crisis, reintroduced many of the policies of the 1970s financialization regime. With regard to industry, the State gave preference to neutral interventions that did not discriminate between production sectors, with these taking the form of so-called competitiveness policies (Peres and Primi, 2009)[3] or horizontal industrial policies (Dosi et al., 2025). Specialization in largely resource-based manufactures (see figure 2), coupled with increasing foreign capital flows, gave rise to structural asymmetries, and deindustrialization set in strongly. SMEs had to develop survival strategies (Schorr, 2021) that involved leveraging cost competitiveness, widening income gaps and increasing their use of informal labour (Ghibaudo and Raccanello, 2021).

Argentina experienced a major shift in its accumulation and growth regime in the early twenty-first century. In an effort to rebuild the domestic market and increase exports, economic

[2] Metalworking, chemicals, electronic equipment and automotive products, among others.

[3] The automotive sector was an exception because of the regional policies implemented by the Southern Common Market (MERCOSUR).

stimulus policies and social programmes were implemented, leading to improvements in material living conditions. A new phase of incipient "reindustrialization" and manufacturing job creation began. Despite structural weaknesses (low productivity, technological and productive heterogeneity and premature deindustrialization), manufacturing activity and GDP increased significantly in the 2000s (Graña, 2018). After 2008, however, Argentina was unable to close the productivity gap, in part owing to the rise of new global actors, most notably China, which acquired enormous capacity through productive and technological upgrading and came to dominate international markets for manufactures. Manufacturing and overall macroeconomic performance stagnated from 2011 onward, while new balance-of-payments constraints appeared, reflecting difficulties such as rising price levels, input supply bottlenecks and the rising cost of the national debt.

Industrial policy management varied in intensity, but included: (i) a number of overlapping and sometimes inconsistent regulations and incentives implemented at different levels of intervention and involving heterogenous actors, particularly at the outset; (ii) strong emphasis on the hierarchical structuring of the science and technology system; (iii) non-automatic trade licensing; (iv) specific instruments for high-technology industries (software, biotechnology and nanotechnology); (v) a growing State role as producer and purchaser; and (vi) the creation, at enormous fiscal cost, of a regionally based maquila cluster to serve the domestic market (Rougier 2021; Santarcángelo et al., 2018). This summary reinforces the point made earlier that any productive development policy must be coordinated with macroeconomic policies.

From 2016 to 2019, a new regime of deregulation, trade liberalization and financialization prevailed again, affecting Argentina's trade balance and exchange-rate stability. Financial vulnerability caused by capital outflows also became a major threat (Médici, 2020). Manufacturing activity declined greatly during the period, with sharp falls in output, employment and the number of firms, placing Argentina at the forefront of deindustrialization (Schteingart and Tavosnanska, 2022).

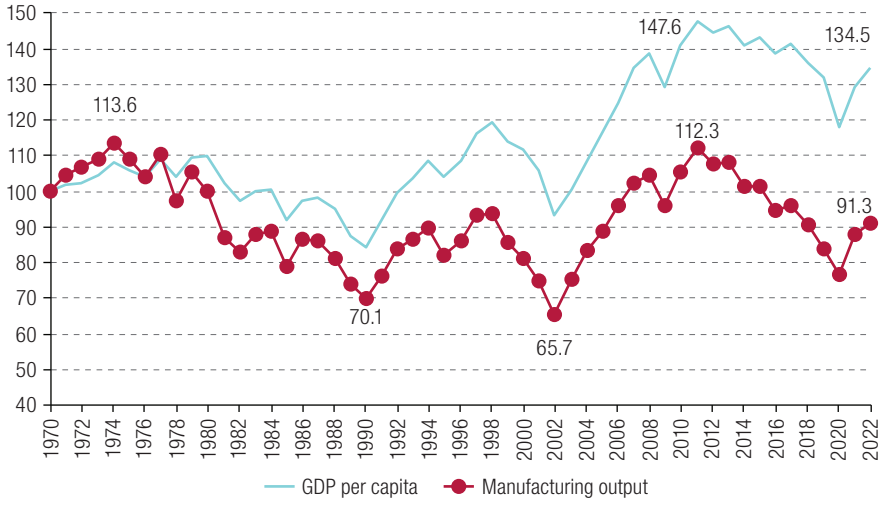
2. Long-term production and export profiles

Figure 1 plots real per capita GDP and manufacturing output, with deindustrialization reflected in their progressive decoupling. Manufacturing output peaked in 1974 before declining until 2002, after which it grew continuously until it reached another peak in 2010. By 2022, per capita manufacturing output was 9% lower than in 1970. Manufacturing and wholesale and retail commerce had accounted for the largest shares of output over the foregoing decade at the ISIC one-digit level, with over 17% of GDP apiece (see annex table A1.1).

Figure 2 plots the export shares of manufactures of industrial origin against those of agricultural origin. The industrial series includes textile, printed and published, chemical and pharmaceutical, rubber and plastic, and fabricated metal products, among others. The agricultural group comprises food and beverages, meat and dairy products, among others. Industrial exports increased between 1983 and 1989 and then declined, while agricultural exports, whose share was consistently higher, expanded between 1985 and 1987 before likewise declining.[4] The industrial share stagnated at about 30% during the 1990s and for the rest of the period, with fluctuations of 5 percentage points either way. As late as 2018, the value of agricultural and industrial exports was almost the same, but a "bad" specialization phase followed, with a gap opening up to the detriment of the latter in the last years of the period. This represents a limitation on the long-term prospects for the Argentine economy, increasingly trapped as it is in an export specialization centred on less complex and more natural resource-intensive products.

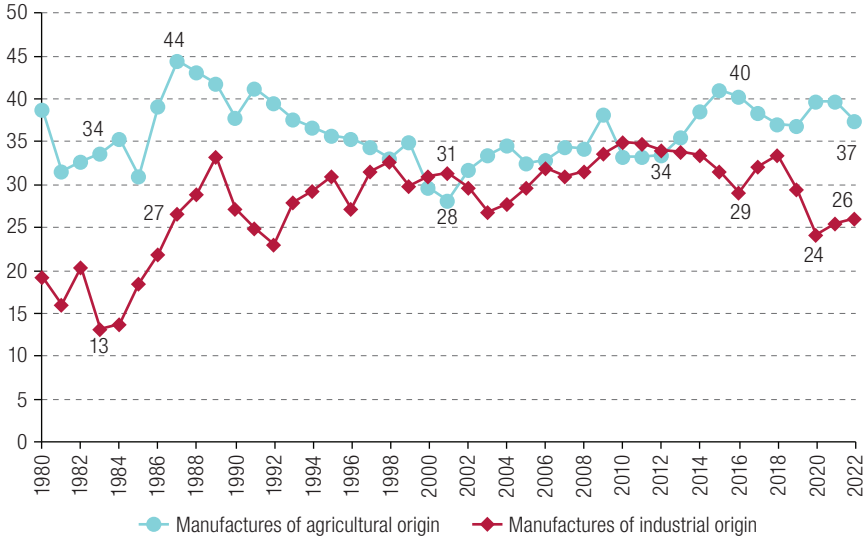
[4] This period was also characterized by a very low level of diversification within groups, with only a narrow range of manufacturing activities taking place (Azpiazu and Kosacoff, 1988).

Figure 1
GDP per capita and manufacturing output, 1970–2022
(Index: 1970 = 100)



Source: Prepared by the authors, on the basis of Ferreres, O. J. (Dir.). (2020). *Dos siglos de economía argentina: historia argentina en cifras*. Fundación Norte y Sur.

Figure 2
Manufacturing share of total exports, 1980–2022
(Percentages)



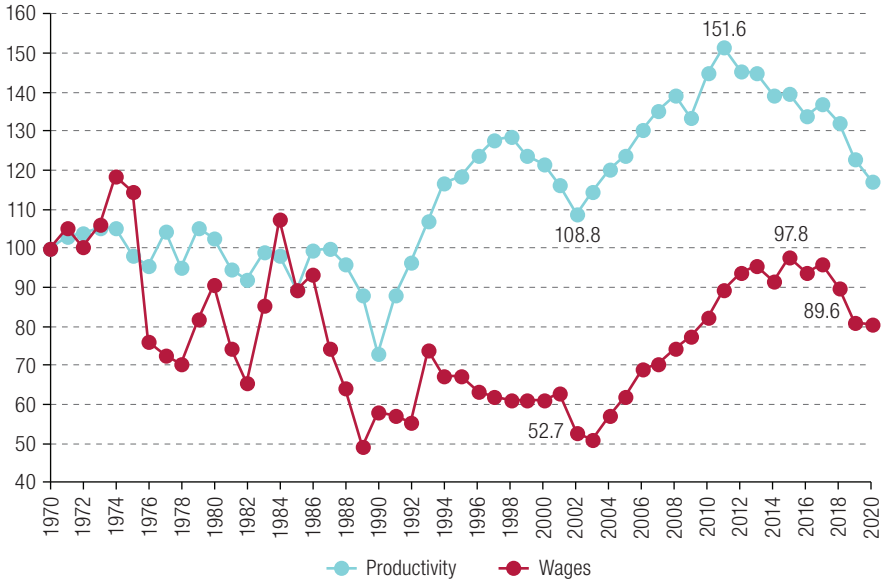
Source: Prepared by the authors, on the basis of Ferreres, O. J. (Dir.). (2020). *Dos siglos de economía argentina: historia argentina en cifras*. Fundación Norte y Sur.
Note: Exports are measured in current dollars. Manufactures of agricultural origin include food and beverages, meat products and the like. Manufactures of industrial origin include textile, printed and published, chemical and pharmaceutical, rubber and plastic and fabricated metal products and the like.

3. Aggregate productivity and wages

Figure 3 shows real wages and productivity, and figure 4 the productivity to wage ratio. Four phases emerge from the comparison between the two variables. In the first, lasting until 1973, wages and productivity are coupled, with a relatively low ratio. The second (1974–1990) exhibits a constant

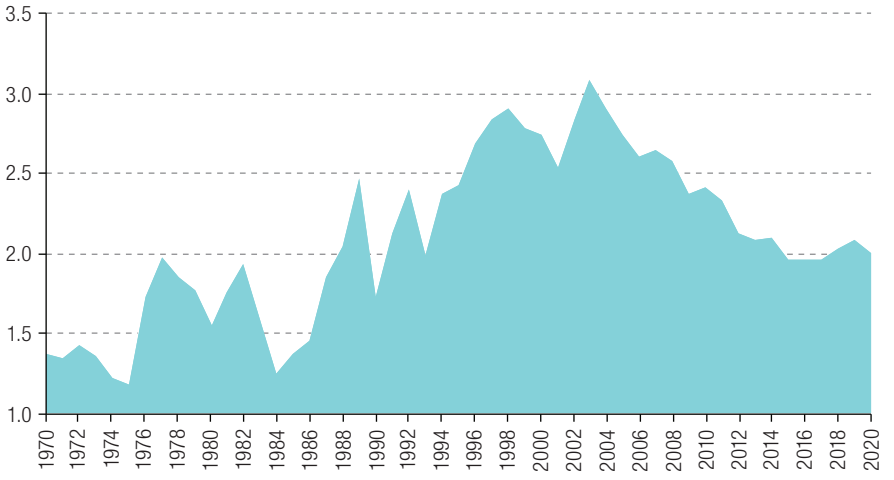
decoupling trend following a sharp fall in wages in 1976 under the new financialization regime. Productivity stagnated, oscillating by 5% above and below its starting value (figure 3), so that the ratio was left higher, albeit stable (figure 4). Both variables, but especially wages, collapsed with the hyperinflation crisis of the late 1980s. The third phase covers the convertibility stage, which ended with the widest wage-productivity gap of the whole period. Lastly, both variables rose in the 2000s before beginning to decline from 2011 and 2015, respectively.

Figure 3
Average labour productivity and wages in manufacturing, 1970–2020
(Index: 1970 = 100)



Source: Prepared by the authors, on the basis of Graña, J. M. and Terranova, L. (2020). Distribución funcional del ingreso en el sector industrial argentino, 1935-2019: valor agregado, remuneración al trabajo, ocupación y salarios. *Documentos de Trabajo*. (26). Research Centre on Population, Employment and Development.
Note: The analysis is restricted to formal (registered) employment.

Figure 4
Average labour productivity to wage ratio in manufacturing, 1970–2020

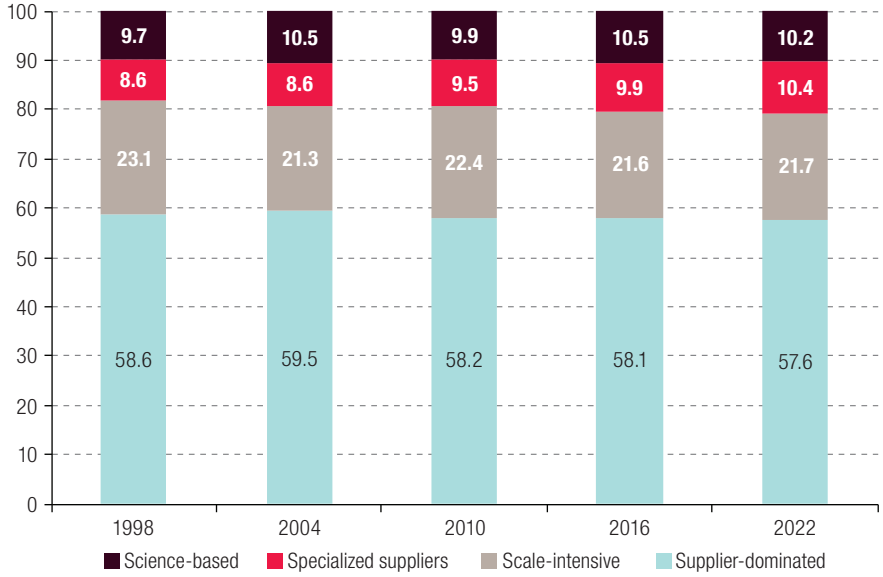


Source: Prepared by the authors, on the basis of Graña, J. M. and Terranova, L. (2020). Distribución funcional del ingreso en el sector industrial argentino, 1935-2019: valor agregado, remuneración al trabajo, ocupación y salarios. *Documentos de Trabajo*. (26). Research Centre on Population, Employment and Development.
Note: The analysis is restricted to formal (registered) employment.

4. Employment and wage structures: the role of labour institutions

Manufacturing employment and wage structures are illustrative of productive heterogeneity in Argentina. Figure 5 shows the distribution of registered jobs by Pavitt classes for selected years between 1998 and 2022. Throughout the period, the supplier-dominated class was responsible for the bulk (about 58%) of manufacturing jobs. Scale-intensive firms accounted for an average of 22% of formal employment and science-based industries for barely one in ten jobs.

Figure 5
Employment shares by Pavitt manufacturing sector, 1998–2022
(Percentages)

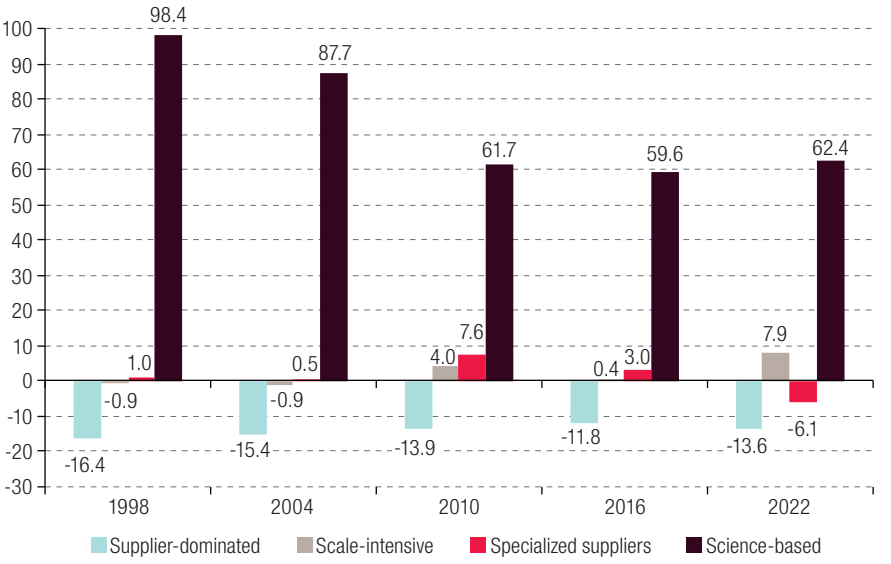


Source: Prepared by the authors, on the basis of Secretariat of Labour, Employment and Social Security.
Note: The analysis is restricted to formal (registered) employment.

Some points deserve consideration. Firstly, the data pertain to formal employment only. Where informal employment is concerned, manufacturing is better placed than other sectors (see annex table A1.1), with the highest rates of informality being mostly associated with the supplier-dominated class (Acosta and Montes-Rojas, 2014). Thus, an analysis that included both registered and unregistered employment would exhibit a greater concentration of informality in low-value added manufacturing sectors. Secondly, there has been lock-in to low-complexity industries (the supplier-dominated and scale-intensive classes) over the years. As expected, the evolution of manufacturing employment closely tracks the per capita GDP trend in figure 1. Taken together, these patterns highlight the absence of the kind of genuine structural shifts towards more complex forms of production that are an essential precondition for sustainable development.

Figure 6 shows the wage gaps between the Pavitt classes and the industrial average, represented by the zero line. Bars above (below) the benchmark represent higher (lower) wages. From 1998 to 2022, the science-based class displays by far the highest wages in manufacturing, while firms in the supplier-dominated class paid the lowest wages (between 12% and 17% below average). The scale-intensive and specialized supplier classes exhibit small negative and positive gaps, respectively, at the beginning of the period, but are close to the average in the following years. The differential between the highest (science-based) and lowest (supplier-dominated) wages shows a slight trend towards compression over time.

Figure 6
Wage gaps between Pavitt manufacturing sectors and the manufacturing average, 1998–2022
(Percentages)



Source: Prepared by the authors, on the basis of Secretariat of Labour, Employment and Social Security.
Note: The zero line represents the manufacturing benchmark. The analysis is restricted to formal (registered) employment.

To conclude this subsection, consideration will be given to trade unions and minimum wages as key institutional determinants of wage-setting regimes that counteract the forces making for wage suppression and the deterioration of employment conditions (Mishel and Bivens, 2021). Where unions are concerned, Argentina has gone in the opposite direction to most advanced Western countries (Acemoglu et al., 2001; Bishop and Chan, 2019). Since 2004, trade unions have been revitalized under a regime of moderately centralized collective bargaining, and a minimum wage policy has been implemented (Morris, 2017), playing an important role in reducing wage inequality (Gómez, 2020a). Collective bargaining is particularly strong in the manufacturing sector, which accounted for more than 34% of all collective agreements negotiated during 2010–2022 (see annex table A1.2). Unfortunately, the dataset used lacks information on union membership at the firm level, but a secondary information source[5] makes it possible to identify collective bargaining coverage in the different Pavitt classes (see table 1). The supplier-dominated class reports the lowest coverage (43.9%) and the specialized supplier class the highest (57.2%).

Table 1
Collective bargaining coverage by Pavitt class, 2010–2021
(Percentages)

Sector	Share of labour that is formal (registered)
Supplier-dominated firms	43.9
Scale-intensive firms	53.1
Specialized suppliers	57.2
Science-based firms	52.7

Source: Prepared by the authors, on the basis of Research Programme on Contemporary Argentine Society. (2015). *National Survey on Social Structure*.
Note: Sectors are classified at the two-digit level of the International Standard Industrial Classification of All Economic Activities (ISIC Revision 4).

[5] National Survey on Social Structure (Research Programme on Contemporary Argentine Society), period 2014–2015.

IV. Data and methodology

1. Data description

We employ a dataset from the National Survey on Employment and Innovation Dynamics (ENDEI). Conducted by the Secretariat of Innovation, Science and Technology of Argentina (MINCyT), this collects information on employment, innovation, production and commercial activities.

ENDEI provides data on manufacturing firms from three waves, 2010–2012, 2014–2016 and 2019–2021, disaggregated at the two- and four-digit ISIC Revision 4 sectoral levels. Although this is not a panel dataset (firms cannot be tracked across periods), it is a statistically representative sample of the universe of Argentine manufacturing firms. The dataset includes only firms with 10 or more registered workers, which means that it does not capture informal employment (see section V).

Firms are grouped at two different aggregation levels: (i) the original database disaggregation using ISIC Revision 4 and (ii) a revised Pavitt (1984) taxonomy including four classes of firms categorized by technological intensity[6] (Bogliacino and Pianta, 2011; Dosi, Riccio and Virgillito, 2021). Each technological class comprises the following manufacturing branches:[7]

- Supplier-dominated: food, beverages and tobacco and textile, leather, wood (including furniture), metal and paper products (ISIC Revision 4, codes 10, 11, 12, 13, 14, 15, 16, 25, 31, 1010, 1050 and 1102).
- Scale-intensive: paper, rubber and plastic, non-metallic mineral and basic metal products and motor vehicles, trailers and semi-trailers (codes 17, 22, 23, 24 and 29).
- Specialized suppliers: machinery and equipment, other transport equipment, domestic appliances, electronic components and boards, computers, and communication and electrical equipment (codes 27, 28, 30, 2610 to 2640, 2750 and 2821).
- Science-based: chemicals and refined petroleum products, pharmaceutical products, measuring, testing and control equipment, and electromedical and optical instruments (codes 19, 20, 21 and 2650 to 2680).

Table 2 presents the descriptive statistics for wages and productivity. The latter registers a modest yearly increase until 2016, with a slight reversal in 2020, while wages display a notably stable pattern throughout the period.

Table 2
Average labour productivity and wage in manufacturing, 2010–2021
(Thousands of 2010 pesos)

Year	Number of firms	Labour productivity	Wage	Log labour productivity	Log wage
2010	3 151	147.07	3.72	11.43	8.09
2011	3 204	169.68	3.85	11.60	8.14
2012	3 215	183.91	3.98	11.72	8.17
2014	3 401	249.48	3.95	11.97	8.21
2015	3 457	272.69	3.96	12.07	8.21
2016	3 431	270.85	3.75	12.06	8.16
2019	2 873	257.47	3.76	11.93	8.13
2020	2 874	230.33	3.56	11.73	8.08
2021	2 875	269.57	3.57	11.92	8.08

Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.
Note: The analysis is restricted to formal (registered) employment.

[6] As measured by R&D intensity, given by the ratio between a firm's R&D expenditure and its sales.

[7] For reasons of statistical confidentiality, ISIC codes 10, 11 and 12 were aggregated in the original database. Sectors 10 and 11 do not include codes 1010, 1050 or 1102, and sectors 27 and 28 do not include codes 2750 or 2821.

2. Wage and productivity distribution trends

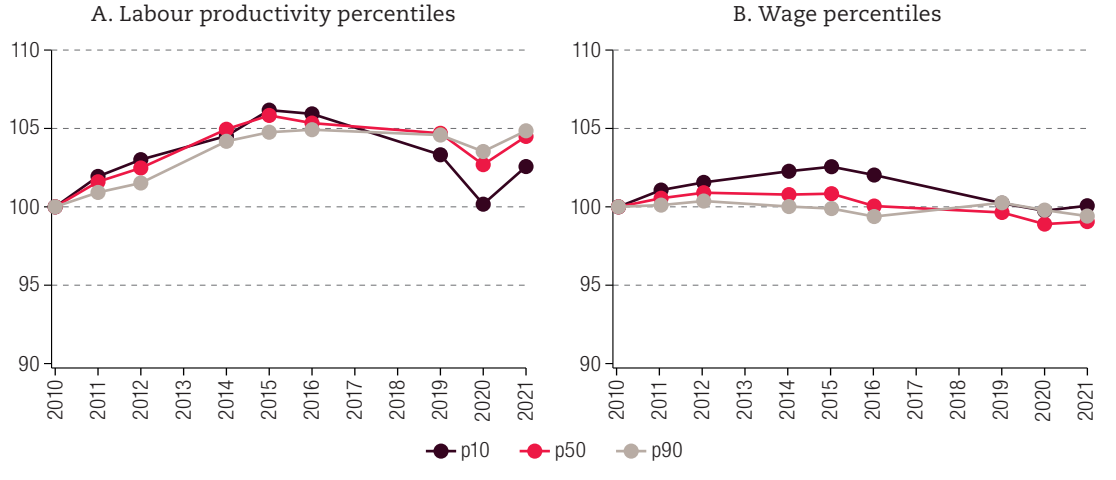
To characterize the evolution of wages and productivity beyond average values, figures 7 and 8 present time trends for selected percentiles and percentile ratios, focusing on the tenth, fiftieth and ninetieth wage and productivity percentiles. In respect of dispersion, the 90/10 ratio (the interdecile gap) captures the widest spread of each distribution. We also calculate the 50/10 and 90-50 wage and productivity ratios to observe inequality in the lower and upper tail of the distributions, respectively. All percentiles and ratios are indexed to 2010 as the base year.

The productivity percentiles in the upper left panel of figure 7 show an upward trend until 2015, followed by a period of stagnation, a decline, and a partial recovery during the coronavirus disease (COVID-19) pandemic. As regards wages (upper right panel), these show a slight rising tendency only among firms in the lowest pay segment (tenth percentile), which anyway is reversed from 2015 (albeit less sharply than in the case of productivity), while the real wages paid by firms in the fiftieth and ninetieth percentiles remain quite steady until 2019. All wage series stabilize during the COVID-19 years.[8]

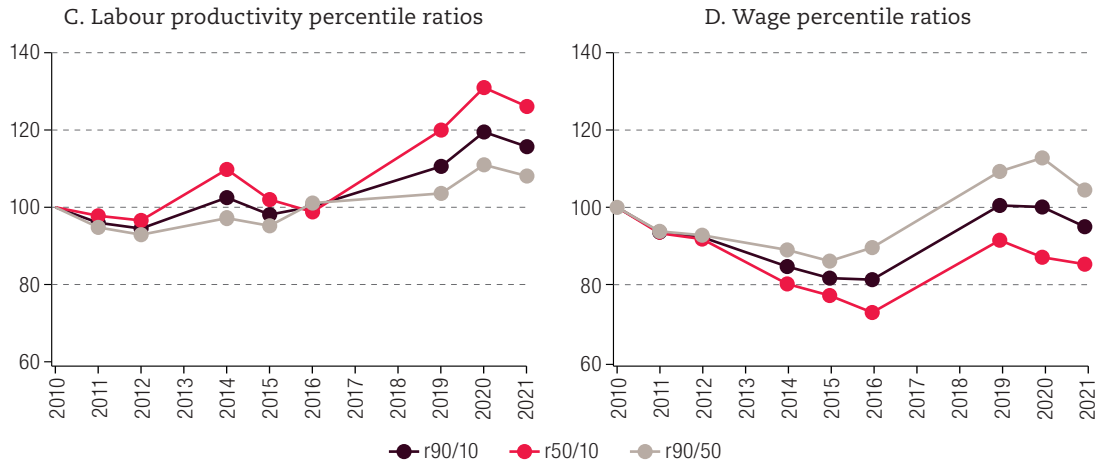
In relative terms, the bottom left panel shows an oscillating pattern for labour productivity ratios between 2010 and 2016 and a divergent trend thereafter. Both the 90/10 and the 50/10 ratios exhibit an initial decline and a subsequent increase (albeit a small one in the case of the 90/50 ratio), reflecting high levels of dispersion. A different pattern emerges for the wage ratios in the bottom right panel, one that is consistent with the percentile trends. Wage inequality displays a clear downward trajectory, with the exception of the 90-50 ratio, which by 2021 had returned to approximately its 2010 level. Conversely, the interdecile (90/10) ratio shows a sharp decline, driven largely by movements in the 50/10 ratio.

As an alternative, figure 8 compares these wage and productivity percentiles and ratios across different segments of the distribution. The upper panels display indexed wage-productivity trends for the tenth, fiftieth and ninetieth percentiles. In every percentile, the labour productivity series displays an increasing trend until 2015, with a period of decline or stagnation thereafter. Conversely, wages do not show any significant movement, with the result that a substantial gap opens up between the two variables throughout the distribution, narrowing significantly only during the pandemic period.

Figure 7
Trends in wage and productivity distributions: absolute percentiles and percentile ratios, 2010–2021
(Index: 2010 = 100)



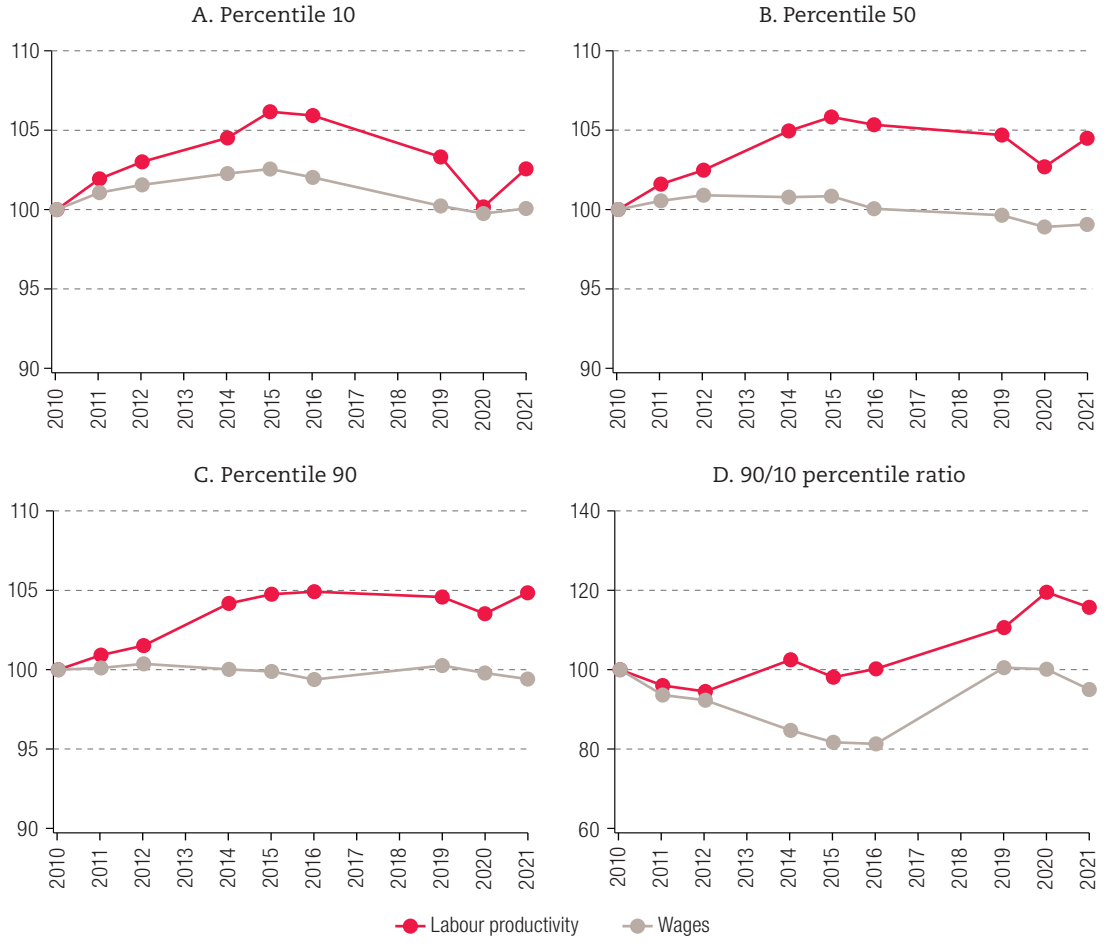
[8] One explanation for this is a national programme that supported formal employment during the pandemic, the Emergency Assistance Programme for Work and Production (ATP).

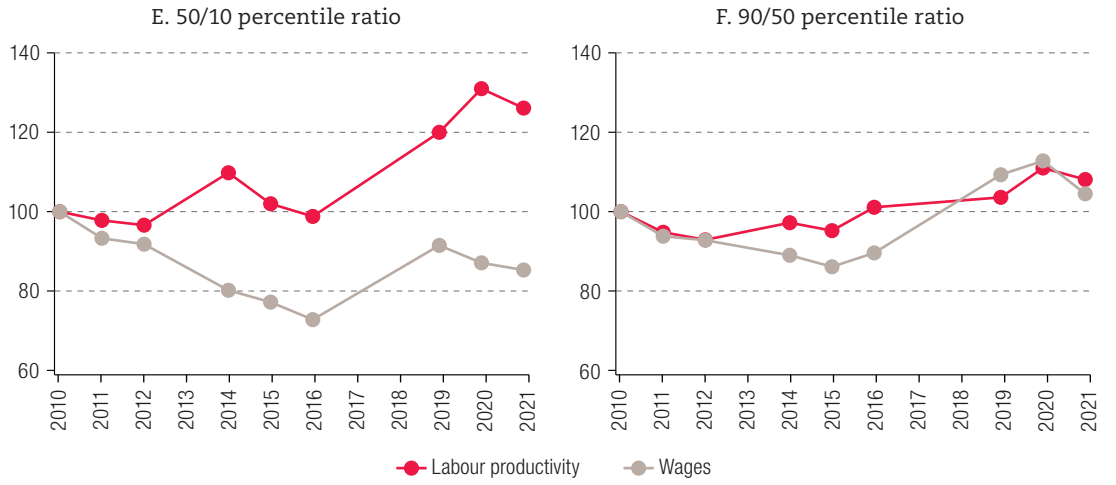


Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.

Note: Panels A and B report the tenth, fiftieth and ninetieth percentiles (p10, p50, and p90) of labour productivity and wages, respectively. Panels C and D report percentile ratios (r90/10, r50/10 and r90/50). The analysis is restricted to formal (registered) employment. No observations are available for the years 2013, 2017 and 2018.

Figure 8
Trends in wage and productivity distributions: selected percentiles and percentile ratios, 2010–2021
(Index: 2010 = 100)





Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.
Note: The analysis is restricted to formal (registered) employment. No observations are available for the years 2013, 2017, and 2018.

The percentile ratio shows the evolution of the indexed percentile ratios for wages and productivity, considered separately. They reveal contrasting patterns across the distributions. Whereas productivity dispersion increased during the period (with a small decline in 2021), the wage gap steadily narrowed until 2016, widening very slightly again thereafter. Similar differences appear in the panel displaying the 50/10 ratios. In the right-hand panel, although the 90/50 wage ratio does not follow the same trend as the productivity ratio, both measures dip slightly at the end of the period.

From figures 7 and 8, we can infer that the evolution of wages and productivity has been very uneven. While productivity gaps exhibit small downturns but large upturns, especially in the lower tail of the distribution, most wage gaps shrank between 2010 and 2021. Moreover, productive heterogeneity proves to be substantially greater than wage inequality. This is manifested not only by their relative values, as labour productivity percentile ratios are higher in 2021 than in 2010 whereas wage ratios are lower (see figure 7), but by their distinct evolution, with a substantial gap opening up between productivity and wages for the 50/10 and 90/10 percentile ratios (see figure 8). These results are consistent with findings from Barrera Insua and Fernandez Massi (2017).

3. Export composition by Pavitt class

The final descriptive analysis deals with firms' export profile. The first column in table 3 shows the proportion of firms in each Pavitt class that are exporters. Firms in the science-based and specialized supplier classes exhibit the strongest propensity to export, with about 53% and 43%, respectively, of them doing so. The second column shows the distribution of exporting firms by Pavitt class, with supplier-dominated industries (46.4%) accounting for the largest share, followed by scale-intensive ones (20.6%). Conversely, the science-based and specialized supplier classes, despite their greater technological intensity, complexity and export propensity, each account for less than 18% of exporting firms. In light of the concepts of "quality of specialization" and "quality of exports" (Hidalgo et al., 2007; Dosi et al., 2022), this distribution is indicative of a weak specialization strategy.

Table 3
Exporting firms, by Pavitt class, 2010–2021
(Percentages)

Pavitt class	Share of firms exporting	Distribution of exporters by Pavitt class
Supplier-dominated firms	22.4	46.4
Scale-intensive firms	30.2	20.6
Specialized suppliers	43.4	17.5
Science-based firms	52.7	15.5
Total		100.0

Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.

V. Empirical strategy

Our empirical strategy evaluates the wage-productivity relationship along the wage distribution, in line with Dosi et al. (2020). The structural heterogeneity and associated wage inequality described above reveal that productivity and wage levels are highly dispersed within each Argentine manufacturing sector (Gómez and Borrastero, 2018). This prompted us to adopt the quantile regression method (Koenker and Bassett, 1978). An advantage of quantile regression is that it allows the relationship between variables to be examined across different points of the conditional distribution, rather than focusing on a single summary measure of inequality such as the mean.

Equations (1) and (2) show the conditional quantile regression structure proposed for the estimates:

$$y_{it} = Q_\tau (y_{it} / x_{it}) + u_{\tau it} = x'_{it} b_\tau + u_{\tau it} \quad (1)$$

with

$$b_\tau \equiv argmin_b E[\rho_t(y_{it} - x'_{it} b)] \text{ and } \rho(u) = \begin{cases} \tau|u| & for\ u \geq 0 \\ (1-\tau)|u| & for\ u < 0 \end{cases} \quad (2)$$

where y_{it} represents the response variable, Q_τ is the τ-th conditional quantile of y_{it} given x_{it} (covariates), b is the vector of parameters at each quantile τ, and u is a vector of residuals. The τ-th quantile, as defined in equation (2), solves a minimization problem by linear programming.

Using a quantile regression approach, our analysis examines firm-level wage elasticities of labour productivity and other relevant covariates across the conditional wage distribution. This empirical strategy does not seek to establish any causality. Indeed, given the analytical framework presented here, any attempt to do so might obscure the full picture of dependencies between the variables analysed.

Two alternative specifications are estimated, reflecting different wage equation structures. First, the baseline quantile regression model, estimated by equation (3), is intended to identify the basic link between productivity and wage levels:

$$w_{it} = \alpha + \beta_\tau \pi_{it} + y_t + \epsilon_{\tau it} \quad (3)$$

where w_{it} is the log of the real average wage for firm i at time t, deflated by the consumer price index (2010 = 100); π_{it} is the log of labour productivity, proxied by the log of real value added per worker[9] and

[9] Both wages and labour productivity are annual average measures per firm.

deflated by the producer price index (2010 = 100); y_t introduces year dummies to capture seemingly unrelated macroeconomic shocks; and β_τ and $\epsilon_{\tau it}$ are the coefficients for productivity and standard errors, respectively.[10]

The second quantile regression model, estimated by equation (4), includes a set of covariates that are specific to individual firms, reflecting their internal structure and international position, and that potentially affect the level of wages.

$$w_{it} = \alpha + \beta_{\tau 1}\pi_{it} + \beta_{\tau 2}exporter_{it} + \beta_{\tau 3}foreign_{it} + \beta_{\tau 4}size_{it} + y_t + \epsilon_{\tau it} \quad (4)$$

The *exporter* variable is a binary indicator equal to 1 if the firm reports export activity, reflecting evidence for wage premiums at exporting firms (Brambilla et al., 2017; Dosi et al., 2023). Firm ownership structure, expressed by *foreign*, equals 1 if the firm has at least 1% foreign-owned capital; according to Schorr (2021), multinational firms pay the highest wages in Argentine industry. Lastly, firm size is proxied by log employment (*size*), capturing the elasticity of wages with respect to this variable (Cobb and Lin, 2017).[11]

Because there are no data available on informality, it is important to consider the possibility of biases in both sets of estimations. They may be of two types: (i) biases arising from the sorting of firms into the proposed classes and (ii) biases associated with the pass-through between labour productivity (or the other firm covariates) and wages. To our knowledge, there are no current firm-level databases covering informality in Argentina. Further studies and broader datasets, which are beyond the scope of this paper, would make it possible to carry out an in-depth evaluation of the nature and sign of these biases and would shed new light on the formal and informal sectors of Argentine manufacturing industry.

To examine the nature of the pass-through between productivity and wages, we estimate each quantile regression model at the sectoral level using the pooled data. We also estimate regressions for the 0.05, 0.10, 0.25, 0.5, 0.75, 0.9 and 0.95 quantiles to evaluate whether the wage-productivity relationship displays any increasing or decreasing trend over the conditional wage distribution. These estimates are combined with sectoral disaggregation based on both the ISIC Revision 4 codes and the Pavitt classes.

In the first case, we present violin plots for each wage quantile. These plots include the median, the interquartile range and the kernel density distribution of the estimated coefficients, capturing both the sectoral and quantile distributions of the dependent variable (Dosi et al., 2020), as an extension of standard ordinary least squares violin plots (Dosi et al., 2015). In the second case, we explore the relationship across different industry types by estimating quantile regression coefficients for each Pavitt class. As an additional exercise, we briefly introduce the results of an alternative model in which the model with control variables is supplemented by the log of the skill ratio (defined as the ratio between workers with professional skills and other workers).[12]

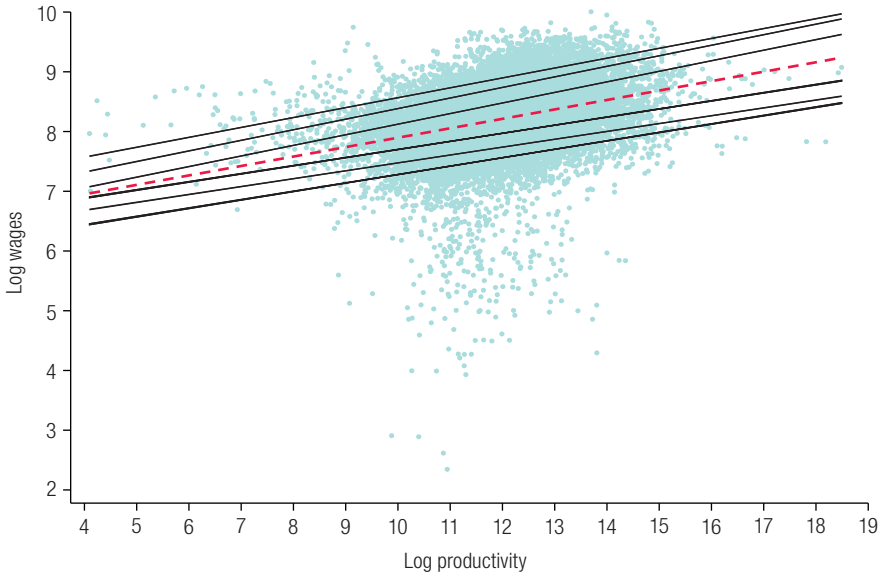
Figures 9 and 10 are scatter plots that show how the conditional quantile regression estimates fit our data at the industry level and by Pavitt class, respectively. The black lines represent the quantile regression estimates, and the dashed red line plots the standard pooled ordinary least squares estimate. These plots show pronounced heterogeneity and the presence of outliers in both wage and productivity levels. In the disaggregation by Pavitt classes (figure 10), we find higher dispersion in the supplier-dominated class but a better fit to the data in the science-based industries.

[10] Alternative specifications using one-year lagged productivity levels revealed strong persistence and autocorrelation, validating the choice of a contemporaneous specification. These results are available upon request.

[11] In the last wave (2019–2021), the firm age variable is absent, preventing it from being used as a control variable.

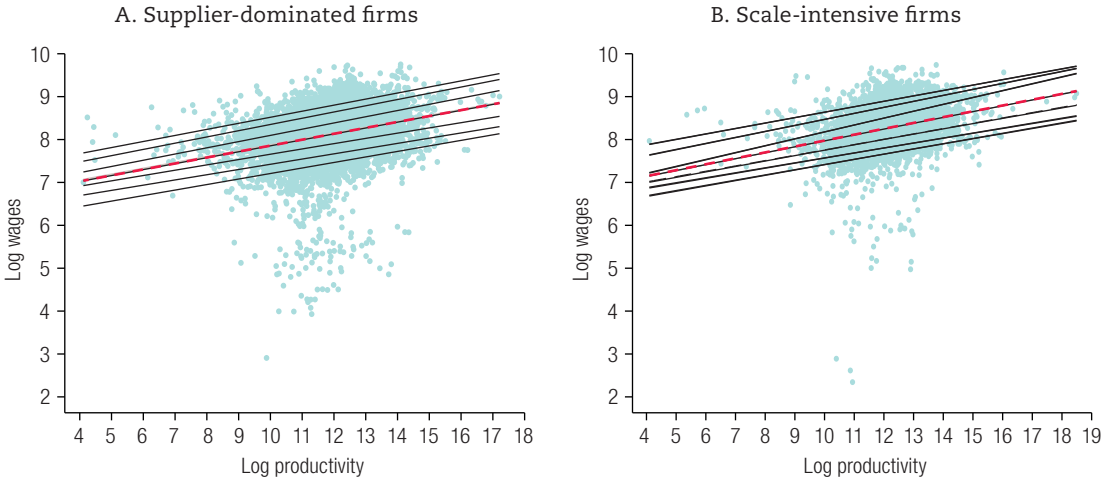
[12] This variable has a great number of observations missing, preventing estimation at the two-digit level. We have therefore included a graphic analysis in annex figure A1.4; the estimates are available upon request.

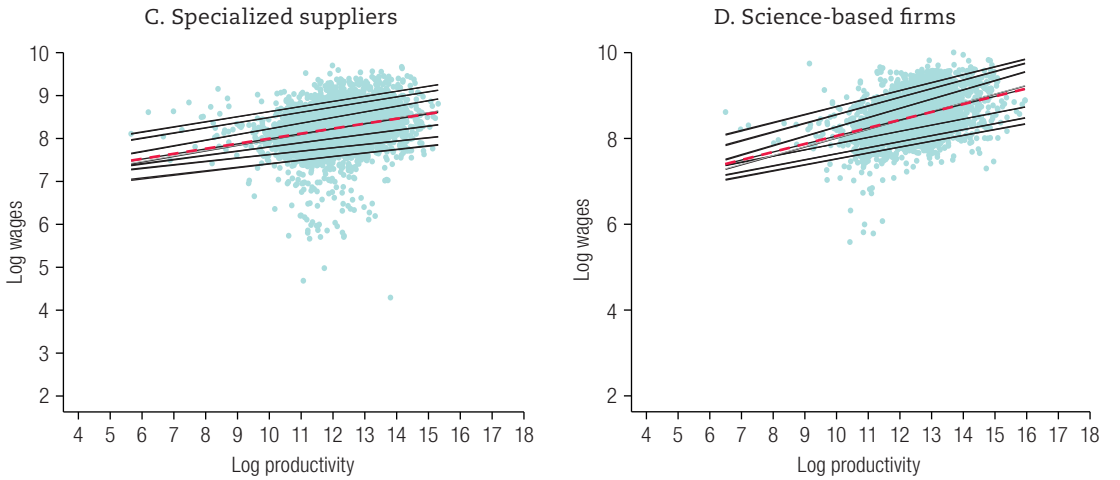
Figure 9
Scatter plot with quantile regression fit for log wages and log productivity, all sectors (baseline model), 2010–2021



Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.
Note: Black lines show the quantile regression fits at the 0.05, 0.10, 0.25, 0.50, 0.75, 0.90 and 0.95 quantiles. The red dashed line shows the ordinary least squares regression fit. The analysis is restricted to formal (registered) employment.

Figure 10
Scatter plot with quantile regression fit for log wages and log productivity, by Pavitt class (baseline model), 2010–2021





Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.

Note: Black lines show the quantile regression fits at the 0.05, 0.10, 0.25, 0.50, 0.75, 0.90 and 0.95 quantiles. The red dashed line shows the ordinary least squares regression fit. The analysis is restricted to formal (registered) employment.

VI. Results

1. The relationship between wages and productivity in the baseline model

Table 4 shows the regression results for the baseline model (equation (3)). The quantile regression estimates confirm significant and positive pass-through between labour productivity and wages in Argentine manufacturing firms, regardless of technological class or production sector. Most of the interquantile results show this relationship strengthening along the intra-industry wage distribution. In the supplier-dominated and science-based classes, the interquantile regressions confirm a strengthening trend in different segments of the distribution, while in the scale-intensive and specialized supplier classes, the median interquartile range (0.25–0.75) and the interdecile range (0.10–0.90) likewise exhibit upward trends.

An analysis at the branch level (ISIC Revision 4 codes) finds significant coefficients for these elasticities in most cases (94% of the estimates) (see table A1.3 and figures A1.1 to A1.3 in the annex).

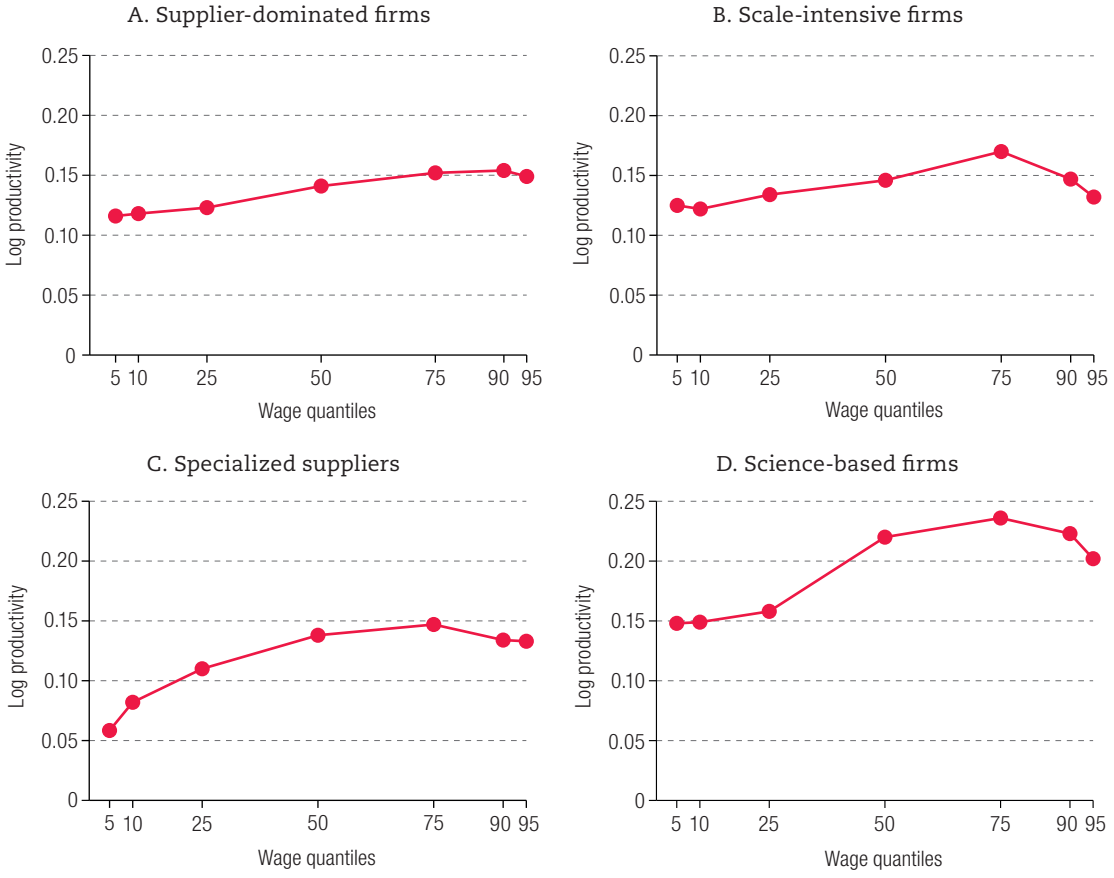
Figure 11 plots the distribution of quantile regression coefficients by Pavitt class, showing a slight rising trend in pass-through up the wage quantiles, indicative of a stronger link between wages and productivity among firms with higher wage levels. Technological classes also differ in the magnitude of the coefficients, with specialized suppliers and science-based firms recording the highest coefficients for the upper quantiles of the conditional wage distribution, while supplier-dominated and scale-intensive firms record the lowest.

Table 4
Quantile coefficients for log productivity in formal manufacturing, by Pavitt class (baseline model), 2010–2021

Pavitt class	Quantile regressions								Interquantile regressions		
	Ordinary least squares	5	10	25	50	75	90	95	βi,95 -βi,05	βi,90 -βi,10	βi,75 -βi,25
All firms	0.162***	0.128***	0.133***	0.139***	0.163***	0.188***	0.195***	0.182***	0.054***	0.062***	0.049***
Supplier-dominated firms	0.140***	0.114***	0.113***	0.122***	0.139***	0.156***	0.163***	0.163***	0.050***	0.050***	0.033***
Scale-intensive firms	0.164***	0.138***	0.130***	0.140***	0.161***	0.193***	0.188***	0.170***	0.032	0.057***	0.053***
Specialized suppliers	0.126***	0.076**	0.081***	0.120***	0.149***	0.155***	0.143***	0.141***	0.066	0.062**	0.035**
Science-based firms	0.201***	0.149***	0.132***	0.142***	0.192***	0.263***	0.260***	0.239***	0.090***	0.127***	0.121***

Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.
Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

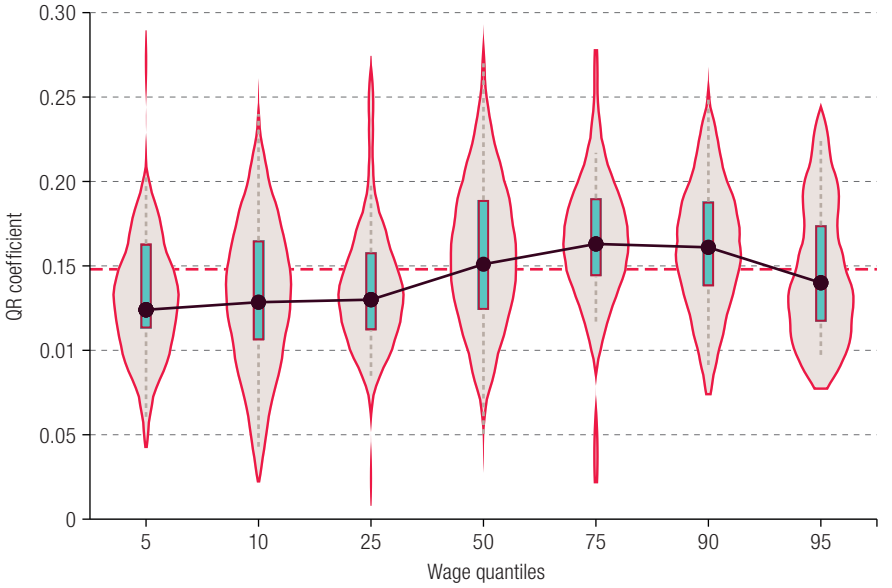
Figure 11
Relationship between wages and log productivity, by Pavitt class (baseline model), 2010–2021



Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.
Note: The analysis is restricted to formal (registered) employment.

Drawing on the quantile regression estimates in the baseline model, figure 12 illustrates the wage-productivity relationship by means of a violin plot, combining the kernel density distribution of the estimates by ISIC code (vertical dimension) and the wage quantile distribution (horizontal dimension). The figure shows a pattern of moderate strengthening in the wage-productivity relationship. The lowest productivity coefficients are observed in the lower quantiles, with a 10% increase in labour productivity being associated with a 1.3% increase in wages in the fifth quantile and a 1.4% increase in the first quartile (all sectors). The relationship is somewhat stronger in the upper tail of the distribution, where a 10% increase in productivity is associated with a 1.8% increase in wages.

Figure 12
Distribution of quantile regression (QR) coefficients for log productivity across wage quantiles (baseline model), 2010–2021



Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.

Note: The figure shows the distribution of QR coefficients for log productivity, estimated using the baseline QR specification. The QR is estimated separately for each sector of the International Standard Industrial Classification of All Economic Activities (ISIC Revision 4). The analysis is restricted to formal (registered) employment. The horizontal dashed line indicates the median of the corresponding ordinary least squares coefficient estimates. The pseudo-R^2 of the median regression across all sectors is 0.082.

To test for interquantile differences, we run two non-parametric tests. First, we use the Kruskal-Wallis test to evaluate overall median differences across the distributions of the 0.05–0.95 quantile estimates (Kruskal and Wallis, 1952). Second, we perform Dunn's test, conducting multiple pairwise comparisons to identify stochastic dominance or median differences between pairs of estimates (Dinno, 2015). Consistently with the foregoing analysis, we identify only minor differences between quantile estimates. Although the Kruskal-Wallis tests reject the null hypothesis that all estimates originate from the same population, Dunn's test shows no statistically significant dominance in the multiple pairwise comparisons, except that there is a significant difference between the seventy-fifth and fifth quantile estimates in the baseline model using the ISIC Revision 4 taxonomy.

2. The relationship between wages and productivity in the model with control variables

The estimates from the model with control variables reveal that the inclusion of covariates related to firms' characteristics (exporting activity, foreign ownership and firm size) reduces the pass-through between wage and productivity levels, as expected. The quantile regression coefficients in the baseline model at the industry level range from 0.13 to 0.20 in the fifth and ninetieth quantiles, respectively, while in the model with control variables they range from 0.11 to 0.12, respectively (see table 5). The reduction in pass-through occurs across all Pavitt classes.

Table 5
Quantile coefficients for log productivity in formal manufacturing, by Pavitt class (model with controls), 2010–2021

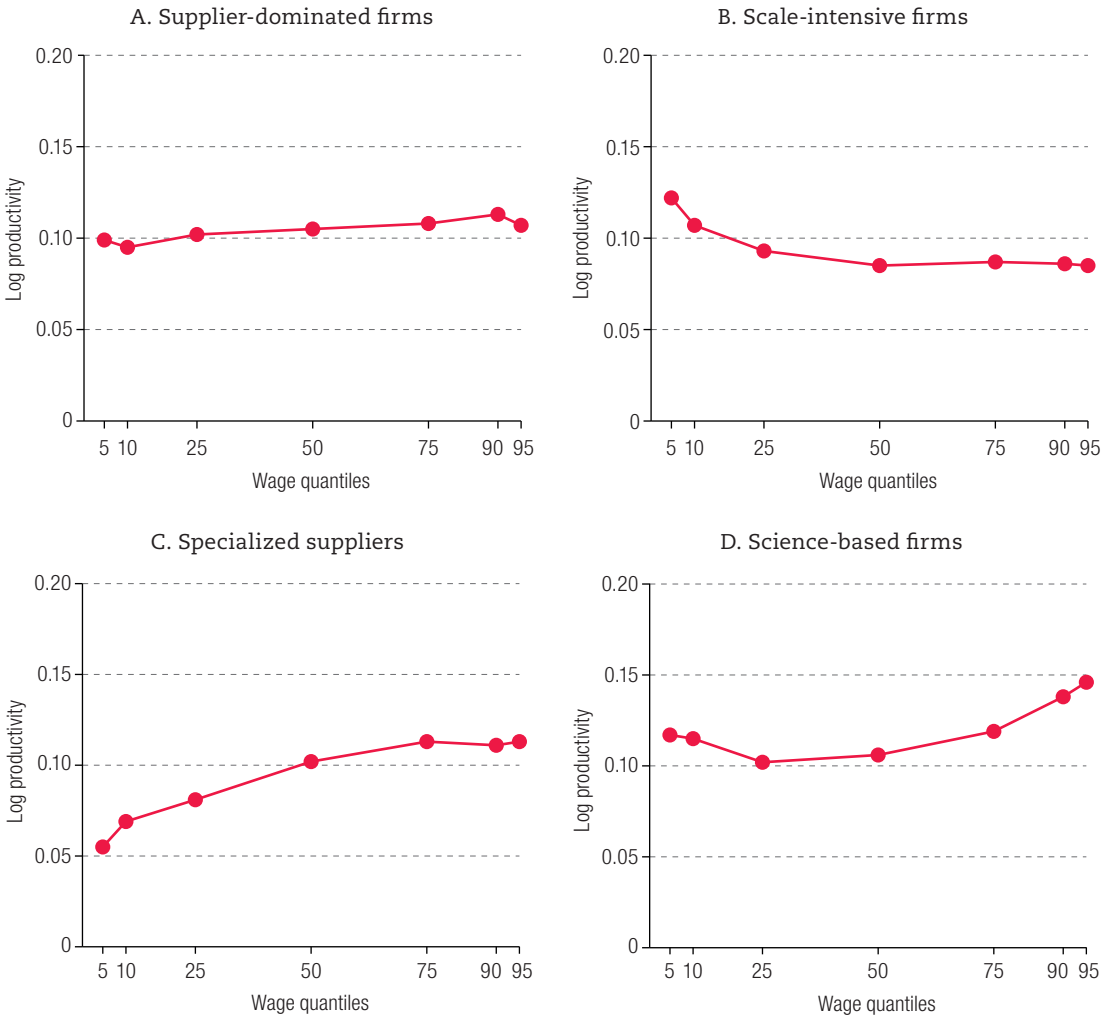
Pavitt class	Quantile regressions								Interquantile regressions		
	Ordinary least squares	5	10	25	50	75	90	95	βi,95 -βi,05	βi,90 -βi,10	βi,75 -βi,25
All firms	0.111***	0.111***	0.115***	0.111***	0.117***	0.122***	0.123***	0.123***	0.013	0.008	0.010***
Supplier-dominated firms	0.103***	0.099***	0.095***	0.102***	0.105***	0.108***	0.113***	0.107***	0.008	0.018**	0.006
Scale-intensive firms	0.090***	0.122***	0.107***	0.093***	0.085***	0.087***	0.086***	0.085***	-0.037**	-0.022**	-0.006
Specialized suppliers	0.090***	0.055***	0.069***	0.081***	0.102***	0.113***	0.111***	0.113***	0.058***	0.042***	0.033***
Science-based firms	0.117***	0.117***	0.115***	0.102***	0.106***	0.119***	0.138***	0.146***	0.03	0.023	0.016

Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.
Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Thus, this model delivers a flatter interquantile pattern than the baseline model. We used interquantile regressions to test the upward trend in different segments of the conditional wage distribution and found that only in the seventy-fifth quantile did the coefficient show higher pass-through than in the twenty-fifth quantile. The same was true in the specialized supplier class, while in the scale-intensive group a modest decreasing trend was found for the fifth to ninety-fifth and tenth to ninetieth quantile ranges. For science-based industries, lastly, the relationship between wages and productivity was found to be constant across the different quantiles.

Figure 13 shows wage-productivity pass-through for each Pavitt class in the model with control variables. Most of the classes do not display significant differences in this relationship at different distribution points. The specialized supplier class is the exception, with a slight upward trend. Thus, wage dispersion is found to be significantly lower than productive heterogeneity, and both are found to be lower than technological heterogeneity (Gómez, 2020b). In addition, the estimates of the alternative model including the log of the skill ratio do not change significantly (see annex figure A1.4).

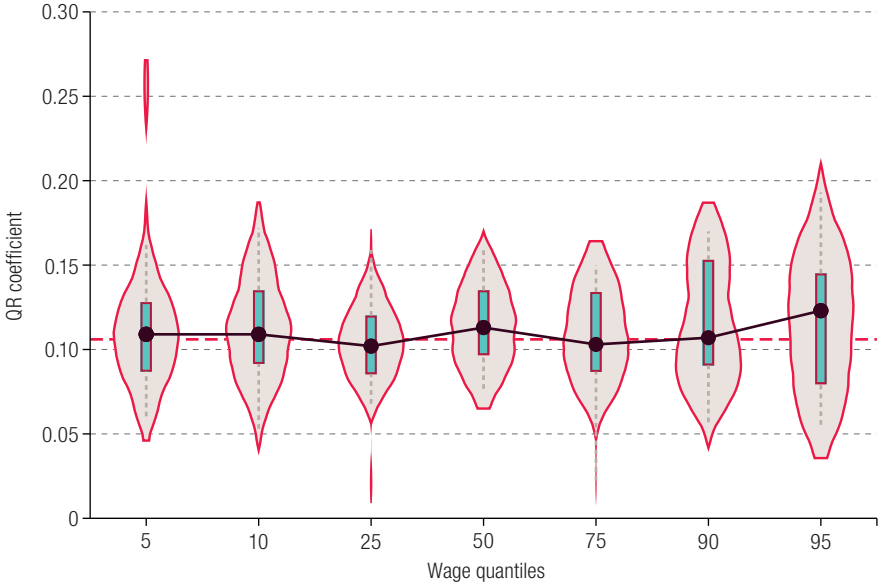
Figure 13
Relationship between wages and log productivity, by Pavitt class (model with controls), 2010–2021



Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.
Note: The analysis is restricted to formal (registered) employment.

The constant pattern in the wage-productivity relationship for the model with control variables is confirmed at the ISIC Revision 4 level of disaggregation. The violin plot in figure 14 reveals no significant differences in pass-through at different wage levels. Accordingly, while the Kruskal-Wallis test rejects the null hypothesis of equal distributions for the estimates in general, Dunn's test does not identify significant differences in most of the pairwise comparisons. A deeper level of disaggregation between firms likewise shows a constant wage-productivity relationship.

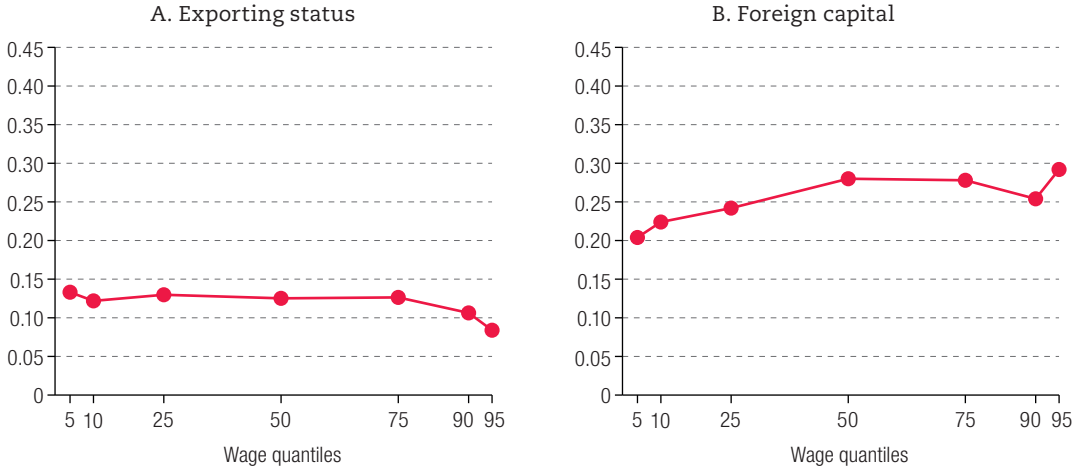
Figure 14
Distribution of quantile regression (QR) coefficients for log productivity across wage quantiles (model with controls), 2010–2021



Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*; Secretariat of Labour, Employment and Social Security.
Note: The QR is estimated separately for each sector of the International Standard Industrial Classification of All Economic Activities (ISIC Revision 4). The analysis is restricted to formal (registered) employment. The pseudo-R^2 of the median regression across all sectors is 0.084.

To identify how the control variables relate to wage levels, figure 15 plots the corresponding quantile regression coefficients. We also tested interquantile differences with interquantile regressions. The estimates reveal a slight downward trend in wage premiums for exporting firm status (with non-significant interquantile differences). Foreign ownership displays a gently increasing pass-through trend that is statistically significant over the fifth to ninety-fifth quantile range. Lastly, the firm size proxy displays a U-shaped pattern across the distribution.

Figure 15
Quantile regression (QR) coefficients for additional covariates (model with controls), 2010–2021



Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.
Note: Only statistically significant QR coefficients are reported. The analysis is restricted to formal (registered) employment.

VII. Implications and concluding remarks

Following a structuralist and distributional firm-level approach and employing a dataset for the 2010–2021 period, this study examined the relationship between wages and productivity in Argentine manufacturing industry. The distributional perspective allowed us to examine pass-through effects at different points of the conditional wage distribution. Applying the Pavitt taxonomy, we evaluated whether pass-through differed according to the technical and production characteristics of firms. Overall, the empirical analysis was designed to capture firm-level wage bargaining processes and ascertain the extent to which technical and organizational capabilities influenced the distribution of productivity gains. The structuralist perspective connects micro-level findings with the country's context-dependent development trajectory, highlighting the influence of institutional and policy factors on the deindustrialization trend.

The study confirms the existence of mildly positive pass-through between productivity and wage levels in manufacturing industry when a baseline model is used, and constant patterns in a model including the most important control variables. Analysis by ISIC Revision 4 codes and Pavitt classes confirms the findings, but the pass-through values estimated are extremely low (ranging between 0.02 and 0.27), which is consistent with other estimates for developing countries. There is a non-trivial difference between supplier-dominated firms and those in more complex Pavitt classes, with values for the latter, particularly in science-based industries, being somewhat higher. The slight upward trajectory seen in the baseline model disappears when controls are included. This means that pass-through, although present, is very low and does not differ between high-paying and low-paying firms.

Our findings may be summarized as follows. First, wage-productivity pass-through is positive in all specifications and uniform across the conditional wage distribution when control variables are included, although values are dramatically lower than in advanced countries (Stansbury and Summers, 2017). Second, natural resource-intensive branches and basic manufacturing (the supplier-dominated and scale-intensive classes) account for a substantial portion of Argentina's sectoral and technological structure. This composition affects the results, particularly since pass-through by supplier-dominated firms, the largest component, is particularly weak. These firms are also characterized by stagnant productivity and higher level of informality. The existing

production structure thus offers little scope for structural change and constrains both productivity growth and the distribution of its gains, consigning the country to a middle-income trap. Third, pass-through at foreign-owned enterprises shows a rising trend across the wage distribution, albeit of a moderate magnitude, making foreign ownership the only firm characteristic to affect the pass-through patterns observed.

These micro- and industry-level findings have major implications at the macroeconomic level and highlight the path-dependent consequences of the early deindustrialization "choice" made during the dictatorship period. Macroeconomic implications span three domains, namely production, redistribution and external constraints, both financial and material, consistently with the logic of cumulative causation and Gunnar Myrdal's vicious cycle (Myrdal,1974). These consequences range from the micro effects that we have presented to further-reaching macroeconomic dimensions.

First, the limited technological and productive upgrading of domestic firms represents the main constraint on the growth prospects of the Argentine economy, which has progressively shifted towards servitization and financialization. If the finance-led accumulation strategy followed in developed countries tends to dampen growth, this is even more the case for countries experiencing early deindustrialization. The financialization turn has also been coupled with an increasing reliance on resource-based export strategies. Therefore, the first macroeconomic implication of our study is the need to reassert manufacturing as a growth-promoting strategy, particularly in a context marked by an energy transition that is heavily dependent on mineral resources, since otherwise Argentina, like many other countries in Latin America and the Caribbean, risks falling prey to new colonial appetites.

Second, the progressive rentification of the economy (Dosi et al., 2024) entails the accumulation of rents, wealth and inequality. Our paper clearly demonstrates that weak labour productivity in manufacturing, quite apart from the problem of productive composition, means weak wage growth and poor redistribution of the already modest value added generated. Stable growth derives from good jobs, and manufacturing, broadly speaking, provides better jobs than many service industries. A manufacturing specialization strategy centred on low-emission industries might represent a potential route towards the productive, social and environmental benefits of a renewed phase of industrialization.

Third, in relation to external constraints, reindustrialization in selected industries, possibly science-based ones with a strong connection to the education and research systems, which are still quite robust in the country, might help alleviate the current structural dependence on external finance and natural resource-intensive exports. Generating value from manufacturing could ease the debt constraint and reposition the country's economy within international trade regimes.

More broadly, Argentina, like many other countries of Latin America and the Caribbean, needs to liberate the competences and capabilities that still very much exist there but are currently repressed as domestically based growth strategies go through a vicious cycle of dismantling. To attain this objective, a renewed industrial policy framework in association with redistributive policies is the place to start. Market forces alone will hardly make the difference.

Some avenues for future research emerge from this analysis. First, there is a need for a micro-level study of trade unions and their influence on the wage-productivity relationship; our findings indicate that intra- and inter-industry wage heterogeneity has been declining in a period characterized by increasing adherence to collective bargaining agreements. Second, more research is needed on the role of production and export specialization as a factor in sustainable development prospects. Lastly, the gender composition and pay structure of manufacturing employment should be assessed to ascertain whether "good" jobs are available irrespective of workers' gender, or whether decent pay and working conditions are the preserve of the male workforce.

Bibliography

Acemoglu, D., Aghion, P. and Violante, G. L. (2001). Deunionization, technical change and inequality. *Carnegie-Rochester Conference Series on Public Policy*, *55*(1). https://doi.org/10.1016/S0167-2231(01)00058-6

Acosta, P. and Montes-Rojas, G. (2014). Informal jobs and trade liberalisation in Argentina. *The Journal of Development Studies*, *50*(8). https://doi.org/10.1080/00220388.2014.919381

Adelman, I. (2001). Fallacies in development theory and their implications for policy. In G. M. Meier and J. E. Stiglitz (Eds.), *Frontiers of Development Economics: The Future in Perspective* (pp. 103-134). https://doi.org/10.1596/0-1952-1592-3

Aguiar de Medeiros, C. and Trebat, N. (2017). Finance, trade, and income distribution in global value chains: Implications for developing economies and Latin America. *Texto para Discussão*. (002/2017). Federal University of Rio de Janeiro.

Azpiazú, D. and Kosacoff, B. (1988). Exports and industrialization in Argentina, 1973–1986. *CEPAL Review*. (36) (LC/G.1537-P). Economic Commission for Latin America and the Caribbean.

Barrera Insua, F. and Fernández Massi, M. (2017). La dinámica productiva como límite superior de los salarios en la industria argentina. *Perfiles Latinoamericanos*, *25*(50). https://doi.org/10.18504/pl2550-014-2017

Barth, E., Bryson, A., Davis, J. C. and Freeman, R. (2016). It's Where You Work: Increases in the Dispersion of Earnings across Establishments and Individuals in the United States. *Journal of Labor Economics*, *34*(S2). https://doi.org/10.1086/684045

Bascur, O. and Coviello, R. (2021). Las instituciones estatales y la industria en perspectiva histórica. In M. Rougier (Coord.), *La industria argentina en su tercer siglo: una historia multidisciplinar (1810-2020).* Ministry of Productive Development.

Berlingieri, G., Blanchenay, P. and Criscuolo, C. (2024). The great divergence(s). *Research Policy*, *53*(3). https://doi.org/10.1016/j.respol.2024.104955

Bishop, J. and Chan, I. (2019). Is Declining Union Membership Contributing to Low Wages Growth?. *Research Discussion Paper*. (2019-02). Reserve Bank of Australia.

Bogliacino, F. and Pianta, M. (2011). Engines of growth. Innovation and productivity in industry groups. *Structural Change and Economic Dynamics*, *22*(1). https://doi.org/10.1016/j.strueco.2010.11.002

Brambilla, I., Depetris Chauvin, N. and Porto, G. (2017). Examining the export wage premium in developing countries. *Review of International Economics*, *25*(3). https://doi.org/10.1111/roie.12231

Card, D., Cardoso, A., Heining, J. and Kline, P. (2018). Firms and labor market inequality: Evidence and some theory. *Journal of Labor Economics*, *36*(S1). https://doi.org/10.1086/694153

Castillo, M. and Martins Neto, A. (2016). Premature deindustrialization in Latin America. *Production Development series*. (205) (LC/L.4183). Economic Commission for Latin America and the Caribbean.

Chena, P. I. and Pérez Caldentey, E. (2020). Structural change and counter-reforms in Latin America: Necessity or possibility? *Cuadernos de Economía, 39*(80). https://doi.org/10.15446/cuad.econ.v39n80.88548

Cimoli, M., Dosi, G. and Stiglitz, J. (2009). The Political Economy of Capabilities Accumulation: the Past and Future of Policies for Industrial Development. In M. Cimoli, G. Dosi and J. E. Stiglitz (Eds.), *Industrial Policy and Development: The Political Economy of Capabilities Accumulation.* Oxford University Press.

Cimoli, M., Pereima, J. B. and Porcile, G. (2019). A technology gap interpretation of growth paths in Asia and Latin America. *Research Policy, 48*(1). https://doi.org/10.1016/j.respol.2018.08.002

Cobb, J. A. and Lin, K. H. (2017). Growing Apart: The Changing Firm-Size Wage Premium and Its Inequality Consequences. *Organization Science*, *28*(3). https://doi.org/10.1287/orsc.2017.1125

Cresti, L. and Virgillito, M. E. (2025). Strategic sectors and essential jobs: a taxonomy for industrial policies. *Economics of Innovation and New Technology*. https://doi.org/10.1080/10438599.2025.2543429

Dasgupta, S. and Singh, A. (2007). Manufacturing, Services and Premature Deindustrialization in Developing Countries: A Kaldorian Analysis. In G. Mavrotas and A. Shorrocks (Eds.), *Advancing Development: Studies in Development Economics and Policy*. Palgrave Macmillan. https://doi.org/10.1057/9780230801462_23

Dinno, A. (2015). Nonparametric pairwise multiple comparisons in independent groups using Dunn's test. *The Stata Journal: Promoting Communications on Statistics and Stata*, *15*(1). https://doi.org/10.1177/1536867X1501500117

Dosi, G. (1982). Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change. *Research Policy*, *11*(3). https://doi.org/10.1016/0048-7333(82)90016-6

Dosi, G. (1988). Sources, Procedures, and Microeconomic Effects of Innovation. *Journal of Economic Literature*, *26*(3). American Economic Association.

Dosi, G., Cresti, L., Riccio, F. and Virgillito, M. E. (2025). Industrial policies for global commons: why it is time to think of the ghetto rather than of the moon. *Journal of Industrial and Business Economics*, *52*. https://doi.org/10.1007/s40812-025-00351-6

Dosi, G., Fanti, L. and Virgillito, M. E. (2024). Attributes and trends of rentified capitalism. *Italian Economic Journal*, *10*(2). https://doi.org/10.1007/s40797-024-00279-1

Dosi, G., Guarascio, D., Ricci, A. and Virgillito, M. E. (2021). Neodualism in the Italian business firms: training, organizational capabilities, and productivity distributions. *Small Business Economics: An Entrepreneurship Journal*, *57*(1). https://doi.org/10.1007/s11187-019-00295-x

Dosi, G., Moschella, D., Pugliese, E. and Tamagni, F. (2015). Productivity, market selection, and corporate growth: comparative evidence across US and Europe. *Small Business Economics*, *45*(3). https://doi.org/10.1007/s11187-015-9655-z

Dosi, G., Riccio, F. and Virgillito, M. E. (2021). Varieties of deindustrialization and patterns of diversification: why microchips are not potato chips. *Structural Change and Economic Dynamics*, *57*. https://doi.org/10.1016/j.strueco.2021.01.009

Dosi, G., Riccio, F. and Virgillito, M. E. (2022). Specialize or diversify? And in What? Trade composition, quality of specialization, and persistent growth. *Industrial and Corporate Change*, *31*(2). https://doi.org/10.1093/icc/dtac008

Dosi, G., Virgillito, M. E. and Yu, X. (2020). The wage-productivity nexus in the world factory economy. *World Development*, *129*. https://doi.org/10.1016/j.worlddev.2020.104875

Dosi, G., Virgillito, M. E. and Yu, X. (2023). Gains from trade or from catching-up? Value creation and distribution in the era of China's WTO accession. *Eurasian Business Review*, *13*(1). https://doi.org/10.1007/s40821-022-00212-5

Freeman, C. (1974). *The Economics of Industrial Innovation*. Penguin Books.

Freeman, C. (2019). History, co-evolution and economic growth. *Industrial and Corporate Change*, *28*(1). https://doi.org/10.1093/icc/dty075

Ghibaudo, F. and Raccanello, M. (2021). Crecimiento y reindustrialización acotada (2002-2015). In M. Rougier (Coord.), La industria argentina en su tercer siglo: una historia multidisciplinar (1810-2020). Ministry of Productive Development.

Gómez, M. C. (2020a). Elementos de poder sindical y sus efectos en la desigualdad salarial argentina: Afiliación, negociación colectiva y conflictos laborales. *Revista CIFE*, *22*(36). https://doi.org/10.15332/22484914/5436

Gómez, M. C. (2020b). Innovación y desigualdad salarial en las empresas manufactureras argentinas. *Problemas del Desarrollo*, *52*(206). https://doi.org/10.22201/iiec.20078951e.2021.206.69719

Gómez, M. C. and Borrastero, C. (2018). Innovación tecnológica y desigualdad productiva y laboral en las empresas manufactureras argentinas. *Desarrollo y Sociedad*. (81). https://doi.org/10.13043/dys.81.6

Graña, J. M. (2018). Labor market trends in a low and heterogeneous productivity country. Evidence from Argentina's manufacturing. *Brazilian Journal of Political Economy*, *38*(2). https://doi.org/10.1590/0101-31572018v38n02a08

Graña, J. M. and Terranova, L. (2020). Distribución funcional del ingreso en el sector industrial argentino, 1935-2019: valor agregado, remuneración al trabajo, ocupación y salarios. *Documentos de Trabajo*. (26). Research Centre on Population, Employment and Development.

Hausmann, R. and Rodrik, D. (2006). *Doomed to Choose: Industrial Policy as Predicament* [Unpublished manuscript]. John F. Kennedy School of Government.

Hidalgo, C., Klinger, B., Barabási, A. L. and Hausmann, R. (2007). The product space conditions the development of nations. *Science*, *317*(5837). https://doi.org/10.1126/science.1144581

Hirschman, A. O. (1968). The political economy of import-substituting industrialization in Latin America. *The Quarterly Journal of Economics*, *82*(1). https://doi.org/10.2307/1882243

Kang, N. and Paus, E. (2020). The political economy of the middle-income trap: The challenges of advancing innovation capabilities in Latin America, Asia and beyond. *The Journal of Development Studies*, *56*(4). https://doi.org/10.1080/00220388.2019.1595601

Koenker, R. and Bassett, G. (1978). Regression quantiles. *Econometrica*, *46*(1). https://doi.org/10.2307/1913643

Kruskal, W. H. and Wallis, W. A. (1952). Use of ranks in one-criterion variance analysis. *Journal of the American Statistical Association*, *47*(260). https://doi.org/10.1080/01621459.1952.10483441
Lewis, W. A. (1984). The state of development theory. *The American Economic Review*, *74*(1). American Economic Association.
Love, J. L. (1995). Economic ideas and ideologies in Latin America since 1930. In L. Bethell (Ed.), *The Cambridge History of Latin America*, *6*(1). Cambridge University Press.
Lundvall, B. Å. (Ed.). (2010). *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. Anthem Press.
Malerba, F. (2002). Sectoral systems of innovation and production. *Research Policy*, *31*(2). https://doi.org/10.1016/S0048-7333(01)00139-1
McMillan, M. S. and Rodrik, D. (2011). Globalization, structural change and productivity growth. *NBER Working Paper*. (17143). http://doi.org/10.3386/w17143
Médici, F. (2020). Financial instability in peripheral economies: an approach from the balance-of-payments constraint. *Journal of Post Keynesian Economics*, *43*(4). https://doi.org/10.1080/01603477.2020.1811126
Mishel, L. and Bivens, J. (2021, 18 July). Identifying the policy levers generating wage suppression and wage inequality. https://portside.org/2021-07-18/identifying-policy-levers-generating-wage-suppression-and-wage-inequality
Morris, M. B. (2017). La revitalización sindical en Argentina (2003-2015): dimensiones e indicadores para su conceptualización. *Población y Sociedad*, *24*(2).
Myrdal, G. (1974). What Is Development? *Journal of Economic Issues*, *8*(4).
Nelson, R. R. and Winter, S. G. (1982). *An Evolutionary Theory of Economic Change*. Harvard University Press.
Odisio, J. and Rougier, M. (2021). Industrialization in Argentina Since 1870: Ideas, Policies, and Evolution. In Kipping, M., Kurosawa, T. and Westney, D. E. (Eds), *The Oxford Handbook of Industry Dynamics*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190933463.013.52
Organisation for Economic Co-operation and Development. (2015). *The Future of Productivity*. https://doi.org/10.1787/9789264248533-en
Ormaechea, E. and Fernández, V. R. (2020). Discontinuous continuity: Structural change and its (divergent) meanings in Latin American structuralism and neo-structuralism. *Cuadernos de Economía*, *39*(80). https://doi.org/10.15446/cuad.econ.v39n80.82518
Pagés, C. (Ed.). (2010). *The Age of Productivity: Transforming Economies from the Bottom Up*. Palgrave Macmillan.
Palma J. G. (2019). Desindustrialización, desindustrialización "prematura" y "síndrome holandés". *El Trimestre Económico*, *86*(344). https://doi.org/10.20430/ete.v86i344.970
Palma, J. G. and Pincus, J. (2024). Is Southeast Asia falling into a Latin American-style middle-income trap? *The Japanese Political Economy*, *50*(3-4). https://doi.org/10.1080/2329194X.2024.2430255
Paus, E. (2017). Escaping the middle-income trap: Innovate or perish. *ADBI Working Paper*. (685). Asian Development Bank Institute.
Paus, E. (2018). The Middle-Income Trap: Lessons from Latin America. In B. Huang, P. J. Morgan and N. Yoshino (Eds.), *Avoiding The Middle-Income Trap in Asia: The Role of Trade, Manufacturing, and Finance*. Asian Development Bank Institute.
Pavitt, K. (1984). Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy*, *13*(6). https://doi.org/10.1016/0048-7333(84)90018-0
Peres, W. and Primi, A. (2009). Theory and practice of industrial policy: evidence from the Latin American experience. *Production Development series*. (187) (LC/L.3013-P). Economic Commission for Latin America and the Caribbean.
Prebisch, R. (1959). Commercial policy in the underdeveloped countries. *The American Economic Review*, *49*(2). American Economic Association.
Raffo, J., Lhuillery, S. and Miotti, L. (2008). Northern and southern innovativity: a comparison across European and Latin American countries. *The European Journal of Development Research*, *20*(2). https://doi.org/10.1080/09578810802060777
Reinert, E. S. (1995). Competitiveness and its predecessors—a 500-year cross-national perspective. *Structural Change and Economic Dynamics*, *6*(1). https://doi.org/10.1016/0954-349X(94)00002-Q
Rodrik, D. (2016). Premature deindustrialization. *Journal of Economic Growth*, *21*(1). https://doi.org/10.1007/s10887-015-9122-3
Rougier, M. (Coord.) (2021). *La industria argentina en su tercer siglo: una historia multidisciplinar (1810-2020)*. Ministry of Productive Development.

Santarcángelo, J. E. (2019). The Manufacturing Sector in Argentina at the Beginning of the Twenty-First Century. In J. E. Santarcángelo (Ed.), *The Manufacturing Sector in Argentina, Brazil, and Mexico* (pp. 7–59). Springer. https://doi.org/10.1007/978-3-030-04705-4_2

Santarcángelo, J. E., Schteingart, D. and Porta, F. (2018). Industrial policy in Argentina, Brazil, Chile and Mexico: a comparative approach. *Revue Interventions Économiques*, *59*. https://doi.org/10.4000/interventionseconomiques.3852

Schorr, M. (2021). Desindustrialización y reestructuración regresiva en el largo ciclo neoliberal (1976-2001). In M. Rougier (Coord.), La industria argentina en su tercer siglo: una historia multidisciplinar (1810-2020). Ministry of Productive Development.

Schteingart, D. and Tavosnanska, A. (2022). El retorno de la desindustrialización. *H-Industri@*, *16*(30). University of Buenos Aires.

Schumpeter, J. (1934). *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*. Harvard University Press.

Stansbury, A. M. and Summers, L. H. (2017). Productivity and Pay: Is the Link Broken?. *NBER Working Paper*. (24165). https://doi.org/10.3386/w24165

Syrquin, M. (1988). Patterns of structural change. In H. Chenery and T. N. Srinivasan (Eds.), *Handbook of Development Economics*, *1*. Elsevier.

Tregenna, F. (2014). A new theoretical analysis of deindustrialisation. *Cambridge Journal of Economics*, *38*(6). https://doi.org/10.1093/cje/bet029

Triador, D. and Pinazo, G. (2021). Reflexiones sobre la sostenibilidad de la industrialización por sustitución de importaciones en Argentina. *H-Industri@*, *15*(28). https://doi.org/10.56503/H-Industria/n.28(15) pp.145-164

Yu, X., Dosi, G., Lei, J. and Nuvolari, A. (2015). Institutional change and productivity growth in China's manufacturing: the microeconomics of knowledge accumulation and "creative restructuring". *Industrial and Corporate Change*, *24*(3). https://doi.org/10.1093/icc/dtv011

Annex A1

Table A1.1
Sectoral shares of GDP and formal (registered) labour, 2010–2021
(Percentages)

Sector	GDP share	Registered labour share (private sector)
Manufacturing	20.6	19.2
Wholesale and retail trade, accommodation and food services	17.5	21.9
Real estate and business services	12.5	14.5
Community and human health and education services	11.9	18.5
Agriculture, forestry and fishing	8.8	5.6
Transport, storage and communication	9.2	8.7
Public administration and defence	5.4	-
Financial	4.5	2.5
Construction	3.7	6.7
Mining	3.8	1.3
Utilities	2.1	1.1
Total	**100.0**	**100.0**

Source: Prepared by the authors on the basis of National Institute of Statistics and Censuses (INDEC) and Secretariat of Labour, Employment and Social Security.
Note: Sectors are classified at the one-digit level of the International Standard Industrial Classification of All Economic Activities (ISIC Revision 4). GDP is calculated in constant 2010 pesos).

Table A1.2
Private sector collective bargaining agreements, by economic sector, 2010–2022
(Percentages)

Sector	Share of collective agreements
Manufacturing	34.2
Transport	18.9
Services	15.6
Wholesale and retail trade	9.8
Utilities	9.1
Financial	5.5
Mining	2.9
Construction	2.6
Agriculture	1.5
Total	**100.0**

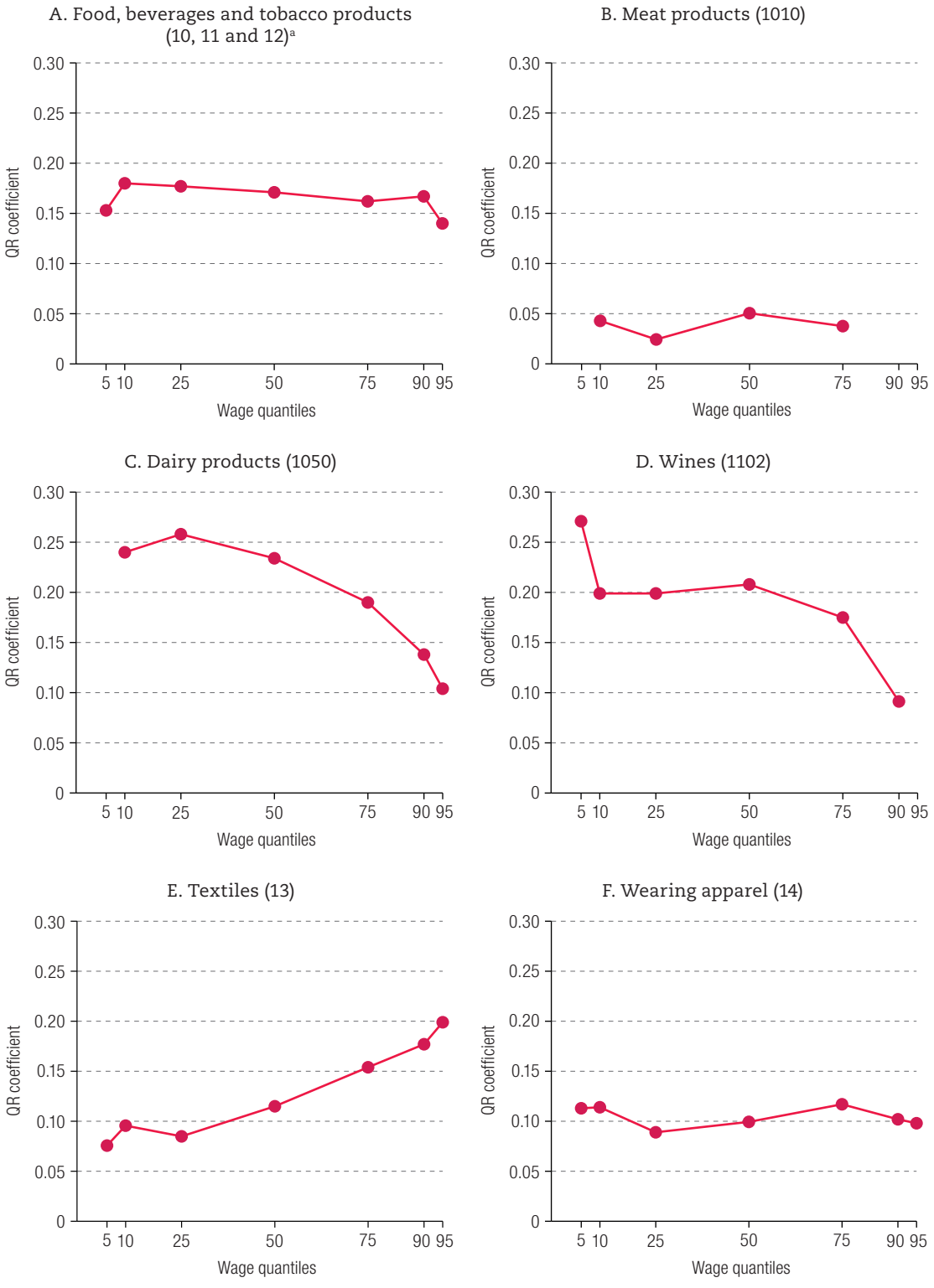
Source: Prepared by the authors on the basis of National Institute of Statistics and Censuses (INDEC) and Secretariat of Labour, Employment and Social Security.

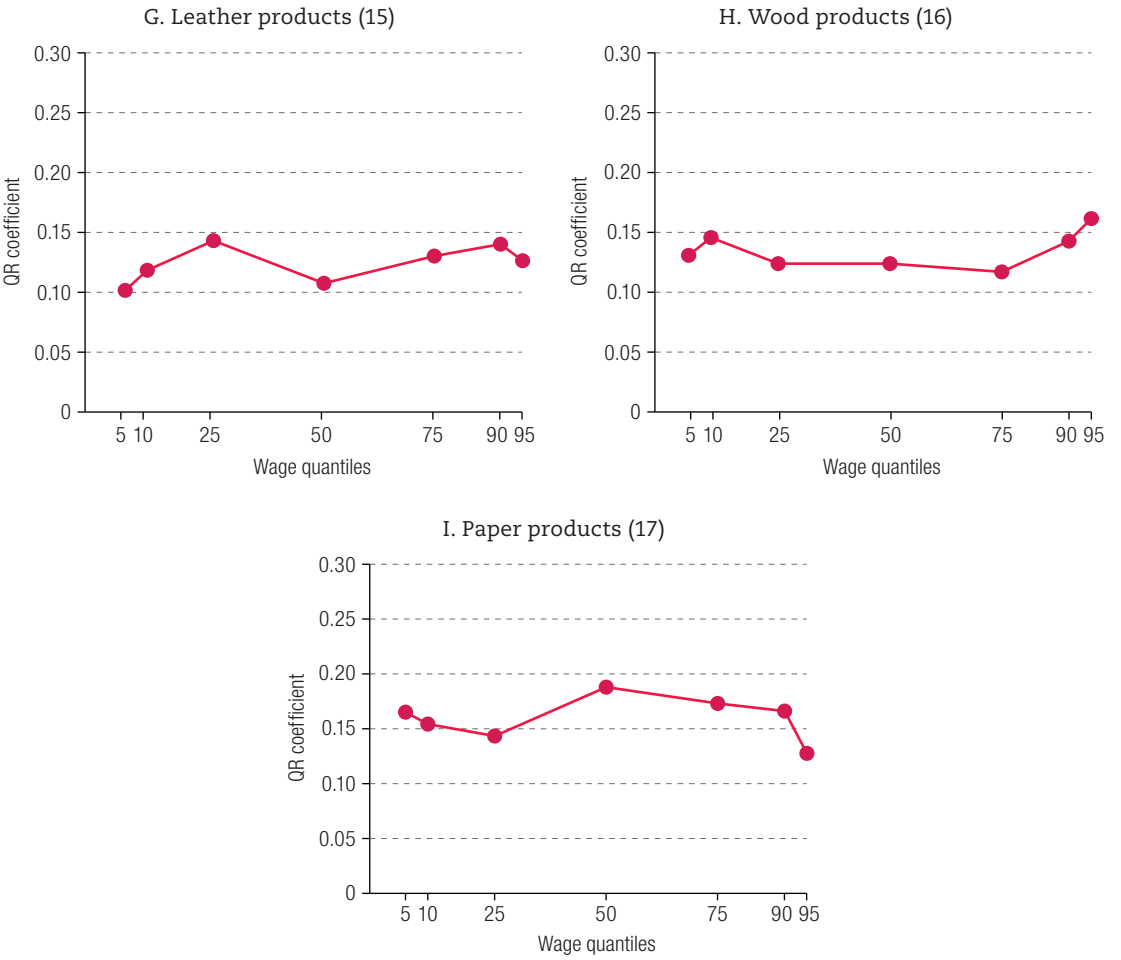
Table A1.3
Median of the distributions, by Pavitt class, 2010–2021

	Pavitt manufacturing sector	ISIC codes	Median coefficient across sectors	Pseudo-R^2 (median)
All		-	0.166***	0.082
Supplier-dominated	Food, beverages and tobacco	10-11-12[a]	0.171***	0.120
	Meat products	1010	0.051***	0.025
	Dairy products	1050	0.234***	0.117
	Wines	1102	0.208***	0.121
	Textiles	13	0.115***	0.066
	Wearing apparel	14	0.099***	0.070
	Leather products	15	0.107***	0.071
	Wood products	16	0.125***	0.074
	Fabricated metal products	25	0.202***	0.098
	Furniture	31	0.124***	0.091
Scale-intensive	Paper products	17	0.189***	0.071
	Rubber and plastic products	22	0.185***	0.080
	Other non-metallic mineral products	23	0.148***	0.069
	Basic metals	24	0.166***	0.109
	Motor vehicles, trailers and semi-trailers	29	0.149***	0.063
Specialized suppliers	Electronic components and boards, computers, consumer electronics, communication and electrical equipment	2610-2620-2630-2640-27[b]	0.125***	0.050
	Domestic appliances	2750	0.199***	0.102
	Machinery and equipment	28[c]	0.148***	0.077
	Agricultural and forestry machinery	2821	0.122***	0.063
	Other transport equipment	30	0.151***	0.064
Science-based	Chemical and refined petroleum products	19-20	0.174***	0.079
	Pharmaceutical and medicinal products	21	0.270***	0.133
	Measuring, testing and control equipment, electromedical and optical instruments	2650-2660-2670-2680	0.175***	0.080

Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.
Note: Sectors are classified at the two-digit level of the International Standard Industrial Classification of All Economic Activities (ISIC Revision 4). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
[a] Sector 10 does not include codes 1010 or 1050, and sector 11 does not include code 1102.
[b] Sector 27 does not include code 2750.
[c] Sector 28 does not include code 2821.

Figure A1.1
Distribution of quantile regression (QR) coefficients by ISIC sector (baseline model), 2010–2021





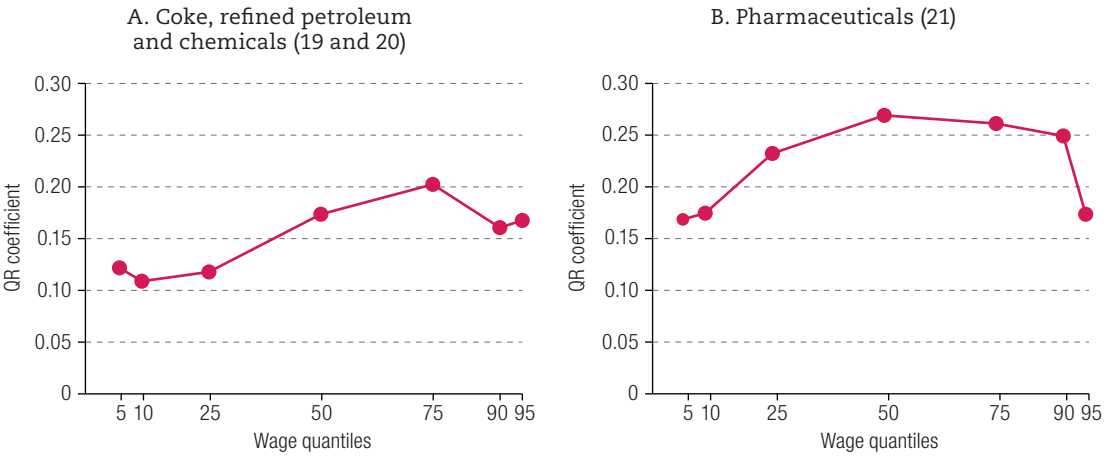
Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.

Note: Sectors are classified according to the International Standard Industrial Classification of All Economic Activities (ISIC Revision 4), with 94% of coefficients being statistically significant. The analysis is restricted to formal (registered) employment.

[a] Sector 10 does not include codes 1010 or 1050, and sector 11 does not include code 1102.

Figure A1.2

Distribution of quantile regression (QR) coefficients by ISIC sector (baseline model), 2010–2021



C. Rubber and plastics (22)

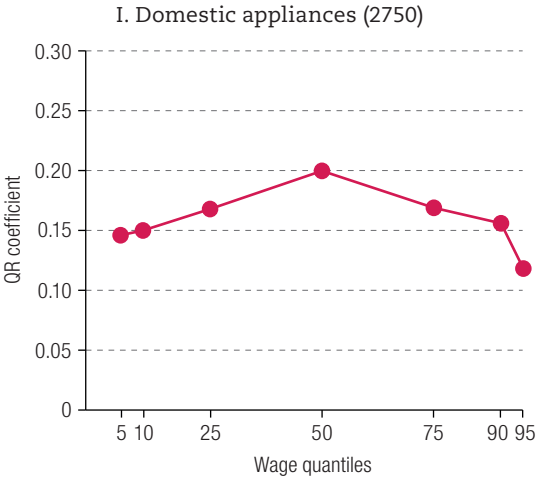
D. Non-metallic mineral products (23)

E. Basic metal manufactures (24)

F. Fabricated metal products (25)

G. Electronic equipment (2610 to 2640, excluding 2627)

H. Optical equipment (2650 to 2680)

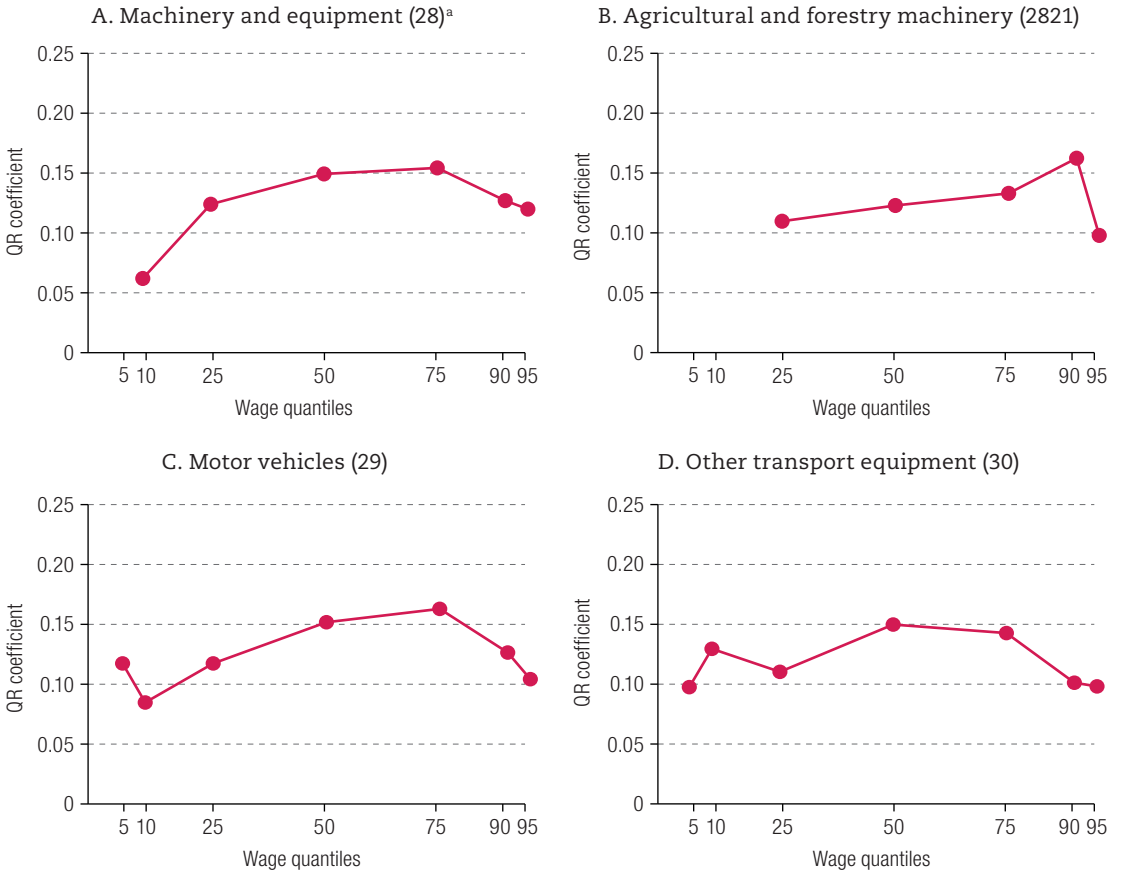


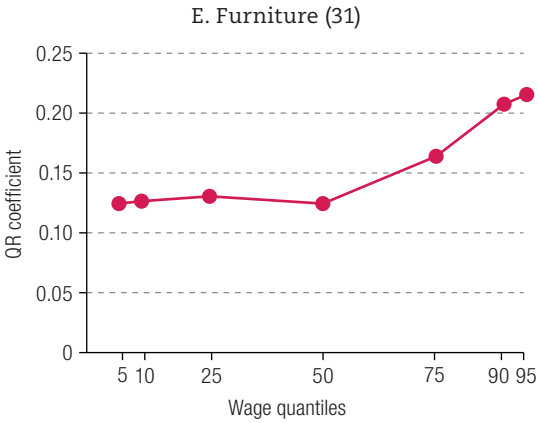
Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.

Note: Sectors are classified according to the International Standard Industrial Classification of All Economic Activities (ISIC Revision 4), with 94% of coefficients being statistically significant. The analysis is restricted to formal (registered) employment.

Figure A1.3

Distribution of quantile regression (QR) coefficients by ISIC sector (baseline model), 2010–2021





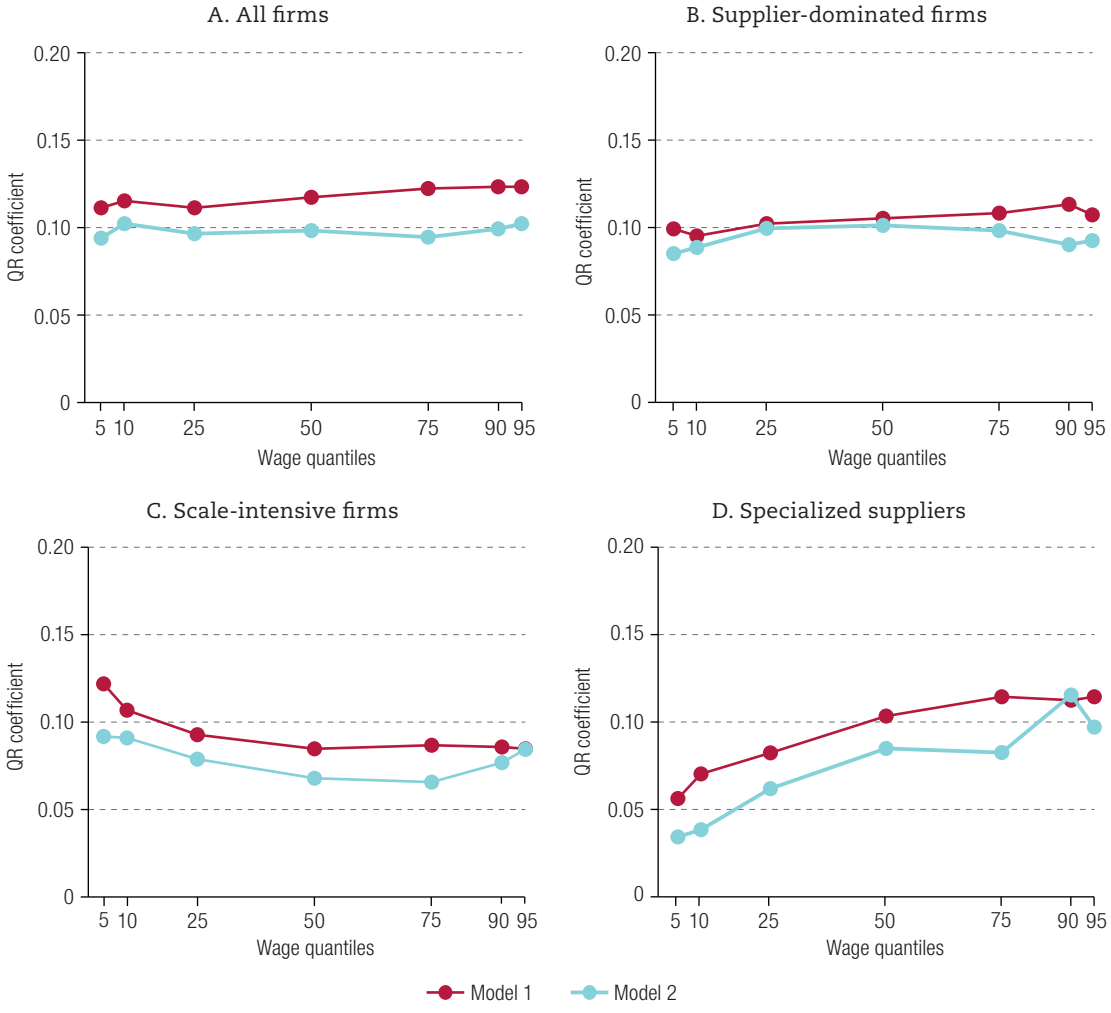
Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.

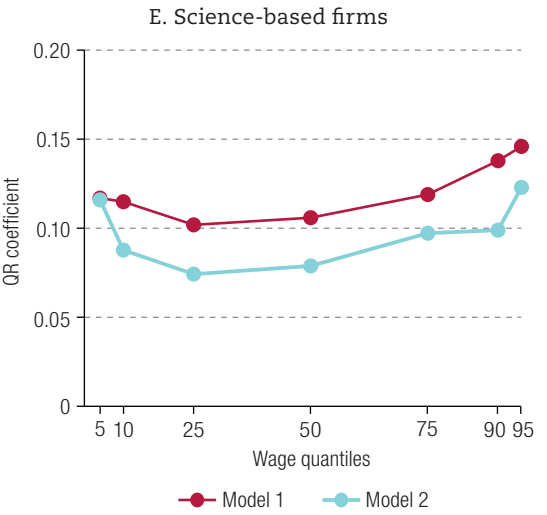
Note: Sectors are classified according to the International Standard Industrial Classification of All Economic Activities (ISIC Revision 4), with 94% of coefficients being statistically significant. The analysis is restricted to formal (registered) employment.

[a] Sector 28 does not include code 2821.

Figure A1.4

Quantile regression (QR) coefficients for log labour productivity, 2010–2021





Source: Prepared by the authors, on the basis of Secretariat of Innovation, Science and Technology. (2021). *National Survey on Employment and Innovation Dynamics*.

Note: Model 1 is the standard model with control variables, while model 2 includes the human capital proxy (log of skill ratio). The analysis is restricted to formal (registered) employment.

Technological change and employment following the coronavirus disease (COVID-19) pandemic in Mexico[1]

María Belén Conde, Agustín Filippo,
Carlos Guaipatin and Lucas Navarro

Received: 21/08/2023
Accepted: 30/09/2025

Abstract

This paper presents an analysis of employment in Mexico from the perspective of exposure to technological change following the recession caused by the coronavirus disease (COVID-19) pandemic. Data from official household surveys from the first quarter of 2019 to the second quarter of 2022 are used, as well as indices measuring the ease of automation of occupations in the country and the possibility of them being performed remotely. Although no effects of technological change are observed at the level of aggregate (formal and informal) employment, in the formal sector, which is more exposed to the adoption of new technologies, employment growth is lower in occupations at high risk of automation and higher in those that can be performed remotely.

Keywords

Employment, labour market, technological change, automation, COVID-19, pandemics, employment creation, employment statistics, Mexico

JEL classification

E24, N36, N76

Authors

María Belén Conde is a research assistant at the Heldrich Center for Workforce Development at Rutgers University (United States). Email: mb.conde@ejb.rutgers.edu.

Agustín Filippo is Lead Economist at the Inter-American Development Bank. Email: agustinf@iadb.org.

Carlos Guaipatin is Lead Specialist in science, technology and innovation at the Inter-American Development Bank. Email: cguaipatin@iadb.org.

Lucas Navarro is an associate professor in the Department of Economics at the National University of Córdoba in Argentina. Email: lucas.navarro@unc.edu.ar.

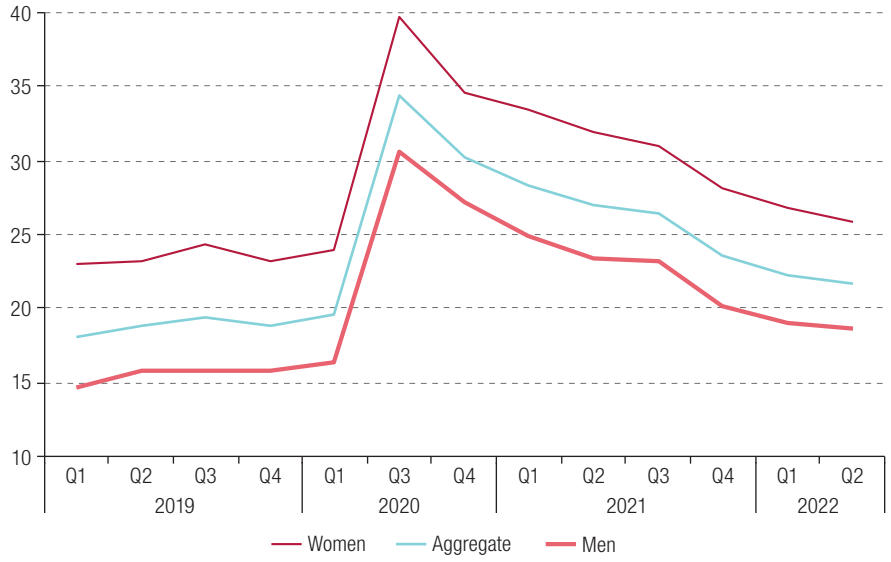
[1] We are grateful for the comments of an anonymous reviewer. Responsibility for any possible errors lies entirely with the authors. Likewise, the opinions expressed in this paper are the sole responsibility of the authors and do not represent the institutions in which they work.

I. Introduction

The economic shock caused by the COVID-19 pandemic had an unprecedented impact on global labour markets (Organisation for Economic Co-operation and Development [OECD], 2021). Like other countries, Mexico experienced the greatest impact during the second quarter of 2020, when lockdown measures were most stringent (Filippo et al., 2021; Hoehn-Velasco et al., 2021). Subsequently, employment recovered, and by the end of 2021, it had exceeded pre-pandemic levels. However, by mid-2022, there were still segments of the working-age population that had been unable to re-enter the labour market.

A comprehensive indicator of labour underutilization that takes this group into account is the employment gap (Kaplan, 2021), defined as the sum of people who are unemployed, underemployed and inactive (not seeking work) but are available to work (the economically inactive population), in relation to the potential economically active population.[2] The employment gap in the second quarter of 2022 stood at 21.7% of the potential economically active population, a substantial recovery compared with 2020 levels, although it was still two percentage points higher than in the fourth quarter of 2019 (see figure 1).

Figure 1
Mexico: employment gap, first quarter of 2019–second quarter of 2022[a]
(Percentages of the potential economically active population)



Source: Prepared by the authors, on the basis of National Institute of Statistics and Geography.
Note: The employment gap is the ratio of the total number of persons who are unemployed, underemployed and inactive (not seeking work) but available to work (economically inactive population) to the potential economically active population.
[a] Data for the second quarter of 2020 are not included.

The data show that the employment gap is significantly higher among women than men, with the most influential factors being underemployment and the available economically inactive population.[3] Although employment in Mexico rose steadily after the pandemic, there was a sharp

[2] The potential economically active population is defined as the sum of economically active people and people who are not economically active but are available to work, which is a measure of "hidden unemployment".

[3] Although these data are available, they are not presented in the current version of this paper. When age groups are considered, the employment gap is found to have a much greater impact on people at the extreme ends of the employment life cycle (ages 15 to 29 and 50 and over).

increase in the number of people who worked less than 35 hours per week but were available to work more (underemployed), and in the number of people who had stopped looking for work but were willing to work (available economically inactive population). Therefore, the fact that the employment gap remains above pre-pandemic levels could reflect weaknesses in employment opportunities for certain population groups.

With regard to the factors that cause structural change in employment, much of the literature produced since Schumpeter (1934) indicates that recessions lead to the acceleration not only of job destruction and business closures, but also of technological change. Therefore, companies take advantage of recessions to adopt new technologies, given the lower labour and opportunity costs during these periods (Kopytov et al., 2018). These technological changes have an impact on the labour market: the data show that, since the 1980s, job losses during recessions in developed countries have occurred primarily in routine occupations that are easy to automate (Hershbein and Kahn, 2018; Jaimovich and Siu, 2020). During recovery phases, however, this type of employment remains stagnant, while high- and low-skilled jobs grow, contributing to job polarization (Jaimovich and Siu, 2020).

In the particular case of the COVID-19 pandemic, the need for greater physical distancing in production processes boosted the incentives —typically seen in recessions— to adopt new technologies, affecting the dynamics of job creation and destruction. These new technologies took various forms, such as automation, the digitalization of tasks and the adaptation of processes to facilitate remote work (Apedo-Amah et al., 2020; Brynjolfsson et al., 2020).

The Mexican labour market is an interesting object of study, as some of its characteristics, such as a high level of informality and low labour costs, do not favour the adoption of new technologies (Beylis et al., 2020; Cerezo García et al., 2020). There is also a formal segment, which is driven by competitive sectors integrated into global value chains, and which is more exposed to new technologies (Artuc et al., 2019; Waddle, 2021).

On the basis of data from the National Survey of Occupation and Employment (ENOE) for the period between the first quarter of 2019 and the second quarter of 2022, this analysis explores employment trends across occupations with varying levels of exposure to technological change, at the height of the pandemic-related recession and over the following two years. To that end, variables are used that approximate automation risk, the degree of routinization and the feasibility of remote work for occupations in Mexico.

The results show that, after controlling for observable worker characteristics, there is no evidence, at the level of aggregate (formal and informal) employment, of slower growth in automatable occupations involving many routine tasks, nor of growth in jobs that can be performed remotely. However, when the analysis is limited to the formal sector, which is potentially more exposed to technological change, there is an observable trend towards lower employment growth in occupations with a higher probability of automation and higher employment growth in occupations that allow remote work.

As discussed in the literature review, the relationship between technological change and employment has been extensively studied in developed countries, where automation has had a differential impact on labour demand, increasing the demand for highly skilled jobs and decreasing the demand for more routine and automatable jobs. In Latin America, a series of recent studies have examined how the COVID-19 pandemic may have accelerated these processes in economies with production structures and labour markets that differ from those of advanced countries. Egana-delSol et al. (2022) analysed the case of Chile and determined that, after the health crisis, greater job losses occurred in the occupations with the highest likelihood of automation, although this effect was mitigated in sectors with a high capacity for remote work. Labour costs are higher and

informality levels are lower in Chile than in Mexico, which may have promoted greater automation in Chile in response to the crisis. Similarly, Bonilla-Mejía et al. (2023) show that, in Colombia, the pandemic amplified the reduction in employment in sectors at high risk of automation, particularly in medium-skilled occupations.

This paper complements the existing literature by analysing the case of Mexico, a country with a dual production structure, in which sectors that are highly integrated into global value chains coexist with an economy characterized by high levels of informality and low labour costs. The study is consistent with previous literature in that it provides data showing that the impact of the pandemic on employment differed depending on an occupation's likelihood of automation and its ability to be performed remotely. However, unlike in Chile and Colombia, where a greater number of automatable jobs have been destroyed, in Mexico, informality seems to have slowed this process. This paper is structured as follows: section II, following this introduction, contains a literature review; section III includes a description of the data; section IV outlines the empirical strategy; section V presents the results; and section VI sets out the conclusions.

II. Literature review

According to the International Federation of Robotics, 4,600 industrial robots were installed in Mexico in 2019. Although this is a small number compared with the more than 33,000 in the United States and the more than 140,000 in China, it places Mexico ninth in the world rankings for robot installations that year. On the basis of data from the Federation on the United States, Acemoğlu and Restrepo (2020) determine that each additional industrial robot replaces 3.3 jobs across the economy.[4] Some authors believe, however, that, although the development of robots may be disruptive, its effects on the labour market are not necessarily negative (Leigh and Kraft, 2018). Leigh et al. (2020) also detect gains in manufacturing employment as a result of the inclusion of robots in production in the United States. Dauth et al. (2021) find, on the basis of data from Germany, that although exposure to robots has a displacement effect on manufacturing employment, this effect is completely offset by the reallocation of workers towards the services sector, where employment levels are higher and productivity exceeds that of the jobs destroyed.[5] Corrocher et al. (2023) present data on the geographical and sectoral distribution of automation through robots and artificial intelligence, which is classified as labour-saving, based on a natural language processing methodology applied to the universe of patents in the United States between 1976 and 2021. The authors conclude that robots still account for a minority of automation patents, and are concentrated in a few geographical areas and sectors. In addition, there has been an increase in the number of automation patents aimed at labour savings since 2010.

The labour market has two well-documented features associated with technological change: job polarization and jobless recoveries following recessions.[6] Job polarization refers to the process by which employment increases in high- and low-skilled occupations but decreases in medium-skilled occupations. Jobless recoveries describes periods following recessions during which aggregate output recovers but employment recovers very slowly. Jaimovich and Siu (2020) argue

[4] The authors suggest that, in the next phase of automation, which will be driven by machine learning and artificial intelligence, inequality could be exacerbated unless technological advances are properly harnessed by governments and guided by public policy. Artificial intelligence can lead to job losses if it is not accompanied by technologies that make it easier to learn and use.

[5] Acemoğlu et al. (2014), however, find that industries with more intensive use of information and communications technologies have not performed better in terms of total factor productivity, output or employment. Acemoğlu (2021) argues that one reason is that automation could be excessive, as those who adopt it ignore its effects on job losses.

[6] Data on job polarisation mainly correspond to developed countries, but the phenomenon also occurs in developing countries (World Bank, 2016).

that the two phenomena, jobless recoveries and job polarization, are related.[7] Using data from the United States, the authors show that, since the mid-1980s, when the information and communications technology revolution began, job polarization has increased during recessions. They also find that routine jobs were the most affected during recessions and never recovered. Non-routine jobs (both high- and low-skilled), however, experienced small declines and recovered quickly. Therefore, jobless recoveries are largely due to the disappearance of routine occupations, which represent a significant share of total employment. The authors find similar results when using State-level data from the United States as well as data from a broader sample of countries.[8] The conclusion is that recessions are a catalyst for the adoption of new technologies that affect different types of employment.

On the basis of this background, a growing body of research suggests that the effects of the pandemic may have accelerated previous trends towards automation, the digitalization of activities and remote work, factors that have an impact on employment (Lund et al., 2021). In that regard, according to Weber Handwerker et al. (2020), investment in new technologies has increased owing to the recession caused by the pandemic, because the fixed costs for investment in technology have fallen as economic activity has declined.[9] However, these incentives for adopting new technologies in response to the health crisis differ depending on the infection risk faced by workers in various occupations and sectors, just as the technical possibilities for automation vary between industries, depending on the prevalence of routine jobs.[10]

One unprecedented and noteworthy development is that the distancing measures adopted during the early stages of the pandemic accelerated the adoption of remote working. For safety reasons, many people abruptly switched to remote work, and companies had to adapt and change their processes to facilitate this new way of working (Brynjolfsson et al., 2020). Furthermore, it is believed that the influence of the pandemic as a catalyst for the expansion of remote work will largely persist over time (Barrero, et al., 2021). In that regard, Davis et al. (2021) predicted that, once the pandemic was over, highly skilled workers would spend 30% of their time working remotely, three times more than before the health crisis.[11]

1. Conditions for automation and the impact of the COVID-19 pandemic in Mexico

In the case of Mexico, Cebreros et al. (2020) use the methodology of Frey and Osborne (2017) to measure the number and type of workers employed in occupations at risk of automation. On the basis of data from ENOE, they conclude that 65% of total employment and 57% of formal employment are at high risk of automation in Mexico.[12] The authors acknowledge, however, that these data do not take into account the fact that, when making decisions about automation, companies consider

[7] Similarly, Groshen and Potter (2003) link this slow recovery in employment to structural changes in the labour market resulting, among other factors, from technological change and the reorganization of production.

[8] Blit (2020a) finds similar data for Canada.

[9] Caselli et al. (2020) find that industries in Italy with a higher number of robots per worker recorded fewer infections.

[10] Blit (2020b) believes that the retail, manufacturing, wholesale and transportation sectors may have undergone the most significant transformations. Ding and Saenz-Molina (2020) suggest that automatable jobs in the high-contact service sector may also have been affected.

[11] Using data from March to May 2020 on the share of tasks that can be performed remotely in the United States and the United Kingdom, Adams-Prassl et al. (2022) determine that the tasks that can be performed remotely vary considerably both between and within occupations and industries. During the pandemic, the share of workers who can perform all tasks remotely increases most in occupations in which the pre-existing share was already high. Lastly, within occupations and industries, they find that women and workers on temporary contracts can perform fewer tasks from home.

[12] It should nevertheless be clarified that the Frey and Osborne (2017) index is a maximum estimate of the risk of automation for two main reasons: first, because it considers occupations as a whole and ignores the fact that only certain tasks within those occupations can be automated (Arntz et al., 2016, 2017), and second, because it focuses on the technical feasibility of automation without considering the incentives for automation.

the relevant costs and benefits. It is therefore to be expected that low wages —in relation to the cost of new technologies— as well as low-skilled human capital, high levels of informality and the prevalence of small and medium-sized enterprises in the formal sector will slow down the automation process (Cerezo García et al., 2020).

Filippo et al. (2021) underscore the severity of the impact on women and young people in Mexico, considering the monthly variations in employment that accompanied the economic fluctuations. According to their analysis, widespread lockdowns led to a catastrophic decline in employment regardless of gender, but subsequently, as restrictions were lifted, the phased approach to reopening prioritized more remote activities over those more dependent on physical presence, which are mainly performed by women, thus delaying employment recovery for women. Hoehn-Velasco et al. (2022) find that employment recovery after the pandemic was slower among women than men, and that most employment gains have been in the informal sector, suggesting a possible increase in job insecurity.[13] Juárez and Villaseñor (2024) conclude that women with young children at home experienced additional negative impacts due to the closure of schools and day-care centres, as the increased demand for care at home affected their participation in the labour market.

III. Data

1. Description of the National Survey of Occupation and Employment

The National Survey of Occupation and Employment (ENOE) of the National Institute of Statistics and Geography (INEGI) is used throughout this study. The new version of ENOE, which was established in the third quarter of 2020, contains monthly and quarterly data for the Mexican labour market. This information is obtained by tracking, for five consecutive quarters, a group of people aged 15 and over, who form a rotating panel, one fifth of whose members are replaced by new members each quarter. This survey, conducted in person, provides information about the labour force, employment, informal employment, underemployment, unemployment and other social and demographic characteristics of the members of the households surveyed.

The ENOE survey is available from the first quarter of 2005 to the first quarter of 2020, as INEGI suspended in-person data collection in April 2020 owing to the COVID-19 pandemic. However, in order to obtain information for the second quarter of 2020, the Telephone Survey of Occupation and Employment was conducted during that period only. Subsequently, starting in the third quarter of 2020, the National Survey of Occupation and Employment, New Edition (ENOEN), began to be conducted, using a mixed data collection method (in person and by telephone).

According to INEGI, the information from the Telephone Survey of Occupation and Employment is not comparable with that from ENOE and ENOEN (National Institute of Statistics and Geography [INEGI], 2021).[14] Therefore, this study does not use data from the second quarter of 2020, which is the period during which widespread lockdown measures were imposed in Mexico.[15] The main

[13] Albanesi and Kim (2021) find that women, particularly those who are married with children, were the most affected by the pandemic (Lee et al., 2021). This is because they are overrepresented in the occupations most affected by the pandemic (Alon et al., 2020), namely, those that involve a high level of contact and cannot be performed remotely.

[14] Although the surveys use the same questionnaires, they are based on different operational strategies. ENOE and ENOEN, however, are comparable, according to INEGI.

[15] Lockdown in Mexico officially began on 23 March (Diario Oficial de la Federación, 2020a) and ended on 30 May, when a phase known as the "new normal" began, during which various sectors of the economy were gradually reopened (Diario Oficial de la Federación, 2020b).

differences between the surveys relate to the method of data collection: in the case of ENOE, in person; in the case of the Telephone Survey of Occupation and Employment, by telephone; and in the case of ENOEN, mixed. According to INEGI, ENOE and ENOEN use the same approach to labour market measurement and are comparable. Even so, the change in data-collection methodology could lead to differences in estimates, particularly when comparing the first and third quarters of 2020. As will be specified below, individual control variables (sex, age, education, marital status and presence of children in the household) are used to mitigate these potential problems, helping to correct for possible differences in the composition of the sample. In addition, State-level fixed effects are incorporated to control for structural changes in the distribution of employment at the regional level.

To control for pre-pandemic effects, data from ENOE for the first quarter of 2019 to the first quarter of 2020 are considered, while to examine the medium-term effects of the pandemic, data from ENOEN for the third quarter of 2020 to the second quarter of 2022 are used, thus creating a sample of people aged 18 to 64 who were employed at some point in time.[16]

Table 1 shows the results. The sample is divided between men and women for the quarters included in the analysis.

Table 1
Mexico: National Survey of Occupation and Employment, first quarter of 2019 to second quarter of 2022[a]

Characteristics	Total		Women		Men	
	Proportion	N	Proportion	N	Proportion	N
Age range						
18–30 years	0.32	757 056	0.31	329 485	0.33	427 571
31–45 years	0.36	844 621	0.37	392 228	0.35	452 393
46–64 years	0.32	756 130	0.32	336 252	0.32	419 878
Education						
Not specified	0.00	2 187	0.00	755	0.00	1 432
Primary education	0.20	472 198	0.19	199 308	0.21	272 890
Secondary education	0.34	795 938	0.34	358 734	0.34	437 204
Upper secondary and higher education	0.46	1 087 484	0.47	499 168	0.45	588 316
Marital status						
Not married or living with a partner	0.40	945 957	0.45	479 439	0.36	466 518
Married or living with a partner	0.60	1 411 850	0.55	578 526	0.64	833 324
Children at home[b]						
No children	0.42	991 040	0.40	423 581	0.44	567 459
Children aged 0 to 5	0.24	556 049	0.24	251 327	0.23	304 722
Children aged 6 to 12	0.31	728 230	0.32	339 151	0.30	389 079
Children aged 13 to 17	0.30	697 821	0.31	325 724	0.29	372 097
Location						
Rural	0.34	798 391	0.32	341 760	0.35	456 631
Urban	0.66	1 559 416	0.68	716 205	0.65	843 211
Economically active population						
Employed	0.85	1 995 769	0.78	820 469	0.90	1 175 300
Unemployed	0.02	52 877	0.02	18 452	0.03	34 425
Economically inactive population						
Available to work	0.04	85 436	0.05	49 135	0.03	36 301
Not available to work	0.09	223 725	0.16	169 909	0.04	53 816

[16] The reason for exclusively including people who had been employed at some point is that occupational characteristics can be identified only for employed people. In other words, the sample does not include people who were unemployed or out of the labour force for the entire duration of the periods indicated.

Characteristics	Total		Women		Men	
	Proportion	N	Proportion	N	Proportion	N
Employment status[c]						
Wage earner	0.61	1 446 518	0.56	588 175	0.66	858 343
Employer	0.04	97 558	0.02	22 179	0.06	75 379
Own-account worker	0.16	388 459	0.16	169 288	0.17	219 171
Non-wage earner	0.03	63 234	0.04	40 827	0.02	22 407
Employment classification[c]						
Formal	0.43	1 018 240	0.38	406 074	0.47	612 166
Informal	0.41	977 529	0.39	414 395	0.43	563 134
Economic sector[c]						
Not specified	0.16	374 478	0.23	241 349	0.10	133 129
Agriculture, livestock farming and other related activities	0.06	143 058	0.02	18 805	0.10	124 253
Extractive industries and electricity	0.01	18 566	0.00	3 193	0.01	15 373
Manufacturing	0.15	349 390	0.13	133 296	0.17	216 094
Construction	0.07	162 379	0.01	7 473	0.12	154 906
Commerce	0.16	385 330	0.19	201 185	0.14	184 145
Restaurants and accommodation services	0.07	166 097	0.09	96 781	0.05	69 316
Transportation, communications and postal services	0.04	105 493	0.01	14 427	0.07	91 066
Professional and financial services	0.06	151 742	0.06	60 944	0.07	90 798
Social services	0.08	187 874	0.11	120 339	0.05	67 535
Miscellaneous services	0.09	207 810	0.11	114 083	0.07	93 727
Government and international organizations	0.04	105 590	0.04	46 090	0.05	59 500

Source: Prepared by the authors, on the basis of National Institute of Statistics and Geography. (2025). *Encuesta Nacional de Ocupación y Empleo (ENOE), población de 15 años y más de edad*. https://www.inegi.org.mx/programas/enoe/15ymas.

Note: The total sample size is N = 2,357,807.

[a] Data for the second quarter of 2020 are not included.

[b] Variables relating to the presence of children in the household cover children aged 0 to 17 and may add up to more than 1 in total because each variable corresponds to a specific age range, and households may have children of different ages.

[c] The variables treat as "Not applicable" people who are unemployed or not economically active.

With regard to employability characteristics, the sample is composed mainly of employed individuals, and there is a marked difference between men and women in terms of number of hours worked per week. With respect to employment status, the labour market is made up largely of wage earners, who represent 61% of the sample. As for employment classification, there is a similar proportion of formal and informal workers, although women account for a larger share of informal workers.[17] At the sectoral level, commerce and manufacturing account for the greatest share of employment. In addition, differences between sexes are evident in the composition of employment by sector, with a higher proportion of women in commerce and a greater ratio of men in the industrial sector.

2. Indices of exposure to technological change

To estimate the degree to which employment is exposed to technological change in Mexico, four indices were used to measure the characteristics of occupations: one index relating to their probability of automation (Frey and Osborne, 2017), one index relating to the number of routine tasks that they involve (Mihaylov and Tijdens, 2019), and two indices relating to the feasibility of them being performed remotely (Dingel and Neiman, 2020; Leyva and Mora, 2021).

[17] The ENOE definition of informality, which refers to working in the informal sector, being an own-account worker or wage earner in the agricultural sector, being a non-wage earner or being a paid domestic worker without access to health institutions, is used (INEGI, 2014).

The Frey and Osborne index (2017), developed using data from the Occupational Information Network (O*NET), is based on surveys conducted in the United States among a random sample of people employed in each of the categories of the Standard Occupational Classification (SOC) 2010 system. O*NET provides detailed and regularly updated information on the tasks, required skills and scope of work associated with each occupation. The Frey and Osborne index (2017) measures an occupation's probability of automation on a scale from 0 to 1. Values greater than or equal to 0.7 under the Frey and Osborne automation probability index (2017) are considered to indicate a high risk of automation.[18]

The routinization index developed by Mihaylov and Tijdens (2019) is based on the International Standard Classification of Occupations (ISCO-08) and ranges between -1 and 1. A value of -1 represents occupations that involve only non-routine activities, while a value of 1 represents occupations that involve only routine tasks. The intermediate values represent occupations that involve both types of task, routine and non-routine. Using criteria similar to those applied to define occupations at high risk of automation, values in the top 30% of the index, corresponding to a routinization index greater than or equal to 0.4, are considered to indicate occupations with a higher number of routine tasks, which would be very easy to automate over time.

The teleworkable index developed by Dingel and Neiman (2020) also uses O*NET to estimate which occupations can be performed remotely. Under this index, a value of 1 is assigned to occupations that can be performed remotely, while a value of 0 is assigned to those that cannot.

Lastly, the teleworkable index developed by Leyva and Mora (2021) is also considered. Under this index as well, a value of 1 is assigned to occupations that can be performed remotely and a value of 0 is assigned to those that cannot. Unlike the three previous indices, the Leyva and Mora index was created specifically for Mexico, using criteria different from those used by Dingel and Neiman (2020) and taking into account the occupations included in the National Occupational Classification System of INEGI.

As in the case of ENOE, the occupations of employed persons are classified in accordance with the National Occupational Classification System. The equivalence tables prepared by INEGI were used to match the occupations covered by the Standard Occupational Classification (SOC) 2010 system and the International Standard Classification of Occupations (ISCO-08) with the categories included in the National Occupational Classification System in order to calculate, using the structure of occupations in Mexico, the automation probability index, the routinization index and the teleworkable index (Dingel and Neiman). As a result, the values of these three indices were obtained for each of the more than 400 occupations covered by the National Occupational Classification System. In table 2, descriptive statistics are presented for the four indices used in the analysis. Although the average value of the automation probability index (0.66) suggests a high risk of job automation in Mexico, the average value of the routinization index (-0.36) indicates a relatively low level of routine activities. With regard to the teleworkable indices, the average value of the Dingel and Neiman index is double that of the Leyva and Mora index, a fact noted by Leyva and Mora in their paper. The reason for this difference could be related to the characteristics of a labour market such as that of Mexico, where the spread of information and communications technologies in households is slower (Leyva and Mora, 2021).

[18] According to Brynjolfsson et al. (2018), although most industrial occupations involve tasks that can be automated, very few, if any, occupations can be completely automated. In fact, they indicate that process re-engineering and task reorganization, rather than complete automation, could lead to the significant transformation of jobs in the economy.

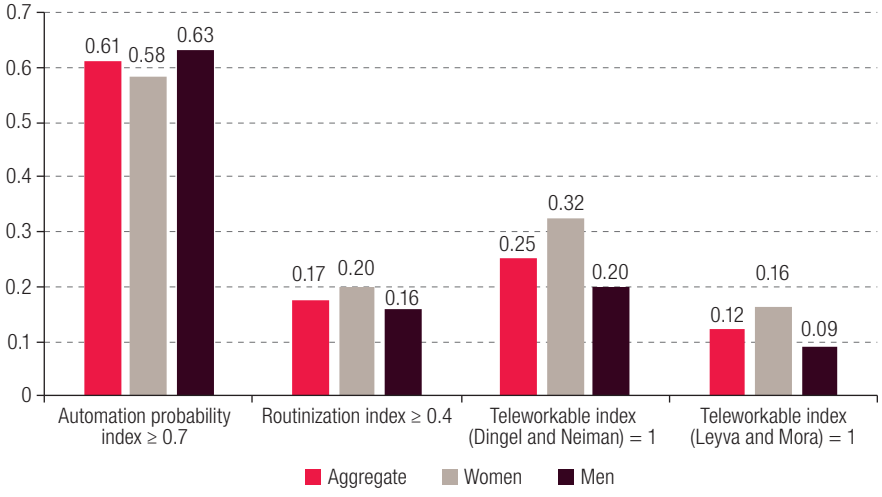
Table 2
Mexico: indices of occupational exposure to technological change, average values from the first quarter of 2019 to the second quarter of 2022[a]

Variable	Mean	Standard deviation	Minimum	Maximum
Automation probability index	0.66	0.31	0.00	0.99
Routinization index	-0.36	0.66	-1.00	1.00
Teleworkable index (Dingel and Neiman)	0.25	0.43	0.00	1.00
Teleworkable index (Leyva and Mora)	0.12	0.32	0.00	1.00

Source: Prepared by the authors, on the basis of National Institute of Statistics and Geography. (2025). *Encuesta Nacional de Ocupación y Empleo (ENOE), población de 15 años y más de edad.* https://www.inegi.org.mx/programas/enoe/15ymas.
Note: The total sample size is N = 1,994,955.
[a] Data for the second quarter of 2020 are not included.

Using the indices presented and the criteria mentioned for defining a high risk of automation and a large number of routine tasks for occupations, figure 2 shows the percentage of total jobs in the first quarter of 2020 that have the greatest potential exposure to automation and that can be performed remotely. Occupations at high risk of automation accounted for approximately 60% of pre-pandemic employment, in line with the findings of Cebreros et al. (2020), with the proportion for women being five percentage points lower than for men. Only 17% of the employed population were in occupations involving a large number of routine tasks, with a greater proportion of women than men performing such work. According to a study by the Inter-American Development Bank (Ripani et al., 2020), which used different methodologies, these levels of exposure of Mexican jobs to automation are in the middle range for the region and above those of developed countries. With respect to teleworking, in line with previous estimates for Mexico (Dingel and Neiman, 2020; Alarcón Osuna, 2021; Leyva and Mora, 2021), 25% and 12% of employed persons had jobs that could be performed remotely, in accordance with the teleworkable indices of Dingel and Neiman and Leyva and Mora, respectively,[19] with remote work being more feasible for women than men.

Figure 2
Mexico: employed population exposed to technological change, first quarter of 2020
(Proportion of the total employed population)



Source: Prepared by the authors, on the basis of National Institute of Statistics and Geography. (2025). *Encuesta Nacional de Ocupación y Empleo (ENOE), población de 15 años y más de edad.* https://www.inegi.org.mx/programas/enoe/15ymas.
Note: The total sample size is N = 169,256.

[19] As shown by Dingel and Neiman (2020), the percentage of jobs that can be performed remotely is low in Mexico compared with developed countries, and similar to that of other countries in the region.

Table 3 shows that, before the pandemic, more than half of jobs at high risk of automation were held by industrial workers, artisans and assistants, followed by merchants. More than 80% of jobs with a large number of routine tasks were held by two categories of workers: office workers; and industrial workers, artisans and assistants. With regard to remote work, the Dingel and Neiman teleworkable index indicates that more than 70% of jobs that can be performed remotely were held by three categories of workers: (i) professionals, technicians and workers in the arts sector; (ii) merchants; and (iii) office workers. However, under the Leyva and Mora teleworkable index, education workers, civil servants and managers accounted for a greater share of jobs that can be performed from home, with merchants representing a smaller share.

Table 3
Mexico: composition of employment exposed to technological change, by occupation, first quarter of 2020

	Automation probability index ≥ 0.7	Routinization index ≥ 0.4	Teleworkable index (Dingel and Neiman) = 1	Teleworkable index (Leyva and Mora) = 1
Professionals, technicians and workers in the arts sector	0.06	0.06	0.25	0.27
Education workers	0.00	0.00	0.15	0.29
Civil servants and managers	0.01	0.01	0.05	0.11
Office workers	0.13	0.34	0.23	0.23
Industrial workers, artisans and assistants	0.35	0.49	0.04	0.03
Merchants	0.19	0.05	0.24	0.04
Transport operators	0.04	0.01	0.01	0.00
Workers in the personal services sector	0.13	0.03	0.02	0.02
Workers in the security and surveillance sector	0.00	0.00	0.01	0.00
Agricultural workers	0.10	0.01	0.00	0.00

Source: Prepared by the authors, on the basis of National Institute of Statistics and Geography. (2025). *Encuesta Nacional de Ocupación y Empleo (ENOE), población de 15 años y más de edad.* https://www.inegi.org.mx/programas/enoe/15ymas.

If the same analysis is performed at the sectoral level, as shown in table 4, results are similar. The manufacturing and commercial sectors account for more than 40% of jobs with a high automation probability index. Furthermore, the manufacturing industry alone accounts for 45% of all jobs involving highly routine tasks. Under the Dingel and Neiman teleworkable index, the commercial and social services sectors account for almost half of all jobs that can be performed remotely. The Leyva and Mora teleworkable index shows a similar result in the social services sector, although the proportion of jobs that can be performed remotely in that sector is much higher.

Table 4
Mexico: composition of employment exposed to technological change, by sector, first quarter of 2020

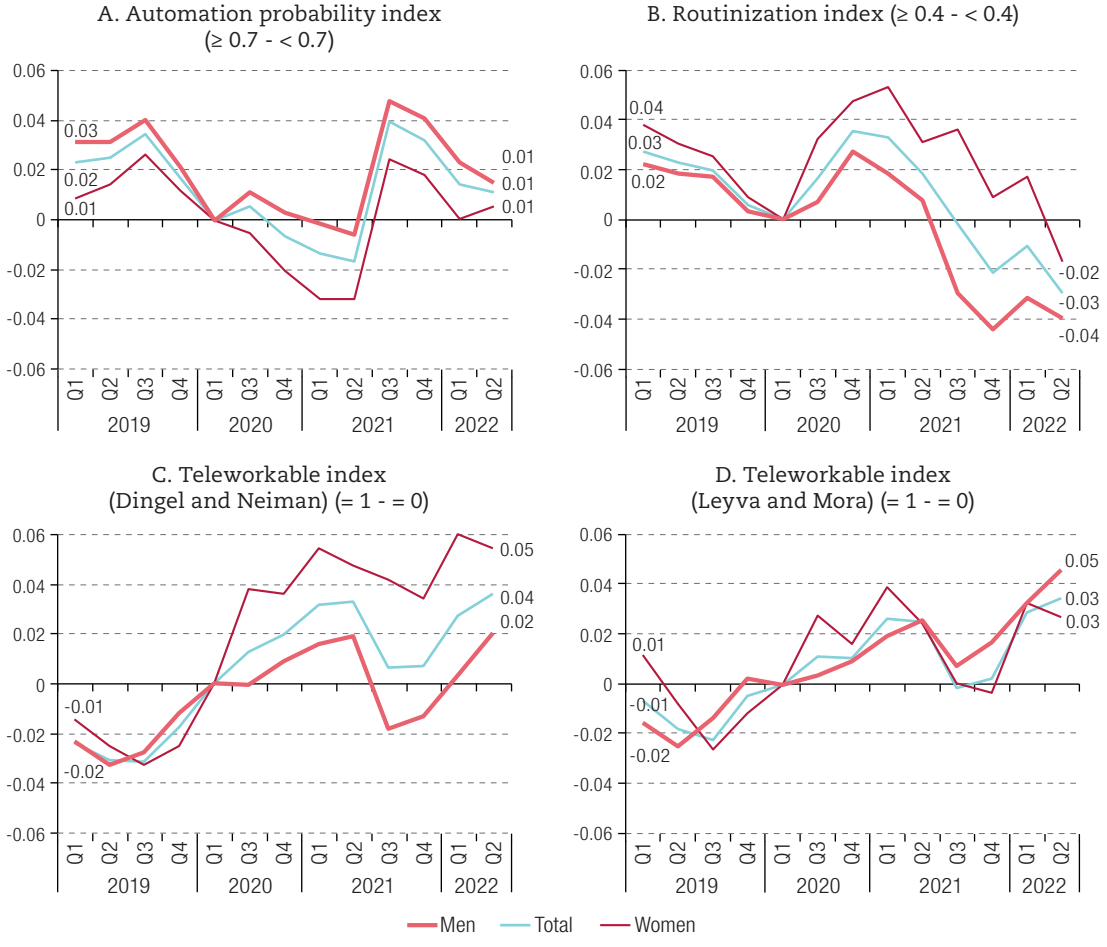
	Automation probability index ≥ 0.7	Routinization index ≥ 0.4	Teleworkable index (Dingel and Neiman) = 1	Teleworkable index (Leyva and Mora) = 1
Not specified	0.01	0.01	0.00	0.00
Agriculture, livestock farming and other related activities	0.10	0.01	0.01	0.01
Extractive industries and electricity	0.01	0.02	0.01	0.01
Manufacturing	0.21	0.45	0.07	0.07
Construction	0.10	0.03	0.03	0.03
Commerce	0.21	0.13	0.25	0.08
Restaurants and accommodation services	0.12	0.04	0.02	0.03
Transportation, communications and postal services	0.04	0.04	0.04	0.04

	Automation probability index ≥ 0.7	Routinization index ≥ 0.4	Teleworkable index (Dingel and Neiman) = 1	Teleworkable index (Leyva and Mora) = 1
Professional and financial services	0.06	0.06	0.16	0.15
Social services	0.04	0.07	0.23	0.40
Miscellaneous services	0.07	0.06	0.04	0.04
Government and international organizations	0.05	0.09	0.14	0.13

Source: Prepared by the authors, on the basis of National Institute of Statistics and Geography. (2025). *Encuesta Nacional de Ocupación y Empleo (ENOE), población de 15 años y más de edad.* https://www.inegi.org.mx/programas/enoe/15ymas.

According to the literature, it would be expected that, after the pandemic, employment in occupations that can be performed remotely would have gained momentum. Likewise, any technological change brought about by the pandemic should affect jobs that are at high risk of automation and involve a large number of routine tasks. However, the data for Mexico for the first quarter of 2020 do not reveal a clear difference, at the level of major employment aggregates, between employment growth in the occupations most exposed to technological change and in other occupations. This information is presented in figure 3.

Figure 3
Mexico: comparison of employment growth in the occupations most and least exposed to technological change, in relation to the first quarter of 2020



Source: Prepared by the authors, on the basis of National Institute of Statistics and Geography. (2025). *Encuesta Nacional de Ocupación y Empleo (ENOE), población de 15 años y más de edad.* https://www.inegi.org.mx/programas/enoe/15ymas.
Note: The total sample size is N = 1,994,955.

Moreover, although, starting in the first quarter of 2020, employment growth was lower in occupations with a high automation probability index than in other occupations, as expected, this trend reversed starting in the third quarter of 2021. Such differences were small, however, and began to decrease towards the second quarter of 2022. Employment patterns under the routinization index were also erratic, although in the second quarter of 2022, employment growth was lower in occupations involving a large number of routine tasks than in other occupations, with this trend affecting mainly men. Indeed, between the first quarter of 2020 and the second quarter of 2022, men's employment in routine occupations increased by 4 percentage points less than in other occupations.

In addition, there has been stronger employment growth since the first quarter of 2020 in occupations that can be performed remotely, particularly under the Dingel and Neiman teleworkable index, and especially among women: since the first quarter of 2020, women's employment in occupations that can be performed remotely has grown at least five percentage points more than in other occupations. The Leyva and Mora teleworkable index reflects a similar pattern, albeit with stronger growth among men.

In summary, the descriptive evidence suggests that, since the start of the pandemic, the slower growth in employment in occupations at high risk of automation has been temporary. However, employment growth for men in routine occupations has trended down slightly since the second half of 2021, compared with the first quarter of 2020. Lastly, employment in occupations that can be performed remotely grew more than in other occupations. The trends could reflect the effect of other factors not necessarily linked to the exposure of occupations to technological change. This will be considered in the following sections.

IV. Empirical strategy

This section describes the empirical strategy used to analyse employment in occupations with high exposure to technological change, in accordance with the four indices considered, and controlling for characteristics of the individuals in the sample that could affect the trends in the aggregate statistics presented in figure 3.

Microdata from ENOE from the first quarter of 2019 to the first quarter of 2020, and from ENOEN from the third quarter of 2020 to the second quarter of 2022, are used to analyse employment trends in accordance with the various indicators of exposure to technological change presented above, applying the following formula:

$$Y_{i,t} = \alpha + \sum_{\tau=-4}^{8} I(\tau)\{\gamma_\tau + \beta_\tau I_i(E_0)\} + \eta I_i(E_0) + \nu X_{i,t} + \epsilon_{i,t} \quad (1)$$

where $Y_{i,t}$ represents the relevant labour market outcome for individual i in quarter t. The outcome variables considered are employment and formal employment (as dichotomous variables). The variable τ denotes the reference quarter in relation to the pandemic, covering four quarters before the pandemic (from the first to the fourth quarter of 2019) and eight quarters after the pandemic (from the third quarter of 2020 to the second quarter of 2022). The period $\tau=0$ corresponds to the first quarter of 2020, which is the reference quarter. The variable $I_i(E_0)$ is a dichotomous variable indicating a person's level of exposure to technological change at the moment that he or she first appears as employed in the sample; the value of E_0 changes depending on which of the four indices is being used.[20]

[20] Unlike surveys in other countries (such as the Current Population Survey in the United States), which identify the occupations of persons who are employed, unemployed and outside the workforce (Albanesi and Kim, 2021), ENOE only reveals the occupations of employed persons. Therefore, ENOE defines each person's occupation as that held by him or her at the time that he or she first appeared as employed in the sample, retaining that information for quarters in which the person might no longer be employed. As a robustness test, the same analysis was performed using the value of technological exposure variables from the previous quarter. The results were very similar to those obtained from the baseline specification.

The variable $X_{i,t}$ includes a series of controls for social and demographic characteristics such as sex, age, years of education, marital status, presence in the household of children aged 0 to 17 and geographical area. In addition, all regressions include State-level fixed effects.[21] Lastly, $\epsilon_{i,t}$ is an error term. State-level fixed effects control for structural differences and regional dynamics in the Mexican labour market. Given that exposure to technological change can vary significantly between States owing to factors such as sectoral composition, technological infrastructure and degree of urbanization, the inclusion of these fixed effects makes it possible to separate the impact of technological change on employment from other regional determinants. Furthermore, by using data from multiple quarters, State-level fixed effects help to capture unobserved heterogeneity.

The relevant interaction coefficients β_τ measure the difference between people exposed and not exposed to technological change on the basis of the variation in Y between τ and the reference period $(\tau=0)$. For example, in the case of the outcome variable of employment and the automation probability index, if $\beta_\tau>0$, employment growth between the first quarter of 2020 and τ is higher for people in occupations with a high automation probability index than for the rest of the sample.

Lastly, the sample includes only people aged 18 to 64 with any occupational status (employed, unemployed, available to work or unavailable to work), provided that they were employed at some point during the period under review.

V. Results

The results of the estimates are presented in this section. The figures only show the coefficients associated with the interaction term between each quarter and the indices of exposure to technological change from the equation presented in the previous section.

In figure 4, the results are shown using employment status (either formal or informal) as the dependent variable. Starting in the third quarter of 2021, slightly higher employment growth is estimated in occupations with a high theoretical probability of automation but limited actual exposure to automation owing to informality.[22] This apparent paradoxical result may reflect a composition effect, as will be seen later.

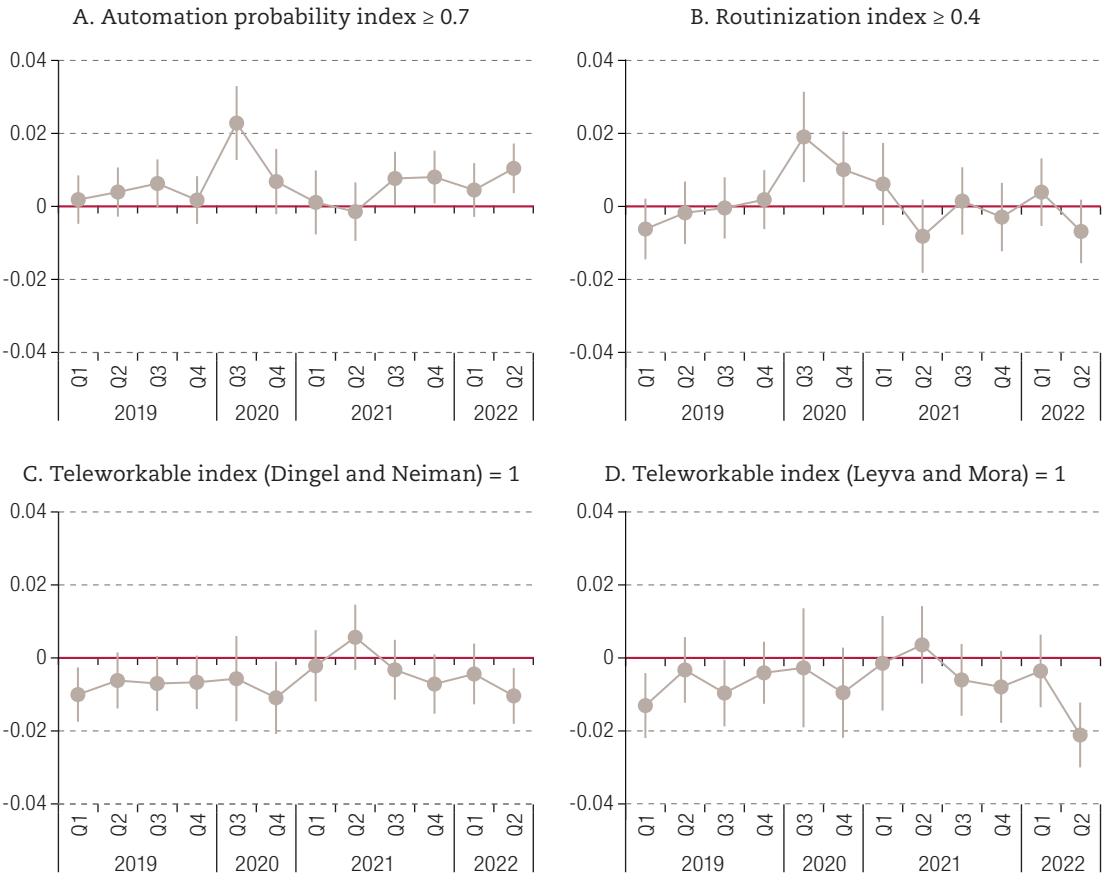
The trend of employment in occupations involving a large number of routine activities does not differ from that of employment in other occupations.[23] There is also no clear increase in remote work at the level of aggregate employment. The results disaggregated by sex, presented in figure 5, are similar.

[21] As mentioned above, ENOE is conducted using a rotating panel, one fifth of whose members are replaced by new members each quarter. This means that not all individuals are present during all periods, making it difficult to identify reliable individual fixed effects. The study focuses, however, on the effect of technological change on occupations rather than on individual changes in the same worker over time.

[22] Almost two thirds of employment at high risk of automation (see table 3) is concentrated in occupations with levels of informality above the average (49% in the first quarter of 2020), such as those performed by industrial workers, artisans and assistants (53%), merchants (62%) and agricultural workers (85%). These occupations recovered more quickly than others after the health crisis (Hoehn-Velasco et al., 2021).

[23] Although the results for the automation probability index and the routinization index appear to be mutually inconsistent, these indices are, by definition, not comparable. The automation probability index classifies entire occupations as automatable, while the routinization index identifies specific tasks that are considered routine and are therefore more likely to be automated (Arntz et al., 2016, 2017). In particular, 73.6% of the observations in the sample with an automation probability index ≥ 0.7 correspond to occupations with routinization index values < 0.4.

Figure 4
Mexico: change in the probability of being employed[a]

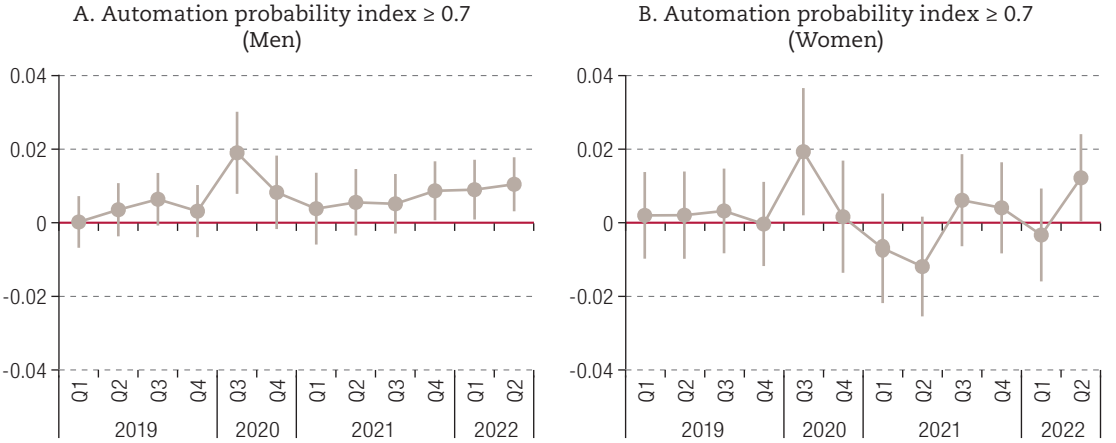


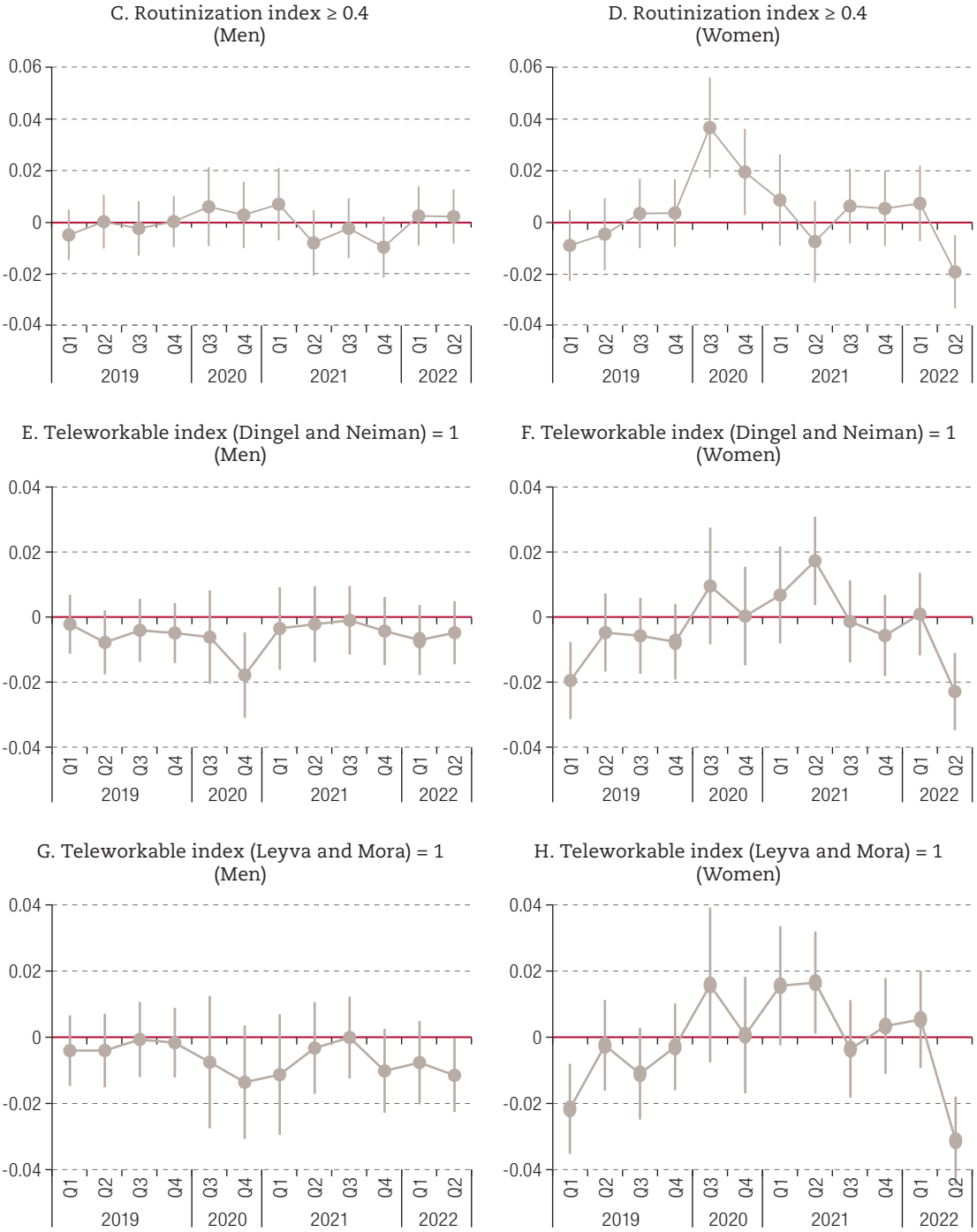
Source: Prepared by the authors, on the basis of National Institute of Statistics and Geography. (2025). *Encuesta Nacional de Ocupación y Empleo (ENOE), población de 15 años y más de edad*. https://www.inegi.org.mx/programas/enoe/15ymas.

Note: Estimates obtained using the ordinary least squares method. Standard errors are grouped at the individual level, and vertical lines represent 95% confidence intervals.

[a] Data for the first and second quarters of 2020 are not included.

Figure 5
Mexico: change in the probability of being employed, by sex[a]





Source: Prepared by the authors, on the basis of National Institute of Statistics and Geography. (2025). *Encuesta Nacional de Ocupación y Empleo (ENOE), población de 15 años y más de edad.* https://www.inegi.org.mx/programas/enoe/15ymas.

Note: Estimates obtained using the ordinary least squares method. Standard errors are grouped at the individual level, and vertical lines represent 95% confidence intervals. The graphs on the left show the results for men, and the graphs on the right for women.

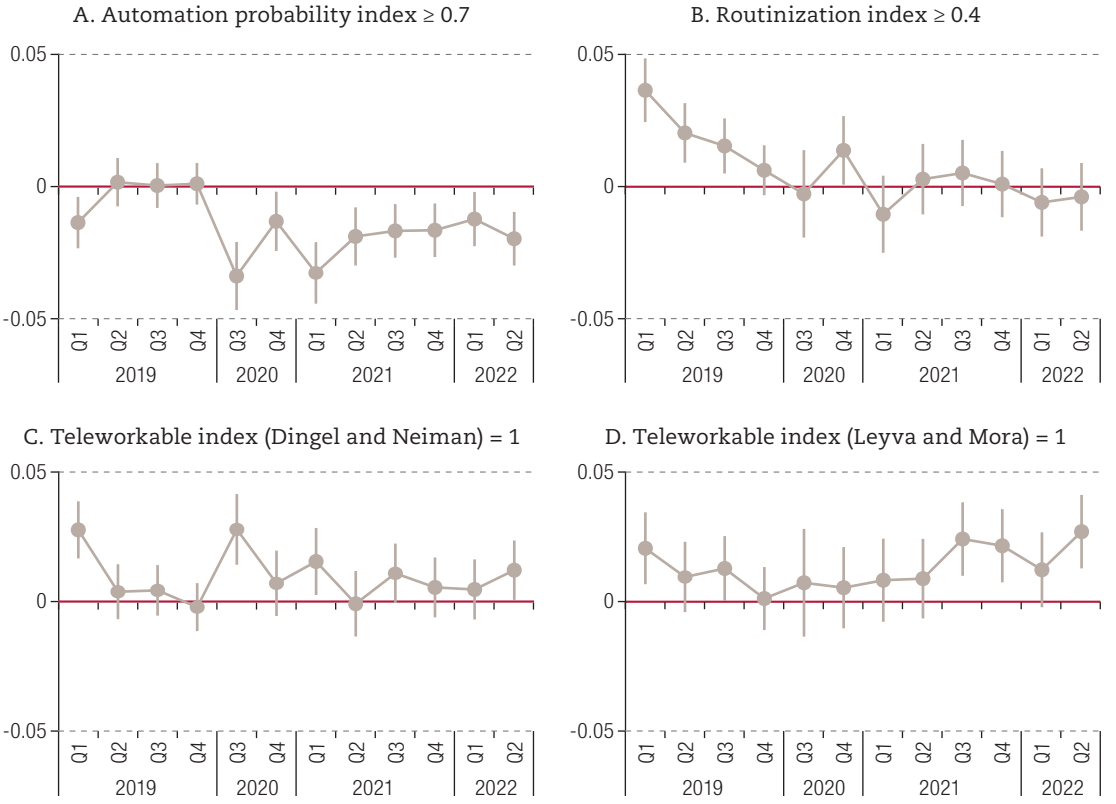
[a] Data for the first and second quarters of 2020 are not included.

As mentioned above, the results presented may reflect an employment composition effect. In the reference quarter (first quarter of 2020), approximately 51% of the people included in the sample (population aged 18 to 64) were employed in the formal sector, compared with 49% in the

informal sector. Given that the adoption of new technologies is more likely to occur in the formal sector of the economy (Cerezo García et al., 2020), the increase in employment in occupations at high risk of automation, reflected in figures 4 and 5, could be occurring in the informal sector.

Figure 6 shows the effect of exposure to technological change on the probability of employment in the formal sector among people who are employed. Since the third quarter of 2020, there has been a statistically significant trend towards lower employment growth (by 2 percentage points in the second quarter of 2022) in occupations with high automation probability indices compared with other occupations. There is no statistically significant difference in employment growth between occupations with a high and low routinization index. Another interesting finding is that the probability of being employed in the formal sector increased more in occupations that can be performed remotely than in other occupations (by between 1.2 and 2.7 percentage points in the second quarter of 2022), especially under the index developed by Leyva and Mora (2021), who analysed the feasibility of remote work for occupations in Mexico.

Figure 6
Mexico: change in the probability of being employed in the formal sector[a]



Source: Prepared by the authors, on the basis of National Institute of Statistics and Geography. (2025). *Encuesta Nacional de Ocupación y Empleo (ENOE), población de 15 años y más de edad.* https://www.inegi.org.mx/programas/enoe/15ymas.

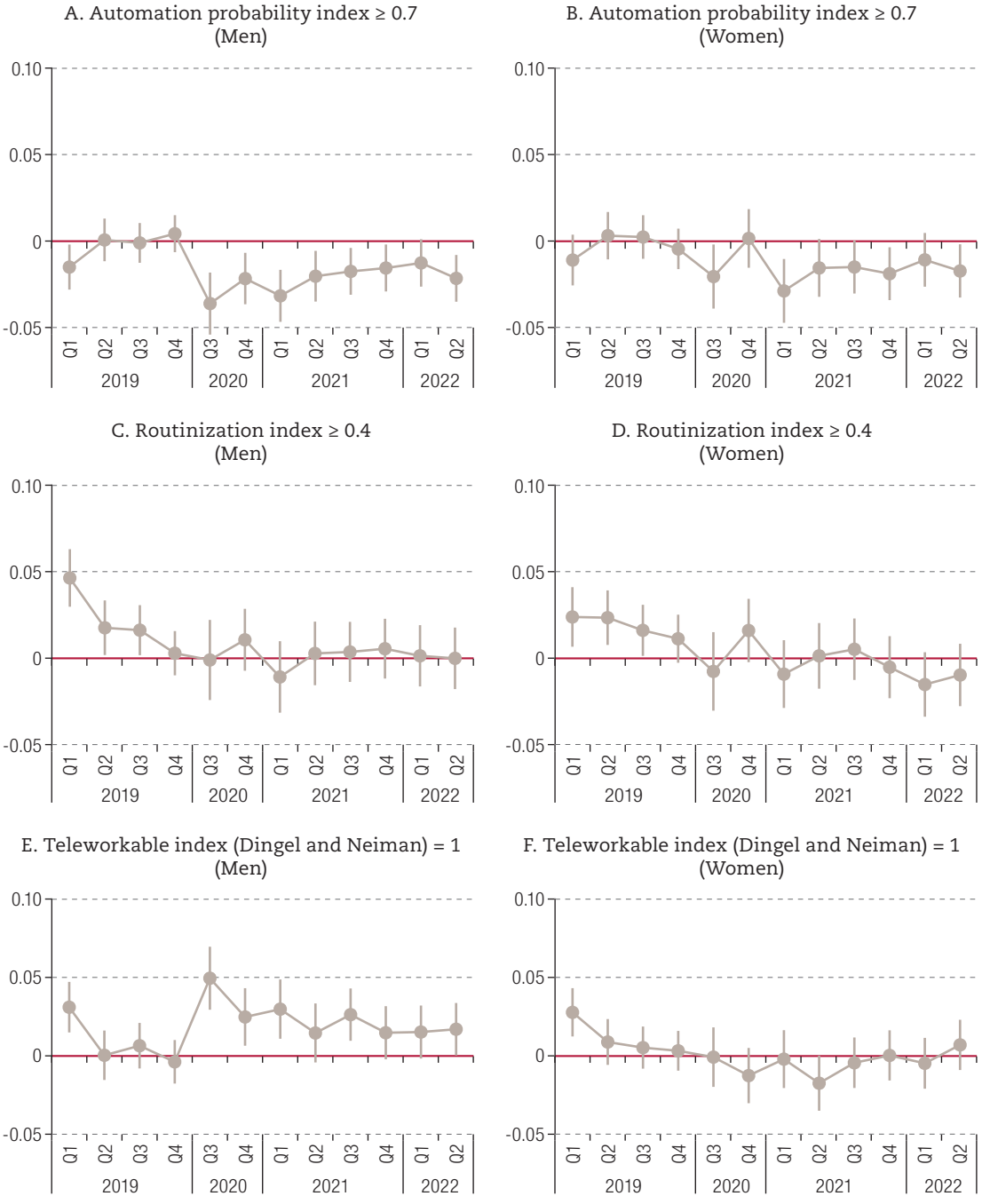
Note: Estimates obtained using the ordinary least squares method. Standard errors are grouped at the individual level, and vertical lines represent 95% confidence intervals.

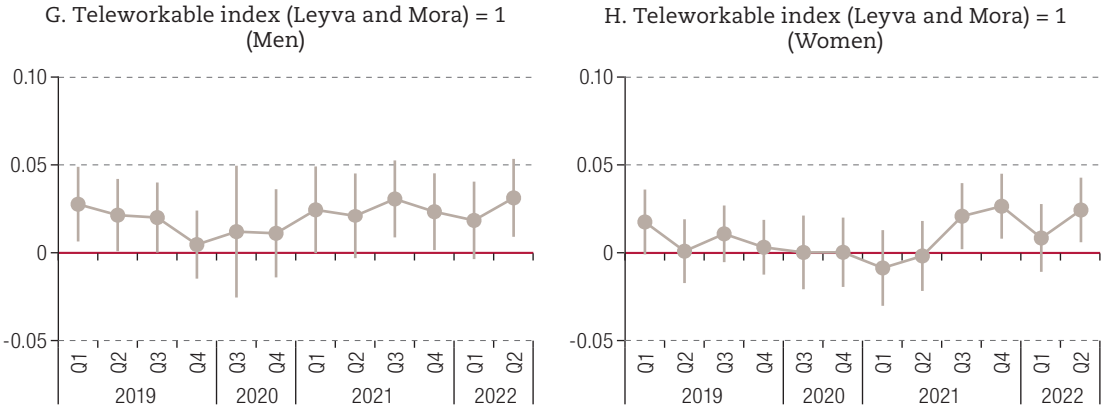
[a] Data for the first and second quarters of 2020 are not included.

Figure 7 presents the same results, disaggregated by sex. The estimates indicate that the growth differential in employment in occupations with high automation probability becomes negative and statistically significant starting in the third quarter of 2020. This pattern is more pronounced among men, although it is also observed among women. The trend towards higher employment

growth in jobs that can be performed remotely is also confirmed. Indeed, the growth differential in employment in occupations with a value of 1 under Dingel and Neiman's teleworkable index in relation to other employment tends to become positive for men starting in the third quarter of 2020, while the effects on women are, on average, indistinguishable from zero. Lastly, the interaction coefficients under the Leyva and Mora teleworkable index are positive and statistically significant with a 95% confidence interval for both men and women, particularly starting in the third quarter of 2021.

Figure 7
Mexico: change in the probability of being employed in the formal sector, by sex[a]





Source: Prepared by the authors, on the basis of National Institute of Statistics and Geography. (2025). *Encuesta Nacional de Ocupación y Empleo (ENOE), población de 15 años y más de edad*. https://www.inegi.org.mx/programas/enoe/15ymas.

Note: Estimates obtained using the ordinary least squares method. Standard errors are grouped at the individual level, and vertical lines represent 95% confidence intervals. The graphs on the left show the results for men, and the graphs on the right for women.

[a] Data for the first and second quarters of 2020 are not included.

In summary, the results of the estimates suggest: (i) lower growth in formal employment in occupations with a high automation probability index, with a slightly greater impact on men than on women; and (ii) higher growth in formal employment in occupations that can be performed remotely, a pattern that is more pronounced among men but also observable among women.

The relationship between technological change and employment means that, in order for effects to be observed on the labour market, companies must be adopting new technologies. Unfortunately, no relevant information is available for the period under review. Sources such as the INEGI National Survey on Productivity and Competitiveness of Micro, Small and Medium Enterprises, which provides data on digitalization and technology use in the business sector, are only available for 2015 and 2018.

Beyond this limitation, the results are consistent with the existing literature in two ways: first, as mentioned above, several studies have shown that economic crises accelerate the introduction of new technologies owing to the need for efficiency and cost reduction (Kopytov et al., 2018; Brynjolfsson et al., 2020); second, the differential impact on formal and informal employment is consistent with what would be expected if new technologies were adopted. Specifically, there is less growth in formal employment in occupations with high exposure to automation and greater growth in employment in occupations that can be performed remotely. These results suggest that, at least in the formal sector, the dynamics are consistent with technological change.

In summary, although it would be valuable to supplement the study with direct information on the adoption of technology in Mexican companies, such information is not available. Current findings suggest, however, that there is a differential impact on formal employment, which is consistent with technological change. Future research could explore this relationship in greater depth by combining labour market data with indicators of investment in automation and digitalization in Mexico.

VI. Conclusions

Considering exposure to technological change, this paper presents an analysis of employment in Mexico following the COVID-19 pandemic using ENOE data from the first quarter of 2019 to the second quarter of 2022, together with indices of exposure to technological change for occupations in the country.

In relation to the first quarter of 2020, there is no conclusive evidence showing a decline in aggregate employment in occupations that have a high probability of automation and involve a large number of routine tasks, nor is there any evidence of growth in aggregate employment in occupations that can be performed remotely.

The results are different, however, when the analysis is limited to the formal sector, where the adoption of new technologies seems more likely. In particular, since the third quarter of 2020, there has been a relative reduction in the creation of formal employment in occupations with a high probability of automation, compared with other occupations. This effect is more pronounced among men, suggesting that automation may have had a greater impact on male-dominated sectors within formal employment. Moreover, growth in formal employment has been higher in occupations that can be performed remotely than in other occupations, especially since the second half of 2021. This effect is most evident when considering a teleworkable index developed specifically for Mexico, suggesting that the pandemic may have accelerated structural changes in the organization of work in certain sectors.

Although effective exposure to technological change still appears to be low, following the pandemic, as expected (Beylis et al., 2020), a series of accelerated changes occurred in the formal labour market that were compatible with the adoption of new technologies. The lack of a broad decline in employment in automatable occupations suggests that the high level of informality in the Mexican labour market may be acting as a buffer against the aggregate effects of automation on employment. Unlike countries with more formal labour markets, where technological progress can quickly translate into job displacement, in Mexico, the presence of sectors with low labour costs and limited access to technology may be slowing this process. However, the effects identified relate to the short and medium term. Over a longer time horizon, at least two additional effects —beyond the scope of this study— may arise. First, the expansion of firms that adopt new technologies may increase labour demand through a scale effect. Second, workers displaced by new technologies should be gradually reallocated to other occupations within the labour market.

Public policy can facilitate these transformations in various ways. In particular, there should be a policy strategy that is focused on productive development and provides incentives for companies to innovate, thereby promoting growth and job creation. In addition, the reallocation of workers towards more productive activities should be facilitated, demonstrating the central importance of policies that promote the training and development of human capital.

In summary, although the pandemic did not cause an abrupt change in the structure of employment in Mexico, the trends indicate that the formal labour market is being slowly but progressively transformed in response to technological change.

Bibliography

Acemoğlu, D. (2021, March). Remaking the post-COVID world: to reverse widening inequality, keep a tight rein on automation. *Finance & Development*. International Monetary Fund.

Acemoğlu, D., Autor, D., Dorn, D., Hanson, G. H. and Price, B. (2014). Return of the Solow paradox? IT, productivity, and employment in US manufacturing. *American Economic Review*, *104*(5). http://doi.org/10.1257/aer.104.5.394

Acemoğlu, D. and Restrepo, P. (2020). Robots and jobs: Evidence from US labor markets. *Journal of Political Economy*, *128*(6). https://doi.org/10.1086/705716

Adams-Prassl, A., Boneva, T., Golin, M. and Rauh, C. (2022). Work that can be done from home: evidence on variation within and across occupations and industries. *Labour Economics*, *74*. https://doi.org/10.1016/j.labeco.2021.102083

Alarcón Osuna, M. A. (2021). Empleo desde casa en México: estimación con el modelo Dingel-Neiman. *Carta Económica Regional*. (128). https://doi.org/10.32870/cer.v0i128.7819

Albanesi, S. and Kim, J. (2021). The gendered impact of the COVID-19 recession on the US labor market. *NBER Working Paper*. (28505). http://doi.org/10.3386/w28505
Alon, T., Doepke, M., Olmstead-Rumsey, J. and Tertilt, M. (2020). The impact of COVID-19 on gender equality. *NBER Working Paper*. (26947). http://doi.org/10.3386/w26947
Apedo-Amah, M. C., Avdiu, B., Cirera, X., Cruz, M., Davies, E., Grover, A., Iacovone, L., Kilinc, U., Medvedev, D., Maduko, F. O., Poupakis, S., Torres, J. and Tran, T. T. (2020). Unmasking the impact of COVID-19 on businesses: firm level evidence from across the world. *Policy Research Working Paper*. (9434). https://doi.org/10.1596/1813-9450-9434
Arntz, M., Gregory, T. and Zierahn, U. (2016). The risk of automation for jobs in OECD countries: a comparative analysis. *OECD Social, Employment and Migration Working Papers*. (189). https://doi.org/10.1787/5jlz9h56dvq7-en
Arntz, M., Gregory, T. and Zierahn, U. (2017). Revisiting the risk of automation. *Economics Letters*, *159*. https://doi.org/10.1016/j.econlet.2017.07.001
Artuc, E., Christiaensen, L. and Winkler, H. (2019). Does automation in rich countries hurt developing ones? Evidence from the U.S. and Mexico. *Policy Research Working Paper*. (8741). https://doi.org/10.1596/1813-9450-8741
Barrero, J. M., Bloom, N. and Davis, S. J. (2021). Why working from home will stick. *NBER Working Paper*. (28731). https://doi.org/10.3386/w28731
Beylis, G., Fattal-Jaef, R., Sinha, R., Morris, M. and Sebastian, A. R. (2020). *Going Viral: COVID-19 and the Accelerated Transformation of Jobs in Latin America and the Caribbean*. Banco Mundial.
Blit, J. (2020a). Automation and reallocation: the lasting legacy of COVID-19 in Canada. *CLEF Working Paper*. (31). Canadian Labour Economics Forum.
Blit, J. (2020b). Automation and reallocation: will COVID-19 usher in the future of work?. *Canadian Public Policy*, *46*(S2). https://doi.org/10.3138/cpp.2020-065
Bonilla-Mejía, L., Florez, L. A., Hermida, D., Lasso, F., Morales, L. F., Ospina, J. J. and Pulido, J. (2023). Is the COVID-19 pandemic fast-tracking automation in developing countries? Evidence from Colombia. *Journal of Human Capital*, *17*(4). https://doi.org/10.1086/726758
Brynjolfsson, E., Horton, J. J., Ozimek, A., Rock, D., Sharma, G. and TuYe, H.-Y. (2020). COVID-19 and remote work: an early look at US data. *NBER Working Paper*. (27344). https://doi.org/10.3386/w27344
Brynjolfsson, E., Mitchell, T. and Rock, D. (2018). What can machines learn, and what does it mean for occupations and the economy?. *AEA Papers and Proceedings*, *108*. http://doi.org/10.1257/pandp.20181019
Caselli, M., Fracasso, A. and Traverso, S. (2020). Mitigation of risks of Covid-19 contagion and robotisation: evidence from Italy. *Covid Economics: Vetted and Real-Time Papers*. (17). CEPR Press.
Cebreros, A., Heffner-Rodríguez, A., Livas, R. and Puggioni, D. (2020). Automation technologies and employment at risk: the case of Mexico. *Working Papers*. (2020-04). Bank of Mexico.
Cerezo García, V., López González, T. S. and López Herrera, F. (2020). Crecimiento económico e inflación en México, 1993-2018: ¿una relación lineal o no lineal?. *Investigación económica*, *79*(311). https://doi.org/10.22201/fe.01851667p.2020.311.72437
Corrocher, N., Moschella, D., Staccioli, J. and Vivarelli, M. (2023). Innovation and the labor market: theory, evidence and challenges. *GLO Discussion Paper*. (1284). Global Labor Organization.
Davis, M. A., Ghent, A. C. and Gregory, J. M. (2021). The work-from-home technology boon and its consequences. *NBER Working Paper*. (28461). https://doi.org/10.3386/w28461
Dauth, W., Findeisen, S., Suedekum, J. and Woessner, N. (2021). The adjustment of labor markets to robots. *Journal of the European Economic Association*, *19*(6). https://doi.org/10.1093/jeea/jvab012
Diario Oficial de la Federación. (2020a, 25 March). *Acuerdo del Comité de Evaluación a que se refiere el artículo 28 de la Constitución Política de los Estados Unidos Mexicanos*.
Diario Oficial de la Federación. (2020b, 29 May). *Acuerdo por el que se establecen los Lineamientos Técnicos Específicos para la Reapertura de las Actividades Económicas*.
Ding, L. and Saenz Molina, J. (2020). "Forced automation" by COVID-19? Early trends from current population survey data. *Discussion Paper*. Federal Reserve Bank of Philadelphia.
Dingel, J. I. and Neiman, B. (2020). How many jobs can be done at home?. *Journal of Public Economics*, *189*. https://doi.org/10.1016/j.jpubeco.2020.104235
Egana-delSol, P., Cruz, G. and Micco, A. (2022). COVID-19 and automation in a developing economy: Evidence from Chile. *Technological Forecasting and Social Change*, *176*. https://doi.org/10.1016/j.techfore.2021.121373
Filippo, A., Flores, I. and Székely, M. (2021). Mujeres y jóvenes: principales grupos afectados en México por la contracción económica durante la pandemia. *Technical Note*. (2224). http://dx.doi.org/10.18235/0003406

Frey, C. B. and Osborne, M. A. (2017). The future of employment: how susceptible are jobs to computerisation?. *Technological Forecasting and Social Change*, *114*. https://doi.org/10.1016/j.techfore.2016.08.019
Groshen, E. L. and Potter, S. (2003). Has structural change contributed to a jobless recovery?. *Current Issues in Economics and Finance*, *9*(8). Federal Reserve Bank of New York.
Hershbein, B. and Kahn, L. B. (2018), Do recessions accelerate routine-biased technological change? Evidence from vacancy postings. *American Economic Review*, *108*(7). http://doi.org/10.1257/aer.20161570
Hoehn-Velasco, L., Silverio-Murillo, A. and Balmori de la Miyar, J. R. (2021). The long downturn: The impact of the great lockdown on formal employment. *Journal of Economics and Business*, *115*. https://doi.org/10.1016/j.jeconbus.2021.105983
Hoehn-Velasco, L., Silverio-Murillo, A., Balmori de la Miyar, J. R. and Penglase, J. (2022). The impact of the COVID-19 recession on Mexican households: evidence from employment and time use for men, women, and children. *Review of Economics of the Household*, *20*(3). https://doi.org/10.1007/s11150-022-09600-2
Jaimovich, N. and Siu, H. E. (2020). Job polarization and jobless recoveries. *The Review of Economics and Statistics*, *102*(1). https://doi.org/10.1162/rest_a_00875
Juárez, L. and Villaseñor, P. (2024). Effects of the COVID-19 pandemic on the labor market outcomes of women with children in Mexico. *Economía LACEA Journal*, *23*(1). http://doi.org/10.31389/eco.438
Kaplan, D. S. (2021). Mercado laboral. In J. E. Heath Constable (Coord.), *Lecturas en lo que indican los indicadores: cómo utilizar la información estadística para entender la realidad económica de México*, *3* (pp. 45-66). Interactive Museum of Economics.
Kopytov, A., Roussanov, N. and Taschereau-Dumouchel, M. (2018). Short-run pain, long-run gain? Recessions and technological transformation. *Journal of Monetary Economics*, *97*. https://doi.org/10.1016/j.jmoneco.2018.05.011
Lee, S. Y. T., Park, M. and Shin, Y. (2021). Hit harder, recover slower? Unequal employment effects of the COVID-19 shock. *NBER Working Paper*. (28354). http://doi.org/10.3386/w28354
Leigh, N. G. and Kraft, B. R. (2018). Emerging robotic regions in the United States: insights for regional economic evolution. *Regional Studies*, *52*(6). https://doi.org/10.1080/00343404.2016.1269158
Leigh, N. G., Kraft, B. R. and Lee, H. (2020). Robots, skill demand and manufacturing in US regional labour markets. *Cambridge Journal of Regions, Economy and Society*, *13*(1). https://doi.org/10.1093/cjres/rsz019
Leyva, G. and Mora, I. (2021). How high (low) are the possibilities of teleworking in Mexico?. *Working Paper*. (2021-15). Bank of Mexico.
Lund, S., Madgavkar, A., Manyika, J., Smit, S. Ellingrud, K., Meaney, M. and Robinson, O. (2021). *The Future of Work after COVID-19*. McKinsey Global Institute.
Mihaylov, E. and Tijdens, K. G. (2019). Measuring the routine and non-routine task content of 427 four-digit ISCO-08 occupations. *Tinbergen Institute Discussion Paper*. (2019-035/V). http://dx.doi.org/10.2139/ssrn.3389681
National Institute of Statistics and Geography. (2011). *Sistema Nacional de Clasificación de Ocupaciones 2011 SINCO*.
National Institute of Statistics and Geography. (2014). *La informalidad laboral. Encuesta Nacional de Ocupación y Empleo: marco conceptual y metodológico*.
National Institute of Statistics and Geography. (2021). *Encuesta Telefónica de Ocupación y Empleo (ETOE) 2020*. https://www.inegi.org.mx/investigacion/etoe
Organisation for Economic Co-operation and Development. (2021). *OECD Employment Outlook 2021: Navigating the COVID-19 Crisis and Recovery*. https://doi.org/10.1787/5a700c4b-en
Ripani, L., Soler, N., Kugler, A., Kugler, M. and Rodrigo, R. (2020). *The Future of Work in Latin America and the Caribbean: What is the Impact of Automation on Employment and Wages?*. http://dx.doi.org/10.18235/0002960
Schumpeter, J. A. (1934). *The Theory of Economic Development*. Harvard University Press.
Waddle, A. (2021). Trade, technological change, and wage inequality: the case of Mexico. *International Economic Review*, *62*(1). https://doi.org/10.1111/iere.12485
Weber Handwerker, E., Meyer, P. B., Piacentini, J., Schultz, M. and Sveikauskas, L. (2020, December). Employment recovery in the wake of the COVID-19 pandemic. *Monthly Labor Review*. https://doi.org/10.21916/mlr.2020.27
World Bank. (2016). *World Development Report 2016: Digital Dividends*. http://doi.org/10.1596/978-1-4648-0671-1

Determinants of pioneering technological innovations in the Brazilian manufacturing industry

Juliana Brito de Oliveira, Elaine Aparecida Fernandes and Jandresson Dias Pires

Received: 23/03/2022
Accepted: 25/07/2024

Abstract

The capacity to innovate drives competitiveness and economic development. From this perspective, the aim of the present study is to improve understanding of the relationship between innovation and its determinants in Brazil's manufacturing industry during the period 2015–2017. Using data from the 2017 Technological Innovation Survey, the authors estimated a generalized linear model with a negative binomial distribution. The findings show that technological capability and expenditure on innovation activities were decisive and positively associated with the number of innovating firms. By contrast, financing or sources of support for innovation, firm size and economic risks were not statistically significant. Lastly, government financial support showed no meaningful impact on innovation, raising doubts about the efficiency of such support, which was received by fewer innovating firms (26.2%) in 2015–2017 compared with previous three-year periods, potentially contributing to the weakness of innovation activities.

Keywords

Industrial enterprises, industrial development, technological innovations, measurement, industrial statistics, statistical methodology, industrial policy, Brazil

JEL classification

O14; O25; O33

Authors

Juliana Brito de Oliveira holds a master's degree in economics from the Federal University of Viçosa (UFV), Viçosa, Minas Gerais, Brazil. Email: juliana.brito93@outlook.com.

Elaine Aparecida Fernandes is a professor in the Department of Economics at the Federal University of Viçosa (UFV), Viçosa, Minas Gerais, Brazil. Email: eafernandes@ufv.br.

Jandresson Dias Pires is a Professor at the Bahia Federal Institute of Education, Science and Technology (IFBA), Brumado Campus, Brumado, Bahia, Brazil. Email: jandresson.pires@ifba.edu.br.

I. Introduction

Owing to globalization and increasingly competitive markets, it is essential that public and private organizations invest in innovative products and processes. The capacity to develop innovations drives economic development, and the countries that have made the greatest progress in innovation are also those that have invested and continue to invest in research and development.

Accordingly, high-income economies occupy leading positions in the Global Innovation Index published by the European Institute of Business Administration. Switzerland, for example, has led the ranking since 2000. Brazil, by contrast, ranked fifty-seventh among the 132 economies analysed in 2021 and placed fourth within Latin America and the Caribbean, behind Chile (fifty-third), Mexico (fifty-fifth) and Costa Rica (fifty-sixth).[1] This scenario illustrates that the Brazilian economy faces numerous challenges that must be addressed. In a highly unequal country such as Brazil, persistent problems related to poverty, health and the quality of education, for example, pose obstacles to the development of science, technology and innovation.

In the face of inequality and the problems it generates, compounded by the magnitude of the crisis triggered by the coronavirus disease (COVID-19) pandemic, risk aversion may increase considerably and, consequently, countries and firms may face greater difficulties in attracting investment and promoting innovation. In this context, innovating is not easy and requires substantial effort on the part of both public and private institutions. It is precisely because of these difficulties, however, that the country should strengthen scientific and technological development. By enabling a more efficient use of resources, innovation can help to reduce the problems facing Brazil. This context provides the rationale for the present study, which is intended to support public and private agents in designing policies for fostering innovation-related activities by identifying the factors that most strongly influence such activities in Brazilian industry.

The manufacturing sector was selected for analysis owing to its broad scope and importance for the Brazilian economy. It currently accounts for 11.2% of GDP, 65.1% of corporate investment in research and development, 46.2% of Brazilian exports of goods and services and 24.1% of federal tax revenues (National Confederation of Industry, 2024). However, as in other countries, the sector's share of GDP has been declining. In addition, Brazilian industry has fallen 10 places in the ranking of the Competitive Industrial Performance Index of the United Nations Industrial Development Organization, moving from thirty-second to forty-second place in the period 2010–2019 (United Nations Industrial Development Organization [UNIDO], 2025). This index measures countries' capacity to produce and export manufactured goods, the degree of technological intensification and upgrading and their impact on global markets. Brazil's performance indicates that the country remains far from the technological frontier.

Despite Brazil's weaker-than-expected performance in innovation and competitive industrial indices, a study by the Organisation for Economic Co-operation and Development (OECD, 2020) points to the country's considerable, as yet untapped, potential in emerging digital technologies, such as the Internet of things and big data. The manufacturing sector could achieve productivity and efficiency gains, reduce costs and enhance sustainability, provided that certain problems —such as the complexity of the tax system and limited access to credit for small firms with high innovative potential— are resolved.

Despite differences in research objectives, studies have focused on uncovering data that explain the relationship between innovation and its determinants in Brazil's industrial sector. Innovation is more likely to occur among firms that undertake greater efforts to innovate, including investments in

[1] See Dutta et al. (2022) for further details on the Global Innovation Index of 2021.

research and development, maintain a workforce with a larger share of employees holding university degrees and receive greater government support. International empirical research in recent years has linked firm characteristics to innovation, indicating that research and development investment, export experience, government subsidies and reduced barriers to innovation contribute to firms' likelihood of innovating. These studies are presented in section II.

Although there is an extensive body of literature on the subject, the innovation indicator used in this study refers specifically to innovations that did not previously exist in the domestic market. This indicator may be considered novel insofar as it captures only genuinely pioneering innovations and excludes product or process innovations that are new to the firm but already exist in the domestic market. Moreover, no studies were identified in specialized journals that use data from the 2017 Technological Innovation Survey (PINTEC).

Against this backdrop, the general objective of this study is to analyse the relationship between innovation and its determinants in Brazil's manufacturing industry during the period 2015–2017. Specifically, the analysis focuses on the effects of the employees, technological capability, government support, expenditure and economic risk variables on innovation activities oriented towards the domestic market.

It is expected that technological capability, investment in research and development, firm size and government support will be positively associated with the number of firms in each sector that introduced product or process innovations. Conversely, economic risk is expected to be negatively associated with innovation.

The article is divided into four sections in addition to this introduction. Section II presents the theoretical and empirical foundations of the relationship between innovation and its determinants. Section III outlines the methodology. Section IV includes the presentation and discussion of results and section V sets out the main conclusions of the study.

II. Theoretical and empirical aspects of innovation and its determinants

1. Theoretical aspects

In his book *The Theory of Economic Development*, Schumpeter was the first to conceptualize innovation as the principal driver of capitalist dynamics —that is, the main mechanism through which capitalism develops. Within this framework, he introduces the concept of the "entrepreneur" as the agent responsible for bringing innovation into industry. The Schumpeterian entrepreneur is responsible for transforming and revolutionizing the prevailing model through the exploitation of an invention or a new technology (Schumpeter, 1934).

According to Schumpeter (1942), both industrial and technological revolutions facilitate the continuous emergence of new products, processes and organizational forms. In this way, innovation generates ongoing industrial change that transforms the economic structure and thus becomes essential to economic development. For the author, innovation is pursued continuously to obtain strategic advantages, based on two central concepts: monopoly profits and creative destruction.

For Schumpeter, monopoly profits are the outcome of the competitive process and represent the gains derived from innovation until competitors replicate it. Creative destruction, meanwhile,

refers to the process whereby firms initially introduce new products —or produce existing products through different processes— and subsequent imitation by competitors gives rise to new ideas and processes, thereby fostering further innovation by the entrepreneur.

Another important Schumpeterian idea is that large firms contribute a relatively significant share to technological progress (Schumpeter, 1934). The rationale is that larger firms are better able to spread the fixed costs of innovation, benefit from economies of scale in research and development, access greater internal resources and leverage complementarities between research and development and other processes. However, subsequent studies questioning this hypothesis found that no systematic relationship can be established between firm size and the intensity of research and development investment, since the determining factor is the type of industry under analysis (Cohen and Levin, 1989).

In their analysis of firm dynamics, Nelson and Winter (1996) also adopt the view that routines are complemented by the notions of selection and search.[2] Routines underpin the behaviour of agents and organizations, which innovate in order to survive through established rules and patterns of conduct —one of the central premises of the neo-Schumpeterian approach (Nelson and Winter, 1996). According to the authors, the trajectory of technical progress becomes endogenous, emerging from the solutions developed to address everyday problems. In the same evolutionary vein, Possas (2008) argues that technical progress is introduced through two fundamental mechanisms: the search for innovations, undertaken by firms through strategic action, and the selection of economic outcomes through the market and other institutions, such as research centres and universities.

Another key concept within the evolutionary perspective relates to search behaviour, which is inherently associated with risk (Rissardi et al., 2009). If search routines —manifested in research and development activities— are subject to some degree of uncertainty, the innovation process becomes guided by heuristics based on prior experience, including both successes and failures (Corazza and Fracalanza, 2004).

By emphasizing the role of behavioural routines, Nelson and Winter (1996) further advance theoretical understanding through the concept of "natural trajectories," which strongly influence technological evolution. In doing so, they depart from neoclassical methodological assumptions of equilibrium, replacing them with the broader notion of trajectory, and substitute maximizing rationality with bounded or procedural rationality.

Rosenberg (1983) conceptualizes technological innovation as a learning process. In the economic literature, learning is understood as a cumulative process that enables firms to refine knowledge and strengthen their capabilities to develop, produce and commercialize goods and services (Rissardi et al., 2009).

According to Rosenberg (1969, 1983), this view challenges certain neoclassical assumptions, since uncertainty lies at the core of innovative activity and is essential to understanding the nature of innovation. The outcomes of technological change involve complex relationships that cannot be fully anticipated ex ante, and both the rate of adoption and the direction of innovation depend on expectations regarding future technological learning. Furthermore, the level of accumulated learning directly influences the trajectory of technological change.

In this context, firms' innovative capabilities are shaped by research and development activities, as well as by learning by doing, learning by using and learning by interacting (Rosenberg, 1983). The innovation process can thus be analysed in two stages: generation and diffusion. The accumulation

[2] Selection refers to the competitive process which, over time, favours the most effective routines (both strategic and operational), thereby generating differentiation among firms in terms of their market performance. When competitive conditions no longer align with the strategies adopted by firms or with their implementation, firms initiate a search for new routines, understood as processes inherently associated with risk (Rissardi et al., 2009).

of these capabilities, together with technological assets, determines both the type and intensity of innovation and contributes to the development of firms' trajectories, as learning may hold the key to enhancing productivity in high-technology industries.

According to Freeman (1974) and Freeman et al. (1982), it is essential to examine the technological strategies within which firms operate in the innovation process. The authors characterize this process as interactive: in addition to acquiring knowledge through their own experience, development and production, firms continuously learn from their relationships with various external sources. Accordingly, the role of scientific knowledge highlighted by Freeman is not exogenous to the innovation process; instead, it is increasingly embedded in the interaction between science and technology.

Freeman et al. (1982) identify six types of technological strategy, which vary across firms: offensive, defensive, imitative, dependent, traditional and opportunistic. The offensive strategy characterizes firms seeking technological leadership in the market; they maintain strong internal research and development processes that play an important role in seeking knowledge from basic research. Similarly, firms adopting a defensive strategy do not aim to launch entirely new products but focus on refining existing innovations. These firms are typically risk-averse but still invest intensively in research and development.

Firms pursuing an imitative strategy do not aim for technological leadership in the market and engage in limited research and development, focusing mainly on adapting to local conditions and optimizing production processes. In the dependent strategy, unlike the others, firms do not conduct research and development, as they are economically and institutionally reliant on other firms. Their resources are thus devoted primarily to production and commercialization.

Lastly, neither traditional nor opportunistic strategies involve research and development activities. In the traditional strategy, firms' products remain unchanged because competition does not stimulate innovation, resembling a perfectly competitive or oligopolistic market structure. By contrast, firms adopting opportunistic strategies focus on occupying market niches that rely on specific product knowledge for particular customers.

The innovation process can be understood as the interaction between firms and the alternatives offered by a technological paradigm. Dosi (1982) refers to the concept of "technological paradigms" to explain the determinants, procedures and directions of technological change, as well as its effects on industrial performance and the structural transformation of organizations.

According to Dosi et al. (1990, p. 84), a technological paradigm can be defined as a "'pattern' of solution of selected problems based on highly selected principles derived from prior knowledge and experience". In this way, technological paradigms define the opportunities for subsequent innovations while establishing the basic procedures that enable their exploitation. Building on this framework, Dosi (1984) introduces the concept of "technological trajectories" in a detailed analysis of the mechanism linking technological change to the socioeconomic system.

This concept is particularly useful for the empirical analysis of organizations, as it indicates the direction taken by technical progress. According to Cardôso (2003, p. 64), a technological trajectory reflects the action of technological progress within a given technological paradigm; in other words, it represents the "normal" way of developing and seeking solutions to specific problems.

Differences in technological capabilities among firms arise from their specific characteristics and depend on changes in their technological trajectories. Accordingly, paradigm shifts, together with development along these trajectories, create the opportunities that firms can exploit in pursuit of profits (Tigre, 2005).

2. Empirical analysis of the relationship between innovation and its determinants

By incorporating the evolutionary perspective on innovation into analyses, many empirical studies have focused on identifying the organizational, institutional and economic characteristics considered determinants of technological innovation (De Marchi, 2012). Factors such as information and knowledge flows, technological and internal absorptive capabilities, sectoral characteristics, firms' innovative behaviour and financing conditions have increasingly been included in these studies (Veugelers, 2012).

The emphasis on this topic and the use of diverse methodologies and indicators in recent decades have made this research even more relevant.

Accordingly, the present study not only builds on the theoretical literature discussed above but also highlights national and international empirical evidence on the determinants of technological innovation in manufacturing activities.

Regarding the national literature, Quadros et al. (2000) identify four variables that condition technological innovation in industry: sector, technical production system, firm size and capital origin. On the basis of data from the São Paulo Economic Activity Survey, the authors conclude that larger firms in São Paulo exhibit significantly higher technological performance than small and medium-sized enterprises.

Using data from PINTEC 2000, Kannebley et al. (2004) find that the factors most strongly influencing a firm's likelihood to innovate were export orientation and firm size (measured by the number of employees). According to the authors, larger firms increase the probability of innovation in manufacturing more than proportionally. Notably, these key factors identified by Kannebley et al. (2004) are also observed in the studies of Póvoa and Monsueto (2011), Mohamed (2018) and De Freitas (2019).

With regard to expenditure on innovation activities (innovation effort), Carrara and Ferreira (2020) provide empirical support for the hypothesis that the number of firms investing in such activities positively influences the performance of the Brazilian manufacturing industry. These findings are replicated both in individual estimations and when the analysis is extended to all regions of Brazil over time.

Thus, investment in research and development, infrastructure and technology represents a viable alternative for developing countries seeking to accelerate their growth trajectory. Scherrer Mendes et al. (2020) find that narrowing the technological gap requires transforming the production structure and raising productivity through the endogenization of technological progress. Drawing on a multilevel analysis based on PINTEC data for 2008, 2011 and 2014, the authors further show that greater expenditure on research and development, machinery and equipment, and workforce training increases the likelihood that firms will innovate.

In the context of today's heightened competitive pressures, innovation costs have become a central consideration in firms' decision-making, as they may act as a barrier to the innovation process (Silva and Dacorso, 2014). The 2014 PINTEC report indicated that, in the manufacturing industry, high costs were regarded as the main obstacle to innovation, ranking first in importance relative to the 2008 and 2011 editions. Consistent with these findings, Silva and Dacorso (2014), in their analysis of innovation costs in the Brazilian manufacturing industry, showed that most sectors assigned high or medium importance to the impact of costs on innovation activities. Kühl and da Cunha (2013) likewise identified these costs as one of the main economic obstacles and barriers to innovation.

Technological capability is of paramount importance. Cohen and Levin (1989) define technological capability as the ability to recognize the value of new knowledge, assimilate it and apply it for commercial purposes. Given its direct linkage with research and development activities that enable the generation of new products or processes, technological capability is indispensable for innovation (Patel and Pavitt, 1994).

In analysing the determinants of innovation and firms' absorptive capacity in Brazil using PINTEC data for 2000 and 2003, De Negri (2006) found that firm-level characteristics related to the labour force, such as educational attainment and diversity of training, strongly influence technological innovation. Mohamed (2018) reached similar conclusions in an analysis of firm-, sector- and region-level factors affecting innovation in the Brazilian manufacturing industry using 2014 PINTEC data, highlighting technological capability and government support as the primary determinants of technological innovation in the country's industrial sector.

With regard to government support, although it remains a subject of debate, the State and public policies play a fundamental role in fostering innovation. According to Pinsky and Kruglianskas (2017), government incentives for innovation can operate through two channels, or a combination of both: technology-push and demand-pull. In the first case, the government acts by reducing the private cost of project development, whereas in the second, government support increases firm profits when innovations succeed.[3]

Avellar et al. (2021) highlight that government support, together with expenditures on research and development, access to information and obstacles to innovation, are important determinants of cooperation in innovation. In their study, the authors examine the factors driving cooperation in innovation, considering collaboration with both national and foreign institutions, as well as the types of partner, including other firms, business groups and research institutions.

Innovation requires substantial financial resources, largely in the form of investment in research and development, and may be reinforced by public policies that complement firms' own efforts through significant investment in research. Mendes and Rocha (2019) analyse the impact of public investment in research on firms' technological innovation performance. Using a sample of 2,500 firms across 45 countries, the authors estimate the effect of public investment on the relationship between firm performance and private investment in research and development. Their results indicate that public investment enhances the private returns on investment in research and development.

Consistent with the national literature on the determinants of innovation, international studies also identify key factors that shape the innovation process. Adams et al. (2016) investigate the impact of technological absorptive capacity in 549 firms located in Austria, Brazil, China, Germany, India and Singapore. Among their main findings, the authors report that technological capability has a positive and statistically significant effect on firm performance in these countries.

Sofka (2008) examines how German firms adapt their technological absorptive capacity to capitalize on opportunities in new markets. Research on the internationalization of innovation activities suggests that investments in research and development, the strength of the domestic market and firms' export experience all contribute to building technological capabilities at the national level.

In his thesis, De Oliveira (2019) analyses firms with innovation potential in developing countries and finds that institutional, market and knowledge-related factors are associated with technological innovation. Using data from Ecuador's National Survey of Science, Technology and Innovation Activities for the period 2009–2014, the author determines that characteristics such as knowledge and

[3] Technology-push refers to subsidies for research and development initiatives, measures to enhance knowledge transfer capacity, support for educational programmes, training and project financing. Examples of demand-pull include intellectual property rights, tax credits and discounts for consumers of new technologies, regulatory frameworks and taxes applied to competing technologies (Pinsky and Kruglianskas, 2017).

market barriers are the most relevant constraints faced by Ecuadorian firms engaged in innovation activities. By contrast, an analysis conducted for Uruguay, covering 2001–2015 with data from the Innovation Activities Survey, shows that market barriers have a significant negative relationship with innovative productivity. Lastly, the analysis for Peru for the period 2009–2014 indicates that institutional factors, such as government support, have a positive and significant association with innovation activities, while innovation obstacles exhibit a negative relationship, as expected.

Exploring the effects of government subsidies, research, development and innovation on Chinese manufacturing industries between 2007 and 2017, Ahia et al. (2022) find a positive and significant causal relationship between investment in research and development and innovation. The authors also observe that firms classified as "younger" and State-owned achieve better short-term innovation performance than private firms. Furthermore, government subsidies not only stimulate short-term research and development but also foster long-term innovation and play a crucial role in research, development and innovation activities in emerging markets.

An extremely important aspect highlighted in the work of Yildiz et al. (2021) is absorptive capacity. According to the authors, this capacity can be developed at both the individual and collective levels, leading to positive outcomes in innovation. Because it reflects the ability to acquire and manage new ideas in the workplace, absorptive capacity plays a central role in promoting innovative processes.

In line with the objectives of this study, this section contributes to the selection of explanatory variables used in the regression model analysing the determinants of technological innovation in the manufacturing industry. Overall, both the national and international literature on the theory of innovation and its determinants in the manufacturing sector —both in Brazil and globally— is extensive and well established.

III. Methodology

1. Description of database and variables

The database used in this analysis was compiled from the 2017 edition of the PINTEC survey conducted by the Brazilian Institute of Geography and Statistics.

Initiated in the 2000s, PINTEC aims to construct sectoral, national and regional indicators of innovation activities undertaken by firms in the industrial sector (extractive and manufacturing industries), the electricity and gas sector and selected service activities. In addition, the purpose of the survey is to deepen the analysis of firms' efforts to innovate in products and processes by identifying aspects such as expenditure on innovation activities, sources of financing, the role of government incentives, obstacles encountered, technology use, sustainability and environmental innovation (Brazilian Institute of Geography and Statistics [IBGE], 2020).

Accordingly, the dataset used in this analysis includes a sample of 3,695 firms distributed across 54 sectors of the Brazilian manufacturing industry. These firms introduced innovations considered new to the domestic market.

Table 1 presents the variables used to estimate the relationship between innovation and its determinants for manufacturing firms in Brazil. The selection of these variables was based on the theoretical and empirical studies discussed earlier. Table 1 also lists the studies that employed the selected variables and the expected signs for each variable.

Table 1
Description of the explanatory variables of the model

Variable	Description of variable	Studies	Expected sign
Innovation	Dependent variable (number of firms that introduced product and process innovations considered new to the domestic market).	None identified	–
Employees (*po*)	Proxy variable for firm size, measured by the number of persons employed on 31 December 2017.	Mohamed (2018), De Freitas (2019) and Avellar et al. (2021)	> 0
Technological capability (*captec*)	Number of employees with university degrees engaged in innovation activities.	Sofka (2008), Adams et al. (2016), Mohamed (2018), De Oliveira (2019) and De Freitas (2019)	> 0
Government support (*ag*)	Number of firms, by sector, that received some form of government support, including tax incentives, grants and public financing.	De Negri (2018), Mohamed (2018), Mendes and Rocha (2019), De Oliveira (2019), De Freitas (2019) and Ahia et al. (2022)	> 0
Expenditure (*dis*)	Number of firms, at the sectoral level, that invested in internal and external research and development activities, acquisition of external knowledge, acquisition of software, machinery and equipment, and training.	Mohamed (2018), Silva and Dacorso (2014), Mendes and Rocha (2019), De Freitas (2019), Scherrer Mendes et al. (2020) and Ahia et al. (2022)	> 0
Economic risk (*re*)	Number of firms, by sector, that attributed medium or high importance to problems and obstacles to innovation.	De Oliveira (2019) and Silva and Dacorso (2014)	< 0

Source: Prepared by the authors, on the basis of Mohamed, A. A. (2018). *Determinantes empresariais, setoriais e regionais da inovação: um estudo para a indústria de transformação* [Master's degree dissertation]. Federal University of Viçosa. http://www.locus.ufv.br/handle/123456789/22501; De Freitas, H. D. (2019). *Determinantes do consumo de água no processo produtivo da indústria de alimentos e bebidas* [Master's degree dissertation]. Federal University of Viçosa. https://locus.ufv.br//handle/123456789/27404; Avellar, A. P. M., Damasceno, A. O. and Silva, F. Q. (2021). Determinantes da cooperação para inovação das empresas brasileiras. *Economia e Sociedade, 30*(3). https://doi.org/10.1590/1982-3533.2021v30n3art07; Sofka, W. (2008). Globalizing domestic absorptive capacities. *Management International Review, 48*. https://doi.org/10.1007/s11575-008-0106-9; Adams, D. R., Flatten, T. C., Brinkmann, H. and Brettel, M. (2016). Consequences and antecedents of absorptive capacity in a cross-cultural context. *International Journal of Innovation Management, 20*(1). https://doi.org/10.1142/S1363919616500031; De Oliveira, F. S. (2019). *Obstáculos à inovação: determinantes, efeitos e complementaridades em países em desenvolvimento* [Doctoral thesis]. University of Santiago de Compostela; De Negri, F. (2018). *Novos caminhos para a inovação no Brasil*. Institute of Applied Economic Research; Mendes, H. D. and Rocha, L. A. (2019). *A contribuição dos investimentos públicos em pesquisa no desempenho da inovação das empresas* [Master's degree dissertation]. Federal Rural University of the Semi-arid Region; Ahia, B. N. K., Song, N., Anafo, S. A. and Boakye, E. A. (2022). A story conveyed for emerging economies: the transitivity effects of subsidy, R&D, and innovation within manufacturing industries. *IEEE Transactions on Engineering Management, 69*(6). https://doi.org/10.1109/TEM.2020.3036614; Silva, G. and Dacorso, A. L. R. (2014). Riscos e incertezas na decisão de inovar das micro e pequenas empresas. *Revista de Administração Mackenzie, 15*(4). https://doi.org/10.1590/1678-69712014/administracao.v15n4p229-255; Scherrer Mendes, P., Britto, G. and Hermeto, A. M. (2020). Brazilian industry and knowledge absorption: internal and external company determinants. *CEPAL Review* (131) (LC/PUB.2020/9-P/Rev.1). Economic Commission for Latin America and the Caribbean.

Note: The analysis covered 3,695 firms that introduced innovations new to the domestic market but already existing in the world market.

2. Generalized linear models

Generalized linear models are in a class that broadens the range of statistical analysis beyond the normal distribution, and are therefore used when the response variable being examined is a count, categorical or asymmetric variable restricted to positive values (Fávero and Belfiore, 2017). In this study, the response variable is the number of firms that implemented product and process innovations considered new to the domestic market. Accordingly, count data regression models were employed. Both the Poisson distribution model and the negative binomial distribution model were considered in the analysis. These models are described in detail in Fávero and Belfiore (2017).

Equation (1) presents the estimation of the parameters of the negative binomial distribution, the method selected for its superior fit to the data used in this study.

$$u_i = e^{\alpha + \beta_1 captec_i + \beta_2 ag_i + \beta_3 dis_i + \beta_4 po_i + \beta_5 re_i} \quad (1)$$

where $captec$ denotes the sector's technological capability; ag represents government support provided to the sector; dis refers to the number of firms or sectors that incurred innovation-related expenditure; po corresponds to the number of employees at 31 December and serves as a proxy for firm size; and re is a variable reflecting economic risks and obstacles to innovation.

The model was subsequently evaluated to assess the goodness of fit of the chosen distribution and to identify poorly fitted and influential observations. Graphical analyses were used to examine the adequacy of the Poisson and negative binomial distributions. Diagnostic measures included Cook's distance, normal probability plots, standardized residual plots and hat matrix ($\widehat{H}$) values, which together helped to detect potential problems related to model fit.

3. Exploratory analysis and descriptive statistics

Regarding the variable measuring the number of firms that implemented product and process innovations, the variance (54,770.76) is substantially higher than the mean (214.19), suggesting the presence of overdispersion. Boxplots were also constructed for the independent variables to identify potential outliers (Faraway, 2014). When outliers were detected, logarithmic transformations were applied to reduce asymmetry in the distributions.

The exploratory analysis showed that the pharmaceutical chemicals sector had the lowest number of firms implementing product and process innovations in the period 2015–2017. A possible explanation, according to Mitidieri et al. (2015), is that the strengthening of Brazil's pharmaceutical industry in recent decades did not generate comparable opportunities for the pharmaceutical chemicals industry, which produces the primary raw materials for medicines. The rise of Asian countries as major suppliers of these inputs has challenged the competitiveness of Brazil's industry, as well as that of other non-Asian countries.

Conversely, the food industry registered the highest value for the response variable. Reflecting the sector's innovation potential in Brazil, driven by growing domestic and international demand, food manufacturers have invested in production capacity and efficiency, securing a prominent position in both domestic and international markets (Raimundo et al., 2017). Food production also accounts for the largest number of employees among the sectors analysed. Despite the impact of the COVID-19 pandemic, which increased production costs by 3.8% in 2020, the food and beverage industry created 20,000 new jobs, representing a 1.2% increase over the previous year. It thus remained the largest employer in Brazil's manufacturing sector, with 1.68 million direct jobs (Brazilian Packaging Association, 2021).

Concerning the number of firms per sector that invested in internal and external research and development activities, the national average over the three-year period was 168.5 firms, a figure considered low relative to previous years. According to the PINTEC report for the period analysed, the intensity of expenditure on total innovation activities in industry fell for the third consecutive time, standing at 1.65% in 2017 (IBGE, 2020). The chemical manufacturing sector recorded the highest level of investment, while the tobacco products sector had the lowest number of firms investing in research and development.

The data on the sources of financing for innovation activities indicate that, on average, 227.35 firms received some form of government support. Once again, the greatest support went to firms producing food products, while the lowest support went to those in the tobacco sector. As noted by Zajonz et al. (2017), Brazil is one of the leading global producers of tobacco, accounting for 11% of worldwide production. In 2014, the government collected approximately 12.8 billion reais

in taxes from this sector. However, in addition to the formulation of measures to discourage tobacco consumption through higher taxes, policies exclusive to this sector that promote production diversification among small rural producers and large industry players pose obstacles.

Lastly, the data on technological capability among employees indicate a limited level of development. On average, 1,325.7 employees with higher education work in manufacturing firms, representing only 0.8% of the total number of employees in the sample. According to the 2017 PINTEC report, 65.5% of innovative firms cited a lack of qualified personnel, making it the third most important obstacle to innovation (IBGE, 2020). In terms of extremes, the motor vehicles, trailers and coachwork manufacturing sector employed the largest number of highly educated personnel, while the printing and reproduction of recorded media sector reported the lowest.

IV. Results and discussion

As noted, the response variable corresponds to the number of firms that implemented product and process innovations for the domestic market. As a count variable, it requires a distribution suited to this type of data. Within generalized linear models, the Poisson distribution with a logarithmic link function is typically the initial specification. When the generalized linear model of the Poisson distribution does not provide an adequate fit, alternative models are considered, with the negative binomial distribution being the most commonly used in cases of overdispersion (De Freitas, 2019).

In addition to identifying overdispersion of the data, the selection of the best-fitting model was based on several statistical criteria. Table 2 presents the results of the likelihood ratio test and the Akaike information criterion for each of the models tested with different distributions. The results indicate that the negative binomial distribution provides a better fit to the data, as it yielded a lower Akaike information criterion and higher likelihood, and was therefore the model analysed in this study.

Table 2
Model selection for the dataset

Fit	Akaike information criterion	Log-likelihood
Poisson distribution	2 060	-1 024
Negative binomial distribution	590	-288

Source: Prepared by the authors.

As explained above, the estimated regression models aimed to relate the number of firms innovating in the Brazilian manufacturing industry to variations in technological capability, sector size, government support, the number of firms per sector that incurred expenditure on innovation, and economic risk. The results are shown in table 3. Model 1 was estimated using a negative binomial distribution by maximum likelihood. Model 2, the final model, was estimated using a stepwise procedure to ensure greater robustness of the estimates. This was the model used in the present study to interpret the results, together with the corresponding marginal effects.

According to the values presented in table 3, at any conventional level of significance, model 1 indicates that technological capability and the number of firms incurring expenditure on innovation are statistically significant. The fitted model also yielded a dispersion parameter greater than 1, which also explains the lack of fit of the Poisson distribution.

Table 3
Innovation and its determinants
(Dependent variable: innovation)

Variable	Model 1	Model 2	Marginal effects
Technological capability	0.1986** (0.0683)	0.1665 (0.0605)	0.3439** (0.1319)
Expenditure on innovation	0.6710*** (0.1995)	0.6009*** (0.1279)	1.2409*** (0.3018)
Government support	0.1905 (0.1316)	0.1797 (0.1293)	0.3711 (0.2702)
Employees	-0.1098 (0.1065)	…	…
Economic risks and obstacles	-0.0127 (0.1476)	…	…
Constant	0.5753 (0.8254)	-0.5907 (0.4742)	…
Dispersion parameter	5.89 (1.01)	4.97 (0.98)	…

Source: Prepared by the authors.
Note: *** significant at 1%; ** significant at 5%. Standard errors are reported in parentheses. The analysis covered 3,695 firms that introduced innovations new to the domestic market but already existing in the world market.

To preserve the robustness of the estimates in the presence of highly correlated variables, the employees and economic risks and obstacles variables[4] were removed from the model using a stepwise procedure. Although both variables are theoretically relevant and have a strong influence on innovation performance, they are highly correlated. As noted by Chiarini et al. (2020), the larger the firm (as measured by the number of employees), the fewer obstacles to innovation it faces. Furthermore, the likelihood ratio test indicated that model 2 fits the sample data as well as model 1, which includes all variables. On this basis, the specification supported by the statistical tests was adopted.

The adequacy of the final model was assessed primarily through the residuals of the fitted model, considering three graphical measures commonly used in residual analysis: Cook's distance, standardized residual plots and hat matrix ($\widehat{H}$) values.

Five observations stand out from the rest. These points should be examined carefully, as they may mask the effect of other variables in the model (masking effect). However, the specific treatment applied through confirmatory analysis indicated that these observations did not alter the inference of the selected model, and the variables should therefore be retained.

Lastly, at the 5% significance level, the Shapiro-Wilk and Breusch-Pagan tests indicated, respectively, that the residuals of the final model follow a normal distribution and that there is no evidence of heteroskedasticity.

Once the tests had been conducted and the model's robustness confirmed, the results were interpreted.

Regarding technological capability, it was found that a 1% increase in the number of employees with higher education corresponds to an approximate increase of 0.35 units in the number of firms implementing product and process innovations for the domestic market. This underscores the role of higher education institutions in training qualified professionals and researchers who,

[4] Studies by Mohamed (2018), De Freitas (2019) and Avellar et al. (2021) found a positive and statistically significant relationship between firm size and innovation. By contrast, De Oliveira (2019) and Silva and Dacorso (2014) found a negative and significant relationship between economic obstacles and innovation. It should be noted, however, that none of these studies used both indicators simultaneously.

once integrated into firms, provide the tacit capacity to absorb technology, acquire it and apply scientific knowledge innovatively, whether in solving complex problems or engaging in research and development to create new products or services. The literature corroborates the findings of this study. De Negri (2006), Mohamed (2018) and Araújo and Garcia (2019) highlight the contribution of technological capability and higher levels of university research to innovation.

There was a positive and significant relationship between innovation effort, measured by the number of firms per sector investing in innovation activities, and the number of firms introducing innovations. Moreover, an increase of 1 unit in this variable corresponds to a 1.24-unit rise in the number of firms implementing product and process innovations. This result was expected and is consistent with the literature. For example, Figueiredo and da Costa (2019) highlight that average expenditure on research and development is one of the most important factors influencing innovation. Similarly, Mohamed (2018) concludes that spending on innovation activities is positively correlated with the number of firms introducing innovations.

Contrary to expectations, the variable representing the number of firms receiving government support was not significant. This result suggests that, during the period analysed, financing and support mechanisms for innovation were not relevant in explaining the number of firms innovating in the manufacturing industry. It is important to note that, over the past two decades, Brazil has implemented a series of measures aimed at strengthening scientific, technological and innovation capacity. Among the policies adopted are the Innovation Act (Act No. 10973 of 2004) and the Good Act (Act No. 11 196 of 2005).[5] Brazil has put in place several instruments used in developed countries to promote innovation, including (i) subsidized credit, (ii) tax incentives, (iii) grants and (iv) funding for research projects in universities and scientific and technological institutions (De Negri, 2018).

According to De Negri (2018), public investment in science and technology in 2015 totalled approximately 33 billion reais. However, the allocation of this budget across the various ministries was markedly different from that of investments in science and technology in countries such as the United States. According to the author, unlike in other countries, most Brazilian investments are not linked to a specific mission. Therefore, there is no guarantee that financial support for innovation activities will effectively increase such activities.

Similarly, Gordon and Cassiolato (2019), who analysed the role of the State in promoting innovation through the *Plan Inova Empresa*, launched in 2013, corroborate the findings of this study. The authors show that, although the government implemented a set of advanced instruments to incentivize and support innovation activity, the policy outcomes did not achieve the intended effect. They conclude that these measures did not succeed in changing firm behaviour.

Zucoloto and Nogueira (2017) specifically analyse the support provided by the National Bank for Economic and Social Development (BNDES) for innovation activities from 2002 onward. Among the results of their evaluation of financing instruments and mechanisms, the authors highlight the growing role of innovation in BNDES disbursements to the manufacturing sector. However, even though non-automatic credit operations for innovation projects totalled 14.3 billion reais (6.5% of the total), traditional support mechanisms —such as tax incentives and financing for research and development projects— remain insufficient to generate and disseminate new products and processes in Brazil. One factor identified by the authors is that the 362 credit operations carried out between 2002 and 2015 covered only 168 manufacturing firms in the country.

[5] The Innovation Act encouraged the public and private sectors to share personnel, resources and facilities in order to promote collaboration between universities, research institutes and private companies. The Good Act, meanwhile, expanded the scope and facilitated the use of tax incentives to support private investment in research and development (De Negri, 2018).

According to the PINTEC report for the 2015–2017 triennium, fewer innovating firms received government support for innovation (26.2%, compared with 34.2% in 2009–2011 and 39.9% in 2012–2014). Within industry, the share of innovative firms using financing instruments to acquire machinery and equipment fell from 31.4% in 2012–2014 to 14.1% in 2017. Conversely, the share of firms benefiting from tax incentives for research and development under the Good Act (Act No. 11 196 of 2005) increased from 3.2% to 4.3% (IBGE, 2020).

This situation, compounded by the COVID-19 pandemic, is having even greater repercussions for the Brazilian pharmaceutical chemicals industry. According to Paranhos et al. (2021), the pandemic showed the segment's dependence on the production of active pharmaceutical ingredients in Asian countries, particularly China and India. It also generated additional pressures owing to logistical disruptions caused by border closures and the suspension of transport services, including air transport. Market instability stemming from medicine shortages, delays in production and vaccine rollout for political reasons and the resulting increase in costs has perpetuated an environment marked by uncertainty, heightened economic risk, lack of trust in institutions and an urgent need to reassess national strategies in response to post-pandemic challenges. Moreover, it is essential to foster a broader debate on Brazilian industrial policy in order to ensure sustainable development.

V. Conclusions

Innovation has become an essential factor in the development of any economy. This is because innovation, in the form of new or substantially improved products or processes, is directly linked to growth, job creation and income. Research in this field is therefore essential, as development cannot occur without innovation.

The results of this study show that technological capability and innovation effort are positively associated with the number of manufacturing firms undertaking technological innovations. These findings support the broader literature, which identifies these variables as key explanatory factors in determining whether productive sectors are innovative.

Although the government support variable was positively correlated with the number of innovating firms, it was not statistically significant. This lack of significance suggests that, during the period analysed, financing and innovation support mechanisms were not decisive in encouraging firms to innovate. This is mainly because financial support from the government is limited to certain sectors and firms and lacks a clearly defined mission, thereby allowing resources to be allocated to activities not directly related to innovation.

In this context, following the relative stability in product and process innovation rates in previous periods, the innovation capacity of Brazil's manufacturing industry remains far below desired levels. The 2017 PINTEC average innovation rate of 33.6% —a decline of 2.4 percentage points from the previous three-year period— illustrates this shortfall, as does Brazil's ranking of fifty-seventh in the 2021 Global Innovation Index.

Lastly, the study has several notable strengths, including the dependent variable indicator (innovations that are genuinely pioneering for the national industrial sector) and the econometric method applied. No other work in the related literature was found to use this combination of indicator and methodology. However, the small sample size limited the analysis, preventing an examination of how regional factors influence the emergence of innovations. Future research should incorporate this dimension into the model, allowing for a more in-depth study of firms in the sector and the application of alternative approaches, such as multilevel models.

Bibliography

Adams, D. R., Flatten, T. C., Brinkmann, H. and Brettel, M. (2016). Consequences and antecedents of absorptive capacity in a cross-cultural context. *International Journal of Innovation Management*, *20*(1). https://doi.org/10.1142/S1363919616500031

Ahia, B. N. K., Song, N., Anafo, S. A. and Boakye, E. A. (2022). A story conveyed for emerging economies: the transitivity effects of subsidy, R&D, and innovation within manufacturing industries. *IEEE Transactions on Engineering Management*, *69*(6). https://doi.org/10.1109/TEM.2020.3036614

Araújo, V. D. C. and Garcia, R. (2019). Determinantes e dependência espacial da inovação nas regiões brasileiras: evidências a partir de um Modelo Tobit Espacial. *Nova Economia, 29*(2). https://doi.org/10.1590/0103-6351/4456

Avellar, A. P. M., Damasceno, A. O. and Silva, F. Q. (2021). Determinantes da cooperação para inovação das empresas brasileiras. *Economia e Sociedade*, *30*(3). https://doi.org/10.1590/1982-3533.2021v30n3art07

Brazilian Institute of Geography and Statistics. (2020, 16 April). *Pesquisa de Inovação PINTEC 2017: resultados principais*.

Brazilian Packaging Association. (2021, 1 March). *Inovação varejo: faturamento da indústria de alimentos cresce 12,8% em 2020*. https://www.abre.org.br/inovacao/faturamento-da-industria-de-alimentos-cresce-128-em-2020

Cardôso, C. E. L. (2003). *Competitividade e inovação tecnológica na cadeia agroindustrial de fécula de mandioca no Brasil* [Doctoral thesis]. University of São Paulo. https://doi.org/10.11606/T.11.2003.tde-04122003-151241

Carrara, A. and Ferreira, G. A. (2020). Dispêndio em P&D no Brasil: uma análise da sua evolução e impacto no produto do país. *A Economia em Revista*, *28*(2). State University of Maringá.

Chiarini, T., De Oliveira, V. C. P. and Rapini, M. S. (2020). Obstáculos à inovação e porte das empresas industriais no Brasil: rumo a políticas públicas de incentivo à inovação mais assertivas. *Planejamento e Políticas Públicas*. (56). https://doi.org/10.38116/ppp56art2

Cohen, W. M. and Levin, R. C. (1989). Empirical studies of innovation and market structure. *Handbook of Industrial Organization*, *2*. https://doi.org/10.1016/S1573-448X(89)02006-6

Corazza, R. I. and Fracalanza, P. S. (2004). Caminhos do pensamento neo-schumpeteriano: para além das analogias biológicas. *Nova Economia*, *14*(2). Federal University of Minas Gerais.

De Freitas, H. D. (2019). *Determinantes do consumo de água no processo produtivo da indústria de alimentos e bebidas* [Master's degree dissertation]. Federal University of Viçosa. https://locus.ufv.br//handle/123456789/27404

De Marchi, V. (2012). Environmental innovation and R&D cooperation: empirical evidence from Spanish manufacturing firms. *Research Policy*, *41*(3). https://doi.org/10.1016/j.respol.2011.10.002

De Negri, F. (2006). Determinantes da capacidade de absorção das firmas brasileiras: qual a influência do perfil da mão-de-obra. In J. A. De Negri, F. De Negri and D. Coelho (Orgs.), *Tecnologia, Exportação e Emprego*. Institute of Applied Economic Research.

De Negri, F. (2018). *Novos caminhos para a inovação no Brasil*. Institute of Applied Economic Research.

De Oliveira, F. S. (2019). *Obstáculos à inovação: determinantes, efeitos e complementaridades em países em desenvolvimento* [Doctoral thesis]. University of Santiago de Compostela.

Dosi, G. (1982). Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change. *Research Policy*, *11*(3). https://doi.org/10.1016/0048-7333(82)90016-6

Dosi, G. (1984). *Technical Change and Industrial Transformation: The Theory and an Application to the Semiconductor Industry*. Palgrave Macmillan.

Dosi, G., Pavitt, K. and Soete, L. (1990). *The Economics of Technical Change and International Trade*. New York University Press.

Dutta, S., Lanvin, B., Wunsch-Vincent, S. and León, L. R. (2022). *Global Innovation Index 2021: Tracking Innovation through the COVID-19 Crisis*. World Intellectual Property Organization. https://doi.org/10.34667/TIND.44315

Faraway, J. J. (2014). *Linear Models with R*. CRC Press.

Fávero, L. P. and Belfiore, P. (2017). *Manual de Análise de Dados: Estatística e Modelagem Multivariada com Excel®, SPSS® e Stata.* Elsevier.

Figueiredo, J. C. F. and da Costa, R. A. (2019). A eficiência do financiamento à inovação no Brasil: uma análise dos dados da Pintec de 2000 a 2014. *Nexos Econômicos*, *13*(2). https://doi.org/10.9771/rene.v13i2.37026

Freeman, C. (1974). Innovation and the strategy of the firm. In C. Freeman and L. Soete, *The Economics of Industrial Innovation*. Penguin Books.

Freeman, C., Clark, J. and Soete, L. (1982). *Unemployment and Technical Innovation*. Frances Pinter.

Gordon, J. L. and Cassiolato, J. E. (2019). O papel do Estado na política de inovação a partir dos seus instrumentos: uma análise do Plano Inova Empresa. *Revista de Economia Contemporânea*, *23*(3). https://doi.org/10.1590/198055272334

Kannebley, S., Porto, G. S. and Pazello, E. T. (2004). Inovação na indústria brasileira: uma análise exploratória a partir da PINTEC. *Revista Brasileira de Inovação*, *3*(1). https://doi.org/10.20396/rbi.v3i1.8648893

Kühl, M. R. and da Cunha, J. C. (2013). Obstáculos à implementação de inovações no Brasil: como diferentes empresas percebem sua importância. *Brazilian Business Review*, *10*(2). Fucape Business School.

Mendes, H. D. and Rocha, L. A. (2019). *A contribuição dos investimentos públicos em pesquisa no desempenho da inovação das empresas* [Master's degree dissertation]. Federal Rural University of the Semi-arid Region.

Mitidieri, T. L., Pimentel, V. P., Braga, C. A. and Pieroni, J. P. (2015). Há espaços competitivos para a indústria farmoquímica brasileira? Reflexões e propostas para políticas públicas. *BNDES Setorial* (41). National Bank for Economic and Social Development.

Mohamed, A. A. (2018). *Determinantes empresariais, setoriais e regionais da inovação: um estudo para a indústria de transformação* [Master's degree dissertation]. Federal University of Viçosa. http://www.locus.ufv.br/handle/123456789/22501

National Confederation of Industry. (2024). *A importância da indústria de transformação para o Brasil.*

Nelson, R. R. and Winter, S. G. (1996). *An Evolutionary Theory of Economic Change*. Harvard University Press.

Organisation for Economic Co-operation and Development. (2020). *Going Digital in Brazil*. https://doi.org/10.1787/e9bf7f8a-en

Paranhos, J., Perin, F. S., Miranda, C., Falcão, D. and Vaz, M. (2021). Desenvolvimento da indústria farmoquímica no Brasil e na Argentina: diagnóstico, desafios e oportunidades. *Texto para Discussão* (021). Federal University of Río de Janeiro.

Patel, P. and Pavitt, K. (1994). National innovation systems: why they are important, and how they might be measured and compared. *Economics of Innovation and New Technology*, *3*(1). https://doi.org/10.1080/10438599400000004

Pinsky, V. and Kruglianskas, I. (2017). Inovação tecnológica para a sustentabilidade: aprendizados de sucessos e fracassos. *Estudos Avançados*, *31*(90). University of São Paulo.

Possas, M. L. (2008). Economia evolucionária neo-schumpeteriana: elementos para uma integração micro-macrodinâmica. *Estudos Avançados*, *22*(63). https://doi.org/10.1590/S0103-40142008000200021

Póvoa, L. M. C. and Monsueto, S. E. (2011). Tamanho das empresas, interação com universidades e inovação. *Revista de Economia*, *37*(4). https://doi.org/10.5380/re.v37i4.28870

Quadros, R., Brisolla, A., Furtado, A. and Bernardes, R. (2000). Força e fragilidade do sistema de inovação paulista. *São Paulo em Perspectiva*, *14*(3). https://doi.org/10.1590/S0102-88392000000300018

Raimundo, L. M. B., Batalha, M. O. and Torkomian, A. L. V. (2017). Dinâmica tecnológica da indústria brasileira de alimentos e bebidas (2000-2011). *Gestão & Produção*, *24*(2). https://doi.org/10.1590/0104-530X2750-15

Rissardi, D. J., Shikida, P. F. A. and Dahmer, V. S. (2009). Inovação, tecnologia e concorrência: uma revisita ao pensamento neoschumpeteriano. Revista Economia & Tecnologia, *5*(1). https://doi.org/10.5380/ret.v5i1.27308

Rosenberg, N. (1969). The direction of technological change: inducement mechanisms and focusing devices. *Economic Development and Cultural Change*, *18*(1). https://doi.org/10.1086/450399

Rosenberg, N. (1983). *Inside the Black Box: Technology and Economics*. Cambridge University Press. https://doi.org/10.1017/CBO9780511611940

Scherrer Mendes, P., Britto, G. and Hermeto, A. M. (2020). Brazilian industry and knowledge absorption: internal and external company determinants. *CEPAL Review* (131) (LC/PUB.2020/9-P/Rev.1). Economic Commission for Latin America and the Caribbean.

Schumpeter, J. A. (1934). *The Theory of Economic Development*. Harvard University Press.

Schumpeter, J. A. (1942). *Capitalism, Socialism, and Democracy*. Harper & Brothers.
Silva, G. and Dacorso, A. L. R. (2014). Riscos e incertezas na decisão de inovar das micro e pequenas empresas. *Revista de Administração Mackenzie*, *15*(4). https://doi.org/10.1590/1678-69712014/administracao.v15n4p229-255
Sofka, W. (2008). Globalizing domestic absorptive capacities. *Management International Review*, *48*. https://doi.org/10.1007/s11575-008-0106-9
Tigre, P. B. (2005). Paradigmas tecnológicos e teorias econômicas da firma. *Revista Brasileira de Inovação*, *4*(1). http://doi.org/10.20396/rbi.v4i1.8648911
United Nations Industrial Development Organization. (2025). *Competitive Industrial Performance Index*. https://stat.unido.org/data/table?dataset=cip#data-browser
Veugelers, R. (2012). Which policy instruments to induce clean innovating? *Research Policy*. *41*(10). https://doi.org/10.1016/j.respol.2012.06.012
Yildiz, H. E., Murtic, A., Klofsten, M., Zander, U. and Richtnér, A. (2021). Individual and contextual determinants of innovation performance: A micro-foundations perspective. *Technovation*, *99*. https://doi.org/10.1016/j.technovation.2020.102130
Zajonz, B. T., Villwock, A. P. S. and Silveira, V. C. P. (2017). A fumicultura brasileira e as políticas públicas associadas ao Programa Nacional de Diversificação em Áreas Cultivadas com Tabaco. *Revista NERA*, *37*(20). https://doi.org/10.47946/rnera.v0i37.4683
Zucoloto, G. F. and Nogueira, M. O. (2017). Inovação nas inovações ou mais do mesmo? O papel do BNDES no apoio ao desenvolvimento tecnológico. In L. M. Turchi and J. M. de Morais (Orgs.), *Políticas de apoio à inovação tecnológica no Brasil: avanços recentes, limitações e propostas de ações*. Institute of Applied Economic Research.

The winemaking sector in the province of La Rioja (Argentina): challenges, opportunities and policy guidelines in a context of structural heterogeneity

Manuel Gonzalo, Gabriela Starobinsky
and Marilyn D'Alessandro

Received: 12/11/2024
Accepted: 21/07/2025

Abstract

Adopting a structuralist perspective, this study furnishes new empirical data on the configuration of one of the most important production sectors in the province of La Rioja (Argentina): the winemaking sector. It profiles the sector's stakeholders, identifies challenges and opportunities, and documents and classifies the support policies implemented over the last decade while suggesting avenues for improvement, given the need to strengthen companies, institutions and policies in a context of structural heterogeneity. The province's agricultural and climatic conditions, business capabilities and institutional history and strength, together with the market opportunities available, mean that the wine sector has the potential to enhance its productive and commercial position in both the domestic and the international market if it implements contextualized, far-reaching and segmented production policies.

Keywords

Viticulture, wine industry, productivity, regional economics, industrial development, industrial policy, industrial statistics, Argentina

JEL classification

R11, O25, L66

Authors

Manuel Gonzalo is a researcher at the National University of Quilmes and the National University of Chilecito (Argentina). Email: gonzalo.manolo@gmail.com.

Gabriela Starobinsky is a researcher at the National University of Chilecito (Argentina). Email: gstarobinsky@undec.edu.ar.

Marilyn D'Alessandro is a researcher at the National University of Chilecito (Argentina). Email: mdalessandro@undec.edu.ar.

I. Introduction

Since independence, the North-western region of Argentina, and particularly the province of La Rioja, has been its least developed region productively, economically and socially. When the port of Buenos Aires was established, the centrality of Pampas agriculture meant that north-western Argentina became a peripheral region in relation to the centre, and so was confronted with problems that still constrain its development and its role in the region and the world today. As part of Argentina's internal periphery, La Rioja is subject to a number of structural challenges, such as higher logistics costs, water scarcity, underdeveloped energy and telecommunications infrastructure and a limited capacity to produce and retain skilled human resources. The result has been a heterogeneous and poorly integrated business structure, characterized by a large informal sector and limited participation in national debates and policymaking (Economic Commission for Latin America and the Caribbean [ECLAC], 2021).

By studying the wine industry, one of the most important production sectors in La Rioja, this paper aims to contribute to the debate on industrial policy in a peripheral province and a sector that is characterized by intrasectoral heterogeneity and structural constraints, but that can also show examples of internationally oriented capacity-building in business methods and in technical and production practices (D'Alessandro et al., 2021, 2025; Gonzalo et al., 2022; Gonzalo et al., 2023; Pizarro Levi et al., 2022; Starobinsky et al., 2020). Employing a mixed methods approach that integrates multiple sources of information and dimensions of analysis, and adopting a structuralist conceptual perspective, the study provides new empirical data on the structural composition of the wine sector in La Rioja, characterizes its productive actors, and analyses and proposes lines of action for industrial policy.

Given the dearth of specific regional and sectoral data and analyses, the collection, systematization and estimation of data in this study represent a major contribution to the generation of new and systematized information on the La Rioja wine sector, providing a key resource to encourage academic problematization and one that should also prove useful for stakeholders in the sector and national and regional policymakers.

The study is structured as follows. The second section sets out the conceptual framework and the third describes the methodology used. The fourth section presents the production structure of La Rioja and the evolution of the wine sector. The fifth section analyses the current situation of the sector, its characteristics and those of its key stakeholders. The sixth section identifies the main challenges and opportunities, while the seventh analyses the promotional policies implemented during the period 2015–2024 and lays out recommendations for the future. Lastly, the eighth section presents some concluding remarks.

II. Conceptual framework

Since its inception, Latin American structuralism has emphasized the pivotal role of centre-periphery dynamics and structures at both the global and regional levels (Prebisch, 1949, 1952; Rodríguez, 2006). Although this concept emerged decades ago within a specific historical and productive context, many of the processes analysed by structuralism remain relevant at the global, national and regional levels. Even now, well into the twenty-first century, concepts such as the internal periphery, duality and structural heterogeneity remain valid for the study of peripheral regions and the sectoral dynamics within them (Abeles et al., 2017; Bielschowsky, 2006; ECLAC, 2024; Gonzalo, 2023; Sztulwark, 2003; Torres and Ahumada, 2022).

According to this conception, the spatial distribution of port and transport infrastructure, and of production and commercial activities, is not uniform within the periphery, but is the result of historical processes shaped by peculiar geographical, economic, political, cultural, technological and environmental contexts (Furtado, 1959, 1966; Rodríguez, 2006). Thus, economic activities are concentrated like geological strata in certain regions, mainly in metropolitan areas, while the remaining regions lag behind as internal peripheries.

Consequently, some regions of the country's interior are more developed than others, with levels of productivity that vary within and between sectors and differing economic agents, capacities and institutions, giving rise to the well-known phenomenon of structural heterogeneity (Cimoli et al., 2005; Gonzalo, 2023; Mancini and Lavarello, 2013; Pinto, 1973, 1976; Pinto and Di Filippo, 1979). While central regions have a higher proportion of capital per person and high productivity comparable to that of developed economies, the internal peripheries are mainly home to traditional communities in which subsistence agriculture, low-productivity urban and service activities, limited mechanization and fixed capital are key features of economic life (Pinto, 1976, 1984). Although there may be sectors and firms that engage in technological innovation in these peripheries, such activities do not pervade the regional production structure as a whole (Bielschowsky, 2006; Cimoli et al., 2005; Pinto, 1976, 1989).

However, territorial configurations are not set in stone. While cumulative causation, the geological layers of productive accumulation and patterns of historical dependence weigh heavily, the territorial distribution of centres of accumulation within capitalism does change over time.[1] Accordingly, structuralism recognized right from the start that the State had a role to play as a promoter of growth and economic development through public policies aimed at consolidating and diversifying the production structure, fostering industrialization, modernizing agricultural technology practices and diversifying exports, among other things (Bielschowsky, 2006; Rodríguez, 2006; Rosales, 1988).

The problematization of industrial and productive development policy is particularly important in peripheral regions, as these face structural problems and locational disadvantages that can be addressed through public policies which recognize the regional dimension. Of particular relevance here are differentiated and context-specific policies aimed at generating far-reaching transformations in the production and social structure, since horizontal instruments do not take account of regional and sectoral structural heterogeneity (Abeles et al., 2017; Cassiolato and Lastres, 2005; ECLAC, 2024; Cimoli et al., 2009; Gonzalo, 2023; Gonzalo et al., in press; Mazzucato, 2023).

Setting out from a classic structuralist conceptual framework that reflects structural heterogeneity at the sectoral and regional levels and recognizes the importance of context-specific, far-reaching and segmented industrial policy, this paper will now analyse the wine sector in La Rioja.

III. Methodology

A mixed methods approach was taken, as this provides flexibility in the analysis of qualitative and quantitative data from various sources, enables a comprehensive understanding of the subject under study to be arrived at, and lends greater validity to the results when it comes to formulating specific and context-appropriate recommendations (Vasilachis de Gialdino, 2006; Yin, 1984).

The quantitative approach involved estimation of updated indicators and a descriptive statistical analysis of data on crops, production, employment and marketing in La Rioja's wine sector.

[1] An example of such a shift is the renewed centrality of Asia in the twenty-first century (Nayyar, 2013; Gonzalo, 2023).

Official statistics provided by the International Organization of Vine and Wine (OIV), the National Institute of Viticulture (INV), the Argentine Wine Observatory (OVA), International Wine and Spirits Record (IWSR), ProWein, the Economic Observatory of Wine Tourism of the Argentine Republic and provincial government bodies such as the General Directorate of Statistics and Censuses of La Rioja (DGEyCLR) and the Chilecito Chamber of Tourism were extensively compiled and processed. This information was supplemented by a database drawn from a survey of 113 wine producers in La Rioja, which forms part of a research project by the National University of Chilecito (UNdeC).[2]

The qualitative approach was based on an analysis of sectoral reports, institutional data and semi-structured interviews with key informants. Twenty-five interviews were conducted between 2022 and 2023, using question guides tailored specifically to each profile and serving to investigate sectoral and business characteristics and the main production and public policy challenges and problems faced. Informants were selected on the basis of the different production, business and institutional profiles that make up the La Rioja wine sector.[3] The information gathered was supplemented and collated with earlier business case studies (D'Alessandro et al., 2021, 2025; Gonzalo et al., 2023; Starobinsky et al., 2020).

Companies were also visited to carry out direct observation, and interviewees were contacted to validate information. The interviews were systematically transcribed and processed, and the information was classified by stakeholder type and category of analysis. Lastly, an exhaustive search of public policy instruments targeting the national and La Rioja wine sectors in the period 2015–2024 was conducted.

IV. La Rioja and the development of winemaking

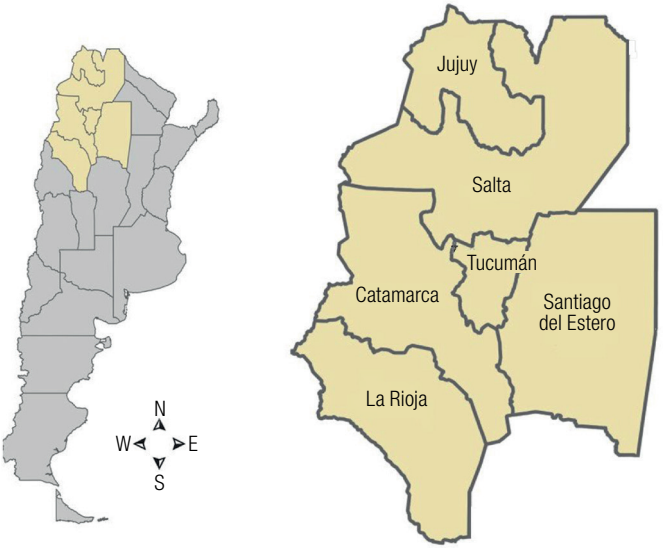
La Rioja accounts for 3.2% of the country's total land area and has a population of 383,865 (0.84% of the national total), most of whom live in the Capital and Chilecito departments (55.2% and 15.6%, respectively) (see map 1) (National Institute of Statistics and Censuses [INDEC], 2022). The province has a desert climate, characterized by intense solar radiation, seasonal rainfall and hot, dry winds. As regards water resources, there are valleys in the north-west that provide water for irrigation, while in the south-east water availability depends on rainfall (Secretariat of Agroindustry, 2019).

La Rioja accounts for about 0.6% of Argentina's gross value added (ECLAC and Argentine Ministry of Economy, 2022), and its social indicators lag behind the national average (ECLAC, 2021; Gonzalo and Starobinsky, 2023; Gonzalo et al., 2022; Niembro and Starobinsky, 2021, 2023; Starobinsky et al., 2020). For example, the province's household poverty rate was approximately 40% in the second half of 2023, almost 9 percentage points above the national average, while the average per capita household income was 68,717 Argentine pesos, well below the national average of 117,230 pesos (INDEC, 2023, 2024).

[2] The database of wine producers was obtained from the project "The role of the local innovation system in technological behaviour within the agro-industrial sector in the province of La Rioja", carried out in the framework of the Research and Development Projects of the Secretariat of Science and Technology (2018 call for proposals) at the National University of Chilecito.

[3] We interviewed 6 small, medium-sized and large winemakers, 10 managers and professional and technical staff from the administrative, financial, commercial and oenological departments of the province's leading wineries, 3 artisanal wine producers from the departments of Chilecito and Coronel Felipe Varela, 2 representatives of the La Rioja Chamber of Agricultural and Livestock Producers, 3 government officials from the Ministry of Labour, Employment and Industry of La Rioja and 1 representative of the Chilecito Chamber of Tourism.

Map 1
Argentina: geographical location of the North-western region and the province of La Rioja



Source: Prepared by the authors, on the basis of National Geographic Institute of Argentina. https://www.ign.gob.ar/.

As regards its production structure, the province presents a specialization profile based on low-technology exploitation of natural resources, mainly in the agricultural and livestock sector and the service sector. Olive, vine and walnut cultivation are to the fore in the agricultural sector and beef and goat farming in the livestock sector. Agricultural and livestock-based manufacturing is also significant, particularly within the olive agro-industrial chain (olive oil and preserved olives) and the vine sector (wine, must and grape juice). Meanwhile, important industrial manufacturing sectors include the textile and forestry sector (paper and cardboard) and the pharmaceutical sector (medicines), both of which were established in the province through industrial development programmes during the 1980s and 1990s. Production sectors that have emerged in recent years include renewable energy and cannabis for medicinal and industrial purposes (ECLAC, 2021; Gonzalo and Starobinsky, 2023).

The wine sector, for its part, has been relatively slow to establish itself compared to the situation in the provinces of Mendoza and San Juan, which by the nineteenth century already had technically developed wine industries integrated into both domestic and international commerce. In the twentieth century, railway-building and other public works projects, land allocation by the provincial government and lending for productive investment by the Bank of the Argentine Nation (BNA) led to an upsurge in activity. For example, there were incentives to expand the area given over to vine cultivation, while family wineries run by immigrants from Spain and Italy and local cooperatives with some level of technological and industrial capacity were established, boosting domestic commerce. The first forays into foreign markets also took place (ECLAC, 1985; Pizarro Levi et al., 2022).

By 1990, the implementing regulations for the project planning and funding provisions of the Industrial Promotion Act No. 22021 of 1979, covering tax relief and deferrals to encourage productive investment, spurred new investment by medium-sized and large wine producers in both established and new wine-growing regions. This led to the emergence of a dual wine sector comprising modern wineries with an international presence and traditional family-run or artisanal wineries focused on the local market (D'Alessandro et al., 2021, 2025; Gonzalo et al., 2023; Pizarro Levi et al., 2022; Starobinsky et al., 2020).

V. The wine industry in La Rioja today

1. Crops, production and employment

In 2023, Argentina was the eighth-largest wine producer in the world and the second-largest in Latin America, with a production volume of 8.8 million hectolitres. It was also the world's tenth-largest exporter, with an export volume of 2 million hectolitres worth US$ 667 million. Although more than half of global production was concentrated in France, Italy and Spain, Argentina's main regional competitor was Chile, the leading producer in Latin America and the world's fourth-largest exporter (International Organization of Vine and Wine [OIV], 2024).

Although Mendoza is the country's leading wine-producing and exporting province, the wine sector in La Rioja is also considerable. Its development has combined the geophysical conditions of its grape-growing valleys, a history and culture of viticulture dating back to the late sixteenth century and a productive, business and institutional fabric that has successfully integrated La Rioja's wine industry into twenty-first century global markets and adapted the sector to changing consumption and production trends (ECLAC, 2021; D'Alessandro et al., 2021, 2025; Gonzalo et al., 2023; Pizarro Levi et al., 2022; Starobinsky et al., 2020).

La Rioja was the country's third-largest wine-producing province (4.3%) in 2023, behind Mendoza and San Juan, which accounted for some 92% of output. Despite its small share of the national total, La Rioja's wine industry exhibits characteristics that reflect its relative strengths: an international presence (it accounts for 2.1% of Argentine wine exports by volume), organic production (it is the country's second-largest producing province) and extensive wine tourism. La Rioja is the leading grape- and wine-producing province in the North-western region of Argentina, accounting for around 97% of the region's organic grape output (see table 1).

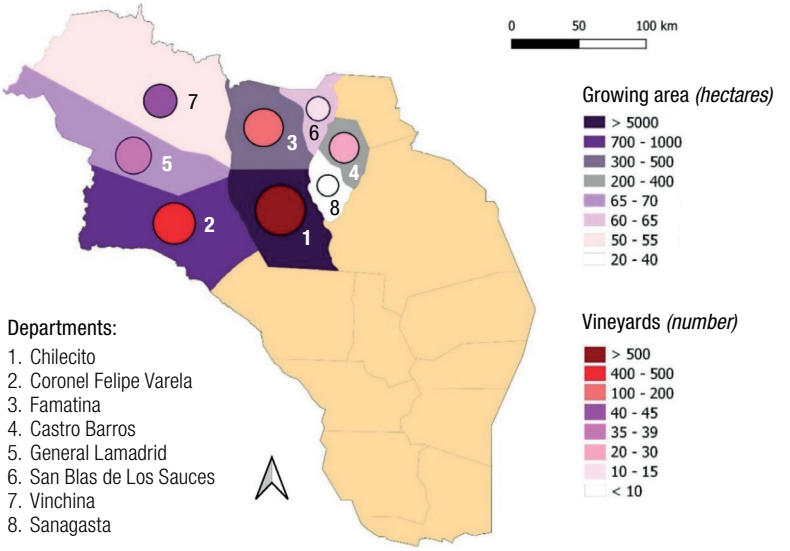
Table 1
Argentina (selected regions and provinces): main wine industry statistics, 2023

Variable	Argentina	Mendoza *(Percentage of national total)*	North-western region *(Percentage of national total)*	La Rioja *(Percentage of national total)*	La Rioja *(Percentage of regional total)*
Growing area *(Hectares)*	204 847	71.0	6.8	3.5	51.2
Grape production *(Quintals)*	1 455 312	64.2	6.7	4.2	66.9
Organic grape production *(Quintals)*	564 966	60.8	22.1	21.4	96.9
Wine production *(Hectolitres)*	8 813 048	73.9	7.3	4.3	58.7
Wineries[a] *(Number)*	885	70.1	10.4	2.0	19.6
Wineries open to tourists[a] *(Number)*	357	48.7	24.9	4.2	17.2
Exports *(Dollars)*	685 984 000	93.1	3.1	1.2	32.4
Exports *(Litres)*	196 611 417	91.3	2.9	2.1	47.1

Source: Prepared by the authors, on the basis of data from the National Institute of Vitiviniculture (INV), the Argentine Wine Observatory (OVA) and the Enotourism Observatory.
[a] Data are from 2022.

Within the province of La Rioja, primary production takes place in eight departments in the producing valleys of Famatina and Bermejo and in the wine-growing areas of Chañarmuyo, Castro Barros and Sanagasta (see map 2). With regard to vineyard size (1,179 vineyards covering 7,180 hectares in 2023), smallholdings and small farms (up to 10 hectares) predominate, accounting for 85%. Medium-sized holdings (between 11 and 50 hectares) and large holdings (over 50 hectares) account for 12% and 3% of the total, respectively (National Institute of Vitiviniculture, 2024b).

Map 2
La Rioja (Argentina): geography and wine production, 2023



Source: Prepared by the authors, on the basis of National Institute of Vitiviniculture (2024). Informe anual de superficie 2023.
Note: Georeferenced location.

Of the 7,180 hectares, 82% are planted with grape varieties suitable for the production of wine, must and grape juice, while the remainder is used for the production of raisins and table grapes. As is the case nationally, the majority of winemaking grape varieties are red (54%), mainly Malbec (26%), followed by white varieties (37%), mostly Torrontés Riojano (83%), although the Chardonnay variety becomes more prevalent as vineyard size increases. Rosé varieties, meanwhile, account for only 9% of the total area under cultivation. It is worth noting that 87% of the area devoted to vine cultivation is planted with varieties of high oenological quality. The department of Chilecito is the main producing location, accounting for 78% of the area under vine, around 80% of the cultivation of high oenological quality varieties, 99% of the province's organic grape output and 80% of medium-sized and large vineyards. Over the last five years, the province's annual grape production has averaged 65,428 tons, of which over 90% has been used for winemaking, with average production of 382,166 hectolitres.

The wine industry in La Rioja also has significant socioeconomic impacts (see table 2). The sector represents an estimated direct contribution of around 13% of total gross value added and employs approximately 9% of formal private sector workers.[4] Then there are the dynamics of the sector, whose indirect effects generate positive externalities not only locally but regionwide, such as the hiring of seasonal workers from other provinces in the North-western region during the grape harvest (Directorate-General for Sectoral and Special Programmes and Projects, 2023).

Despite all this, La Rioja occupies a peripheral position compared to Mendoza's central role in Argentina's wine industry. The centre-periphery relationships between La Rioja and Mendoza are evident in several aspects, such as the selling of La Rioja wine with Mendoza labels, the integration of La Rioja wineries under the coordination and ownership of Mendoza wineries, and the need to bottle in Mendoza and to draw on the oenological expertise and services of that province (D'Alessandro et al., 2021, 2025; Gonzalo et al., 2023; Pizarro Levi et al., 2022; Starobinsky et al., 2020).

[4] Estimates based on information from DGEyCLR. Wine production was calculated from the percentage of grapes used for winemaking in 2021 (latest available data), and the annual labour input of primary sector employees was estimated at an average of 80 working days per hectare per year on the basis of information provided by the producers interviewed.

Table 2
La Rioja (Argentina): economic contribution of the wine sector, 2023

Variable	Share of provincial total and number
Gross value added	13%
Registered private sector employment	8.7%
Exports	6%
Industrial establishments[a]	20%
Main sectoral support institutions	15[b]

Source: Prepared by the authors, on the basis of National Institute of Vitiviniculture (INV) and General Directorate of Statistics and Census of La Rioja (DGEyCLR).

[a] As a proportion of all companies and organizations in the La Rioja manufacturing sector in 2021.

[b] National Institute of Vitiviniculture (INV), National Institute of Agricultural Technology (INTA), National Institute of Industrial Technology (INTI), Federal Council of Investments (CFI), National University of Chilecito, Government of the Province of La Rioja, Argentine Wine Corporation (COVIAR), Wineries of Argentina, Federation of Wine and Related Industry Workers and Employees, La Rioja Chamber of Wineries, La Rioja Chamber of Agricultural and Livestock Producers and Regional Consortiums for Agricultural Experimentation (CREA Groups), among others.

2. Commercialization and markets

Winemaking in La Rioja is characterized by the production and commercialization of various types and styles of wine, ranging from table wines to fine wines and sparkling wines, and to a lesser extent of grape must and grape juice. In 2023, wine production was dominated by regional red wines (51% of the total), which is consistent with the intensive cultivation of red grape varieties of high oenological quality, particularly Malbec (INV, 2024a). As is the case nationally, 75% of total output by volume goes to the domestic market. Sales over the last five years have averaged 168,962.5 hectolitres, although in the post-pandemic context of 2021 they peaked at 188,997 hectolitres (Argentine Wine Observatory [OVA], 2024).

La Rioja accounts for about 2.5% of domestic shipments in Argentina.[5] Its sales present certain peculiarities, such as the predominance of regional wine sold in Tetra Paks (52%), a product that is considerable in volume terms but has a very low commercial value compared to regional wine sold in glass bottles. Although special and sparkling wines with a greater commercial value are produced in the province, their share of sales is still below 1% (OVA, 2024).

Trade flows also include the interprovincial transport of bulk wine. The volume entering La Rioja, mainly from the province of Mendoza (90%), is barely more than a seventh of that shipped from La Rioja, primarily to Mendoza (60%) and San Juan (27%). This dynamic involves a large outflow of wines whose value added and commercial value are low and whose processing is completed mainly in the provinces of the Cuyo region (INV, 2023).

In 2023, Argentine exports registered a significant decline of 25% in volume and 16% in value. La Rioja shared in this downward movement, although the decline in value was steeper, with volume down 25% and value 24%. The province thus forfeited approximately US$ 8 million and 4.2 million litres of exports that would mainly have gone to countries such as the United Kingdom, the United States, Sweden, Denmark and China. Although the market share of white wines has been growing, it is still below that of red wines. The main type of wine exported is varietal wine in glass bottles (59%) at an average price of US$ 2.60 per litre. The remainder is exported in bulk (64% white wine) at an average price of US$ 0.72 per litre (OVA, 2024).

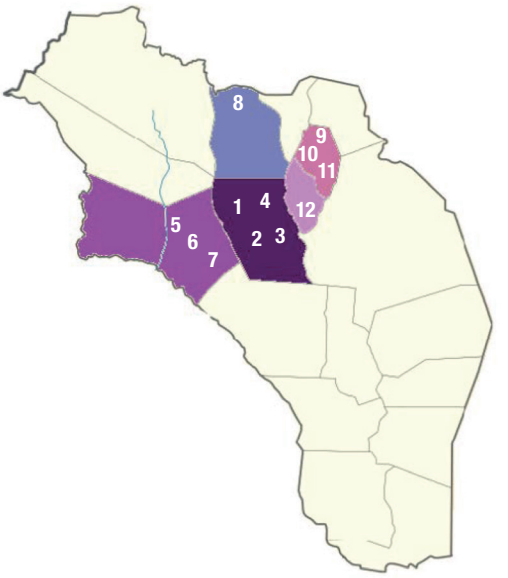
[5] In analysing domestic sales, INV only includes direct purchases in shops.

3. The heterogeneity of producers

Wine is produced and processed industrially in five departments of La Rioja: Chilecito and Famatina (Famatina Valley), Coronel Felipe Varela (Bermejo Valley), Castro Barros (La Rioja Coast) and Sanagasta (Capital Region) (see map 3).

The La Rioja wine sector comprises a range of producers, as presented below.

Map 3
La Rioja (Argentina): leading winemakers, 2024



Chilecito:
1. La Riojana Cooperativa (headquarters)
2. La Puerta
3. Elías Hermanos
4. Las Flechas Group

Coronel Felipe Varela:
5. La Riojana Cooperativa (subsidiary)
6. Sacavino Arrieta
7. Vinos de Aicuña

Famatina:
8. Chañarmuyo

Castro Barros:
9. Las Carolinas
10. San Huberto
11. Bodega y Fincas de Aminga

Sanagasta:
12. Vista Larga

Source: Prepared by the authors, on the basis of National Geographic Institute of Argentina. https://www.ign.gob.ar/.

The leading winemaker is La Riojana Cooperativa, which applies a cooperative model of production and commercialization. With over eight decades' experience, it is the leading player in La Rioja's wine industry, bringing together a third of local wine producers as members and commanding the output of over 4,000 hectares, 45% of the province's wine production and more than 70% of its wine exports. It has a production capacity of around 30 million litres and produces various types of wine (classic, organic, vegan and biodynamic), both high-end and low-end (ranging from regional wines in Tetra Pak cartons to high-quality bottled wines), as well as other products (must and juice). It has also made considerable efforts in the area of organic production and certification.

Its distinguishing feature is its system for providing primary producers with inputs and advice. The Agricultural Department purchases inputs (seedlings, fertilizers and tools) from suppliers elsewhere in Argentina (Mendoza, Córdoba and Buenos Aires) and abroad, delivers them to members and deducts the cost from the value of their harvest, as contractually stipulated. It also provides technical advice to its membership of mainly smallholders and small-scale producers.

It comprises more than 300 diverse producers, so that the raw material it receives (which is added to the output of its own vineyards) varies in quality and is sorted to produce the different ranges of wines, musts and juices. Although the Malbec, Cabernet and Syrah red grape varieties are important, the prevalence of small producers growing the Torrontés Riojano variety explains the dominance of that grape and the winery's pioneering innovation efforts to position it in the market, for example by developing ecotypic yeast, organic and biodynamic wines and new products.

La Riojana Cooperativa operates primarily in the domestic market for bottled and boxed wine, although it also acts as a wholesaler, selling in bulk to wineries in other provinces, and enters into processing agreements with local producers. In the export market, it has entered into strategic partnerships (like the venture it has formed with a Swedish company) and obtained international trade standards certification based on the standards of Fairtrade International (a system focused primarily on the development of small producers) and other international quality certifications. It also exports to European markets such as the United Kingdom and Sweden.

Next after La Riojana Cooperativa come medium-sized wineries such as Valle de La Puerta S. A., Bodega Chañarmuyo S. A., Bodegas San Huberto S. A. and Bodega Elías Hermanos S. A., all privately run, and Bodega y Fincas de Aminga S. R. L., which is run by the provincial government. These are relatively young Argentine-owned companies (established since 1990) that produce wines of different types (classic, organic and vegan) and grades (regional wines, wines in bottles and demijohns, and fine bottled wines).

These wineries employ integrated production models: mechanized vineyards of between 50 and 220 hectares planted mainly with red grape varieties such as Malbec and Douce noir, industrial facilities with an average production capacity of 3.5 million litres and state-of-the-art European equipment and technology. They source their raw material from their own vineyards and also purchase grapes from third parties, selecting them by variety and quality. They also source supplies from various provinces in Argentina (Mendoza, Córdoba, Santa Fe and Buenos Aires).

Other characteristics of these wineries include their strong links with Mendoza (ownership, consultancy, technical and professional resources), their location in relatively new wine-growing areas at high altitudes (over 1,400 metres above sea level) such as Chañarmuyo and Aminga and their focus on innovation as producers of fine, exclusive and high-end wines, as in the cases of Valle de La Puerta S. A., Bodegas San Huberto S. A. and Bodega Chañarmuyo S. A.

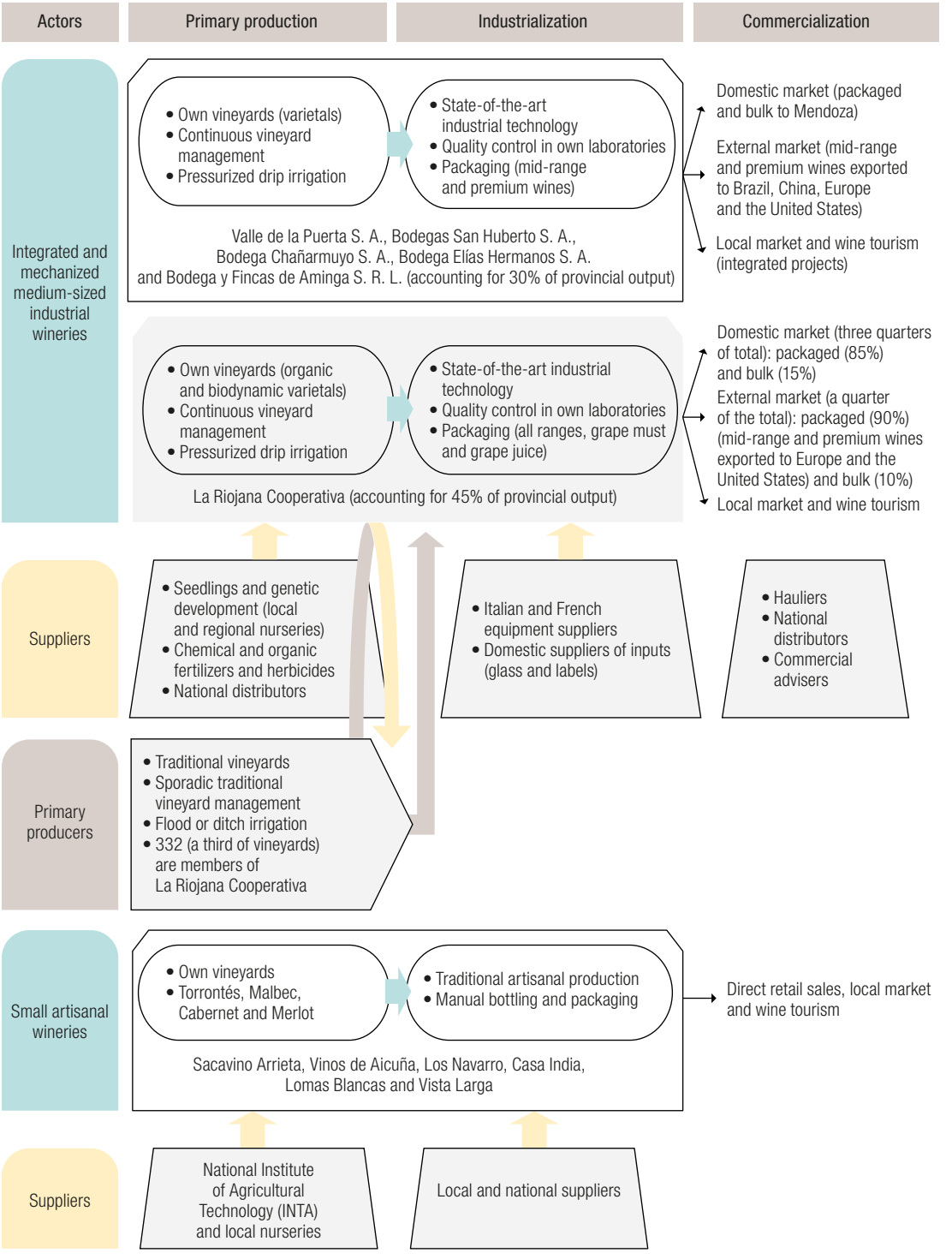
They have dedicated commercialization, sales and marketing departments and commercial and logistics systems comprising networks of hauliers and distributors in different provinces. Some companies such as Bodegas San Huberto S. A. and Bodega Elías Hermanos S. A. are primarily engaged in the commercialization of wines packaged for retail, while others such as Bodega Chañarmuyo S. A. and Valle de La Puerta S. A. focus mainly on providing winemaking services for Mendoza-labelled wines, although they also produce organic wines.

They have forged ties with strategic partners and importers in various countries, including China, the United States and South American nations, and have made successful forays into wine-producing countries such as Australia and South Africa. While each company has its own market presence, on average they export 30% by volume of their total sales of packaged wines. As for wine tourism, they offer more sophisticated activities such as guided tours, dining experiences in their own restaurants and accommodation services.

Thirdly, there are small, family-run wineries producing artisanal wines, such as Bodega Sacavino Arrieta, Vinos de Aicuña, Casa India, Los Navarro and Lomas Blancas. They are mainly located in the Bermejo Valley area, and their history dates back to the twentieth century. Although they have redesigned their production processes to produce red, organic and exclusive wines, they use raw material from their own vineyards, which is of lower oenological quality. They have older, Argentine-manufactured equipment and carry out their production activities to lower process control standards. Given their relatively rudimentary vineyard management practices, they source inputs from local suppliers (small nurseries, provincial suppliers or artisanal producers) or public organizations, such as the National Institute of Agricultural Technology (INTA), which also provides technical assistance.

Furthermore, they have few sales outlets, are focused on the local market and rely heavily on wine tourism activities, such as guided tours, wine museums and cultural and gastronomic experiences organized by the municipal or provincial authorities (see diagram 1).

Diagram 1
La Rioja (Argentina): overview of the wine sector



Source: Prepared by the authors.

VI. Challenges and opportunities for the sector's development

La Rioja and its wine sector face a number of structural socioeconomic problems resulting from their peripheral location relative to the port of Buenos Aires and the country's central region, certain natural factors such as water scarcity, high transport costs which result in greater input and commercialization costs, high electricity costs and limited availability of staff with professional, technical and even manual training. This is compounded by intrasectoral heterogeneity in respect of production, capitalization and capacity-building in the areas of science and technology, innovation and management.

At the primary level, smallholders and small-scale producers often face the challenge of restructuring and modernizing. Although many of these producers survive thanks to the cooperative system operated by La Riojana Cooperativa, capitalization and the development of various management skills are priority challenges. The main challenge facing medium-sized and large producers, which have made efforts to modernize and invest in technology and production, is to reduce production costs, particularly as regards electricity consumption for groundwater extraction.

As regards stakeholders in the industrial and commercial segments of the value chain, family-run and artisanal wineries face the challenge of improving production quality and commercialization channels. Medium-sized wineries and La Riojana Cooperativa, for their part, need to generate greater value added for the wine sold in interprovincial bulk markets and increase their presence in new export markets if they are to consolidate their growth and expand. In particular, La Riojana Cooperativa needs to modernize its production and packaging lines. Reducing structural costs and facilitating technology transfer between the region's stakeholders are becoming priority challenges. The development of wine tourism is also a shared challenge for all stakeholders (see table 3).

The history of the wine sector in La Rioja and its entry into and growing presence on international markets reflect well on the capabilities and efforts of the province's businesses and support institutions, which have helped producers take advantage of domestic and international market opportunities. Specific opportunities have opened up in the current context, examples being organic production, sustainable practices, the exploration of new wine styles (low-alcohol or alcohol-free and premium wines), the revitalization of traditional viticulture and the promotion of wine tourism. The growth of Asian markets can also be capitalized upon.

Global trends have been shifting towards a greater emphasis on territorial and cultural aspects and sustainable production. Where the latter is concerned, at a local level the sector has demonstrated its capacity to produce organic, vegan and biodynamic grapes and wines, and it is covered by protected geographical indications and designations of origin. The industry's waste management capabilities are another strong point. The market's increased demand for quality and safety also aligns with the ability of businesses to obtain a wide range of certifications for production, organizational and commercial processes (D'Alessandro et al., 2021, 2025; Gonzalo et al., 2023; Pizarro Levi et al., 2022; Starobinsky et al., 2020). Lastly, bulk sales to less sophisticated markets or to third-party producers can complement more diversified and value added strategies.

Table 3
La Rioja (Argentina): main challenges in the wine sector, by producer type

Primary production	
Smallholders and small-scale producers	• Capitalization and higher returns • Training in production, financial, technological and commercial management • Adoption of modern techniques and efficient use of scarce water resources • Conversion to grape varieties of higher oenological quality • Exploitation of the Torrontés Riojano grape variety • Generational change among wine producers • Productive investment in modernization of farming practices and vineyard management
Medium-sized and large producers	• Reduction of production costs • Investment in irrigation and groundwater extraction systems to improve their efficiency • Capacity-building to advance the energy transition • Greater collaboration with scientific and technological institutions
Industrialization and commercialization	
Family or artisanal wineries	• Investment in higher-quality machinery and barrels • Improvement and expansion of sales channels • Certification of quality, production and commercial standards • All-round development of wine tourism
Medium-sized wineries and La Riojana Cooperativa	• Investment in new production and packaging lines in line with international trends • Expansion of sales of bottled wine, particularly high-end wines with greater market value • Entry into new international markets • Reduction in structural costs • Promotion of technology transfer between stakeholders in the innovation system to increase value added and product diversification • All-round development of wine tourism

Source: Prepared by the authors, on the basis of information from interviews with winemakers, winery managers and public officials in the province of La Rioja; National Institute of Vitiviniculture (2023). *Relevamiento vitivinícola argentino: parte II, contexto industrial de la vitivinicultura*; Argentine Wine Observatory (2024). *Estadísticas: reportes interactivos*. https://www.observatoriova.com/category/reportes-interactivos/; Gonzalo, M., D'Alessandro, M. and Yañez Mayorga, B. (2023). Bodega Chañarmuyo: vinos de alta gama y enoturismo desde la periferia riojana. *Revista Actualidad Económica, 33*(111), 19–33; Pizarro Levi, E., D'Alessandro, M., Filipetto, S., Starobinsky, G. and Gonzalo, M. (2022). Trayectoria socioproductiva, estructura empresarial, tendencias y desafíos del Torrontés Riojano. *Revista Rivar, 9*(25), 191-210; D'Alessandro, M., Gonzalo, M., Filipetto, S. and Starobinsky, G. (2021). Valle de La Puerta: recursos, capacidades y vínculos para la internacionalización empresarial desde Chilecito, La Rioja, Argentina. *Revista Pymes, Innovación y Desarrollo, 9*(3), 3-25; D'Alessandro, M., Gonzalo, M., Starobinsky, G. and Yañez, B. (2025). Bodegas San Huberto: integración productiva de recursos y capacidades en la periferia argentina, 1998-2023. Revista Rivar, 12(35), 214-233; Starobinsky, G., Gonzalo, M., Filipetto, S. and D'Alessandro, M. (2020). Dinámica de mercados y esfuerzos tecnológicos en un sistema de innovación periférico: la riojana cooperativa vitivinifrutícola. *Revista Rivar, 7*(20), 67-87.

VII. Policies: progress, limitations and guidelines for the future

A number of productive, industrial and business promotion instruments, some general in nature and others specifically for the wine sector, have been implemented over the last decade in accordance with the production guidelines established by national governments. We have studied the general scope[6] of these instruments in the province's wine sector by systematically compiling information on the main sectoral support instruments and conducting fieldwork involving in-depth interviews.

Nationally, certain institutions such as the Federal Council of Investments (CFI), the Bank of the Argentine Nation (BNA), the Investment and Foreign Trade Bank (BICE) and ministries working with agro-industry have implemented arrangements (generally credit lines) to fund technological and productive investment, working capital and international quality certifications for processes and

[6] It should be noted that this section does not conduct a detailed study of the impact of public policies targeting the wine sector in the province of La Rioja, but presents the instruments identified and analyses them collectively in a general and contextualized way on the basis of the qualitative and quantitative information detailed in the methodology.

products, while carrying out international trade promotion work. In the province, State bodies such as the La Rioja Public Guarantee Fund (FOGAPLAR) and Banco Rioja, supported by the Ministry of Production and Environment and the Ministry of Labour, Employment, Industry and Mining, make loans at subsidized rates for technological upgrading and modernization, working capital and the transition to renewable energy and efficient irrigation, albeit on a small scale.

Initiatives that address other types of needs are also being implemented, examples being online training courses covering various viticulture-related topics (marketing, international trade, financial organization and management and wine tourism), delivered by INV. There are also undergraduate and postgraduate courses in oenology, tourism and agronomy, UNdeC internship programmes and research projects, and the food safety, food quality and biotechnology services provided by the National University of La Rioja (UNLaR) and UNdeC (see table 4).

Table 4
La Rioja (Argentina): national and provincial policies for the wine industry, 2015–2024

Type of instrument or financing	National	Provincial
Capital investments	• Financing for wine producers (2015, Bank of the Argentine Nation (BNA)) • Microcredits for wine producers (2017, BNA) • Business development loans (2021, Federal Council of Investments (CFI), Argentine Wine Corporation (COVIAR) and provincial governments)	• Financing for small and medium-sized enterprises in La Rioja (2020, Ministry of Productive Development of Argentina, Government of La Rioja) • Non-refundable contributions to the Integrated Wine System (2021, La iojana Cooperativa, COVIAR, national Ministry of Productive Development)
Working capital	• Credits for transport and harvesting (2023 and 2024, BNA) • Credits for working capital (2023, Banco Ciudad de Buenos Aires, Wineries of Argentina)	• 2022 Harvest Credit (2022, BNA, Government of La Rioja) • Irrigation and Water Efficiency Programme (2022, Government of La Rioja, CFI, La Rioja Public Guarantee Fund (FOGAPLAR)) • Distributed generation of renewable (solar) energy (2022, Government of La Rioja, CFI and FOGAPLAR)
Training	• International Argentine wine industry negotiations (2016, COVIAR) • Enhancement of sustainability in the Argentine wine sector (2022, National Institute of Vitiviniculture (INV), National Institute of Industrial Technology (INTI), CFI)	• Wine Tourism in La Rioja (2023, Government of La Rioja, COVIAR, national Ministry of Tourism and Sport)
Technological innovation	• Support Programme for Small-Scale Wine Producers in Argentina (PROVIAR II) (2023, Ministry of Agriculture, Livestock and Fisheries, INV, Inter-American Development Bank) • Financing for water efficiency (2024, Ministry of Economic Affairs, Investment and Foreign Trade Bank (BICE)) • *Leasing* for the acquisition of agricultural machinery (2024, Ministry of Economic Affairs, BICE)	• Credits to improve productivity (FOGAPLAR)
Standards certification	• Funding and support for the Sustainable Argentine Viticulture label (2024, COVIAR, CFI, provincial governments)	
Marketing	• "Opening markets" programme (2017, national Ministry of Agro-industry) • Argentine Wine National Drink (2018, national Ministry of Agro-industry, COVIAR) • Plan 1000 for the Winemaking Value Chain (2021, national Ministry of Productive Development) • "Reverse export missions" bringing potential buyers to the province (2022–2023, CFI, COVIAR) • Export promotion credits (2023, Banco Ciudad de Buenos Aires, Wineries of Argentina)	
Wine tourism	• Wine Tourism Development Fund (2023, Ministry of Economic Affairs, COVIAR, BICE trust funds)	• La Rioja Torrontés Route (2018, Government of La Rioja, Ministry of Agro-industry, COVIAR)

Source: Prepared by the authors, on the basis of official publications of the organizations concerned.

Despite the different national and provincial tools and initiatives mentioned, the fieldwork revealed a number of factors that limit the availability and reach of national credit lines and non-repayable grants for the wine sector in the province. They include in particular a lack of publicity and limited awareness of these schemes, competitive disadvantages compared to larger, higher-capacity enterprises and producers (particularly in the province of Mendoza) and a failure to consider the structural problems of La Rioja.

It also became apparent that most smallholders and small-scale producers were excluded from public policy, and that medium-sized and large producers faced competitive disadvantages due to their location. Although provincial policies are better adapted to local needs and are implemented more promptly, as well as being more widely publicized among local producers, they are insufficient in their scope and funding levels. Furthermore, some instruments overlap and there is little coordination between the institutions that manage them. All this is compounded by issues associated with macroeconomic instability and uncertainty at the national level.

Problems with the scope of productive development policies in the province stem from shortcomings in their design, implementation and impact assessment and from the need to adapt policy instruments to sectoral and regional peculiarities. General recommendations for the design of public policies in the sector, with a view to their reaching a larger number of producers, achieving greater impact in a peripheral context and so reducing intrasectoral heterogeneity and duality, are presented below (see table 5).

Table 5
Differentiated needs, objectives and policy guidelines for the productive development of the La Rioja wine sector

	Need or objective	Policy guidelines
Cross-cutting aspects	• Achieve water efficiency • Reduce energy costs • Improve biotechnology aspects • Ensure process sustainability • Promote national and international market participation	• Promotion and funding of investment in provincial water infrastructure projects and modernization of irrigation systems • Promotion and funding of investment in renewable energy development • Promotion and funding of research and development in areas relating to plant genetics, bio-inputs and propagation techniques • Funding and grants for organic production • Funding for business intelligence systems
Smallholders and small-scale producers	• Improve productivity, yields and wine quality • Increase profitability • Carry out variety conversion	• Technical assistance and training to improve production capabilities and vineyard management • Funding and tax differentiation for the supply of inputs • Long-term financing for productive restructuring
Medium-sized and large producers and wineries	• Increase production capacity • Enhance genuine competitiveness by producing differentiated, higher-quality products • Move into the production of high-end wines with greater value added • Respond to new consumption trends • Expand domestic and international sales channels • Improve marketing and publicization strategies	• Technical and financial support for quality improvements, product differentiation and measures to increase value added • Encouragement and medium-term funding for technological modernization and innovation • Financial and technical support for the development of marketing strategies and expansion into foreign markets • National and provincial management of specific international trade agreements • Differentiated incentives to strengthen and develop local suppliers • Financial or fiscal support for wine tourism projects and ventures • National and international marketing and promotional campaigns

Source: Prepared by the authors.

To begin with, there are cross-cutting needs requiring larger-scale interventions, coordination between the national and subnational levels and institutional commitment. Meeting these needs would impact the competitiveness of the wine sector and other sectors of La Rioja's production structure. Four key areas for action are:

(i) Investment in water and energy infrastructure.

(ii) Funding for research and development programmes and teams, and extension services in areas relating to biotechnology, improvement techniques, organic farming and variety conversion.

(iii) Funding for business intelligence systems based on global trends in food production and consumption.

(iv) Progress with information technology systems for collecting, processing and monitoring data on the province's wine sector so that policy can be based on accurate, up-to-date information.

At the same time, there are differentiated needs that reflect the diversity of business stakeholders:

- Smallholdings and small-scale producers seek to improve the oenological quality of their raw material and thereby increase yields and incomes. This requires the implementation of technical assistance and extension initiatives and tools, together with provision of and access to better inputs and affordable, low-cost financing to enable them to restructure and to introduce new varieties.
- Medium-sized and large producers and wineries need to enhance their competitiveness so that they can increase the value added, differentiation and quality of their products, while scaling up production and commercialization with a view to expanding more strongly into domestic and foreign markets. Technical support instruments, funding for innovation and scaled-up production, specific trade policies and more comprehensive tools for promoting and positioning La Rioja's wine industry in Argentina and abroad are needed to underpin these efforts.

VIII. Final considerations

This paper has conducted a structural analysis to bring out the special features of the La Rioja wine sector, which has succeeded in consolidating local business capabilities that enable it to operate on a regional and international scale despite the heterogeneity and duality of its firms and production characteristics. The paper has also described the challenges and opportunities for the sector and sought to portray, analyse and problematize La Rioja's wine industry, operating as it does in a peripheral region that carries less weight domestically and internationally than Mendoza or Cuyo. Conceptually, structural heterogeneity largely reflects the configuration of the province's wine industry, in which actors with cutting-edge technology, international reach and access to sophisticated markets exist alongside artisanal wineries with seasonal sales and with very limited innovation capacity or national and international reach.

Nevertheless, La Rioja's agricultural and climatic conditions, business capabilities, institutional history and strength and sectoral support policies mean that the province's wine industry has the potential to expand its reach and improve its productive and commercial position. New consumer and market trends in Argentina and internationally (organic production, designations of origin, wine tourism, fresh wines and grapes of high oenological quality), the growth of the Asian market and collaboration with wineries in other provinces and regions offer clear opportunities for the sector's future.

If these opportunities are to be capitalized upon, productive development policies that reflect the region's challenges and the diversity of stakeholders are needed to overcome current constraints. Thus, designing instruments that are tailored to the sector's capabilities, challenges and opportunities means taking account of the structural and cross-cutting issues affecting this peripheral province and of the inter- and intrasectoral heterogeneity of the wine industry. According to structuralist thinking, the impact of support policies can be increased via greater contextualization, targeting, outreach to various types of producers and linkages.

Adopting policies that promote and support medium-sized and large wineries in their efforts to increase production and commercialization of higher-quality wines, value added and differentiation in new markets, while also aiming to improve the oenological quality and technical production practices of small producers, would have the greatest impact at the provincial level. However, each specific sectoral policy requires further study. Additionally, each instrument needs to be analysed in detail to identify any potential design or implementation shortcomings that may limit the impact of policies in the province.

Consideration should also be given to the potential for complementing and integrating the wine industries of Mendoza and La Rioja, as various wineries and producers in the two provinces have established formal and informal relationships and, in some cases, have achieved full or partial vertical integration. Furthermore, new ventures involving businesses and capital from Mendoza and other provinces have appeared in La Rioja. Although part of this topic has been addressed in the present paper, it will be studied in greater detail in future research.

Bibliography

Abeles, M., Cimoli, M. and Lavarello, P. (Eds.) (2017). *Manufactura y cambio estructural: aportes para pensar la política industrial en la Argentina*. ECLAC Books (149) (LC/PUB.2017/21-P). Economic Commission for Latin America and the Caribbean.

Argentine Wine Observatory (2024). *Estadísticas: reportes interactivos*. https://www.observatoriova.com/category/reportes-interactivos/

Bielschowsky, R. (2006). Celso Furtado's contributions to structuralism and their relevance today. *CEPAL Review* (88) (LC/G.2289-P). Economic Commission for Latin America and the Caribbean.

Cassiolato, J. and Lastres, H. (2005). Sistemas de innovación y desarrollo: las implicaciones de política. *São Paulo em Perspectiva*, *19*(1), 34-45.

Cimoli, M., Dosi, G. and Stiglitz, J. (2009). *Industrial policy and development: the political economy of capabilities accumulation*. Oxford University Press.

Cimoli, M., Porcile, G., Primi, A. and Vergara, S. (2005). Cambio estructural, heterogeneidad productiva y tecnología en América Latina. In M. Cimoli (Ed.). *Heterogeneidad estructural, asimetrías tecnológicas y crecimiento en América Latina*. (LC/W.35). Economic Commission for Latin America and the Caribbean.

D'Alessandro, M., Gonzalo, M., Filipetto, S. and Starobinsky, G. (2021). Valle de La Puerta: recursos, capacidades y vínculos para la internacionalización empresarial desde Chilecito, La Rioja, Argentina. *Revista Pymes, Innovación y Desarrollo*, *9*(3), 3-25.

D'Alessandro, M., Gonzalo, M., Starobinsky, G. and Yañez, B. (2025). Bodegas San Huberto: integración productiva de recursos y capacidades en la periferia argentina, 1998-2023. *Revista Rivar*, *12*(35), 214-233.

Directorate-General for Sectoral and Special Programmes and Projects. (2023). *EPSA La Rioja. Estrategia provincial para el sector agroalimentario*. Ministry of Economic Affairs.

Economic Commission for Latin America and the Caribbean (1985). *Principales consecuencias socioeconómicas de la división regional de la actividad agrícola*. Documentos de trabajo (17).

Economic Commission for Latin America and the Caribbean (2021). La Rioja en el siglo XXI: desafíos y oportunidades para su transformación productiva. *Project Documents* (LC/TS.2021/164; LC/BUE/TS.2021/5).

Economic Commission for Latin America and the Caribbean (2024). *Overview of Productive Development Policies in Latin America and the Caribbean, 2024* (LC/PUB.2024/15-P).
Economic Commission for Latin America and the Caribbean and Ministry of Economic Affairs of Argentina (2022). Desagregación provincial del valor agregado bruto de la Argentina, base 2004. *Project Documents* (LC/TS.2022/196; LC/BUE/TS.2022/9).
Furtado, C. (1959). *Formação econômica do Brasil*. Fondo de Cultura.
Furtado, C. (1966). *Subdesenvolvimento e estagnação na América Latina*. Civilização Brasileira.
Gonzalo, M. (2023). *India from Latin America: Peripherisation, Statebuilding, and Demand-Led Growth*. Routledge.
Gonzalo, M. and Starobinsky, G. (2023). Emergencia del cannabis medicinal en el Noroeste Argentino (NOA): avances y desafíos de gestión y articulación de Agrogenética Riojana. *Documentos y Aportes en Administración Pública y Gestión Estatal* (41), 1-17.
Gonzalo, M., D' Alessandro, M. and Yañez Mayorga, B. (2023). Bodega Chañarmuyo: vinos de alta gama y enoturismo desde la periferia riojana. *Revista Actualidad Económica*, *33*(111), 19-33.
Gonzalo, M., Kababe, Y., Starobinsky, G. and Gutti, P. (2022). Agrogenética Riojana: oportunidades y desafíos de una empresa pública provincial. *Ciencia, Tecnología y Política*, *5*(9), 083.
Gonzalo, M., Mucarsel, L., Starobinsky, G. and Burlot, G. (in press). *State-owned enterprises as drivers for regional missions in the Global South: insights from INVAP in Patagonia and Agrogenética Riojana in Northwest Argentina*. Cambridge Journal of Regions, Economy and Society.
International Organisation of Vine and Wine. (2024). *State of the world vine and wine sector in 2023*.
Mancini, M. and Lavarello, P. (2013). Heterogeneidad estructural: origen y evolución del concepto frente a los nuevos desafíos en el contexto de la mundialización del capital. *Entrelíneas de la Política Económica* (37), 28–34.
Mazzucato, M. (2023). *Transformational change in Latin America and the Caribbean: a mission-oriented approach* (LC/TS.2022/150). Economic Commission for Latin America and the Caribbean.
National Institute of Statistics and Censuses (2022). *Censo Nacional Económico 2020-2021*. Ministry of Economic Affairs of Argentina.
National Institute of Statistics and Censuses (2023). Evolución de la distribución del ingreso (EPH): tercer trimestre de 2023. *Informes técnicos*, *7*(274).
National Institute of Statistics and Censuses (2024). Incidencia de la pobreza y la indigencia en 31 aglomerados urbanos: segundo semestre de 2023. *Informes técnicos*, *8*(73).
National Institute of Vitiviniculture (2023). *Relevamiento vitivinícola argentino: parte II, contexto industrial de la vitivinicultura*.
National Institute of Vitiviniculture (2024a). *Informe anual de cosecha y elaboración 2023*.
National Institute of Vitiviniculture (2024b). *Informe anual de superficie 2023*.
Nayyar, D. (2013). *A corrida pelo crescimento: países em desenvolvimento na economia mundial*. Contraponto.
Niembro, A. and Starobinsky, G. (2021). Sistemas regionales de ciencia, tecnología e innovación en la periferia de la periferia: un análisis de las provincias argentinas (2010-2017). *Estudios Socioterritoriales. Revista de Geografía* (30), 097.
Niembro, A. and Starobinsky, G. (2023). Looking at regional innovation systems and industrial knowledge bases from the South: an analysis of Argentine provinces. *International Journal of Technological Learning, Innovation and Development*, *15*(1), 1–27.
Pinto, A. (1973). *Heterogeneidad estructural y modelo de desarrollo reciente de América Latina*. Economic Commission for Latin America and Latin American Institute for Economic and Social Planning.
Pinto, A. (1976). Naturaleza e implicaciones de la "heterogeneidad estructural" de América Latina. *El Trimestre Económico*, *37*(1), 83-100.
Pinto, A. (1984). Metropolización y terciarización: malformaciones estructurales en el desarrollo latinoamericano. *CEPAL Review* (24), 17-38. Economic Commission for Latin America and the Caribbean.
Pinto, A. (1989). Notas sobre industrialización y progreso técnico en la perspectiva Prebisch-CEPAL. *Pensamiento Iberoamericano. Revista de Economía Política*, *16*, 59-84.
Pinto, A. and Di Filippo, A. (1979). Desarrollo y pobreza en América Latina: un enfoque histórico estructural. In Franco, R. (coord.), *Pobreza, necesidades básicas y desarrollo* (E/ICEF/TACRO/G.1006). Economic Commission for Latin America and the Caribbean, Latin American and Caribbean Institute for Economic and Social Planning and United Nations Children's Fund.

Pizarro Levi, E., D'Alessandro, M., Filipetto, S., Starobinsky, G. and Gonzalo, M. (2022). Trayectoria socioproductiva, estructura empresarial, tendencias y desafíos del Torrontés Riojano. *Revista Rivar*, *9*(25), 191-210.
Prebisch, R. (1949), *The Economic Development of Latin America and Its Principal Problems* (E/CN.12/89), United Nations.
Prebisch, R. (1952). *Theoretical and practical problems of economic growth* (E/CN.12/221), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).
Rodríguez, O. (2006). *El estructuralismo latinoamericano*. Siglo XXI.
Rosales, O. (1988). *Balance y renovación en el paradigma estructuralista del desarrollo latinoamericano*. *CEPAL Review* (34) (LC/G.1521-P), 19-36.
Secretariat of Agroindustry (2019). *Caracterización de la agricultura familiar en La Rioja*. Ministry of Production and Labour of Argentina.
Starobinsky, G., Gonzalo, M., Filipetto, S. and D'Alessandro, M. (2020). Dinámica de mercados y esfuerzos tecnológicos en un sistema de innovación periférico: la riojana cooperativa vitivinifrutícola. *Revista Rivar*, *7*(20), 67-87.
Sztulwark, S. (2003). *El estructuralismo latinoamericano: fundamentos y transformaciones del pensamiento económico de la periferia*. Prometeo Libros.
Torres, M. and Ahumada, J. M. (2022). Las relaciones centro-periferia en el siglo XXI. *El Trimestre Económico*, *89*(353), 151-195.
Vasilachis de Gialdino, I. (2006). *Estrategias de investigación cualitativa*. Gedisa.
Yin, R. (1984). *Case Study Research*. Sage.

The Superintendency for the Development of the North-East (SUDENE) and the training of a generation of development planners in Brazil's north-east

Darlan Praxedes Barboza

Received: 14/11/2024
Accepted: 21/07/2025

Abstract

This article examines the training of development planners in north-eastern Brazil by the Superintendency for the Development of the North-East (SUDENE) in the 1960s and 1970s. Supported by the Economic Commission for Latin America (ECLA), SUDENE held courses on development and economic and social planning and trained generations of specialists with a view to tackling inequalities and underdevelopment in the region. It was one of the main channels for the dissemination of ECLA ideas in Brazil, acting as a producer of knowledge about the regional situation, a laboratory for institutional reforms to modernize the bureaucratic machinery and a standard-bearer for the ideology of national developmentalism. Institutional documents, press coverage and testimonials from former members of SUDENE are used to reconstruct the activities involved in training specialist staff and the processes that led to the constitution, expansion and disbanding of the SUDENE technical team.

Keywords

Economic development, regional development, development planning, technical cooperation, training programmes, ECLA, administrative agencies, public sector, history, regional economics, Brazil

JEL classification

A11, B15, O15

Author

Darlan Praxedes Barboza holds a doctorate in Sociology and is a postdoctoral researcher with the Institute of Brazilian Studies at the University of São Paulo (IEB/USP) (Brazil). Email: dpraxedes@gmail.com.

I. Introduction[1]

The Superintendency for the Development of the North-East (SUDENE) was created in 1959 with the aim of restructuring the economy of north-eastern Brazil by attracting industrial investment, modernizing the region's political and administrative structure and investing to train staff in economic and social development planning techniques. With the creation of SUDENE, the developmentalist government of Juscelino Kubitschek (1956–1961) sought to reduce the development asymmetries between the regions of the centre-south, which industrialized rapidly thanks to the exchange-rate and tariff policies adopted by Brazil after the Second World War, and the north-east, which was then in ruins, with an economy based on agricultural production, dependent on the export of capital and skilled labour to the centre-south region and harmed by the official exchange-rate policy.

SUDENE was also a response by the Kubitschek government to the pre-revolutionary political situation in the north-east, where the struggle for land and the demands of campesinos for better living conditions had come to threaten the stability of the country and the government itself (Cohn, 1976; Oliveira, 2013).

One of the challenges in implementing the SUDENE development programme was the shortage of qualified personnel in the north-east. The report "Uma política para o desenvolvimento econômico do Nordeste" ("A policy for the economic development of the north-east") prepared by the Working Group for the Development of the North-East (GTDN), which was linked to the federal government, and SUDENE Master Plans I (1961–1963), II (1963–1965), III (1966–1968) and IV (1969–1973) pointed out that training professionals was an indispensable condition for the development of the region.

Regional imbalances were reflected in the concentration of skilled labour in the centre-south of the country. The small contingent of university-trained professionals in the north-east would migrate to the centre-south, exacerbating the region's underdevelopment. To reverse the situation, SUDENE prioritized investment in staff training, with the support of the Economic Commission for Latin America (ECLA), and expanded job opportunities for regional development specialists, thus boosting the labour market for professionals with higher education. This *autarquia*[2] developed a new narrative about the north-east, presenting it as a region with natural riches and industrial potential, and arguing that a large technical corps working within SUDENE itself, at universities and in the public and private sectors was needed to understand and exploit these.

This article also contributes to the field of studies on the history of economics and economic thought in Brazil and Latin America by showing the links between the ECLA school of planning and the developmentalist ideology prevailing in Brazil in the 1950s and 1960s, of which the creation of SUDENE was the most emblematic result. Despite the important role played by the agency in training hundreds of technical staff committed to development planning in the second half of the twentieth century, its history, structure, functioning and disbandment have been little studied. This is due partly to the hostility of the civilian-military regime established in 1964 towards SUDENE, then a symbol of the struggle for structural change in the poorest and most unequal region of the country, and partly to a lack of interest among the intellectual elites of the south-east in political and administrative innovations and new knowledge production in that peripheral region.

[1] The author wishes to thank the former SUDENE staff interviewed, whose passion and commitment to regional development are undimmed. He is also grateful to the anonymous reader at *CEPAL Review* whose thorough, capable and critical reading helped make the article more accurate and complete.

[2] In Brazil, an *autarquia* is an agency established by law to manage specific public services. Although overseen by the State, it has administrative and financial autonomy and its own assets and acts in a decentralized manner.

Against this background, the present article contributes to the specialized literature by analysing SUDENE with an emphasis on its personnel training efforts. As will be shown, SUDENE was in many ways an advance guard for the ECLA structuralist school in north-east Brazil.

In its theoretical and methodological approach, this article systematically investigates, from the perspective of the sociology of intellectuals, what was a paradigmatic case in the north-east: the reconfiguration of the hierarchy for the division of technical work among the bureaucracies operating within the Brazilian State in the mid-twentieth century and the emergence of a new State elite, namely economists, endowed with scientific legitimacy and using the new knowledge from their discipline to influence the economic strategies of government elites at a critical political juncture. The article also contributes to the study of the circulation of agents, ideas and practices among the countries of the Latin American periphery.

This article draws on the *SUDENE Informa* newsletter, contemporary news reports and interviews with former SUDENE officials to reconstruct the development agency's initiatives in training generations of economic development planners in the 1960s and 1970s, the period when it was at its peak, after which its influence waned.

The article is organized into six sections after this introduction. The second section reconstructs the cooperation between ECLA and the Brazilian Government in planning policies for structural change and organizing the Training Course on Problems of Economic Development (CTPDE). The third section analyses the transfer of this course to Recife and the cooperation between ECLA and SUDENE on the training of personnel. The fourth section deals with the structuring of the Human Resources Department (DRH) and of the Economic Development Technician (TDE) course. The fifth section examines SUDENE activities in the area of education, highlighting the creation of the Education Division and the Educational Planning Technician (TPE) course. The sixth section describes the investments made in the training of SUDENE technical staff, with courses held in the north-east, the south-east and abroad. The seventh section focuses on the development institution's offering of intensive courses in sectoral planning and on the training of hundreds of specialists in numerous fields with the aim of restructuring local bureaucracies and universities in the region. Lastly, the eighth section offers some concluding remarks.

II. The dissemination of ECLA thinking in Brazil

A substantial part of the modern economic bureaucracy of the Brazilian State was created between the 1930s and the 1960s in response to the transformations brought about by the industrialization process and the new demands being put on the central State, which began to expand its sphere of action within the country and to specialize its functions. This was the background to the creation of the Public Service Administrative Department (DASP) (1938), the Superintendency of Currency and Credit (SUMOC) (1945), the National Bank for Economic Development (BNDE) (1952), the Banco do Nordeste do Brasil (1952), the Superintendency of Economic Recovery Plan of the Amazon (SPVEA) (1952) and the Development Council of the Presidency of the Republic (1956), which was responsible for drafting the Targets Plan of the Juscelino Kubitschek administration.

In addition, the proliferation of economic organizations and the creation of State-owned companies tasked with expanding economic infrastructure, such as the National Steel Company (CSN), Petrobras and what was then called the Vale do Rio Doce Company, led to the emergence of specialists in economics and public administration. These professionals proliferated between the 1950s and 1960s and took on the planning and execution of State-coordinated development policies.

Amid growing demand for qualified professionals to work in the State bureaucracy, and given the rising complexity of economic problems, which required increasingly specialized knowledge, schools of economics and public administration were established in Rio de Janeiro and São Paulo. With the proliferation of initiatives in the field of economic studies, the need for professional development courses soon arose, and this was met by institutions such as the National Economic Council (CNE) (1949–1967), the Professional Development Centre for Economists (CAE) (1960–1966) and BNDE, in cooperation with ECLA (1956–1967), these initiatives being based in Rio de Janeiro (Biderman et al., 1996; Mantega and Rego, 1999; Klüger, 2017).

With rapid economic growth and the advance of the industrialist and State interventionist agenda in the 1950s, notwithstanding the brief anti-Statist and anti-industrialist interregnum of the João Café Filho government (1954–1955), ECLA ideas found their way into new niches of the Brazilian economic bureaucracy, providing ammunition and a justifying ideology of a scientific hue for the government's industrialist schools (Bielschowsky, 1988; Oliveira, 2003).

Distinguished by its acceptance of the unorthodox thinking of economist Raúl Prebisch (1901–1986), which sparked a Copernican revolution in the way the industrialization process and the role of the State as a coordinator of economic development in Latin America were understood, exerting a strong influence in Brazil (Bielschowsky, 1988; Oliveira, 2003; Klüger, 2017; Barbosa, 2021), ECLA sponsored several editions of the Training Course on Problems of Economic Development (CTPDE), in partnership with BNDE, and disseminated economic planning techniques among the upper echelons of the Brazilian civil service.

In the 1950s, ECLA expanded its activities in Brazil and introduced Portuguese as one of its working languages. It participated actively in the Brazilian economic debate, which was marked by polarization between orthodox and heterodox economists, and held its fifth session in Rio de Janeiro in 1953, when a cooperation agreement with BNDE (1953–1955) was signed with the aim of producing a diagnosis of the economic situation and a development plan for Brazil (Bielschowsky, 1988; Klüger, 2017; Barbosa, 2021; Sola, 2023).[3]

The convergence between the second Getúlio Vargas administration (1950–1954) and the so-called "golden age" of ECLA thinking (1949–1956) (Dosman, 2011, p. 380) also helped make Brazil a priority for ECLA, as did the creation in the country of financial institutions for economic development such as BNDE and the Banco do Nordeste do Brasil, the predominance of developmentalist thinking in the Brazilian economic bureaucracy and the work of Celso Furtado on the pioneering ECLA team.

Celso Furtado (1920–2004) was from Paraíba and completed a Law degree at the University of Brazil (now the Federal University of Rio de Janeiro) (1940–1944) before working as a specialist at the Public Service Administrative Department (DASP) (1944–1946), obtaining a doctorate in Economics from the University of Paris (1948) and joining ECLA in 1948. He quickly became Director of the Economic Development Division (1950–1955), which was considered the centre of thought on development theory and planning within the organization (Dosman, 2011, p. 320). Furtado led a multinational team of economists and headed technical assistance missions in Chile (1950–1952), Brazil (1953–1955), Mexico (1955–1957) and Venezuela (1957). He also participated in studies on the economies of Argentina, Peru, Bolivia and Ecuador (Furtado, 2014).

[3] The Latin American organization was primarily responsible for the movement of agents and ideas between Chile and Brazil, and played a central role in structuring the field of economics in the latter. As Klüger et al. (2022, p. 129) put it, "The movement of people and ideas between Brazil and Chile was two-way. On the one hand, the Centre received [ECLA] officials from other Latin American countries, and they acquired new perspectives on the continent by deepening their knowledge of Brazil, which helped them review and refine [ECLA] analyses. On the other hand, [ECLA] participated in the intellectual and professional training of many Brazilians, both through its operations in Brazil and by welcoming to Santiago many intellectuals exiled from Brazil after the advent of the military dictatorship in 1964."

Following disagreements with Prebisch over the direction of ECLA and its relations with Latin American governments (Dosman, 2011, pp. 377–378) and a period of study at Cambridge (United Kingdom), Furtado created his own institution focused on economic development planning in Brazil. He launched himself as a reformer of the public administration and recruited a small army of planners, who recognized his intellectual authority and spread his structuralist ideas within the State apparatus.

As can be seen, Furtado's nearly 10 years' experience at ECLA (1948–1958) were vital to the creation of SUDENE, an autonomous development agency set up with the aim of spreading the benefits of industrial progress throughout the north-east and doing away with entrenched rural socioeconomic and political structures.

Furtado took ECLA programme guidelines for personnel training with him to the north-east. In the 1950s, he taught the ECLA Training Course on Problems of Economic Development (CTPDE) in Santiago (Chile), training generations of State specialists and accumulating a solid stock-in-trade of theoretical and practical knowledge about development problems in Latin America. Created in 1952, CTPDE contributed to the continent-wide spread of ECLA thought (Furtado, 2014, p. 126).

> "Promising young economists from governments right across the region would be given 24 weeks of basic training [at ECLA] in economic analysis, social accounting, sociology, economic development theory and project planning. This basic training was followed by a further 16 weeks of work in small groups, focusing on specific topics such as public sector administration, budget planning and human resource development. Besides its annual "basic course", Ahumada's Division[4] ran intensive courses and special seminars throughout the region at the request of governments and in collaboration with universities and institutes (Dosman, 2011, p. 320)."

From 1955, in response to growing demand for ECLA courses in the Latin American countries, where there was a shortage of planners with a modern outlook, it became necessary to run them intensively in the countries themselves, sending teaching staff out for limited periods and calling on local specialists to teach certain subjects (Furtado, 2014, p. 126).

In 1956, BNDE and ECLA held the first CTPDE in Brazil. This intensive two-month full-time course trained civil servants in modern techniques for preparing and analysing economic development projects and provided tools for formulating and coordinating the economic policies required for development and for presenting a coordinated overview of their countries' long-run economic problems and development prospects (Klüger, 2017, p. 65).[5]

CTPDE, which operated between 1956 and 1967, with 21 editions in 12 Brazilian cities (Klüger et al., 2022, p. 136), stimulated the circulation of ideas, professionals and practices between Chile and Brazil (Klüger, 2017), contributed to knowledge of planning techniques in Brazil, trained generations of civil servants and intellectuals and was embraced by a variety of governmental bodies and academic institutions (Klüger et al., 2022, p. 132).[6] These courses also treated the issue of regional development as a structuring axis.

[4] Jorge Ahumada (1917–1965), who was a member of the ECLA team of economists (1950–1961) and served as Director of the Economic Development Division.

[5] Those travelling to Rio de Janeiro on this occasion were Jorge Ahumada of Chile, who taught Economic Development Programming; three Argentines, namely Manuel Balboa, who taught Social Accounting, Julio Melnick, head of Project Preparation and Evaluation, and Carlos Oyarzún, who taught Economic Development Financing; and Furtado himself, who taught Problems of Brazilian Development and Economic Development Perspectives (Klüger, 2017). These ECLA members were received as major stars of economic development and planning in Latin America (Garcia, 1992, p. 94).

[6] Over the various editions of CTPDE, courses covered a wide range of topics, including foreign trade and industrial issues, fiscal and monetary arrangements and the balance of payments, transport, energy, natural resources and minerals, agriculture, regional development, statistics and national indicators, demography, human resources training, education, and public health (Klüger et al., 2022, p. 133).

III. The arrival of ECLA in north-east Brazil

With the prestige he had built up at ECLA and BNDE, Furtado moved CTPDE from Rio de Janeiro to Recife and brought an elite team from the Latin American organization to the north-east, with the mission of recruiting and training the first generations of economic planners for SUDENE, thereby inoculating the region with the "ECLA virus" (Limeira and Alves, 1992, p. 74).

The course was taught in Recife between 1959 and 1965 with the support of ECLA, BNDE, the Pernambuco Development Commission (CODEPE), the Coordination for the Improvement of Higher Education Personnel (CAPES), the state governments of the North-East region and, from 1963, the Latin American and Caribbean Institute for Economic and Social Planning (ILPES), which produced supporting material to train specialists in social and economic problems.

In the second half of 1959, Jorge Ahumada, a Chilean who had studied at postgraduate level at Harvard University, worked as an International Monetary Fund (IMF) official and an economic advisor to Central American countries (Puerto Rico and Guatemala) and founded and served as the first Director of the Economic Development Division of ECLA, went to Recife to train the first cohort of SUDENE specialists. This journey symbolized ECLA support for the federal government's new policy for the Brazilian north-east.

During this initial phase of SUDENE, Chilean economist Osvaldo Sunkel (born in 1929) also taught in Recife. With a specialization from the London School of Economics and Political Science (LSE), Sunkel took over from Jorge Ahumada in 1955 as the coordinator of the ECLA Economic Development Division in Santiago. He was a member of the so-called "red division" of more radical economists at ECLA and participated in the team led by Celso Furtado which prepared a report on the Mexican economy (1955–1957) (Dosman, 2011, p. 320). He was also the organizer and first Director of the ECLA office in Rio de Janeiro (1960–1961).

In 1959, with the support of Piauí economist Cláudio Correa Lima, Osvaldo Sunkel coordinated the selection process for the ECLA CTPDE in Recife. Sunkel noted that it had been very interesting to hear what people from different states and, later, Furtado had to say (Sunkel, 2020, p. 296). He was also one of the course lecturers, teaching Economic Development Analysis and Programming and promoting the ECLA structuralist method.

Another Chilean, Aníbal Pinto Santa Cruz (1919–1996), a Law graduate and economist who had studied at postgraduate level at LSE, also taught the CTPDE Development Finance course in Recife. On Sunkel's return to Santiago to coordinate the new ILPES training programme, Pinto took over the running of the ECLA office in Rio de Janeiro (1962–1965), becoming a teacher to generations of ECLA staff in Brazil and Latin America (Oliveira, 2013, p. 150) and an "intellectual mentor" to Brazilian economists starting out in their careers (Klüger et al., 2022, p. 139).

Other participants in the earliest training courses for SUDENE technical staff included Argentine engineer Julio Melnick, an advisor to the ECLA Technical Assistance Programme and author of the *Manual de proyectos de desarrollo económico* ("Economic Development Projects Handbook") (1958), used on ECLA and SUDENE courses; Venezuelan Braulio Jatar, author of *Planificación del desarrollo: sus aspectos institucionales* ("Development Planning: Its Institutional Aspects") (1958); and Argentine economist Alberto Fracchia, a pioneer in the field of national accounts in Latin America.

These ECLA members exported their organization's tradition of thought to Brazil through its courses, expanding the country's development prospects. In return, they gained a greater awareness of Brazilian and north-eastern problems, enriched the Commission's work with new points of view and used the detailed knowledge of specific regional realities thus acquired to refine their theories (Klüger et al., 2022, p. 138).

As with the editions of CTPDE held in Rio de Janeiro, students attending the first ECLA-BNDE courses in Recife took classes in Introduction to Economics, Social Accounting, Statistics, Capital Formation, Theory, Economic Development Programming and Financing, Problems of Brazilian Development and Project Analysis and Administration (Diário de Pernambuco, 1959).

IV. The Economic Development Technician course and the training of SUDENE staff

With the expansion of available resources and the creation in 1961 of the Department of Technical Assistance and Personnel Training (DATFP), later renamed the Human Resources Department (DRH), SUDENE began offering its own Economic Development Technician (TDE) course. Like CTPDE, this was modelled on the course run by ECLA in Santiago. The most substantive difference lay in the emphasis placed on the subject of regional development, which was already present in the CTPDE editions in Rio de Janeiro and in lectures given by Furtado at the Higher Institute of Brazilian Studies (ISEB) and to the Armed Forces General Staff (EMFA) (Furtado, 2014).

Besides the ECLA contingent, the Economic Development Technician courses also involved young economists trained at the orthodox National Faculty of Economic Sciences (FNCE) of the University of Brazil (Mantega and Rego, 1999), who were associated with the ECLA-BNDE Economic Development Centre in Rio de Janeiro. Among them were Carlos Lessa (1936–2020), then Deputy Director of the ECLA-BNDE office, Antonio Barros de Castro (1938–2011) and Portuguese mathematician Maria da Conceição Tavares (1930–2024). Lessa and Castro co-authored *Introdução à economia: uma abordagem estruturalista* ("Introduction to Economics: a Structuralist Approach"), the manual used on the ECLA-BNDE courses. Something the trio shared was a close connection to Aníbal Pinto (Klüger, 2017).

Furtado mobilized his contacts in Brazil and brought in leading experts from the State bureaucracy and the Brazilian intelligentsia as lecturers on the Economic Development Technician courses. They shared a common set of issues, methods and solutions that were part of that generation's repertoire (Barbosa, 2021, p. 103). Most of them were nationalist developmentalists from the public sector (Bielschowsky, 1988, p. 127), committed to transforming the country's underdeveloped structures through State planning. Leading names among those who went to Recife include Gerson Augusto da Silva and Casemiro Ribeiro (both from the Customs Policy Council of the Ministry of Finance), Inácio Tosta Filho (then chair of the Bahia Economic Planning Commission) and Rômulo Almeida, former head of Vargas's economic advisory team (1951 and 1953), former President of the Banco do Nordeste do Brasil (1953–1954), federal deputy (1954–1955 and 1957) and Secretary of Finance of Bahia (1955–1957).

Other figures who participated as lecturers in Recife included Isaac Kerstenetzky, a young economist from Rio de Janeiro who had studied abroad and would go on to preside over the Brazilian Institute of Geography and Statistics (IBGE) between 1970 and 1979, and Eduardo Sobral, a nationalist-leaning economist who was head of Petrobras's Economic Department in the early 1960s and was imprisoned, dismissed from the State-owned company and stripped of his political rights after the 1964 coup. Also present were Raul Barbosa, a former federal deputy (1946–1951), former governor of Ceará (1951–1954) and President of the Banco do Nordeste do Brasil (1956–1967), and Jesús Soares Pereira, who served in various federal government bodies, such as the National Department of Mineral Production (DNPM), the Federal Foreign Trade Council and the National

Pine Institute between the 1930s and 1940s, as well as having been an economic advisor to Getúlio Vargas and the Ministry of Transport and Public Works in the 1950s (Contemporary Brazilian History Research and Documentation Centre [CPDOC], 2009a).

Sociologist Gilberto Freyre, President of the Joaquim Nabuco Institute (IJN), Director of the Recife Regional Centre for Educational Research (CRPER) and representative of the Ministry of Education and Culture on the SUDENE Deliberative Council, also lectured in his Economic Development Technician courses. He was an obvious choice to participate because of his standing in Brazil and abroad, his political role as spokesman for the interests of the north-east in negotiations with the central government (Mesquita, 2018) and the control he exerted over important bodies (IJN and CRPER) in the region's balance of power. Another important factor was the scientific legitimacy accrued by sociology and its practitioners in the 1950s and 1960s as interpreters of the nation's problems and as an influence on government policy (Botelho et al., 2008). Furtado usually gave the closing lecture at the end of the Economic Development Technician courses.

With a high-level technical staff in the mid-1950s and considerable influence in the civilian government (Benevides, 1976), the armed forces were an important ally in the political struggle to create SUDENE. They also lent some of their best personnel, people with nationalist and developmentalist profiles, as lecturers on Economic Development Technician courses. Among them were Admiral Lúcio Meira, Deputy Chief of the Military Cabinet in the second Getúlio Vargas government, champion of the automotive and shipbuilding industries in Brazil and Minister of Transport and Public Works between 1956 and 1959 (CPDOC, 2009b), and General Carlos Berenhauser Junior, President of the San Francisco Hydroelectric Company (CHESF), who was admired by Furtado for having shielded the company from political influence (Hirschman, 2009, p. 186).

Some military specialists participated in the Economic Development Technician courses in Recife, joined the SUDENE technical staff and helped conduct the early studies and organize the departments of the regional agency. These military personnel who cooperated with Furtado in the struggle against underdevelopment in the north-east were later dismissed from their positions at SUDENE, expelled from the corporation or forced into retirement by the *entreguistas* in the armed forces (those willing to "give up" strategic sectors and industries to foreign ownership and control) after their faction was victorious in the 1964 coup (Barboza, 2023).

The Economic Development Technician courses attracted candidates from all the north-eastern states, including Bahia and Maranhão, which were integrated into the new configuration of the north-east redesigned by SUDENE. In 1959, of 100 candidates who enrolled for CTPDE in Recife, 50 were selected. The following year, 1960, there were 120 candidates for the ECLA-BNDE CTPDE in Recife, of whom 84 were selected and 52 approved (Limeira and Alves, 1992, p. 46). In 1962, 280 people registered, of whom 80 were approved and only 25 completed the course, subsequently being recruited by SUDENE (A. A. Silva, personal communication, 2021). On the 1963 Economic Development Technician course, 40 of the 80 students selected were approved and joined the agency's staff (L. Alves Filho, personal communication, 2021).

Students on the Economic Development Technician courses, most of whom were from the north-east and had graduated from universities in the region, were trained in accordance with the new developmentalist outlook that had originated at ECLA. Through its Human Resources Department, SUDENE structured its own intensive full-time economic development course, lasting six months. After passing a written exam, candidates were interviewed by Department directors. Those who passed the essay and oral stages were taken to Recife by SUDENE itself to attend the Economic Development Technician course on scholarships, following the model already adopted for the ECLA courses in Santiago and CTPDE in Rio de Janeiro.

These scions of the north-eastern middle classes, with their outdated university education, updated their knowledge on the Economic Development Technician courses, where they learned to organize bibliographic surveys, plan studies, analyse budgets and programmes, prepare reports and make projections. In the process, they absorbed both the new structuralist thinking and technical knowledge imparted by their teachers and by ECLA manuals.

> "Those ECLA orientation courses were decisive in ensuring that the staff recruited to the ranks of our institution were of a high technical calibre" (Limeira and Alves, 1992, p. 20).
>
> "SUDENE was a second university for me" (T. Bacelar, personal communication, 2021).
>
> "It was almost like doing another degree. […]. We wanted to complete our training […] and do a good, substantive course" (J. L. R. Albuquerque, personal communication, 2021).
>
> "There [at SUDENE] I learned more than I did at the universities, study centres and research institutes I attended" (Brazileiro, 2001, p. 95).

After this period of study focused on development issues in peripheral countries, with an emphasis on the Brazilian and north-eastern experience, graduates were hired by SUDENE as economic development technicians. According to one respondent, this was more or less equivalent to a civil service exam (J. L. R. Albuquerque, personal communication, 2021). The professional category they entered was deemed "flexible" and was not listed by the Public Service Administrative Department (DASP), and its standing was as unstable as the Brazilian public administration itself (Limeira and Alves, 1992, p. 59). The new specialists were assigned to one of the departments of the agency in accordance with their skills and university education and with institutional needs (Limeira and Alves, 1992, p. 65).

Building on the administrative revolution in Brazilian public management that had been led by institutions such as DASP, BNDE, the Superintendency of Currency and Credit (SUMOC) and the Banco do Nordeste do Brasil, all part of the modern public service that Furtado knew well, SUDENE innovated in the area of staff training and recruitment, establishing a selective system based on merit and competence and demanding wholehearted and exclusive commitment from its technicians.

As can be seen, SUDENE drove the development of what had been a very limited labour market for university-educated professionals in the north-east (T. Bacelar, personal communication, 2021), and this made it the most sought-after of the autonomous federal agencies among youth graduating from universities in the region who were looking for good employment opportunities. As one respondent put it, SUDENE was a focal point, an aspiration; every student wanted to work at SUDENE (S. Weber, personal communication, 2021).

The regional organization also attracted young university students from the north-east by becoming an emblem of the struggle against political traditionalism and a symbol of the effort to raise moral standards in the Brazilian public administration, giving it the added attraction of idealism. As a former SUDENE technician summed it up in an interview with the author, SUDENE captured the imagination of these young students (Z. M. D. Oliveira, personal communication, 2022). To fortify the missionary spirit in the organization, Furtado often highlighted the exceptional effort and extraordinary faith in the future of the north-east shown by SUDENE technicians (Diário de Pernambuco, 1963a), who, as he put it, had accepted the call and the challenge of transforming the region (Diário de Pernambuco, 1963b).

SUDENE offered competitive pay rates both to graduates in traditional professions such as engineering, law and medicine and, most particularly, those in the new disciplines of economics,

veterinary science, chemistry, physics, mathematics, biology, geology, agronomy, geography, sociology, social work and education. These professionals, little considered until then, fought to obtain legal recognition for their activities and positions in the civil service.

> "SUDENE technicians will be remunerated in accordance with prevailing labour market conditions. Recognizing that SUDENE is not a traditional State service provider, but rather an agency of the modern developmentalist State, when faced with the choice between poor remuneration with accumulated benefits or adequate remuneration without privileges, the legislature opted for the latter. And in so doing, it paved the way for genuine reform in our public service. SUDENE is ready to compete in the labour market with private organizations and will have more than a hundred graduate technicians on its staff by the end of this year [1960]" (Furtado, 2009, p. 168).

The transformation of the graduate labour market in the north-east by this autonomous development agency —SUDENE was the largest source of employment in the region, outstripping even local private sector companies (Alcântara, 1963)— is one of the factors explaining the strong identification of these youth with Furtado and SUDENE, which provided them with careers, social standing, good salaries and opportunities for ongoing training, both on the courses of SUDENE itself and at institutions in the country's south-east and abroad.

In addition to these advantages, the regional development agency offered them the feeling of being part of a political project to transform Brazilian and north-eastern socioeconomic structures, under the auspices what was deemed to be a "technical" body.

> "We thought it was the work of the century, the most daunting and arduous of all the tasks that had to be achieved to build a harmonious nation, without the glaring disparities we saw around us. My generation threw itself wholeheartedly into that endeavour, and we tried to turn our weakness into strength: unprepared for such a great undertaking, we made up for the scientific knowledge we lacked with energy and enthusiasm" (Oliveira, 2009, p. 194).

From just five graduate technicians at the beginning of 1959, the SUDENE technical staff grew rapidly: by the end of that same year, it already had 32 professionals, including 5 from the United Nations and 1 from the French Government (Correio da Manhã, 1959). The number rose to around 100 in 1960, to 250 in 1961, including technicians from other public bodies and those who passed the Economic Development Technician course that year (Correio da Manhã, 1961), and to 400 by the end of 1962. By mid-1964, the federal agency had 626 graduate technicians, forming the largest and most homogeneous team of professionals in Latin America (Diário de Pernambuco, 1964), in addition to 1,487 mid-level and administrative staff (Souza, 1979, p. 164).

In 1966, the total number of SUDENE employees reached 2,912, of whom 1,632 were graduates (Souza, 1979, p. 164). In 1968, there were 2,939 employees, including 965 university graduates and 1,974 administrative staff (Souza, 1979, p. 164). This reduction in the number of professionals with higher education was due to the departure of hundreds of technicians for political and ideological reasons and to the consolidation of a more competitive labour market for them, both in the public and private sectors and in the region's universities.

The agency's permanent staff exceeded 4,000 in mid-1969 (Bariou, 1969, p. 20), but had fallen back to around 2,000 by the end of the 1970s, of whom 1,120 were graduate professionals and the rest administrative staff (Souza, 1979, p. 164). This reflected the progressive dismantling of the institution by the military regime.

V. The Educational Planning Technician course and the training of public sector officials

In the period following the Second World War, a time of rapid political and economic change, education became a central issue on the Brazilian political agenda. This shift was due both to pressure from political groupings interested in bringing the working and urban middle classes into the electoral process and to the modernizing influence of multilateral institutions, including ECLA, ILPES and the United Nations Educational, Scientific and Cultural Organization (UNESCO), and of United States agencies such as the United States Agency for International Development (USAID) and the Alliance for Progress, which were active in the so-called "Third World" (Beisiegel, 2004) and sought to calm the social unrest in north-eastern Brazil.

At the national level, the centrality of the issue of education was linked to mass mobilizations around the fundamental reforms proposed by the government of João Goulart (1961–1964), including university reform and, in particular, the demands of secondary and university students for the expansion and democratization of access to higher education. In the north-east, in an atmosphere of growing political dissatisfaction and social unrest around the agrarian question, the adult literacy campaign mounted in both rural and urban areas by reformist intellectuals from the Popular Culture Movement (MCP) and by the team of Pernambuco educator Paulo Freire, head of the Cultural Extension Service of what was then the University of Recife (now the Federal University of Pernambuco) (Coelho, 2012), came to represent a threat to the *pax agraria* in the region, owing to the potential increase in the number of citizens eligible to vote (illiterate people were banned from voting until 1985) and the bringing of the masses into the political process.

With an economic approach to personnel training (V. M. V. Cavalcanti, personal communication, 2022), SUDENE sought to restructure education in the region in line with its developmentalist paradigm. The institution proposed the development of a new outlook suited to development needs, encouragement for a process of cultural change capable of overcoming resistance to change, and an accelerated modernization process. Its goals included coordinating state and municipal education bodies in the north-east, meeting the demand for labour in the production system and training professionals to provide educational services at all levels in order to improve the qualifications of existing staff and increase the number of education professionals in the region (Superintendency for the Development of the North-East [SUDENE], 1971, pp. 5–6).

With these aims, and supported by the Recife Regional Centre for Educational Research (CRPER),[7] which was a regional standard-setter for educational training at the time, the SUDENE Human Resources Department ran its first Educational Planning Technician (TPE) course between January and March 1963. With a workload of 200 hours, the course served as the basis for selecting technicians responsible for structuring the agency's Education Division.

The first Educational Planning Technician course trained Philosophy, Literature, Sociology and Education graduates from all the states in the north-east, whose career prospects had been largely confined to teaching at primary or secondary level. The course taught subjects such as Statistics and Economic Development, School Administration, General Theory of Education and Educational Planning (Maciel, 1973, p. 7). According to one former participant, the aim was to open students' minds to the idea of an education geared towards the training of economic development personnel (V. M. V. Cavalcanti, personal communication, 2022).

[7] Directed by Gilberto Freyre, CRPER was linked to the Anísio Teixeira National Institute of Educational Studies and Research (INEP). It conducted educational and social research in the north-east and sponsored teacher training courses, exerting a significant influence on the education debate at the time (Meucci, 2015). Some of the technicians working at the SUDENE Education Division attended CRPER courses.
Not long before this, between September and December 1962, ILPES held its 13 week, 185 hour Training Course in Education Planning in Santiago (Maciel, 1973, p. 5).

The students, most of them women, received scholarships from SUDENE while on the course. Of the 25 participants, 13 were approved and recruited as educational planning technicians, whereupon they were distributed among the five sectors of the Education Division, which was created in 1961 and structured in 1963: Primary Education, Basic Education, Agricultural Education, Industrial Education and Higher Education and Basic Sciences.

> "I was finishing university when they opened applications for a selection process to create an education group at SUDENE. I applied and passed the selection process, which was very tough. There was a training course with several people on it. It was very different from what we had learned at university, from normal pedagogy. It was broader. There was politics, regional sociology, economics […]. Educational Planning Technician course students took part in courses, lectures, debates [...]. You worked with the students in the classroom, pedagogy and psychology [...] and suddenly you were in an economics class about what the north-east was [...]. What on earth was the north-east? I'd never given it a thought! So you gradually discovered these things in your training. [The Educational Planning Technician course] didn't teach statistics the way you learned it at university [...], with the little formulas. But it taught the situation in the north-east in statistical terms, those kinds of statistics: how many people there were, how many were literate, how many weren't. Education in the political sense. We didn't get that at university. University confined itself to education from the educator's point of view, the teacher and the student in the classroom, nothing beyond. Not education from a macro point of view. That didn't come into it. The Department of Education [of the State of Pernambuco] itself dealt with teaching methods, school materials, books, exercise books. But not with the issue of deficits, the educational reality of the state [...]. It was a larger structure. It wasn't just teachers in classrooms. We discovered that at SUDENE" (H. M. R. Brasileiro, personal communication, 2022).

> "I had this whole [humanistic] idea about the values education should have. At SUDENE, I came into contact with a different vision of education. It was quite shocking, it seemed so outlandish [...] this whole ECLA way of thinking. I found it a rather exotic vision. It wasn't easy to take in, to understand this new concept. A very technical vision. It wasn't the vision for education I had been taught at the Faculty of Philosophy [in Recife]. We studied the situation in Brazil, principles of economics, the relationship between economics and education, statistics. When it came to the theoretical conceptualization, there was a lot I didn't understand. It was a mystery to me" (M. C. A. Mendonça, personal communication, 2022).

> "I came from a quite orthodox background in philosophy, from the French school of philosophy. […] [The SUDENE Educational Planning Technician course] was a revolution in my mind. […] We had to take a broader view. It was another paradigm" (Z. M. D. Oliveira, personal communication, 2022).

Other technicians joined the Education Division via the second Educational Planning Technician course, which also trained civil servants from state education secretariats and universities in the north-east, as well as providing qualifications for technicians already working at SUDENE who wished to transfer to the agency's education section (M. G. C. Oliveira, personal communication, 2021).

The first and second Educational Planning Technician courses featured lectures by leading intellectuals, such as educator Paulo Freire (1921–1997), Swiss pedagogue Pierre Furter (1931–2020), and São Paulo sociologist Octavio Ianni (1926–2004), who addressed the tensions and emerging educational problems created by industrialization and the social and political transformations under way in the country (Ianni, 1963, p. 191).

> "He [Naílton Santos, Director of the Human Resources Department between 1961 and 1964] was very concerned to put us in touch with intellectuals who were sympathetic to the SUDENE ideology. He did these seminars, lectures. Afterwards, there were debates. He made a point of seeing to it that we got to know these mentors from ECLA" (M. C. A. Mendonça, personal communication, 2022).

As can be seen, the SUDENE Educational Planning Technician courses contributed to the training of education specialists of a new type, with a modern sensibility and outlook, equipped to create the educational conditions necessary for the transformation of the region's socioeconomic and administrative structures and to mitigate the imbalances caused by the changes under way in the north-east.

It was a time of slowing economic growth and political radicalization in Brazil. Pessimism about planning and industrialization was growing, and the core ideas of ECLA were losing their power, which led to a political and intellectual reorientation among the formulators of ECLA thought (Bielschowsky, 1988). In this context, the Educational Planning Technician courses represented a tactical change in the development agency's approach. Accused of "economism", SUDENE began to argue more emphatically for social reforms as an essential precondition for unblocking the industrialization process and redistributing its fruits (Barboza, 2023).

VI. The training of sectoral specialists on SUDENE professional development courses

SUDENE technicians attended a variety of professional development courses throughout their professional careers and were always discovering new things (S. V. Santos, personal communication, 2022). This ongoing training effort was made necessary by the breadth of the agency's activities and the rotation of technicians between its different departments and divisions. According to two former technicians, this was a functional approach in which SUDENE specialists did a whole range of jobs (Limeira and Alves, 1992, p. 64), broadening their field of knowledge. In the summation of another former official, economic development technicians were all-rounders (J. A. Pereira, personal communication, 2022).

The Human Resources Department funded the ongoing training of SUDENE technical staff in the south-east of the country through agreements with the Institute of Applied Economic Research (IPEA), the United States Census Bureau, the Pan American Training Center for Research on Natural Resources, the French Technical Cooperative, UNESCO and various universities in the South-East region (SUDENE, 1966a).

> "SUDENE played a role in specialization. The ECLA courses and those [refresher] courses I taught […] were specialization courses for graduates. Those young people then became interested in pursuing formal postgraduate studies and sometimes even left SUDENE and went to university" (T. Bacelar, personal communication, 2021).

> "My postgraduate course [at the Faculty of Economics and Administration of the University of São Paulo] was funded by SUDENE. Everything that happened after graduation, the big conferences, seminars in Brazil and abroad, a postgraduate course, a course in Japan […], SUDENE sent me on all that" (G. A. M. Brazileiro, personal communication, 2022).

Described as a very active department (J. L. R. Albuquerque, personal communication, 2021), the Human Resources Department also invested in the further training of SUDENE technicians abroad,

with the aim of helping them acquire new knowledge that could be applied to the socioeconomic and environmental conditions of the north-east. As a result of technical assistance agreements signed with other countries, many of these technicians attended specialization courses run by government agencies and universities in Germany, Chile, the United States, France, Israel, Japan and the Netherlands (Barboza, 2023).

> "Not only those of us at SUDENE but an entire generation of professionals from the states in the region were also given great opportunities for intellectual and scientific development through training programmes in the most varied areas of knowledge and at all kinds of different training institutions in Brazil and abroad" (Silva and Muniz, 2005, p. 2).

Some of the agency's technicians travelled to what at the time was the spiritual home of development ideology in Latin America, Santiago, where they attended general and sectoral planning courses run by ECLA. Those sent on these courses belonged to the Technical Advisory Section, a kind of special department reporting directly to the Superintendent that brought together the most highly qualified staff in the institution and had a more general outlook (T. Bacelar, personal communication, 2021).

SUDENE also held seminars featuring internationally renowned Brazilian and foreign intellectuals and specialists, including economists Paul Baran (1910–1964) and Everett Hagen (1906–1993), geographers Michel Rochefort (1927–2015) and David Harvey (born in 1935), and sociologist Manuel Castells (born in 1942), and dealing with issues of economic and social development. These initiatives contributed to the ongoing professional development of its team of technicians (SUDENE, 1966b, 1966c).

VII. SUDENE and the construction of a planning bureaucracy in the north-east

Many SUDENE technicians travelled the north-east from Bahia to Piauí (A. A. Silva, personal communication, 2021), working as instructors on intensive courses dealing with economic development and sectoral planning at the behest of local public bodies and universities in the region. As a former technician recalls (J. L. R. Albuquerque, personal communication, 2021), the demand for development courses was too great to meet: everyone wanted to take SUDENE courses. These itinerant courses were held in collaboration with the Brazilian Institute of Municipal Administration (IBAM), universities in the north-east, ECLA and ILPES.

In the 1960s, SUDENE created the Division of Technical Assistance to States and Municipalities, the Regional Centre for Municipal Administration (CRAM) and the North-East Training Centre (CETREINO) within the Human Resources Department to meet the growing demand for its courses and advisory services.

> "We would put the courses together and then teach them. We were a young group. We were asked to give classes by doing the things they were about. There was no one to teach us how. We just went out on a limb and did things. And we gave courses in a lot of states" (J. L. R. Albuquerque, personal communication, 2021).

According to an assessment by the regional agency itself, by 1965 SUDENE had trained 2,700 technicians, held 66 courses, financed 80 internships in the south-east of the country and awarded 110 scholarships for specialists from the north-east to study abroad (SUDENE, 1966d). The Training Division estimated that 154 courses were held and around 6,300 people were trained

by the agency between 1959 and 1967 (SUDENE, 1968). During the same period, approximately 150 state officials and 373 technicians from SUDENE itself benefited from scholarships and internships in Brazil and abroad (SUDENE, 1968).

In 1968, some 2,000 people received training on 36 courses run by the Training Division, either directly or in partnership with specialist agencies, in areas such as health, food, poultry farming, cattle farming, cooperatives, road paving, educational programming, nursing, sanitation, industry and agricultural marketing (SUDENE, 1969). That same year, 167 scholarships were awarded for internships in Brazil and abroad (SUDENE, 1968). Also during the period, SUDENE trained 3,563 technicians from the north-east on 101 intermediate- and higher-level technical courses (SUDENE, 1967).

Over the 1960s and 1970s, a decade on from the creation of SUDENE, 9,679 people were trained on 341 courses focusing on areas such as agriculture and livestock farming, natural resources, transport, energy, basic sanitation, telecommunications, industry, crafts, education, health, administration and community action (SUDENE, 1970a). The agency also awarded 1,362 scholarships for study abroad (mainly in the United States and France, but also in Germany, Italy, Japan and Mexico) and in southeastern Brazil to technicians from the institution itself and from various government agencies operating in the north-east (SUDENE, 1970a). As Maciel (1969) summarized, SUDENE was, among other things, a school of administration and a centre of study, research and training for the brightest and best.

Civil servants trained by SUDENE in planning techniques returned to their home areas and, with scholarships funded by SUDENE itself, helped to create sectoral planning centres in areas such as education, health, sanitation and industry and to disseminate the knowledge they had acquired at the development institution to local bureaucracies. The SUDENE Human Resources Department was, in the words of a former technician, an agency for training staff and developing technical infrastructure for the region (T. Bacelar, personal communication, 2021). During this period, SUDENE trained approximately 1,000 state, municipal and federal officials throughout the region (SUDENE, 1970b).

From 1964, the new political and economic approach and successive administrative reforms introduced by the military governments paradoxically made the assistance provided by SUDENE to states and municipalities in the north-east even more necessary, just when the agency's powers were being undermined by those same reforms, which stripped it of the power to initiate activities in various fields and transferred this to ministries and other federal bodies (Carvalho, 1979; Colombo, 2015).

VIII. Final considerations

The witch hunt instigated at SUDENE from 1964 onward by the military regime saw the development agency, accused by reactionary forces of being a "communist machine" (O Jornal, 1964), progressively hollowed out, disfigured and weakened (Carvalho, 1979; Colombo, 2015).

Created to stem the brain drain and build a technical elite earning competitive salaries, SUDENE ended up experiencing the progressive disintegration and exodus of its team of specialists, known for a level of technical expertise that was both a hallmark and a strategic asset of the development agency. Over 1,300 civil servants are estimated to have left in 1969 (Limeira and Alves, 1992, p. 74), many of them moving to the private sector in search of better salaries in a labour market that had been dynamized largely by the actions of SUDENE itself in the region.

The appearance of new public bodies, of private sector consultancies specializing in industry and of universities capable of producing information and analysis to support decision-making in

the region, a task that had been carried out almost exclusively by SUDENE until the mid-1960s, also contributed to the loss of technical expertise and the departure of staff whom the institution had trained to a high standard (Oliveira, 2009, p. 195).

The exodus worsened over the following decades as the agency was shut out of projects devised by the central government for the region and began to suffer from a shortage of resources and qualified professionals, gradually succumbing to bureaucratization (Colombo, 2015). Persecuted, imprisoned, tortured, stripped of political rights, exiled, returned to their original departments,[8] disparaged and disillusioned about the future of the institution, which had become one of the main targets of the authoritarian regime, SUDENE technicians, possessing technical and scientific capital that was highly valued in the regional academic and business market, left the agency in search of new career prospects.

From 1964, the new management of SUDENE discontinued its Economic Development Technician courses, and technicians in this field, who had been given the same status as other senior specialists in the federal public administration by Law No. 4089 of 1962, were demoted to a mid-level professional category in the federal bureaucracy's hierarchy of positions. They lost their status as a separate category and were incorporated into the civil service by the SUDENE Post Classification Plan (Law No. 5645 of 1970). With the enactment of Law No. 6257 of 1975, these professionals were placed on an equal footing with the technicians of the Ministry of Planning and Budget (Limeira and Alves, 1992, pp. 59–60), becoming a general category (J. L. R. Albuquerque, personal communication, 2021). In 1995, the 50 or so economic development technicians still at SUDENE were redistributed and assigned to the Ministry of Planning and Budget.[9]

For its part, the Education Division underwent various restructurings between the 1960s and 1980s, shrinking as SUDENE was progressively dismantled by the military governments. These governments did away with the reformist and democratic orientation of the agency and imposed a technocratic planning model (Oliveira, 1991, p. 104), accompanied by an economistic perspective on education, which was conceived as human resource training (Barboza, 2023).

Viewed from a long-term perspective, SUDENE was responsible for a critical reappraisal of the causes of underdevelopment in the north-east, the introduction of new methods for the design and effective implementation of public policies and the training of hundreds of technicians committed to transforming the country's most underdeveloped and stigmatized region. The generations of technicians trained on its courses spread new ideas and knowledge at the various levels of the State bureaucracy, challenging old practices of patronage rooted in the region's administrative structures. This knowledge and these practices were not confined to the State sphere or to disputed areas of economics, but engendered a broader conception of underdevelopment in the north-east, which came to be understood not only as an economic phenomenon, but also as a problem that required structural changes in society and education. This new vision won over broad sectors of Brazilian society, enthused by the window of opportunity that was opening up for the development of the country's most economically depressed region, and spread to the universities of the north-east, which SUDENE itself helped to expand, thus fertilizing the scientific output of the region.

[8] During the administration of General Castelo Branco (1964–1967), a federal government decree ordered SUDENE to reincorporate civil servants assigned to other departments and stripped the agency of its authority to offer them pay top-ups. This measure contributed to the depletion and weakening of its technical staff.

[9] This information is taken from correspondence dated April 1996 between SUDENE and the Human Resources Coordination Department of the Ministry of Planning and Budget, retrieved from the personal archives of Janiza Lima Ribeiro de Albuquerque.

Bibliography

Alcântara, M. A. (1963, 11 April). Informativo econômico. *Diário de Pernambuco.*

Barbosa, A. F. (2021). *O Brasil desenvolvimentista e a trajetória de Rômulo Almeida: projeto, interpretação e utopia.* Alameda.

Barboza, D. P. (2023). *Fé, carisma e virtú: a trajetória de Celso Furtado, a criação da SUDENE e a estruturação do campo científico no Nordeste brasileiro.* [Doctoral thesis]. University of São Paulo. https://doi.org/10.11606/T.8.2023.tde-06122023-174601

Bariou, J. P. (1969). *Relatório sobre uma missão ao Nordeste do Brasil.* Superintendency for the Development of the North-East.

Beisiegel, C. R. (2004). *Estado e educação popular: um estudo sobre a educação de adultos.* Liber Livro.

Benevides, M. V. M. (1976). *O governo Kubitschek: desenvolvimento econômico e estabilidade política, 1956-1961.* Editora Paz e Terra.

Biderman, C., Cozac, L. F. L. and Rego, J. M. (1996). *Conversas com economistas brasileiros.* Editora 34.

Bielschowsky, R. (1988). *Pensamento econômico brasileiro: o ciclo ideológico do desenvolvimentismo.* Contraponto.

Botelho, A., Bastos, E. R. and Villas Bôas, G. (Orgs.) (2008). *O moderno em questão: a década de 1950 no Brasil.* Topbooks.

Brazileiro, G. A. M. (2001). *Abrindo arquivos e revelando histórias quase inverrossímeis.* Comunigraf.

Carvalho, J. O. (1979). *Desenvolvimento regional: um problema político.* Campus.

Coelho, G. (2012). *MCP: História do Movimento de Cultura Popular.* CEPE Editora.

Cohn, A. (1976). *Crise regional e planejamento: o processo de criação da SUDENE.* Editora Perspectiva.

Colombo, L. A. (2015). *A SUDENE no sistema federativo brasileiro: a ascensão e queda de uma instituição.* Superintendency for the Development of the North-East.

Contemporary Brazilian History Research and Documentation Centre. (2009a). *Pereira, Jesus Soares.* http://fgv.br/cpdoc/acervo/dicionarios/verbete-biografico/pereira-jesus-soares

Contemporary Brazilian History Research and Documentation Centre. (2009b). *Lúcio Martins Meira.* http://www.fgv.br/cpdoc/acervo/dicionarios/verbete-biografico/lucio-martins-meira

Correio da Manhã. (1959, 26 April). *Vive o Nordeste a esperança de dias melhores no futuro.*

Correio da Manhã. (1961, 24 November). *Problemas do Nordeste já equacionados pela SUDENE.*

Diário de Pernambuco. (1959, 19 August). *Candidatos ao curso na CEPAL começaram a prestar exames, ontem (Sunkel examina) – vagas serão limitadas (42) para 100 candidatos inscritos.*

Diário de Pernambuco. (1963a, 25 December). *Altas autoridades confraternizam com o povo pernambucano: mensagens.*

Diário de Pernambuco. (1963b, 14 December). *Recebeu 175 mil dólares da USAID.*

Diário de Pernambuco. (1964, 30 May). *Estudantes viram o que fazem SUDENE e USAID desenvolvendo a região.*

Dosman, E. J. (2011). *Raúl Prebisch (1901-1986): A construção da América Latina e do terceiro mundo.* Contraponto Editora.

Furtado, C. (Ed.) (2009). *O Nordeste e a saga da SUDENE: 1958-1964.* Contraponto Editora and International Celso Furtado Centre for Development Policies.

Furtado, C. (2014). *Obra autobiográfica* (R. Freire d'Aguiar, Coord.). Companhia das Letras.

Garcia, C. (1992). Sudene, 12 de junho. In A. L. Limeira and G. Alves (Eds.), *Sudene: nós bem que tentamos.* Inojosa Editores.

Hirschman, A. (2009). Notas de uma entrevista com Celso Furtado (1960). In C. Furtado (Ed.), *O Nordeste e a saga da SUDENE: 1958-1964.* Contraponto Editora and International Celso Furtado Centre for Development Policies.

Ianni, O. (1963). *Industrialização e desenvolvimento social no Brasil.* Civilização Brasileira.

Klüger, E. (2017). *Meritocracia de laços: gênese e reconfigurações do espaço dos economistas no Brasil.* [Doctoral thesis] University of São Paulo.

Klüger, E., Wanderley, S. and Barbosa, A. F. (2022). The ECLA-BNDE Economic Development Centre and the training of a generation of development planners in Brazil. *CEPAL Review.* (136) (LC/PUB.2022/5-P). Economic Commission for Latin America and the Caribbean.

Limeira, A. L. and Alves, G. (Eds.). (1992). *Sudene: nós bem que tentamos.* Inojosa Editores.

Maciel, C. (1973). Curso de planejamento da educação: registro de algumas iniciativas. *Cadernos Região e Educação, 13*(25). Regional Centre for Educational Research of the North-East.
Maciel, Z. (1969, 20 December). A Sudene. *Diário de Pernambuco*.
Mantega, G. and Rego, J. M. (Orgs.). (1999). *Conversas com economistas brasileiros II*. Editora 34.
Mesquita, G. (2018). *Gilberto Freyre e o Estado novo: região, nação e modernidade*. Global Editora.
Meucci, S. (2015). Gilberto Freyre no comando do Centro Regional de Pesquisas Educacionais do Recife: educação em debate (1957-1964). *Sociologia & Antropologia, 5*(1). https://doi.org/10.1590/2238-38752015v516
O Jornal. (1964, 22 August). *Celso saiu da Sudene: Nordeste libertado.*
Oliveira, F. M. C. (2003). *A navegação venturosa: ensaios sobre Celso Furtado*. Boitempo.
Oliveira, F. M. C. (2009). Depoimento na CPI sobre a Sudene (1978). In C. Furtado (Ed.), *O Nordeste e a saga da SUDENE: 1958-1964.* Contraponto Editora and International Celso Furtado Centre for Development Policies.
Oliveira, F. M. C. (2013). *A noiva da revolução: elegia para uma re(li)gião.* Boitempo.
Oliveira, M. G. C. (1991). Conteúdo do planejamento: uma questão relevante. In S. Weber (Org.), *Democratização, educação e cidadania: caminho do Governo Arraes (1987-1990)*. Cortez.
Silva, J. C. R. and Muniz, L. N. (2005). *Algumas historíolas: o lado lúdico do nosso trabalho na SUDENE.* Livro Rápido.
Sola, L. (2023). *Ideias econômicas, decisões políticas: técnicos e políticos no governo da economia.* Editora da Universidade de São Paulo.
Souza, J. G. (1979). *O Nordeste brasileiro: uma experiência de desenvolvimento regional.* Banco do Nordeste do Brasil.
Sunkel, O. (2020). Um intelectual indispensável para entender o mundo das últimas décadas. In C. M. Sousa, I. M. Theis and J. L. A. Barbosa (Orgs.), *Celso Furtado: a esperança militante.* Editora da Universidade Estadual da Paraíba.
Superintendency for the Development of the North-East. (1966a). Curso no Japão. *SUDENE Informa, 4*(11).
Superintendency for the Development of the North-East. (1966b). Seminário. *SUDENE Informa, 4*(9).
Superintendency for the Development of the North-East. (1966c). Industrialização. *SUDENE Informa, 4*(9).
Superintendency for the Development of the North-East. (1966d). Sudene preparou 2700 técnicos. *SUDENE Informa, 4*(3).
Superintendency for the Development of the North-East. (1967). Treinamento. *SUDENE Informa, 5*(5).
Superintendency for the Development of the North-East. (1968). Mão-de-obra para projetos prioritários. *SUDENE Informa, 6*(11–12).
Superintendency for the Development of the North-East. (1969). Recursos humanos. *SUDENE Informa, 7*(1-2).
Superintendency for the Development of the North-East. (1970a). O curso de dez anos. *SUDENE Informa, 8*(7-8).
Superintendency for the Development of the North-East. (1970b). Recursos Humanos. *SUDENE Informa, 8*(11-12).
Superintendency for the Development of the North-East. (1971). *Estratégia de ação da SUDENE junto às Secretarias de Educação*.

Assumptions, history and rent A conversation with Jayati Ghosh[1]

Esteban Pérez Caldentey and Miguel Torres

Jayati Ghosh (16 September 1955, (India)) taught economics at Jawaharlal Nehru University in New Delhi for 35 years and is currently a professor of economics at the University of Massachusetts Amherst in the United States. She has authored or edited 21 books and 230 scholarly articles and writes regularly for popular media, including newspapers, journals and blogs. Awards received include the International Labour Organization's Decent Work Research Prize for 2011, the 2023 Galbraith Award of the Agricultural and Applied Economics Association "in recognition of breakthrough discoveries in economics and outstanding contributions to humanity through leadership, research and service" and the 2023 International Economics Association Fellow Award for "outstanding work and excellence in economic research, research-driven popular writing, and economic policymaking". She has advised governments in India and other countries and consulted for various international organizations. From 2002 to 2021, she was the Executive Secretary of International Development Economics Associates (IDEAs). She has been a member of several international boards and commissions, including the United Nations High-Level Advisory Board on Economic and Social Affairs, the World Health Organization Council on the Economics of Health for All, the High-Level Advisory Board on Effective Multilateralism of the Secretary-General of the United Nations, the Club of Rome, the Jubilee Debt Commission created by Pope Francis and the Group of 20 (G20) Extraordinary Committee of Independent Experts on Global Inequality constituted by President Cyril Ramaphosa for the South African G20 Presidency.

Professor Ghosh, how did you become interested in economics, and what circumstances led you to pursue a career in this field?

I started out in college studying sociology because I was interested in how societies worked. I wanted to understand more about social hierarchies and inequalities and things like that. But the more I studied it, the more I felt that a society rested on the material basis of its economy. And so I realized that I had to understand that first.

[1] This interview was conducted virtually by Esteban Pérez Caldentey, Chief of the Financing for Development Unit at the Economic Commission for Latin America and the Caribbean (ECLAC), and Miguel Torres, Editor of *CEPAL Review*, on 22 July 2025. The views expressed in this interview are those of the interviewee and do not necessarily reflect the views of ECLAC.

So for my graduate degree, my master's degree in India, I switched to economics, and I got very inspired and drawn in by some very good teachers I had at Jawaharlal Nehru University: people like Krishna Bharadwaj, Prabhat Patnaik and others who were giants of development economics and political economy.

So that's how I got interested in it. I felt that to understand society, you first needed to understand the economy. But I think now I've come full circle. I now feel that you can't understand the economy unless you also understand the society and its politics and history. So, in a way, I feel that it's impossible to do good economics without taking a very transdisciplinary approach. Not interdisciplinary, but trying to absorb as much as you can of what other disciplines have to tell us.

You earned your undergraduate degree from Delhi University in 1975 and your master's degree from Jawaharlal Nehru University in 1977. Can you share how this formative period influenced your views on developing economies and development economics? What key lessons did you learn during that time?

This was a really exciting time for me. Absolutely transformative, I would say. If I had to think of a two-year period that has determined the rest of my life, it would be those two years when I was doing an MA in economics at Nehru University. We had a very small faculty. There were really only eight teachers there at the time. But they were brilliant. They were dedicated, committed; they were progressive. Of the eight people who taught us, six had actually gone to the University of Cambridge and been taught there in its heyday. They were students of Joan Robinson and Nicholas Kaldor and Richard Kahn and so on, and now they were teaching us.

So it was very much economics in the Cambridge tradition that I was introduced to. It's true that there were also neoclassical economists who had been trained in the United States and who did general equilibrium, who did micro, who were getting into welfare economics. But I always found the macro side, the development and Keynesian economics, much more interesting.

I learned different things there, though, and some of those things I believe are absolutely critical to the way I look at the world today. And that is, first, because we actually had economists from very different streams. We had the neoclassicals, as I mentioned, and these were more in the general equilibrium neoclassical tradition, as in the work of Frank Hahn and the Arrow-Debreu school.

Then we had Marxist economists who were very explicitly Marxist, and subgroups within that, as always. We had Ricardian economists, Krishna Bharadwaj was one of Sraffa's favourite colleagues, and he was a great mentor to her. So we had Sraffian economists, neo-Ricardian economists. We had post-Keynesian economists, Amit Bhaduri, for example, who had worked with John Robinson and others. It was a very eclectic, and fascinating, place to be because we were exposed to all of these different views at once. And I think that's absolutely vital, because it allows you to realize that there are so many different ways to look at a particular economic problem, or even to identify a problem.

So much depends on perspective, but the assumptions you make are absolutely critical too. A lot of the disagreements between these different schools actually stemmed from assumptions rather than the logic they employed. This is something that I believe has stayed with me, and that I try to teach my students as well. Whenever you're looking at any economic reality that you want to understand, or if you're looking at a model, if you're looking at any theory, you have to begin by asking what is being assumed, how valid that assumption is, and how critical to the rest of that logic, to the theory, to the model. If it is absolutely critical to the model but it doesn't apply, it's not relevant, then that's not the way you should be looking at it. This is why a whole bunch of trade theories that assume perfect competition and full employment were actually irrelevant as far as I was concerned, even though they have retained such a grip on policy in developing countries.

The other thing you learn is that history is very important because economics is not static. Thinking of economics as comparative statics is such a limited, unimaginative approach, because economies

are inherently dynamic. They are about processes, and that is what today we identify as hysteresis. That is to say, once you start a process, you cannot undo it. It's going to have a particular unfolding, and that will have implications for the next period and the period after that, and so on. The ability to look at how processes unfold, the dynamism aspect, which I think is now well recognized even in neoclassical theories, was another huge eye-opener for me.

The third thing that was a huge inspiration was that all our faculty and many of our fellow students were deeply engaged with the policy debates and discussions of the time. And these of course were global in nature—for example, a lot of structuralist models were emerging at the time. I'm talking about the second half of the 1970s and the early 1980s. There was also very strong engagement with Indian policymaking. Our teachers would be regularly commenting or writing in public spaces. There is a journal called the *Economic and Political Weekly* which everybody who mattered read, in the sense of people who were impacting policymaking and the people who were actually making and implementing the policies, like legislators and bureaucrats, and of course actual economists as well. It was an interesting combination, a current affairs weekly that also had long research articles. In fact, some of the most important economic contributions from India in the '60s, '70s, '80s and '90s appeared in the pages of the *Economic and Political Weekly*. It was a remarkable journal that created an atmosphere of constant engagement with policies, constant discussion and debate and critique. Would policies work? Under what conditions? Or why not? What could be done better? And so on. This brought home to us the need to be always dealing with reality. It was not enough for you to do your course on general equilibrium or welfare economics and then just do further extensions of that; or pick up a particular international trade model or endogenous growth model and maybe tweak it a bit. That was never enough. You had to be able to relate it, because you were always confronting policies. You were always debating policies. And so there was an element of realism in the teaching I got there which again I think is unparalleled in a way. I didn't experience that even when I went to study at Cambridge later. It was a remarkable time for me, of huge intellectual ferment and intellectual inspiration.

That's very interesting. You are very fortunate to have been exposed to different traditions in economics and to have learnt early on in your career that economics must be related to real-world problems. Mainstream economics, and even non-mainstream economics too sometimes, lacks generality. For example, parts of post-Keynesian economics are mainly applicable to the developed world, not the developing world. Can you comment on this issue?

Yes. It's not just the post-Keynesians. Marxists get caught up in these models too. And then they're constantly debating the finer points of something. Did Marx actually say this in volume three, page so and so? That kind of thing bores me today, frankly. I'm not really interested in it any more. I'm interested in whatever will help me understand an economy. And that's why I often find it very difficult when people ask, "Which 'school' are you?" Because I'm not sure which school I'm in. I will pick up whatever insights I can from any of them, to try and understand the particular economic reality I'm confronting, or a historical process I'm observing, or a medium-term pattern or process that is working itself out. I'm not going to say, "Well, I'm a Marxist, so I'm going to look at this purely from a class perspective." No. I'm no longer very loyal to any one tradition. I'm happy to be a magpie, picking up whatever I find helps me understand different realities.

You mentioned all these different traditions you encountered when you were studying for your undergraduate and master's degrees in India. Were there any interactions, any debates between the different schools of thought that coexisted at the university?

What was exciting about Jawaharlal Nehru University was the constant interaction. There were very bitter fights, there was blood on the floor in a lot of these debates. Everybody was very intense and passionate, but everybody interacted, everybody engaged with the other schools. And I think that's quite remarkable.

I have to confess that I found less of that when I went to study for my PhD at the University of Cambridge. I expected there would be much more. In fact, I found a much greater tendency in Cambridge for people to be siloed in their own worlds.

There was a neoclassical group, and Frank Hahn dominated that space. There were some of the famous old Keynesians. Most of them were still around, but they had retired. I mean, Piero Sraffa was still alive. Joan Robinson was alive. Richard Kahn was no more, but Nicholas Kaldor, Austin Robinson and Robert Neild were also around. People from the old Cambridge tradition were definitely around, but those teaching us had somehow evolved into groups that were more siloed. There were Marxist economists like Bob Rowthorn, the applied Keynesian kind like Francis Cripps, and so on. What you perceived was, not sectarianism exactly, but something more like isolationism in the different groups.

So you didn't get the same rather heady, exciting feeling of always having to think about shifting policies and different ways of responding to them and to changing realities, and having arguments with each other about how those realities should be interpreted. There was less of that; everyone was much more doing their own specialized thing.

There were some brilliant development economists as well. Suzy Paine was a very brilliant economist. She was my supervisor until she passed away from cancer. Ajit Singh had very interesting ideas too. He came more from a sort of Penrosean tradition of the theory of the firm, but he had changed and developed over time. There were some good labour economists.

Cambridge was an exciting place, but to be honest I think I learned most from other graduate students. It was a very international crowd, lots of Latin Americans, who gave the most fabulous parties, I have to say. Juan Carlos was one of them, Juan Carlos Moreno-Brid, whom you're all familiar with. It really was international. I think there was basically only one British PhD student out of maybe 100 graduate students altogether, then a lot of Italians and some other Europeans, a lot of Latin Americans, a lot of South Asians, a couple of Americans, some Japanese. It was a very interesting place in that sense.

At Cambridge, who were you closest to among the faculty and among colleagues, students?

Among the faculty, there were some who were huge figures that you kept a bit of distance from even when you interacted with them, right? Joan Robinson, Kaldor, and so on. They were there, and they would go to conferences and seminars, and you could discuss things with them, but you couldn't really get that close.

I did get close to Suzy Paine, and then subsequently, during her final illness with cancer, Geoff Harcourt became my supervisor and I grew very close to him. He was one of the finest men I have ever met, and not just as an academic and an economist, but as a human being. Deeply, deeply generous, humane, very modest, very concerned and engaged. While his interests were essentially theory and the history of economic thought, he was also very open to looking at longer-run policy issues. He opened himself up to development economics, which was not something he'd been very familiar with before, in ways that were very interesting to me.

We had, as I said, a very international crowd. There were all the Latinos with lots of interesting perspectives. There were many students with individual intellectual quirks. For example, Massoud Karshenas, who was from Iran, spent two years reading Hegel in the middle of his PhD, before getting back to trying to understand patterns of industrialization in different countries. Those were the days when you could still afford to do that.

We had some Italians who I think also had a great influence on me because of the ways in which they brought Sraffian economics to life. They actually applied the theory; they weren't just stuck in some highly theoretical mode, but used the approach in analyses of the economies around us. I had previously thought of Sraffa's economics as fundamentally conceptual rather than applied.

But they were trying to bridge that gap, which to me was highly intriguing. I made some amazing friends over that period, and it's wonderful to meet some of them even now. They include some very important and influential economists. In Italy, for example, Fabrizio Barca, who was a member of the Communist Party, was briefly a minister, and he was also at the central bank. And he's extremely active in the progressive movement even now. And Giuliana Campanelli, Lilia Costabile, Francesca Bettio, Valeria Termini... There were many Italians whom I got close to and am still in touch with. It was a fascinating group of graduate students, and we were really, really lucky to have each other.

When you were in India and decided to pursue a PhD, did you go to Cambridge because you felt closest to the Keynesian and Sraffian traditions?

To be honest, it was almost a foregone conclusion for me that that would be the aim, that I would want to go to Cambridge, because, as I told you, six out of the eight people who taught me had been at Cambridge. They were very much part of that tradition.

I wanted to know more. I wanted to meet all the people whose books I'd been reading. I wanted to be exposed to that world. And I was lucky. I got a scholarship. It was the only place I applied to and the only scholarship I applied for.

And so, yes, I spent five years on my MPhil and PhD and two years as a research fellow at Darwin College. It was another formative period. I would say the period before that, at Jawaharlal Nehru University, was possibly even more formative. But those seven years in England were formative too, because they were so international, because it was a little bubble. It wasn't really part of England. We actually got a different perception of the whole context and of economics as well.

Your PhD dissertation, titled *Non-capitalist Land Rent: Theories and the Case of North India* (1983), and your article "The Determination of Land Rent in a Non-capitalist Agriculture: North India, 1860–1930" (*Modern Asian Studies*, 1988; 22(2): 355–382), make two points that are highly relevant to anyone interested in doing economics "the right way".

The first point, thinking specifically of your reference to the notion of rent as developed in the works of Ricardo and Marx, which includes "cultivation solely for profit and free mobility of capital between agriculture and other sectors" (Ghosh, 1988, p. 335), is that the assumptions underlying economic theories are, as you put it, "very strict" and lack generality. In the case of rent, you note that these assumptions "do not apply to the majority of agrarian systems historically known" (Ghosh, 1988, p. 335). When we set these assumptions aside, economic analysis can change dramatically. This insight is crucial, because mainstream economics has developed in part by applying the properties of rent to the determination of wages and profits. Could you comment on the role of assumptions?

I'm so glad you raised this, because after my PhD, I did a postdoc, which moved my work entirely into the domain of international finance. I was looking at the external debt problems of developing countries. So there was this shift, and for several decades I didn't think again about the things I had looked at for my PhD in quite the same way. But there are two things that I now realize were absolutely critical.

You've raised the first one, the issue of assumptions and particularly the idea that every factor gets its marginal product and so on. And the critical difference that emerged for me was that the Ricardian approach comes from scarcity and the Marxian approach from control: ownership and control and the legal codes that enable that control. That was a very important distinction. I tried to apply it historically in the case of India over the colonial period and in the post-colonial period within a particular Indian state, looking at what exactly happened to rents. It became very clear to me that what you had was really what Marx called absolute rent, meaning the extra you get, the surplus you are able to extract, not necessarily because something is scarce, but because you are able to establish property rights and control, which were bestowed by the state.

Now this, I find, is a very powerful idea today. I recently delivered the Heilbroner Lecture at The New School for Social Research in New York, and what I spoke about was actually rents. I have gone back to this idea because what I really think is that capitalism has moved beyond the profit-driven model to a rent-driven model. We are now in rent-driven capitalism, where large multinational capital is increasingly oriented towards extraction through rent rather than towards the generation of greater profits through so-called innovation, productivity increases and the like. And this is because multinationals are able to influence State policies, legal codes, regulatory authorities and so on, and that is what enables them to take larger and larger shares of the surplus.

So what we've got now is a capitalism that is rent-driven, which means that it is inherently less dynamic. A lot of that becomes clear if you use this idea of absolute rent, which stems from power. And once you recognize that interplay, then a lot of what we're seeing, not just massive increases in wealth inequality, which are also associated with income inequality, but massive relational inequalities, the power that comes from being able to influence policies and regulations and the like, becomes clearer too. As does the fact that multinational enterprises are no longer just multinational, but multi-zonal. They are generating different kinds of economic zones, forcing governments to create special zones that are often bespoke, with different regulations from the rest of the country. It all contributes to this dramatic increase in rents, which is really what's driving a lot of large capitalist behaviour.

This process has all kinds of outcomes. It means, first of all, that multinational companies' share of total global profits is increasing. Within that, the share of United States multinationals is increasing. Large capital's share of total profit is increasing and, as we know, the share of profits in national income is increasing around the world. The share of wages is coming down pretty much everywhere. All these tendencies are really part of this emergence of rent-driven capitalism.

It's interesting that in coming back to a concept I first thought about 40 years ago, I'm finding that it's actually very powerful in explaining a lot about the world today.

Rent-driven extraction doesn't have to be about just land. It can be about minerals, of course, and fossil fuels and the rest—you're very familiar with that in Latin America. It's also about new forms of property, intellectual property and the rents that come from it. It's a classic example of the different ways in which you can manipulate rules and laws and regulations to extract more surplus, either from wages or from smaller capital. And all those processes really come back to the idea of rent, reflecting not scarcity so much as power and control over ownership.

This is a very different concept from Ricardian rent.

Absolutely. Yes.

And it's rent driving profits.

Yes.

Can you give examples of two or three assumptions that really prevent economic analysis from accurately depicting or understanding how capitalism works?

I have so many, I don't think I can stop at two or three, so let me give you a few. Some of them are obvious, and I think everybody is familiar with them, right? The assumption of full employment that is in so many models, growth models, trade models, and so on—complete garbage, to the point that everybody now recognizes it. The assumption of perfect competition, again: it doesn't exist anywhere, and never has done, so again, completely irrelevant. Constant returns to scale are hugely irrelevant.

But do you know what concerns me even more? Because people have pretty much recognized all of this. Economists, even mainstream economists, are increasingly bringing in models that do

not make such assumptions. There are models of imperfect competition and trade. Although full employment is still often assumed, there are also models that recognize there's no full employment. So these things are obvious, and more economists are beginning to recognize them.

But there are some concepts that really bother me because I'm unable to grasp them. I want to highlight three. The first is the most basic thing you get in Economics 101, right? In every micro textbook, in any textbook that is "introducing" economics, you find utility maximization of the individual. And that's supposed to be the basis for rational economic behaviour thereafter, rational economic man.

There's a reason why it's a man. Because what are we told that you maximize? You maximize your utility, which is a trade-off between leisure and work for which you get income. And this is so basic and intrinsic to everything else that follows in terms of consumer utility that people (or students) take it for granted and move on and say that's the way it works. Now, imagine if people were actually doing that—then there would be no unpaid care in the world. There would be none because you're not getting paid for the care you do. So then you have to bring in another dimension; maybe claim that some people get utility out of caring even when it's unpaid. But a lot of care work is performed even when people do not get utility out of it, even when they don't enjoy doing it. Whether it's housework or looking after the elderly or the sick or the young or whatever, it's not always enjoyable and pleasurable. So what happens in real life? Our societies and our economies are basically little ships floating on a sea of unpaid care work. And yet we don't recognize it. And our economic theories have explicitly eliminated the very possibility of it. There's this distorted view of human motivation which leaves out an essential feature of all societies and economies, yet the discipline doesn't seem bothered by it. So that's one angle.

Another concept that really bothers me is related to this. It's productivity. And I wish I could say I had resolved it in my head, but I have a real problem with this term, productivity. Total factor productivity is hugely problematic for many, many reasons. Sraffians could tell you them in detail, but it's clear that, conceptually, total factor productivity has issues. Consider one example, labour productivity, which is usually just output per worker. And increasing that is supposed to be a good thing. The more output you get per worker, the better. Really? Especially in service industries, is it really better if one waiter has to wait on 20 tables instead of 10? Is it better if a nurse or a teacher has to look after 100 patients or 200 students rather than 30 or 40? And so on and so forth.

Once you begin to define productivity as the value of output divided by the number of workers, you're asking for trouble. Because by that criterion, the most productive workers on the planet are probably bankers at Goldman Sachs or Morgan Stanley or some hedge fund managers, or maybe now the likes of Elon Musk and Peter Thiel. And those doing unpaid care work are the least productive, or maybe they're completely unproductive, because they get zero income for doing that. There's zero "productivity" in their work.

So I have a deep conceptual problem with productivity as something that has to be constantly pushed up, if you see what I mean. Yet it's such a widely accepted tenet even among progressive economists that I think we really need to go back to thinking seriously about what we value, how we value it, what we measure, and how we give some importance to the things that we're not measuring correctly.

And it's not just about GDP, though of course GDP is critical. It is true that, especially when we're looking at developing countries, we do need to increase output per worker, to get to higher per capita GDP. We do need people's incomes to move up. But somehow we link that with notions of productivity that are very, very limited, and I would say even counterproductive, for many reasons.

In the service sector, for example, Kenneth Boulding made the famous argument that it takes exactly the same number of people to play a Beethoven quartet now as it did 200 years ago. There's no productivity improvement there. (Interestingly, he was also an early proponent of looking at sustainability in an economy and a pioneer of ecological economics.) But we don't think about

that at all. And we somehow see all that as being outside the economy. But by being so beholden to this concept, I believe that in some ways we are denying ourselves a better way of imagining an economy. We are constantly thinking of what we can do to serve the economy (defined in terms of total monetary exchanges) rather than how we can make the economy serve us, serve society within planetary boundaries.

And that relates to another bugbear of mine when it comes to concepts, which is efficiency. Again, it's so hard to define. And I have talked to some very famous economists who have ended up telling me, literally, "Well, I know it when I see it." Efficiency is such a widely used and yet fundamentally loose concept. We can say, for example, that a steel plant is more efficient if it's using more inputs in a particular way. That's one notion of efficiency. We can talk about the efficiency of workers doing a particular task and how quickly they can do it. That's another very specific and limited use. But when we start talking about sectors or organizations or corporations or governments in terms of efficiency, we are in a quagmire. We haven't understood the concept. We can proclaim that public services are inefficient without really getting to the bottom of just what we mean by efficiency and what things would actually make them more valuable to society rather than just "efficient".

These are two concepts I have a problem with, although that doesn't mean I have a very well-worked out analytical critique. I have written a paper critiquing the idea of productivity. I delivered it as a David Gordon lecture a couple of years ago. Efficiency, I think, is something else that really needs to be thought through much more and critiqued in terms of the ways it's used.

Let's move on to the second point you make in your dissertation. You discuss the "forces" that determine rent, which are much broader than just "market forces". These include physiological factors, land ownership patterns and power structures influenced by history and culture, such as "sub-infeudation", along with the effects of tradition and extra-economic factors on the relative bargaining power of landlords and tenants (Ghosh, 1988, pp. 379–380). Can you elaborate on this?

Yes. In my thesis, I was trying to apply these ideas to nineteenth-century colonial India and the India of the 1950s, '60s and '70s, post-independence India, and to a particular state, where I looked at agrarian relations through this lens. And in both cases I found that in fact market relations were deeply embedded in society, in the Polanyi sense. Incidentally, I had had this idea before I read Polanyi, but when I did read him, I found he confirmed so many of the processes I had observed.

Polanyi has this notion of fictitious commodities that should not be commodities: land, labour, money. Fictitious commodities are things that have been forced into an exchange relationship, commodified, so that the functioning of markets in them is inherently problematic. And so either they have to be hugely regulated or they are regulated by other forces, extra-economic forces: power relationships, cultural protocols and motivations, and so on.

I do believe that these notions of rent and fictitious commodities are immensely applicable today, not just in those specific contexts that I was talking about, but to the global economy, to the way transnationals behave, to the way States behave today, to the way not just natural resource exploitation and mineral extraction occur, but all kinds of trade occur.

For example, I don't think you can understand pricing in any market, let's say the agricultural commodities market, without looking at power relationships and at how far the price is actually set by the rent-driven kinds of behaviour that I've been mentioning. In the case of labour, it's obvious that there are all these other things in play. It's not so obvious in a lot of other markets, like those for commodities or even high-grade services, yet they operate just as much in those as well.

I really do believe that you cannot see markets in isolation. That's why I said that to understand the economy, you have to understand the politics of a society, its history and culture. You really do, because those things don't just determine the workings of markets within countries or localities or regions. They are making our global markets work in a particular way.

Towards the end of the article you published in *Modern Asian Studies*, you talked about the determination of rent and about the factors pulling it upward and those pulling it downward. So implicitly there's some kind of stability, despite the fact that rent is driven by different and contradictory forces.

I think in hindsight I'd be more cautious about saying that, because I now feel that we can get extremes of domination and control that I really had not anticipated 40 years ago. We can get greater relational inequalities, meaning the power one person or group has over others and the ability to control their behaviour and outcomes. We have much more of that. Of course, we've always had it with patriarchy and so on, but in the global economy there's a lot more of it. So, in a way, the countervailing factors that I mentioned, that kind of create a balance over the medium term—I don't know whether we still have those. I'm not sure we haven't created a world in which capital, large capital, has become too powerful even for its own good, a world where there are too few counterbalancing forces.

Would you say you have become more prone to thinking the system is unstable?

I am prone to believing that the system is not just unstable, but heading for collapse. Wolfgang Streeck, the German political philosopher, had a wonderful quotation about this. He wrote a book called *How Will Capitalism End?, b*ut his argument is really that capitalism is already dead. It's just that there's no one to take away the body, and that dead weight is lying on top of all of us.

The dynamism that characterized capitalism, with productive forces being constantly improved and so on, doesn't exist. Yes, there are individual pockets of rising productivity and emerging technologies, but the system as a whole is fundamentally undynamic. It is a lower-growth, lower-investment system that is much more rent-extractive. And that is what is giving us all the economic inequality, the social polarization, the rampant injustice in the way economic processes work themselves out, all of which strikes me as highly unstable. And of course, in planetary terms, in terms of our resource use, the way we are overexploiting nature and the damage we are doing to the earth don't make for a stable process.

You have been a major force, alongside colleagues such as C.P. Chandrasekhar, Jomo Kwame Sundaram and Vikas Rawal, in the creation and consolidation of IDEAs, an international network dedicated to research and the dissemination of heterodox perspectives in economics. You served as the Executive Secretary of IDEAs from 2002 to 2021. Can you describe how the project to create IDEAs originated, what its purpose is and why it's important?

IDEAs originated with Jomo Kwame Sundaram. He's a very famous development economist from Malaysia who was also an Assistant Secretary-General at the UN for some time.

Jomo grew up in an environment of Third World nationalism. He's very much a Bandung Spirit kind of person, if you like, and was involved in several attempts to bring together people from the developing world, especially economists. He came up with this idea that we really need to bring together the economists of the developing world so that they can have a direct dialogue with one another. Because too much of everything we do, write, say and learn is mediated by the Global North. We write in its journals, we publish there, we go to seminars and conferences there, we go and study there. Everything is mediated by the Global North.

And yet there is so much knowledge, so much wisdom in the work that is being done in the Global South. Often we're just unaware of it. With Latin America there is a language barrier, for sure, for those of us who are English-speaking. But that's not the only reason.

We are unaware of work done in East Asia, in India, in Africa, where many English-speaking economists live. So the purpose of IDEAs was, first of all, to bring together economists from the developing world who had a different perspective on how economics should be conducted. I mean those of us who were not stuck in the mainstream. We didn't say you had to be a Marxist or a neo-Ricardian or a neo- or post-Keynesian or anything specific like that. No, we just wanted people who had recognized that the mainstream paradigm was not really all that useful and then opened up to other paradigms.

The goal was to bring together heterodox development economists based in the Global South. I think this was very important, critical in fact, because you experience daily what the problems are, what the issues are, what the realities are, and we needed to talk to each other. Besides getting to know each other, getting to know each other's work and so on. We realized that the dominance of neoliberal economics had led to a real de-skilling of young economists around the world.

They simply hadn't been exposed to some of the most basic Keynesian or Kaleckian ideas or some of the most basic development theories. They had a simplistic model that was already outdated way back when, but most of these younger scholars had simply not had the exposure. So IDEAs also started holding capacity-building workshops for young people —which you're very familiar with, Esteban, because you've helped with many of them— followed by research conferences where they could then meet and interact with a lot of the people doing research into recent and ongoing issues.

And I'm absolutely amazed and delighted that IDEAs has not only survived this long but is actually, to my mind, scaling greater heights. Thankfully I'm no longer involved. I say "thankfully" because it was exhausting to do that for two decades, though of course I enjoyed it. But I'm delighted that it's still in such good hands, that there is still so much activity, that there is such great and growing engagement, and I think it meets a real need.

It's not just that an alternative economics is needed, though it absolutely is. But we need to move away from the North-centred kind of dependence that we've had, the intellectual subjugation that too many of us have been through, and to recognize, celebrate and learn from the huge amount of fascinating and really important work that's being done in the Global South. And I am delighted that you now have your own branch in Latin America and that it's being so active, because I believe it's very important for us to get to know each other and to be able to disseminate that work to each other as well. And it's a continuous learning process for me, for sure, but it's also very exciting to see younger people becoming a greater part of this global desire to know more about the world as it really is.

Since its creation, IDEAs has increased in importance, activity and influence. IDEAs fills a very large gap in the effort to better understand the developing world.

You have visited Latin America many times. Can you share your thoughts on what you see as some of the main challenges for development in the region? How do economic and social conditions in the countries you've visited compare to those of India and Asian economies more generally?

I'm so glad you've asked me that question, because I have arguments with my Latin American friends. Latin American economists are very depressed about their economy and its future. They say that Latin America has deindustrialized, that it is characterized by low productivity, and that growth rates are not good enough. You come from India and you think, "Oh my God, wow." There's been so much progress already. You're so developed. Your per capita incomes are maybe 10 times ours or 5 times

ours. And your standards of living and your levels of social protection and minimum wages are so much better. I mean, 95% of our workers in India, I think, are informal. That's true of much of South Asia, though Sri Lanka's an exception. But in Latin America you complain because 30% are informal.

One difference I have found that quite amuses me is that you Latin American economists seem to think yours is the worst-performing region because you arrived at some kind of autonomous industrialization and it's been downhill since then. You know, a lost decade, than a bit of a recovery, but much more speculative, bubble-based, and then another lost decade.

But for us, Latin America has been a source of inspiration, especially during the decade of what has been called the pink tide, when we saw in Brazil, in Argentina, in Ecuador, that you could have increases in minimum wages along with increases in employment, the spread of social protection, greater formalization in positive ways.

Yes, there was inequality, of course. The inequality in Latin America is obscene, and it's wrong, and it's terrible. But it's so much less than the inequality in India, which is massive and multi-dimensional. We have some of the world's richest billionaires in India. And we have huge quantities of the most destitute people. You've been to India. You've seen some of the conditions people live in, especially the poor in different parts of the country. And we also have caste, a social inequality that is unique in its oppressiveness and its persistence. It has persisted through everything, through the colonial period, through a Nehruvian statist, dirigiste regime, through a neoliberal market-oriented regime, through a patronage-based crony capitalist regime… Caste is a terrible, terrible reality for India. And it condemns Indians to inequality because you don't really think of people lower down the ladder as being the same as you. That's why we didn't even legislate for universal school education until 2006. And even now, it's not fully happened. That's why our healthcare is so terrible.

Caste actually enables us to treat a large portion of our own citizens as though they were a different order of beings from the elite. In a way, I've always found that people in Latin America haven't understood just how bad things can be. I do recognize you have lots of problems. I'm not saying you have no challenges. I think there are huge challenges. But somehow I always come back from Latin America thinking that there are many more opportunities here, and sometimes your governments take them, and sometimes your governments show an ability to do things, to swim against the tide, that we haven't had enough of in India.

Do you think the ideas of ECLAC have influenced economic thinking in Asia?

There are phases. There was a period when ECLAC writers, and the structuralist economists in particular, were very widely read and talked about and debated, when I was a student actually. So that was 40 years ago. And ECLAC thinking was very much part of the conversation because we could relate to it. Structuralist approaches to inflation were a very good fit with the Asian reality. I mean, most of our wages were not index-linked, that wasn't what was causing inflation. We could relate immediately to the concept of sectoral imbalances. There was so much we could relate to, such as the role of elites in perpetuating certain industrial policy patterns or the characteristics of the underdevelopment process. Many, many features of different economists' thinking were widely discussed in that period and became part of the thinking of many economists, and especially political economists, development economists, in India at that time.

Now, I have to admit, there seems to me to be much less knowledge of the work being done by ECLAC in the rest of the world, not just in South Asia, but also in Africa and East Asia. I think very interesting work has been done, and I know because I am familiar with your work, and because of IDEAs and friends who have been at ECLAC. You have done very interesting and important work, but there is not much knowledge of it. I think it would be great to get IDEAs to work together with ECLAC to disseminate the very important ECLAC research that we are not fully aware of.

Is there or has there been anything like Latin American structuralism in India? I'm thinking of concepts like structural heterogeneity, which can be applied to society but also to the production structure. What are your views on this?

I think so. I think there was very much a tradition along the lines of structuralism. It might not have been called that exactly, but it was a broad tradition in political economy and had many strands.

There were huge numbers of dual economy or triple economy models that were structuralist in their assumptions and thinking and modelling. There were exercises in political economy that considered ways of establishing different kinds of economic strategies that would work in the context of the social and other divisions that are so predominant across the country.

This work wasn't described in quite the same way, and possibly a lot of it is not well known. Recently, the Nobel Prize was won by a bunch of people who looked at economic history in institutions. Personally, I find those arguments trivial compared to the really important work done by Amiya Kumar Bagchi, Prabhat and Utsa Patnaik, or even Walter Rodney in Africa.

I think there have been interesting theses along these lines which are not widely known outside of their specific regions. So once again, this is an important element of what I think IDEAs can contribute.

You sit on several international boards and commissions focusing on financing for development, a major topic in development economics. What can you tell us about the recent Fourth International Conference on Financing for Development (Seville, 30 June to 3 July 2025) as regards achievements, missed opportunities and the challenges ahead for developing nations?

I think the first big positive takeaway is that it happened at all, because this was something the United States walked away from. The Sevilla Commitment is a reasonably good document. It says a lot of positive things about global taxation and the need to reform it. It is not as strong on sovereign debt, but it makes a lot of the right noises on several other issues.

However, the Sevilla Commitment is the fourth Financing for Development document at the global level, and we know that the other documents didn't make a huge difference. What may change things now —and the Spanish government showed remarkable initiative in this matter— is the creation of the Sevilla Platform for Action for coalitions of countries willing to work together to take specific issues forward. The Platform has many different thematic areas, and there have been more than 130 specific initiatives. One of them concerns taxation, the taxation of the extremely wealthy, and was launched by Brazil, South Africa, Spain and Chile with the hope that more countries would join. Others are concerned with social protection, demanding changes in the way the multinational development banks operate, and so on. Then there are debtors, who are mentioned in the Sevilla Commitment. If debtors can share information about what they are being asked to do compared to what others are being asked to, what kind of deal someone managed to get, how they went about getting it, this is immediately helpful and opens up promising avenues for further collaboration.

In the medium term, working through coalitions may be the only way to advance progressive measures internationally. The point is that you don't have to be alone, you can form groups and work out common strategies. This is a critical issue, because we need to deal with the power imbalances that exist, and particularly the power imbalance that divides very large capital and very large capitalists from everyone else. Since the official forums are still restricted, we need to create these alternative platforms where a greater number of groups and countries can come together to move forward. The effects will show up, not immediately, but over the medium term.

I've been on several multilateral boards and commissions. I'm still on the High-level Advisory Board on Economic and Social Affairs of the United Nations. And I was part of a board on effective multilateralism. And I have seen that too often we expend our time and energy preparing a document, arguing about the phrasing and about every statement and goal, trying to insert more progressive elements into that document. And then that document disappears into cyberspace and doesn't really have an impact or even get widely known. With that experience in mind, I think I'm now much more interested in what we can do practically by working with smaller groups of countries to change power balances so that over time we can actually make multilateralism itself more progressive and more effective.

Do you think the fact that some European countries like the United Kingdom, France and Germany are imposing major restrictions on social spending because they're giving priority to the military may represent a constraint for the implementation of the Sevilla Commitment?

I think there's no doubt that geopolitics is moving in a very unhappy way. It's certainly not desirable, but I don't think we should be too obsessed with the dramatic decline in ODA. Remember that 85% of ODA from the G7 in the last three years has gone to Ukraine, not to developing countries affected by such phenomena as starvation or civil war. But ODA had already shown itself to be mostly irrelevant.

We need to think of a different model now. I am very much an advocate for a global public investment model that recognizes the importance of global public goods, with every country contributing to the financing of these according to its means. That would move away from a patronage-based approach of "being good to the poor" and providing some money, and towards a system where countries were doing something that was good for themselves. It's only by switching to that kind of model that we can get some real movement in terms of the minimum financing we need. Countries must recognize that it's enlightened self-interest and not charity, that they're actually enabling their own survival.

Last year, IDEAs organized an event on financing for development in Rio de Janeiro. The main question on one of the panels was whether there was any prospect of global financial institutions changing and becoming more attuned to developing countries' needs. One of the panellists gave a strongly negative answer: the global financial architecture will not change. And I think there was some consensus at that meeting that things were not going to change. Have you been more optimistic about the global financial architecture since the Fourth International Conference on Financing for Development in Seville?

I'm not a fan of the current global financial architecture, for sure. I think we all know the reforms that are required. Reform of the Bretton Woods institutions, regulatory reforms, all of those things: I think most of the people involved are aware of what is needed. But we also know it won't happen because the countries that control these institutions will not allow it to happen.

What I think is more likely is that many more countries are going to opt for a plan B. They're going to develop their own linkages and ways of dealing with an increasingly unreliable global system. That's already happening with exchange mechanisms like BRICS Clear as an alternative to the SWIFT system; central bank digital currencies, which are going to be employed more widely; and new kinds of trade credit extending across different groups of countries. In addition, the current international institutions are showing themselves to be not just ineffective, but counterproductive in many ways. The IMF is still prescribing the same old austerity medicine, the same regressive policies, wherever it goes. I believe that these institutions will, like the WTO, become essentially irrelevant if they continue along these lines.

What advice would you offer younger economists currently being trained at universities in the region and around the world, drawing on your expertise as a leading development economist?

The most basic advice: question everything about any argument you are presented with, especially its assumptions, whether it is an economic model or a particular statement of fact or supposed fact or a policy measure. Begin by asking what the assumptions are, and then see whether those assumptions correspond to the reality being analysed and how important they are. Accept or reject the argument on that basis. Hence the number one piece of advice is to question everything.

Number two, please read more than just economics. Read history, read politics, read sociology, read about culture, because all of that will help you understand the economy better.

And I guess the third piece of advice is a tough one: because of the sad state of our discipline and because of who the gatekeepers of that discipline are, you must have a lot of courage. You must be prepared to swim against the mainstream. Mind you, the results aren't always too disastrous. I am living proof of that: in my own life, I've enjoyed professional success way beyond anything I would have imagined, even though I've never conformed to typical mainstream perceptions. So being courageous can have its benefits, apart from being necessary!

Would you say that, where assumptions are concerned, the advice should be to start with an analysis of stylized facts?

Yes. That's certainly the way, more and more, that I do it myself now. Look at the reality. And for empirical work, especially when you're looking at processes, look at the time series.

Don't use any regression or other fancier technique before you have looked at the time series and identified patterns. Nowadays it's so easy, they just do these panel regressions or other empirical exercises without looking carefully at the evidence for clear patterns. Far too many students tend to do this, and then if they are asked what actually happened to an economy during a given period, they have no idea because they haven't really observed its behaviour over time and tried to understand it, not least by recognizing its complexity. So I agree that looking at stylized facts —and, importantly, recognizing their context— is an essential first step.

And would you also agree that younger economists would be well advised not to be too technical, but to look at concepts first?

Let me put it this way. What I would advise is: be very careful about the precise meaning of every concept you use, and its applicability and limitations. In theoretical work (which must provide the framework for all empirical work), clarify and recognize all the assumptions you are making. In applied work, don't get obsessed by the empirical techniques and don't let the techniques get the better of your understanding. Today, unfortunately, many young researchers go the other way, following the latest fashions in techniques and shaping their research to fit them. For example, over the past few years, the fashion in applied work has been to do difference-in-difference studies. So too many young scholars look for a problem that fits the difference-in-difference method. I find that so limiting and so unnecessary. Choose a problem that excites you and then use any method you can get hold of that enables you to understand and explain it. Don't let the technique rule your research or your attempt to understand economic reality.

Thank you, Professor Ghosh, for sharing your valuable thoughts, which will undoubtedly encourage further reflection among our readership.

Selected writings of Jayati Ghosh

Ghosh, J. (1983). *Non-capitalist Land Rent: Theories and the Case of North India* [Doctoral dissertation, University of Cambridge].

Ghosh, J. (1985). Differential and absolute land rent. *Journal of Peasant Studies, 13*(1). https://doi.org/10.1080/03066158508438283

Ghosh, J. (1988). The Determination of Land Rent in a Non-capitalist Agriculture: North India, 1860–1930. *Modern Asian Studies, 22*(2). https://doi.org/10.1017/S0026749X00001001

Ghosh, J. (2012). Women, Labor and Capital Accumulation in Asia. *Monthly Review, 63*(08). https://monthlyreview.org/articles/women-labor-and-capital-accumulation-in-asia

Ghosh, J. (2015). The creation of the next imperialism: The international architecture. *Monthly Review, 67*(03). https://monthlyreview.org/articles/the-creation-of-the-next-imperialism

Ghosh, J. (2021). *Feminist Economics Lectures* [Video]. Institute for New Economic Thinking. https://www.ineteconomics.org/perspectives/videos/feminist-economics

Ghosh, J. (2022). What Do We Really Know about Productivity Differentials across Countries?. *Review of Radical Political Economy, 54*(4). https://doi.org/10.1177/04866134221099507

Ghosh, J. (2024). Why and How Economics must Change. *Finance and Development*. https://www.imf.org/en/publications/fandd/issues/2024/03/symposium-why-and-how-economics-must-change-jayati-ghosh

Ghosh, J. (2025a). Power, Control, Inequality, and Democracy in the Twenty-First Century. *Monthly Review, 77*(04). https://monthlyreview.org/articles/power-control-inequality-and-democracy-in-the-twenty-first-century/

Ghosh, J. (2025b, 30 September). *Albert Hirschman Lecture with Jayati Ghosh*. United Nations Educational, Scientific and Cultural Organization. https://www.unesco.org/en/articles/albert-hirschman-lecture-jayati-ghosh

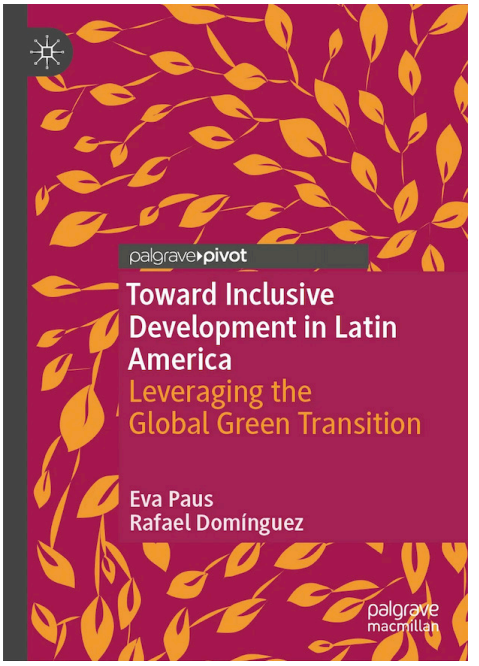
Book review

Towards inclusive development in Latin America: Leveraging the Global Green Transition, by Eva Paus and Rafael Domínguez

José Eduardo Alatorre and Santiago Lorenzo

Abstract

This essay presents a review of the book *Towards inclusive development in Latin America: Leveraging the Global Green Transition*, by Eva Paus and Rafael Domínguez, which addresses a dilemma shared by the countries of Latin America and the Caribbean: how to leverage their natural resources to create a virtuous cycle of competitive sustainable development in an evolving international landscape.



JEL

F6, H1, L5, O2, Q5

Authors

José Eduardo Alatorre is an Economic Affairs Officer of the Sustainable Development and Human Settlements Division of the Economic Commission for Latin America and the Caribbean (ECLAC). Email: joseeduardo.alatorre@un.org.

Santiago Lorenzo is Chief of the Economy of Climate Change Unit of the Sustainable Development and Human Settlements Division of ECLAC.
Email: santiago.lorenzo@cepal.org.

I. Introduction

In their book *Towards inclusive development in Latin America: Leveraging the Global Green Transition,* Eva Paus and Rafael Domínguez attempt to answer one of the most persistent and relevant questions regarding the economic development of Latin America: how to use the wealth of natural resources to support sustainable and inclusive economic development. They also address the question of whether it is possible under current conditions to take advantage of the global green transition as an opportunity to reduce dependency on extractive activities by harnessing natural resources as a driving factor. The authors explore some avenues for improving development and analyse enabling conditions and potential internal and external barriers in that regard.

The global vision of a green future represents an opportunity for Latin America and the Caribbean, a region rich in natural resources, to lower the historical structural barriers and to extend social well-being to the broad swathes of the population who are currently marginalized. This book's innovative and timely proposal calls upon decision makers of the region to take advantage of the opportunity before them.

On the basis of a theoretical framework built with certain elements of theoretical heterodoxy from the fields of economics and political economy, the authors envisage a new role for the State in the light of the urgent need for a green transition and current geopolitical trends.

In that connection, the book analyses possible development strategies in the context of the environmental emergency, in particular the climate crisis, and proposes an inclusive green development model that would involve returning to a State protection of sorts, with the revival of industrial —or rather, productive— policies, but approached through the lens of environmental sustainability.

Leaving behind the current polycrisis in the countries of Latin America and the Caribbean requires systemic change centred on inclusive green development to simultaneously address low economic productivity, limited social inclusion and the present model of environmentally unsustainable development. This effort must also address the geopolitical crisis affecting the existing international order, by engaging in an unprecedented level of regional coordination based on the economic integration of new green value chains.

In the authors' view, the green transition represents a path to well-being for the population. This topic has attracted interest from a growing number of academics since the beginning of the twenty-first century, as well as from international organizations, such as the United Nations Environment Programme and, in the field of economics, the Organisation for Economic Co-operation and Development, the International Energy Agency, the International Monetary Fund and the Economic Commission for Latin America and the Caribbean (ECLAC).

The book's contribution to the debate is its meticulous description of the potential challenges for implementing necessary State policies in the current geopolitical climate, as well as the regional integration processes that will be required.

In that regard, the authors point to the possible role of progress in energy efficiency, the transformation of (public) transport and leveraging the potential that unconventional sources of renewable energy and rare earth minerals represent in the region. Most crucially, for the authors, there is still time for the region to develop technology, goods and services for the green economy of the future.

II. Green development in Latin America and the Caribbean and the ECLAC vision of a big push for sustainability

The book's basic premise is that progress in Latin America and the Caribbean relies on green inclusive development. It is not a novel thesis: Raúl Prebisch, Celso Furtado, Enrique Iglesias and Osvaldo Sunkel, among other noted economists, viewed the region's extractivist imperative as a key element of its structural problem, resulting not only in dependency but in environmental degradation as well (Sunkel and Gligo, 1980). However, this book goes into significant detail about how green, inclusive industrialization can become the foundation of regional progress. Underlying this major contribution to the debate is an awareness that the effects of the coronavirus disease (COVID-19) pandemic had exposed the failure of the dominant hypothesis of the past 40 years, which held that the market would overcome obstacles to well-being.

Thus, State intervention returns to the foreground as a necessary means of steering the economy to benefit all people in an environmentally sustainable manner, given the understanding that the cost of inaction is greater than the required investment (Stern, 2006). That active State role informs the authors' proposal of the type of industrial policy to be designed and implemented.

The Washington Consensus years were a period of worsening environmental deterioration, increasing income concentration among the few, very weak economic growth rates and deplorable working conditions in vital sectors for the functioning of society. Public health services also fell away, including in areas beyond the scope of the private sector, such as monitoring, prevention and preparation for epidemics.

In 2018, ECLAC proposed its "big push for sustainability" (ECLAC, 2020), which involved a coordinated reorientation of public policies, investments, regulations and tax systems aimed at uniting multiple economic stakeholders on a path towards higher quality economic growth, based on technological innovation and decent work and decoupled from environmental impact.

The more recent approach identifies climate action as an opportunity for structural transformation to decarbonize and adapt production while addressing the three development traps: low capacity for growth; high inequality, low social mobility and weak social cohesion; and weak institutional capacities and ineffective governance (ECLAC, 2025). In addition, regional cooperation is recognized as the key to supporting the next generation of productive development policies (Organisation for Economic Co-operation and Development et al., 2025).

Paus's and Domínguez's book follows in this same vein, proposing industrial policies that take into account social inclusion, which is integral to the concept of social justice and essential for ensuring that "creative destruction" (Schumpeter, 1942) is a positive force for social well-being and cohesion.

III. Constraints on green development and the three-gap model

In their analysis, Paus and Domínguez identify three constraints on inclusive green development: structural change that hampers growth; limited social inclusion; and global warming. This approach is largely consistent with the ECLAC three-gap model, detailing the interrelated nature of external constraints, social exclusion and environmental degradation (ECLAC, 2020), and an analysis based

on that framework, further supporting the proposed big push for sustainability as a possible means to breaking the vicious cycle (ECLAC, 2022), as is also discussed in the final report of the Expert Review on Debt, Nature & Climate (2025).

However, Paus and Domínguez present a much more granular analysis of enabling circumstances for productive policies that would replace the vicious cycle with a virtuous one and leverage the green transition to integrate the region into international markets, not in its historical role as a commodities producer but as a link in extended value chains, with social inclusion driving its internal market expansion and improving its human and social capital.

In the three-gap analytical framework presented by ECLAC (2020), which synthesized the Sustainable Development Goals in relation to three growth rates, the production structure (as symbolized by the export basket) revealed the external constraint as a major barrier to accelerated economic growth in the region. Surmounting this while pursuing equality and reducing poverty requires higher growth rates, but the region's pattern of production renders positive growth incompatible with climate objectives. From that perspective, the book posits that increased demand for critical minerals would relax the external constraint, as had occurred in the early twenty-first century during a period of high commodity prices. Implementing an industrial policy of productive diversification is the only way for the production structure to generate higher growth through better global economic integration.

The analysis and proposed solution clearly echo past proposals advanced in ECLAC position documents (ECLAC, 2016, 2018, 2020, 2022 and 2024) and identify national and global barriers. The book also outlines a crucial research agenda for regional development, on how to strengthen the State so that it can fulfil its leadership function, how to ensure that natural resource governance maximizes social well-being within planetary boundaries, how to cultivate the necessary conditions to create new sectors that are more knowledge intensive, how to identify and encourage growth-boosting activities that have a smaller environmental footprint and, lastly, how to forge the partnerships needed to politically sustain the required changes. Every step in this direction will make it easier to identify the internal changes (including fiscal and regulatory reforms) and the global changes (i.e. financial architecture and trade reforms) needed in transitioning to more sustainable economies.

IV. Navigating troubled waters towards the markets of the future

One notable aspect of the book is that its proposal —which, as mentioned, is part of an extended conversation in the region— is made in the context of the geopolitical rivalry between a hegemonic United States and an emerging China. In the authors' view, for the region to leverage its wealth of resources to generate opportunities, non-alignment is the best course, together with a strategy of lengthening value chains for inclusive green development. Of course, non-alignment with a hegemonic power calls for extraordinary diplomatic skill and, more importantly, solid agreements among the countries of the region, which are not easy to achieve.

Another of the book's key contributions is its appraisal of the limitations that the international trade framework of the World Trade Organization (WTO) imposes on sovereign productive policies. This set of agreements on trade in goods and services, including measures related to investments, hems in economic policy decisions: the need for State intervention in the economy was rejected in favour of the free market during the corporate globalization rush of the late twentieth century, but in the present-day context of intellectual property concerns, technological innovation is shaping a new industrial revolution, and the region should be a more prominent player than it was in the past.

The climate transition is another unavoidable issue, in which the need for State intervention is undeniable. Indeed, private economic actors are asking for State involvement and expanding public-private partnerships, but what they desire even more is certainty with regard to investing in the transition, alongside necessary infrastructure improvements.

Even with the global trading system experiencing one of its worst crises owing to the current resurgence of protectionism, there are still binding measures in force that check the independence of productive policies. Paus and Domínguez offer a much-needed analysis to understand the trade situation and to mitigate the risks and seize the opportunities that it presents.

The central proposal of the book should be the dominant focus of the region's economic agenda; that is, there is a need to identify economic activities in the climate transition that have the greatest potential for generating competitive value chains in the markets of the future and to pursue regional collaboration as a catalytic force in order to ensure that these chains' integration paves the way for enhanced economic integration, all the while demonstrating political aptitude and sensitivity to strike the right geopolitical balance in a landscape shaped by the United States-China struggle for market control. The ECLAC-proposed approach to lithium and e-mobility, involving the integration of the regional mining sector complemented by the integration of the regional automotive industry, would offer a model for such an undertaking (ECLAC, 2023).

V. Final reflections

One highly important issue that is not fully addressed in the book is how the proposed green inclusive development would be measured. It also suggests that popular theories in the green economy context, like degrowth, may be inadequate, but while not necessarily viable in countries where populations still face major material deprivations, degrowth is still relevant to the debate on the nature of well-being.

Since its conception by Kuznets (NBER,1934), gross domestic product (GDP) growth has been recognized as a limited indicator in terms of its ability to capture all aspects of development, in particular sustainability (Stiglitz, Sen and Fitoussi, 2009). All countries aspire to provide well-being for their populations, and GDP has historically offered a sort of compass for determining whether they are on the right track. However, since the beginning, it has been understood that the methodology for calculating GDP is skewed in favour of material production, in that it prioritizes material well-being over all other facets. This was appropriate in a world of widespread material deprivation, but in the current state of affairs, where there is a growing relative shortage of goods to meet the population's social and environmental needs, cautious interpretation of GDP growth is a matter of vital and urgent importance.

The book also addresses the crucial issue of the region's global market entry, which must ultimately be the locus of green industrial policy advances. Even their detailed analysis of the WTO framework and its constraints on sovereign industrial policy does not allow the authors to say with certainty where global trade currents will lead, with the world's largest economies displaying complete disregard for the rules and revealing a neocolonial attitude very similar to the one that largely motivated the trade liberalization agenda of the late twentieth century.

Moreover, in view of the boom in artificial intelligence and the overwhelming quantity of data in existence, the State's proposed function will evolve, and its economic role as an engine for green development will have to be flexible and responsive to change in an environment in constant flux. Designing such a State requires technical, operational, political and prospective (TOPP) capabilities (ECLAC, 2024) to leverage available technology. The reimagining of the State in this new reality and the need for productive policies that are responsive to the economic transition in an uncertain world are important matters— and fertile ground for the application of the authors' sound proposals.

Bibliography

Economic Commission for Latin America and the Caribbean. (2016). *Horizons 2030: Equality at the Centre of Sustainable Development* (LC/G.2660(SES.36/3)).

Economic Commission for Latin America and the Caribbean. (2018). *The Inefficiency of Inequality* (LC/SES.37/3-P).

Economic Commission for Latin America and the Caribbean. (2020). *Building a New Future: Transformative Recovery with Equality and Sustainability* (LC/SES.38/3-P/Rev.1).

Economic Commission for Latin America and the Caribbean. (2022). *Towards the transformation of the development model in Latin America and the Caribbean: Production, inclusion and sustainability* (LC/SES.39/3-P).

Economic Commission for Latin America and the Caribbean. (2023). *Lithium extraction and industrialization: opportunities and challenges for Latin America and the Caribbean*.https://repositorio.cepal.org/server/api/core/bitstreams/5c1c160a-557d-42d9-bfa8-929142d2fa21/content

Economic Commission for Latin America and the Caribbean. (2024). *Development Traps in Latin America and the Caribbean: Vital Transformations and How to Manage Them* (LC/SES.40/3-P/-*).

Economic Commission for Latin America and the Caribbean. (2025). *The economics of climate change in Latin America and the Caribbean, 2025: climate action to overcome development traps* (LC/TS.2025/86).

Expert Review on Debt, Nature & Climate. (2025). *Healthy debt on a healthy planet: Towards a virtuous circle of sovereign debt, nature and climate resilience. Final report.*https://debtnatureclimate.org/reports/healthy-debt-on-a-healthy-planet-towards-a-virtuous-circle-of-sovereign-debt-nature-and-climate-resilience/

National Bureau of Economic Research. (1934). *A report on national income, 1929–32.*https://fraser.stlouisfed.org/files/docs/publications/natincome_1934/19340104_nationalinc.pdf

Organisation for Economic Co-operation and Development, Economic Commission for Latin America and the Caribbean, Development Bank of Latin America and the Caribbean, and European Commission. (2025). *Latin American Economic Outlook 2025: Promoting and financing production transformation*. https://doi.org/10.1787/80e48de5-en

Schumpeter, J. (1942). *Capitalism, socialism and democracy.* Harper and Brothers.https://ia801501.us.archive.org/30/items/in.ernet.dli.2015.190072/2015.190072.Capitalism-Socialism-And-Democracy.pdf

Stern, N. (2006). *The economics of climate change: The Stern Review*.https://webarchive.nationalarchives.gov.uk/ukgwa/20100407172811/https:/www.hm-treasury.gov.uk/stern_review_report.htm

Stiglitz, J., Sen, A., and Fitoussi, J. P. (2009). *Report by the Commission on the Measurement of Economic Performance and Social Progress.*https://web.archive.org/web/20150720212135/http://www.stiglitz-sen-fitoussi.fr/en/index.htm

Sunkel, O., and Gligo, N. (Eds.). (1980). *Estilos de desarrollo y medio ambiente en la América Latina.* Fondo de Cultura Económica.

Guidelines for contributors to the *CEPAL Review*

In order to facilitate the submission, consideration and publication of articles, the editorial board of the *CEPAL Review* has prepared the following information and suggestions to serve as a guide for future contributors.

The submission of an article implies an undertaking by the author not to submit it simultaneously to other publications. The copyright to all articles published in the *Review* shall be owned by the United Nations.

Each article will be reviewed by the editorial board, which may decide to submit it to external referees.

Papers should be submitted in the original language (English, French, Portuguese or Spanish). They will be translated into the appropriate language by the relevant ECLAC services.

Each article must be accompanied by a summary, no more than 150 words in length, giving a brief description of its subject matter and main conclusions.

Each article must also carry three jel (Journal of Economic Literature) classification codes. The JEL Classification Codes Guide is available online at www.aeaweb.org/jel/jel_class_system.php.

Papers should be no longer than 10,000 words, including the summary, notes and bibliography. Shorter papers will also be considered.

Articles should be sent by e-mail to *revista@cepal.org* in Word format. Papers in pdf format will not be accepted.

Style guide:

Titles should not be excessively long.

Footnotes

- It is recommended that footnotes be kept to a minimum.
- It is recommended that footnotes not be used to cite bibliographical references; such references should preferably be incorporated into the text.
- Footnotes should be numbered consecutively using superscript Arabic numerals.

Tables, figures and equations

- It is recommended that tables and figures be kept to a minimum, avoiding any redundancy with the text.
- Equations should be written using the Office equation editor "MathType"; they should not be inserted as "pictures".
- Tables, figures and other elements should be inserted at the end of the text in the format in which they were designed; they should not be inserted as "pictures". Figures in Excel should include the corresponding worksheets.
- The location of tables and figures in the body of the article should be indicated in the appropriate place as follows:

  Insert figure 1

  Insert table 1
- Tables and figures should include an explicit and complete reference to their sources.
- Tables should indicate the period covered at the end of the title, and should indicate the units in which the data are expressed in a subtitle (in italics and between brackets).
- The symbols referred to in the "Explanatory notes" which appear on the page preceding the table of contents should be taken into account in the preparation of tables and figures.
- Footnotes to tables and figures should be ordered consecutively using superscript lower-case letters.
- Figures should be prepared bearing in mind that they will be printed in black and white.

Acronyms and abbreviations

- Acronyms and abbreviations should not be used unless absolutely necessary, in which case the full name should be written out the first time it occurs in the article.

Bibliography

- Bibliographical references should be directly related to the content of the article and should not be excessively long.
- At the end of the article, under the title "Bibliography", all the necessary information should be included accurately and in alphabetical order by author: name of author(s), year of publication, full name of article (if any) and publication (including any subtitle), city of publication, publisher and, in the case of a periodical, month of publication.

The editorial board of the *Review* reserves the right to make any necessary editorial changes in the articles, including their titles.

Authors will receive a one-year courtesy subscription to the *Review*, plus 30 offprints of their article in Spanish and 30 in English, at the time of publication in each language.

Publicaciones recientes de la CEPAL
ECLAC recent publications

www.cepal.org/publicaciones

Informes Anuales/*Annual Reports*
También disponibles para años anteriores/*Issues for previous years also available*

Balance Preliminar de las Economías de América Latina y el Caribe, 2025
Preliminary Overview of the Economies of Latin America and the Caribbean, 2025

Panorama Social de América Latina y el Caribe, 2025
Social Panorama of Latin America and the Caribbean, 2025

Perspectivas del Comercio Internacional de América Latina y el Caribe, 2025
International Trade Outlook for Latin America and the Caribbean, 2025

Panorama de las Políticas de Desarrollo Productivo en América Latina y el Caribe, 2025
Panorama of Productive Development Policies in Latin America and the Caribbean, 2025

Estudio Económico de América Latina y el Caribe, 2025
Economic Survey of Latin America and the Caribbean, 2025

La Inversión Extranjera Directa en América Latina y el Caribe, 2025
Foreign Direct Investment in Latin America and the Caribbean, 2025

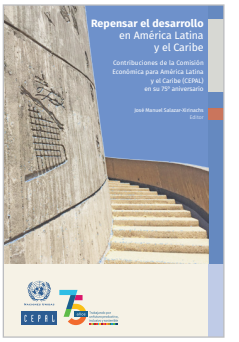
Anuario Estadístico de América Latina y el Caribe, 2025
Statistical Yearbook for Latin America and the Caribbean, 2025

El Pensamiento de la CEPAL/*ECLAC Thinking*

Repensar el desarrollo en América Latina y el Caribe: contribuciones de la Comisión Económica para América Latina y el Caribe (CEPAL) en su 75° aniversario

América Latina y el Caribe ante las trampas del desarrollo: transformaciones indispensables y cómo gestionarlas
Development Traps in Latin America and the Caribbean: Vital Transformations and How to Manage Them

Cooperar o perecer: el dilema de la comunidad mundial. Tomo I: Los años de creación (1941-1960)



Libros y Documentos Institucionales
Institutional Books and Documents

Acuerdo Regional sobre el Acceso a la Información, la Participación Pública y el Acceso a la Justicia en Asuntos Ambientales en América Latina y el Caribe: guía para la transversalización de la perspectiva de género
Regional Agreement on Access to Information, Public Participation and Justice in Environmental Matters in Latin America and the Caribbean: guide on gender mainstreaming

Gobernanza endógena: teoría, datos y herramientas para salir de la trampa de gobernanza poco efectiva en América Latina

Agenda 2030 en América Latina y el Caribe: ¿cómo acelerar el paso hacia su cumplimiento en la nueva era de incertidumbre y fragmentación geopolítica?
The 2030 Agenda in Latin America and the Caribbean: Accelerating Implementation in a New Era of Uncertainty and Geopolitical Fragmentation

Libros de la CEPAL/*ECLAC Books*

Gestión de pasivos ambientales: diagnóstico, desafíos y lecciones para la minería en la región andina
Managing environmental mining legacies in the Andean region: analysis, challenges and lessons learned

Endeudarse para cuidar: género y desigualdad en la Argentina

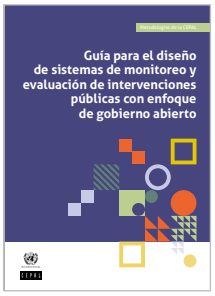
Sistemas de pensiones no contributivos en América Latina y el Caribe: avanzar en solidaridad con sostenibilidad
Non-contributory pension systems in Latin America and the Caribbean: towards solidarity with sustainability

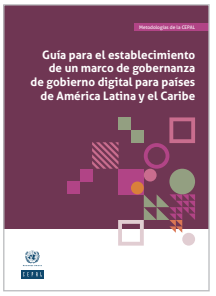
Versiones accesibles/*Accessible versions*

Las personas con discapacidad: de la visibilidad estadística al ejercicio de derechos. Versión accesible
Persons with Disabilities: From Statistical Visibility to the Exercise of Rights. Accessible version

Perspectivas del Comercio Internacional de América Latina y el Caribe, 2024. Resumen ejecutivo. Versión accesible
International Trade Outlook for Latin America and the Caribbean, 2024. Executive summary. Accessible version

Metodologías de la CEPAL
ECLAC Methodologies

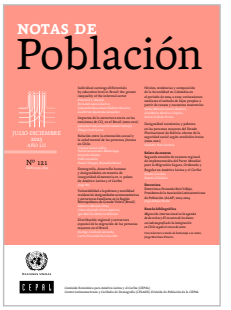


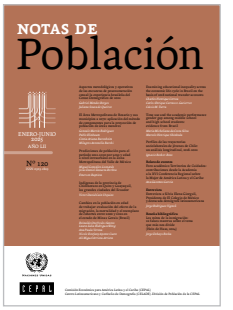


Observatorio Demográfico
Demographic Observatory

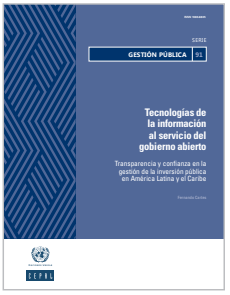
Revista CEPAL/*CEPAL Review*

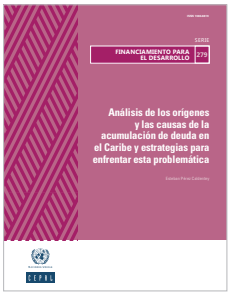
Notas de Población



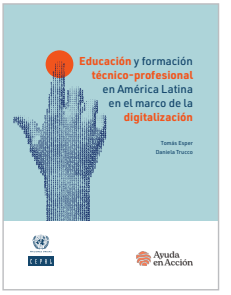


Series de la CEPAL
ECLAC Series

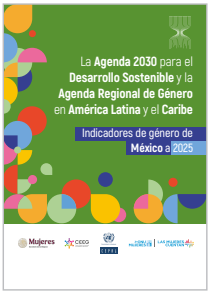




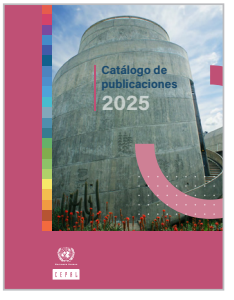
Documentos de Proyectos
Project Documents



Coediciones/*Co-editions*



Catálogo de Publicaciones 2025



Suscríbase y reciba información oportuna sobre las publicaciones de la CEPAL

Subscribe to receive up-to-the-minute information on ECLAC publications

NACIONES UNIDAS
UNITED NATIONS

CEPAL
ECLAC

https://mailchi.mp/cepal/suscripciones-cepal

https://bit.ly/m/CEPAL

Las publicaciones de la CEPAL también se pueden adquirir a través de:
ECLAC publications also available at:

shop.un.org

United Nations Publications
PO Box 960
Herndon, VA 20172
USA

Tel. (1-888)254-4286
Fax (1-800)338-4550
Contacto/*Contact*: publications@un.org
Pedidos/*Orders*: order@un.org

CEPAL REVIEW

ISBN: 978-92-1-003494-4

Digital version available online

https://bit.ly/CEPALreview_147

UNITED NATIONS

ECONOMIC COMMISSION FOR LATIN AMERICA AND THE CARIBBEAN

ECLAC

United Nations Publication • S.2500597[E] • December 2025 • ISSN 0251-2920